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Single-Shell Tank Closure Work Plan

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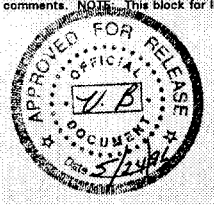

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SINGLE-SHELL TANK CLOSURE WORK PLAN

FOREWORD

The Single-Shell Tank Closure Work Plan provides an overlay of closure strategy with ongoing Tank Waste Remediation System activities. Though single-shell tank operable unit closure occurs late in the Tank Waste Remediation System mission, decisions on closure configuration and closure actions impose constraints on elements of the program initiated earlier in the mission. The closure strategy and decisions must be integrated with the balance of the Tank Waste Remediation System program. Tank waste retrieval is the Tank Waste Remediation System program element principally affected by closure strategy and decisions.

All units located within the boundaries of each tank farm will be closed in accordance with the Washington State Department of Ecology's Dangerous Waste Regulations (Ecology 1994). Closure strategy is based on the assumption that sufficient waste will be retrieved from the single-shell tanks so that the residual waste following retrieval, including contaminated soil and ancillary tank farm equipment, will not be high-level waste. Closure will then consist of those actions necessary to isolate the remaining sources of radioactive and hazardous waste from the environment in-place, in accordance with applicable regulations. Initially, closure strategy will focus on analysis of risk to workers, the public, and the environment resulting from alternative closure configurations and approaches. Results of these analyses will be factored into selection of the preferred closure configuration and approach. The issues associated with characterization needs, analytical methodology, and technology, which are considered elements of the closure decisions are also discussed in this closure work plan.

The purpose of this closure work plan is to provide a description of the ongoing work and the integration process in support of closure. Issues are discussed in a narrative format within each chapter and summarized in Appendix 1A. This closure work plan is provided to the regulators for review and comment in accordance with the *Hanford Federal Facility Agreement and Consent Order* Milestone M-45-06 (Ecology et al. 1994) and is intended to provide a roadmap for closure of the single-shell tanks, as stated:

> "The Single-Shell Tank Closure Work Plan will be prepared describing the work integration process for single-shell tank closures and status of work and the integration process. Known issues will be identified and an explanation will be given on how these issues are being addressed. This work plan will be provided to Ecology (Washington State Department of Ecology) for review/comment and will be used as a roadmap for closure of the single-shell tanks. Because of the uncertainties in the closure process, the work plan will evolve as these uncertainties are resolved and eventually it will become the SST closure/post-closure plan(s) that will be issued prior to closing the single-shell tanks. Major work areas covered in the work plan will include waste

retrieval, operable unit characterization, technologies developed to support closure, regulatory pathway and strategy for achieving closure."

Because of the uncertainties surrounding the closure process, the closure work plan is intended to be the vehicle to address and resolve closure issues and to evolve into the single-shell tank closure/postclosure plan(s). A single-shell tank closure/postclosure plan for closure demonstration of an operable unit or tank farm is scheduled to be submitted to the Washington State Department of Ecology by November 30, 2004.

CONTENTS

FOREWORD

GLOSSARY

1.0 INTRODUCTION

2.0 HANFORD SITE AND TANK FARM DESCRIPTION

3.0 REGULATORY PROCESS

4.0 OPERABLE UNITS CHARACTERIZATION

5.0 SINGLE-SHELL TANK WASTE RETRIEVAL

6.0 CLOSURE STRATEGY FOR SINGLE-SHELL TANK SYSTEM COMPONENTS

7.0 RISK MANAGEMENT

8.0 TECHNOLOGY DEVELOPMENT REQUIRED TO SUPPORT RETRIEVAL AND CLOSURE

9.0 REFERENCES

APPENDICES

1A CLOSURE ISSUES

2A HYDROGEOLOGIC INVESTIGATIONS

2B DESCRIPTION OF SINGLE-SHELL TANK FARMS AND SINGLE-SHELL TANKS

2C SINGLE-SHELL TANK INTERIM STABILIZATION OPERATIONS AND SURVEILLANCE SYSTEM UPGRADES

2D TEMPERATURE MONITORING SCHEDULES FOR WATCHLIST SINGLE-SHELL TANKS

2E PROPOSED TRANSFER ROUTES FOR EMERGENCY PUMPING OF SINGLE-SHELL TANKS

3A SINGLE-SHELL TANK WASTE CLASSIFICATION: REFERENCED LETTERS

7A DATA AND INFORMATION REQUIREMENTS FOR RISK ASSESSMENTS

8A BARRIER AND MARKER SYSTEM DESIGN CONSIDERATIONS

GLOSSARY

AEA	*Atomic Energy Act of 1954*
AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATG	Advanced Technology Gauge
ATSDR	Agency for Toxic Substances and Disease Registry
BHI	Bechtel Hanford, Inc.
CASS	Computer Automated Surveillance System
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CWP	closure work plan
DCRT	double-contained receiver tank
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DP	differential pressure
DQO	data quality objective
DSS	double-shell slurry
DSSF	double-shell slurry feed
DST	double-shell tank
ECN	engineering change notice
Ecology	Washington State Department of Ecology
EDE	effective dose equivalent
EDTA	ethylenediaminetetraacetic acid
EIS	environmental impact statement
ENRAF	Enraf-Nonius 854 Advanced Technology Gauge
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ERA	*Energy Authorization Act of 1974*
ERC	Environmental Restoration Contract
ERDA	Energy Research and Development Administration
ERT	Electrical Resistance Tomography

GLOSSARY (cont)

F&R	functions and requirements
FIC	Food Instrument Corporation
FLTF	Field Lysimeter Test Facility
FML	flexible membrane liner
GAO	U.S. General Accounting Office
GCL	geosynthetic clay liner
GM	Geiger-Mueller
HDPE	high density polyethylene
HDW-EIS	Hanford Defense Waste-Environmental Impact Statement
HEDOP	Hanford Environmental Dose Overview Panel
HEDTA	hydroxyethylethylenediaminetriacetic acid
HEIS	Hanford Environmental Information System
HEPA	high-efficiency particulate air
HLW	high-level waste
HSBRAM	Hanford Site Baseline Risk Assessment Methodology
HWMA	*Washington Hazardous Waste Management Act of 1976*
HWVP	Hanford Waste Vitrification Plant
ICF KH	ICF Kaiser Hanford Company
ID	inside diameter
ILL	interstitial liquid level
IRIS	*Integrated Risk Information System*
ISCS	in situ chemical stabilization
ISV	in situ vitrification
LANL	Los Alamos National Laboratory
LDM	leak detection and monitoring
LDP	leak detection pits
LDUA	Light-Duty Utility Arm
LFI	limited field investigations
LLW	low-level waste
LOW	liquid observation wells
M&O	Maintenance and Operations
MCL	Maximum Contaminant Level
MEMO	Monitoring Efficiency Model
MEPAS	Multimedia Environmental Pollutant Assessment System
MIT	multifunctional instrument trees
MSL	mean sea level
MTCA	*Model Toxics Control Act*

GLOSSARY (cont)

NARM	naturally occurring and accelerator-produced radioactive material
NAS	National Academy of Science
NEC	National Electric Code
NEPA	*National Environmental Policy Act of 1969*
NOI	notice of intent
NPH	normal paraffin hydrocarbons
NRC	U.S. Nuclear Regulatory Commission
NRDA	Natural Resource Damage Assessment
NRDWL	Nonradioactive Dangerous Waste Landfill
OSD	Operating Specification Document
OSR	Operational Safety Requirement
PA	performance assessment
PARCC	precision, accuracy, representativeness, completeness and comparability
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratories
PO	Performance Objective
PUREX	plutonium-uranium extraction
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RAGS	Risk Assessment Guidance for Superfund
RCRA	*Resource Conservation and Recovery Act of 1976*
RCRA Permit	*Dangerous Waste Portion of the Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste*
REDOX	reduction/oxidation
RERA	Risk Evaluation of Remedial Alternatives
RF	Radio frequency
RFI/CMS	RCRA Facility Investigation/Corrective Measures Study
RI/FS	remedial investigation and feasibility study
RKK	RKK LTD
RLS	Radiologic Logging System
ROD	Record of Decision
ROM	rough-order-of-magnitude
RTD	resistance temperature detectors
RTWG	Retrieval Technology Working Group
SHMS	Standard Hydrogen Monitoring System
SPAR	Spar Aerospace Limited
SpG	specific gravity
SST	single-shell tank
Supply System	Washington Public Power Supply System
SWL	Salt Well Liquid

GLOSSARY (cont)

TBP	tributyl phosphate
TC	thermocouple
TFSA&S	Tank Farm Surveillance, Analysis, and Support
TMACS	Tank Monitoring and Control System
TRAC	Tracks Radioactive Components
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRU	transuranic
TSD	treatment, storage, and/or disposal
TU	temporary unit
TWRS	Tank Waste Remediation System
UPR	unplanned release
USQ	unresolved safety question
WAC	*Washington Administrative Code*
Westinghouse Hanford	Westinghouse Hanford Company
WIPP	Waste Isolation Pilot Plant
WPPSS	Washington Public Power Supply System

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METRIC CONVERSION CHART

The following conversion chart is provided to the reader to aid in conversion.

To metric units			From metric units		
If you know	Multiply by	To get	If you know	Multiply by	To get
Length			**Length**		
inches	25.40	millimeters	millimeters	0.0393	inches
inches	2.54	centimeters	centimeters	0.393	inches
feet	0.3048	meters	meters	3.2808	feet
yards	0.914	meters	meters	1.09	yards
miles	1.609	kilometers	kilometers	0.62	miles
Area			**Area**		
square inches	6.4516	square centimeters	square centimeters	0.155	square inches
square feet	0.092	square meters	square meters	10.7639	square feet
square yards	0.836	square meters	square meters	1.20	square yards
square miles	2.59	square kilometers	square kilometers	0.39	square miles
acres	0.404	hectares	hectares	2.471	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.0352	ounces
pounds	0.453	kilograms	kilograms	2.2046	pounds
short ton	0.907	metric ton	metric ton	1.10	short ton
Volume			**Volume**		
fluid ounces	29.57	milliliters	milliliters	0.03	fluid ounces
quarts	0.95	liters	liters	1.057	quarts
gallons	3.79	liters	liters	0.26	gallons
cubic feet	0.03	cubic meters	cubic meters	35.3147	cubic feet
cubic yards	0.76	cubic meters	cubic meters	1.308	cubic yards
Temperature			**Temperature**		
Fahrenheit	subtract 32 then multiply by 5/9ths	Celsius	Celsius	multiply by 9/5ths, then add 32	Fahrenheit

Source: *Engineering Unit Conversions*, M. R. Lindeburg, PE., Second Ed., 1990, Professional Publications, Inc., Belmont, California.

TANK CONVERSION FACTORS

The following conversions are provided to aid in understanding tank volumes and cleanup goals:

1,000,000 gallons = 133,700 cubic feet
1,000,000 gallons = 3786 cubic meters
1 cubic foot = 7.48 gallons
1 cubic foot = 28.35 liters

360 cubic feet is approximately 1 inch of displacement in a Series 100 tank
30 cubic feet is approximately 1 inch of displacement in a Series 200 tank

TANK SPECIFICATIONS

See Figure 2B-14 for additional information

Series	Volume	Diameter	Height
Series 100	500,000 gal 1,900,000 liters	75 feet 22.9 meters	37 feet 11.3 meters
	750,000 gal 2,800,000 liters	75 feet 22.9 meters	45.33 feet 14 meters
	1,000,000 gal 3,790,000 liters	75 feet 22.9 meters	50 feet 15.2 meters
Series 200	55,000 gal 210,000 liters	20 feet 6 meters	37.25 feet 11.25 meters

CONTENTS

1.0 INTRODUCTION 1-1

1.1 OBJECTIVES AND SCOPE 1-1

1.2 BACKGROUND 1-3

1.3 CLOSURE STRATEGY 1-7

1.4 APPROACH 1-9
1.4.1 Closure Decision Logic and Schedule of Activities . . . 1-10
1.4.2 Single-Shell Tank Closure and the Site Systems Engineering Effort 1-14

1.5 SCOPE AND OVERVIEW 1-15

1.6 UNRESOLVED CLOSURE ISSUES 1-17

FIGURES

1-1 A Decision Logic to Support Tank Farm Closure F1-1.1
1-2 An Integrated Schedule to Support Tank Farm Closure F1-2

TABLES

1-1 Single-Shell Tank Operable Units T1-1
1-2 Closure Issues T1-2.1

1.0 INTRODUCTION

In January 1994, the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) was amended to reflect a revised strategy for remediation of radioactive waste in underground storage tanks (Ecology et al. 1994). These amendments include milestones for closure of the single-shell tank (SST) operable units, to be initiated by March 2012 and completed by September 2024.

Tri-Party Agreement Milestone M-45-00, requiring closure of all SST farms by September 2024, is categorized as a "major" Tri-Party Agreement milestone. It specifies that closure of the single-shell operable units, including contaminated soil and tank farm ancillary equipment, is to be in accordance with Washington Administrative Code (WAC) 173-303 regulations. It also clarifies regulatory jurisdiction and involvement in the closure process relative to the dangerous waste component of the SST wastes.

Tri-Party Agreement Milestone M-45-06, also requiring closure of all SST farms by September 2024, is categorized as an "interim" Tri-Party Agreement milestone. It requires submittal of a Single-Shell Tank Closure Work Plan to serve as a "road map" for closure of the SSTs, and a tool for resolving issues prior to submittal of the actual Closure/Post-Closure Plan required by WAC 173-303 regulations. The CWP describes the regulatory pathway, defines key activities and interfaces, outlines the closure strategy, identifies major decisions to be made concerning closure configuration, and provides a means for tracking resolution of issues. As issues and uncertainties are resolved, the CWP provides the basis for preparation and approval of the Closure/Post-Closure Plan for the SST farms or operable units.

Tri-Party Agreement Milestone M-45-06-T01, Submit Closure/Post-Closure Plan to Ecology for Approval, November 2004, is categorized as a "target" Tri-Party Agreement milestone. Issuance of the Final Closure/Post-Closure Plan by Ecology, Tri-Party Agreement target Milestone M-45-06-T02, is scheduled by September 2006. This will be the permit for closure of at least the first SST farm. Tri-Party Agreement Milestone M-45-06-T03 requires initiation of closure activities, in accordance with the Final Closure/Post-Closure Plan, by March 2012.

The CWP is scheduled for two-year revision cycles as the strategy evolves and uncertainties are resolved.

1.1 OBJECTIVES AND SCOPE

The CWP addresses regulatory pathway, characterization of operable units, waste retrieval, closure strategy, and technology development to support closure. The CWP:

1. Provides the strategy for complying with closure regulations including the appropriate use of risk-based decisions, cost-benefit analysis, and regulatory variances.

2. Promotes application of systems engineering methodology in development of closure configurations.

3. Provides input on scope and basis for closure activities to be implemented by the multi-year work plan and other management systems.

4. Supports the evaluation of environmental impact and alternatives considered in accordance with the *National Environmental Policy Act of 1969* (NEPA) documentation requirements.

5. Describes the work integration process and reports work performed.

Although SST operable unit closure occurs relatively late in the Tank Waste Remediation System (TWRS) mission, decisions on closure configuration and actions impose constraints on elements of the TWRS program that are initiated relatively early in the mission. Tank Waste Retrieval is the TWRS program element principally affected.

Issues facing SST waste retrieval closely related to closure decisions include the following:

- How much leakage, if any, is permissible during retrieval, and how will retrieval systems be designed and operated to detect and/or mitigate leakage?

- How much residual waste, if any, will be allowed to remain in tanks following completion of retrieval?

- What are the requirements for removal or reconfiguration of: (1) tank internal hardware to minimize interference with tank closure activities, (2) discrete radioactive sources such as samarium balls, and (3) dangerous waste such as metallic lead?

Interdependencies between closure and other elements of TWRS may be identifiable only through analysis and engineering development of closure alternatives. Closure strategy and decisions must therefore be integrated in a timely manner with the balance of the TWRS disposal program. The objective of this *Single-Shell Tank System Closure Work Plan* (SST-CWP) is to facilitate this process. This document describes current and planned work activities supporting closure of the SST operable units, and identifies related issues. As the plan for closure is defined and accepted, this agreement (scope and ground rules) will be integrated into the balance of the TWRS disposal program and eventually into the plan for cleanup and closure of the 200 Area plateau.

DOE has committed to the development and implementation of a safe, permanent means for final disposition of SST operable units in compliance with applicable laws and regulations, and in accordance with milestones specified in the Tri-Party Agreement. Completion of these activities by September 2024 requires planning that integrates technology development, waste characterization, engineering, performance analysis, permitting, construction, and operations in compliance with legal requirements, expressed public values,

Tri-Party Agreement milestones, as low as reasonably achievable (ALARA) guidelines, and financial constraints.

1.2 BACKGROUND

Radioactive waste has been generated since 1944 at the Hanford Site as part of the program to support national defense activities. Liquid radioactive and chemical waste from nuclear materials production and research was transferred to underground, reinforced-concrete, steel-lined SSTs for storage. Since 1944, the SSTs have been used for storing several types of liquid waste.

Since November 1980, double-shell tanks (DST) have been used exclusively for receipt of new waste and for transfer of waste from SSTs. The DSTs were designed, fabricated, and placed in service in 1971. The DSTs have the capability to detect leakage into the annular space between the inner and outer shell and pump leaked liquids to other DSTs. To date, no DSTs have leaked.

A total of 149 SSTs, with capacities ranging from 208,000 liters (55,000 gallons) to 3.8 million liters (1,000,000 gallons) each, were constructed on the 200 Areas Plateau of the Hanford Site. Waste from several of the SSTs was retrieved in the 1950's for extraction of uranium and in the 1960's and 1970's for extraction of cesium and strontium fission products. Evaporator operations and transfer of pumpable liquids to DSTs also reduced waste stored in the SSTs, leaving mostly moist sludge and salt cake.

The SSTs now contain about 137,000 cubic meters (36.1 million gallons) of waste, consisting of salt cake (88,000 cubic meters [23.3 million gallons]), sludge (46,000 cubic meters [12.2 million gallons]), and supernatant liquids (2,274 cubic meters [0.6 million gallons]). This total includes an estimated 26,000 cubic meters (6.9 million gallons) of drainable liquid, of which an estimated 20,440 cubic meters (5.4 million gallons) are pumpable (Hanlon 1994). The waste contains both radionuclides and dangerous chemicals.

In May 1987, the U.S. Department of Energy (DOE) issued a final rule (10 *Code of Federal Regulations* [CFR] 962) stating that the hazardous waste components of radioactive waste, defined as hazardous waste under the *Resource Conservation and Recovery Act of 1976* (RCRA), are subject to RCRA regulations. In November 1987, the U.S. Environmental Protection Agency (EPA) authorized the Washington State Department of Ecology (Ecology) to regulate the hazardous component of radioactive mixed waste within the state of Washington (51 FR 24504). Consequently, the SST waste is jointly regulated by DOE (radioactive constituents) and Ecology (hazardous chemical constituents).

In May 1989, DOE, EPA, and Ecology signed the Tri-Party Agreement (Ecology et al. 1994). This agreement established the roles and responsibilities of the agencies involved in the remedial restoration of the Hanford Site, which includes the SST operable units.

The 149 SSTs are contained in 12 SST farms. These 12 tank farms are grouped in 6 SST operable units, as listed in the Tri-Party Agreement. Table 1-1 identifies the SST operable units and tank farms. The SST operable units consist of the SSTs, ancillary equipment (i.e., approximately 28 miscellaneous underground storage tanks, diversion boxes, diversion stations, valve pits, and associated piping), and contaminated soil[1]. The remediation of groundwater is not included in the SST-CWP.

Final disposal alternatives for SST waste, as well as other defense waste forms, were evaluated in the "Final Environmental Impact Statement for the Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision" (53 FR 12449). The following alternatives were evaluated by DOE in 1987 (DOE 1987a):

- Geologic Disposal--Most of the SST waste would be retrieved, processed, immobilized in glass form, packaged, and transported to an offsite geologic repository for final disposal. SSTs with residual waste would be filled with basalt gravel, and a protective barrier and marker system would be placed over the SST farms.

- In-Place Stabilization and Disposal--Pumpable liquids would be removed from SSTs. The tanks would be filled with gravel, sand, grout, or other substances to provide subsidence protection. A protective barrier and marker system would be placed over the SST farms.

- Reference--For SST waste and tanks, this alternative is identical to Geologic Disposal.

- Preferred--Decisions on SST waste would be deferred pending additional development and evaluation of disposal alternatives.

- No Disposal Action--Monitoring, maintenance, and transfer of pumpable liquids from SSTs would continue.

The Record of Decision (ROD) (53 FR 12449) documented DOE's decision to implement the Preferred Alternative, which included: (1) retrieval of DST waste, (2) separation of DST waste into low-level waste (LLW) and high-level waste (HLW) streams in an existing facility (tentatively, at that time, B Plant), (3) vitrification of the HLW stream in a form that could be transported and disposed of offsite in a geologic repository, and (4) disposal of the LLW stream onsite in the form of grout monoliths. The ROD deferred a decision on disposal of SST waste and DOE elected to evaluate SST waste disposal alternatives in a supplement to the Hanford Defense Waste-Environmental Impact Statement (HDW-EIS) (DOE 1987a).

Since publication of the ROD in April 1988, several developments have overtaken those decisions. Ecology's objections to using B Plant for

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[1]Throughout this document, the term "soil" is used in an engineering context and refers to both topsoil (plant root zone) and bottom soil (unconsolidated sediments).

pretreatment processing resulted in the decision to abandon plans to upgrade the facility for that purpose and to redefine the strategy for tank waste disposal. This redefinition effort resulted in a recommendation (WHC 1991a) to (1) integrate disposal of DST waste and SST waste under a single program, (2) delay the Tri-Party Agreement milestones for completion of construction and initiation of operations of the Hanford Waste Vitrification Plant (HWVP) for 15 months to incorporate cesium ion exchange pretreatment processing, and (3) continue the program to dispose of LLW in a cement form (i.e., grout).

During this study, a parallel reassessment of the DST waste disposal strategy (Miller 1991) and an independent review by a DOE 'Red Team' (DOE 1991a) identified programmatic risk in integrating program elements supporting the HWVP. Based on the latter two studies and input from Ecology, the recommendations resulting from the redefinition study (WHC 1991a) were not accepted.

In December 1991, DOE, with Ecology's concurrence, initiated a 15-month rebaselining effort (Duffy 1991) to develop a strategy for the newly formed TWRS. In November 1992, DOE directed that the retrieval of SST waste be used as a planning basis for the rebaselining effort (Duffy 1992). Also during this period, public opposition expressed at public meetings to onsite disposal of LLW as grout resulted in the decision to abandon this approach.

Results of the rebaselining were documented in several reports issued in March 1993 (DOE-RL 1993o, n, p, l, m; WHC 1993). From April 1993 through September 1993, DOE, Ecology, and the EPA met to reach consensus on revisions to the tank waste disposal strategy, and to renegotiate terms of the Tri-Party Agreement affected by the revised strategy. These meetings resulted in revisions to the Tri-Party Agreement (Ecology et al. 1994) that required: (1) retrieval of SST waste, (2) pretreatment of retrieved tank waste to separate waste into high-level and low-level fractions, (3) vitrification and disposal of low-level tank waste at the Hanford Site in a manner that would not preclude subsequent retrieval, (4) vitrification of HLW for disposal offsite in a geologic repository, and (5) closure of SST farms by 2024. The Tri-Party Agreement also was revised to stipulate that the SST farm operable units, including tanks, contaminated soil, and ancillary equipment, will be closed as TSD units under a single set of regulatory standards pertaining to the hazardous waste constituents (i.e., WAC 173-303, "Dangerous Waste Regulations"). Previously, contaminated soil and ancillary equipment were to have been remediated under RCRA past practice regulations. The radioactive constituents continue to be managed in accordance with the *Atomic Energy Act of 1954* (AEA). Laws, regulations, and DOE Orders applicable to closure of the SST operable units are discussed in Chapter 3.

On January 28, 1994, DOE announced, via a notice of intent (NOI) in the *Federal Register* (59 FR 4052), that an environmental impact statement (EIS) would be prepared for disposal of waste in the 149 SSTs, 28 DSTs, 601 strontium fluoride capsules, and 1,328 cesium chloride capsules, under the scope of the TWRS. The purpose of the TWRS-EIS is to evaluate environmental impacts of reasonable waste disposal alternatives, including the alternative represented by the proposed actions in the recently amended Tri-Party Agreement (Ecology et al. 1994). The TWRS-EIS will also evaluate other

alternatives, as identified in the NOI and public scoping meetings. Nine such alternatives, including the alternative represented by the Tri-Party Agreement, will be addressed in the TWRS-EIS. These alternatives are as follows:

- Long Term Management--New DSTs would be constructed every fifty years. Pumpable liquid waste would be transferred from the SSTs to DSTs. The remaining sludge, salt cake, and interstitial liquids would be left in the SSTs. The SSTs would be backfilled as necessary with basalt gravel to prevent tank dome collapse and subsidence. Contaminated soil sites and tanks would continue to be monitored. Sampling and characterization of the contaminated soil sites would continue. Soil contaminated from tank leaks and spills would be left in place.

- No Action--This alternative is identical to the Long Term Management alternative, except that no new DST construction, transfer of waste from SSTs, or backfilling of SSTs would occur.

- Ex Situ Alternatives--There are three ex situ disposal alternatives evaluated in the TWRS EIS. These differ with respect to treatment processes and disposal of treated waste, but do not differ with respect to waste retrieval and closure. For all the Ex Situ alternatives, as much waste as practicable (nominally 99%) would be retrieved from SSTs and transferred to interim storage in DSTs, or transferred directly to process facilities. The SST operable units, including tanks, residual waste in tanks, ancillary equipment, and contaminated soil, would be closed in accordance with appropriate regulations for hazardous chemical and radioactive constituents. A surface protective barrier and marker system would be placed over the SST farms.

- Phased Implementation--Tank waste remediation and tank closure is as described for the Ex Situ alternatives, but is carried out through privatization in two phases.

- In Situ Fill and Cap --Remaining liquids in SSTs would be removed to the extent practicable by continuation of salt well pumping. SSTs would be filled with basalt gravel to prevent tank dome collapse and subsidence. The remainder of the SST operable unit, including ancillary equipment and contaminated soil, would be closed in accordance with applicable regulations for hazardous chemical and radioactive constituents. A surface barrier and protective marker system would be placed above the SST farms.

- In Situ Vitrification--Remaining liquids in SSTs would be removed to the extent practicable by continuation of salt well pumping. Void space in tanks would be filled with Hanford Site sand, and the residual waste and sand would be immobilized by in situ vitrification. Following vitrification, any void space that might remain in SSTs would be filled with basalt gravel or grout to prevent tank dome collapse and subsidence. The remainder of the SST operable unit, including ancillary equipment and contaminated soil, would be closed

in accordance with applicable regulations for hazardous chemical and radioactive constituents. A surface barrier and protective marker system would be placed above the SST farms.

- Ex Situ/In Situ Combination--Waste would be retrieved from a portion of the tanks and treated for disposal as in the Extensive Retrieval alternative. Waste in the remaining tanks would not be retrieved, but would be disposed of in place as in the Fill and Cap alternative. A risk-based approach will be used to determine which tanks fall in each category. Closure of the SST Operable Units for each category of tanks would be as described above for the Ex Situ and In Situ alternatives.

Environmental impacts of these alternatives will be evaluated in accordance with NEPA. A ROD is scheduled to be issued by November 1996. SST farm closure will be addressed for all the alternatives except No Disposal Action to ensure a consistent basis for comparison of all the disposal alternatives. However, alternatives for cleanup, immobilization, or disposal of contaminated soil, ancillary tank farm equipment, residual waste in tanks, and the tanks themselves will not be sufficiently developed to permit final decisions on closure configuration and closure technologies in the time frame of the TWRS-EIS. Subsequent NEPA documentation would have to be prepared as a basis for reaching final decisions on closure. This would have to be in place before initiation of detailed design (Title II) for closure of the first SST farm.

1.3 CLOSURE STRATEGY

The closure strategy assumes that waste retrieval will remove sufficient waste from the SSTs that the residual waste following retrieval, the SSTs themselves, tank farm ancillary equipment, and contaminated soil will be considered by the U.S. Nuclear Regulatory Commission (NRC) to be non-HLW, and may be disposed of in place in accordance with applicable regulations and agreements. Decisions on general closure configuration and approach will be reached through a process consistent with NEPA. The closure strategy assumes this will occur through preparation of a supplement to the TWRS EIS, which addresses remediation of tank waste and cesium/strontium capsules. A discussion of closure alternatives is provided in Section 3.3.

As will be discussed in Chapter 3, there are several issues that need to be addressed before a detailed closure strategy can be defined. In the meantime, a closure strategy framework has been assumed. Within this framework is a range of possible configurations and conditions of the SST operable units at closure. Decisions that determine such configurations and conditions will consider a wide variety of factors. Quantifiable or estimable factors that affect these decisions include the following:

- Characterization of radioactivity and chemical content
- Long-term contaminant transport to the environment
- Short-term risk to the public and environment (during closure)
- Long-term risk to the public and environment (following closure)

- Accident and health risk to workers (during closure)
- Compliance with applicable regulations and DOE orders
- Cost and schedule.

Cost/benefit analysis (i.e., quantification of estimated costs and benefits, and comparison of alternatives on such basis), while not ordinarily a factor in regulatory compliance, is a well-founded approach used traditionally in the private sector for decisions on capital investment and funding of research and development activities. Assessment and comparison of costs and benefits of alternatives is also required of federal agencies under NEPA, and will be completed by TWRS prior to selection of the tank farm closure approach. To the extent closure alternatives result in differences in risk reduction (in terms of the quantifiable factors listed above) and/or differences in cost, cost/benefit analysis can be a useful tool in the decision process. One objective, therefore, of the closure strategy will be to develop cost/benefit comparisons of alternatives for the decision makers as part of the NEPA process leading to selection of a generalized closure approach, or for detailed concept development within the bounds of the generalized closure approach established under NEPA. Factors other than those listed above, though non-quantifiable, also will be important in the decision process. Tradeoffs between these factors will be weighed differently by the decision makers and the groups they represent.

The closure strategy is to obtain the quantifiable information, as listed previously, that will be important to the decision makers, and to provide it in a timely manner to support the decision process. This necessitates an early focus on engineering studies, sampling and characterization, contaminant transport modeling, and development of risk analysis methodology as a basis for evaluation of closure alternatives. As decisions affecting closure are made, the closure strategy will be better defined and this will be reflected in future revisions of this document. This work plan is scheduled to be revised every two years.

The SST-CWP addresses a range of closure options that is believed to encompass all reasonable alternatives. With time, the closure strategy will need to be reviewed and revised. This will be accomplished during the two-year updates.

1.4 APPROACH

The disposal strategy reflected in the Tri-Party Agreement (Ecology et al. 1994) is to retrieve and process the waste contained in the SSTs. An EIS (i.e., TWRS-EIS) is being prepared to assess the environmental impact and cost of alternative disposal strategies, including the alternative represented by Tri-Party Agreement. This Work Plan is based on the assumption that the disposal alternative ultimately selected will involve retrieving as much waste as practicable from the SSTs, but that some residual waste will remain in the tanks following completion of retrieval actions. This Plan also assumes removal of additional waste from tanks following retrieval (i.e., as part of closure) will not occur, and tanks with residual waste will be closed in place. The scope of SST operable unit closure covered in this Work Plan

therefore includes tanks, residual waste in tanks following retrieval, materials added to tanks to immobilize residual waste and/or prevent subsidence, and contaminated soil and tank farm ancillary equipment within the boundaries of the SST operable units. Development of closure configuration will be integrated with other established processes within TWRS. These include planning and budgeting, systems engineering, safety analysis, environmental permitting, NEPA, waste characterization, and technology development.

Planning and Budgeting. Closure work will be defined, planned, scheduled, funded, statused, and controlled in accordance with existing program management procedures and systems applicable to all of TWRS.

Systems Engineering and Risk Assessment. The TWRS systems engineering process will provide the framework within which supporting analyses are conducted, decisions on closure configuration are made, and closure of SST operable units is eventually achieved. This includes engineering studies and risk analyses to compare alternatives relative to established performance criteria, as a basis for selection of preferred alternatives.

Safety Analysis. Facilities and processes for closure will be analyzed for hazards and potential consequences to workers and the public. Processes and equipment will designed to comply with applicable regulations, DOE orders, contractor procedures, and industry requirements protecting the health and safety of workers and the public.

Environmental Permitting. Regulatory analysis will identify applicable federal, state, and local environmental permitting requirements pertaining to construction and operation of facilities and processes for closure. Permitting activities and constraints will be identified in closure schedules. Construction and operation of facilities and processes to close SSTs will be carried out in accordance with environmental permits. This includes, as a minimum, approved closure plans for the SST operable units, in accordance with applicable sections of WAC 173-303 Dangerous Waste Regulations.

NEPA. Closure decisions will be made in accordance with NEPA, and DOE's NEPA regulations (10 CFR 1021).

Waste Characterization. Characterization of residual waste to support design, technology development, safety analysis, and performance assessment will be conducted through a TWRS process that involves specification of data needs through preparation of "data quality objectives" (DQO). Sampling and analysis activities are prioritized and scheduled to support a variety of activities inside and outside TWRS.

Technology Development. Technology development activities will be coordinated through various "Focus Areas" serving the entire DOE complex, of which the "Tank Focus Area" is most applicable. An effort will be made to keep abreast of available technology, use existing technologies where available, and allocate research dollars in the most cost-effective manner.

1.4.1 Closure Decision Logic and Schedule of Activities

Key elements that must be addressed in determining the physical condition and/or configuration of closed SST farms include the following:

- The physical tank structure
- In-tank hardware (if not removed during retrieval)
- Residual waste and other radioactive and hazardous material in SSTs (if not removed during retrieval operations)
- Contaminated surface soil and subsurface sediments
- Tank farm ancillary equipment (external to SSTs)
- Potential plume migration and long-term monitoring.

Key elements that will be considered to mitigate, remediate, and/or close the SST farms include the following:

- Leak mitigation measures (if used)
- Surface barriers (if used)
- Tank fill materials (if used).

The decision process for closure must involve specifying the configuration or disposition of each of these elements. This process must be carried out in an integrated manner because of the interdependency of these elements. For example, the function of leak mitigation devices is to contain leakage during retrieval and/or to limit the migration of contaminants in the sediments. A decision to deploy leak mitigation devices may be coupled with a decision to treat contaminated soil.

Determination of closure configuration must also be integrated with the systems engineering process in other areas of TWRS. One interface is with waste retrieval, because choice of waste retrieval technology and operating practices will affect: (a) whether, and to what degree, additional contamination of sediments may result from tank leakage during retrieval (potential plume migration); and (b) the amount of residual waste remaining in SSTs following retrieval. Another interface is with LLW disposal, because closure of the SST operable units and onsite disposal of vitrified LLW must collectively be demonstrated as capable of meeting long-term performance standards for protection of human health and environment.

Finally, determination of closure configuration must be integrated with other Hanford Site programs outside of TWRS. For example, to avoid physical or functional interference, design and construction of leak mitigation devices placed over SST operable units regulated by Ecology must be integrated with design and construction of surface barriers placed over adjacent past practice units regulated by the EPA.

Figure 1-1 is a decision logic diagram that reflects the interdependence of decisions and specifies configuration of the key elements of a closed tank farm. The key closure configuration decisions are described within each solid-bordered rectangle. Activities that provide essential input to each decision are identified within parallelograms, shown with dashed lines. Decisions are shown between alternatives. Alternatives for each decision are identified within rounded borders. The decision hierarchy (i.e., level of independence, or sequence) and possible decision paths are indicated by arrows. Decisions determining closure configuration will be made in phases.

Figure 1-1 reflects three phases, each tied to a Tri-Party Agreement milestone. The first phase includes decisions necessary to support Tri-Party Agreement Milestones M-45-04-T02, "Complete Design for the Initial SST Retrieval Systems" (December 31, 2000) and M-45-08A, "Complete design and operating strategy for tank leak monitoring and mitigation systems" (December 31, 2000). The second phase includes decisions necessary to support Tri-Party Agreement Milestone M-45-06-T01, "Submit tank closure/postclosure plan" (November 2004). The third phase includes decisions necessary to support Tri-Party Agreement Milestone M-45-06-T03, "Initiate closure actions on an operable unit or tank farm" (March 2012).

As diagrammed in Figure 1-1, the decision, "determine soil remediation approach" is predecessor to Tri-Party Agreement Milestones M-45-04-T02 and M-45-08A, because a decision on treatment of contaminated soil will affect selection of leak detection, leak prevention, and/or leak minimization approaches for waste retrieval. Accordingly, SST retrieval system and leak detection/mitigation system design for the first SST farm to be retrieved cannot be completed until decisions are made on the soil remediation approach. Leaving SSTs in place precludes one of the three options for soil remediation (i.e., removal and treatment). Therefore, the decision, "determine disposal approach for SSTs" is a predecessor to the decision on soil remediation. The two alternatives for disposal of SSTs are: (1) dispose in place, or (2) remove for disposal elsewhere. The latter alternative would be possible only if residual waste in tanks was removed (i.e., decontaminate SST to bare metal). Thus, "determine remediation approach for residual waste in SSTs" is a predecessor to, "determine disposal approach for SSTs." The alternative to remove SSTs for disposal elsewhere would also potentially affect decisions on the need to remove tank internal hardware and discrete sources as part of the waste retrieval function, and therefore would also be a direct predecessor to completion of design for the first SST retrieval system.

The decision logic structure for Phase 2 of Figure 1-1 reflects those key decisions determining the closure configuration that do not affect SST retrieval system design. Of these, the decision, "determine subsidence prevention approach for SSTs left in place" is dependent on whether or not surface barriers are used, because surface barriers will impose additional loads on tanks left in place. Thus the decision, "determine whether to use surface barriers" is a predecessor to the decision, "determine subsidence prevention approach." Because the purpose of surface barriers, if used, is to prevent or minimize migration of remaining contaminants by infiltration of rainwater or snowmelt, biointrusion, or erosion, the decision, "determine whether to use surface barriers" must be made based on the quantity and

configuration of residual waste (i.e., following decisions on remediation of residual waste in tanks, contaminated soil, and ancillary equipment). As diagrammed in Figure 1-1, the decision, "determine remediation approach for ancillary equipment" is a predecessor to the decision, "determine whether to use surface barriers."

Phase 3 of the closure decision logic includes activities necessary to support the final decision to proceed with closure actions for the first tank farm or operable unit (Tri-Party Agreement Milestone M-45-06-T03), in accordance with the approved closure plan. Input to this decision includes post-retrieval in-tank waste characterization data, results of vadose zone monitoring (contaminated soil characterization), final performance assessment of the closure system, safety analysis (worker and public risk assessment), and final design of the closure system. These inputs will be affected by the key closure decisions made in Phases 1 and 2. Those ties are not reflected in Figure 1-1.

Figure 1-2 is a bar chart schedule showing the major activities necessary to support closure development and closure decisions through fiscal year 2014, when closure of the first SST farm is scheduled to be completed. Figure 1-2 also reflects sequential dependencies between activities, ties to major retrieval program activities, and ties to Tri-Party Agreement milestones. To integrate SST closure into the TWRS program, activities on this schedule are included, either item by item, or by groupings, in the overall planning, authorization, and management control of TWRS work scope. This includes preparation of Work Breakdown Structure (WBS) Dictionaries describing work scope, resource loading activities, identification and description of milestones, estimating activity durations, identifying and coding of logic ties to other TWRS activities, prioritizing and authorizing work, monitoring cost and schedule performance, and reporting progress.

From fiscal year 1995 through fiscal year 2000, closure activities are focused on engineering studies to identify and evaluate alternatives, performance assessment model development for use in screening alternatives, and interaction with regulatory agencies to define performance criteria against which alternatives will be evaluated. This is followed by laboratory testing and field testing of preferred alternatives, detailed engineering evaluation, hazards analysis, and performance assessment (performance assessment will be required to provide assurance that long term health and safety risk will be in compliance with regulatory criteria relating to classification and disposal of the radioactive constituents of residual wastes). Because of the interrelationships between closure and retrieval, these activities support Tri-Party Agreement Milestone M-45-04-T02, "Complete Design for the Initial SST Retrieval System" (December 2000). At the end of this engineering study phase, preferred alternatives for tanks, contaminated soil, and ancillary equipment are identified.

After December 2000, closure planning and engineering development are sufficiently mature and interfaces with waste retrieval are sufficiently well established to support the general contracting of this service to the private sector, or to initiate conceptual design activities under DOE Order 4700.1. The DOE Order 4700.1 (DOE 1987b) option is reflected in Figure 1-2.

Completion of the activities necessary to finalize retrieval system design and finalization of the closure strategy also support initiation of the closure plan for the first SST farm. From fiscal year 1995 through fiscal year 2001, this SST-CWP will be updated every 2 years to report on work in progress as well as work planned to support closure, decision-making and resolve closure issues before initiation of the closure plan for the first SST farm, and to update the closure strategy, logic, and schedule as necessary to reflect resolved issues and decisions affecting closure configuration.

Two other key activities supporting closure, reflected in Figure 1-2, are sampling and characterization of residual waste in tanks and characterization of contaminated soils (site data). Characterization of contaminated soils provides input to decisions on whether or not excavation or treatment of such soils may be required. Characterization of residual waste in tanks (following retrieval) is necessary to determine whether tank closure criteria have been met. Both characterization of contaminated soils and characterization of residual waste in tanks are essential inputs to final performance assessment for closure permitting.

A general note: This work plan does not include or address the potential impact associated with proposed privatization activities.

1.4.2 Single-Shell Tank Closure and the Site Systems Engineering Effort

A systems engineering process has been initiated across the Hanford Site to establish and maintain the integrated Hanford Site Technical Baseline, which is necessary to accomplish the Hanford Site Mission. The SST closure activities described in this CWP can be found within the Hanford Site functional breakdown.

The second level of the Hanford Site functional breakdown includes the function Remediate Tank Waste. The Remediate Tank Waste function is subdivided into the following level three functions: (1) Manage Tank Waste, (2) Retrieve Tank Waste, (3) Process Waste, and (4) Dispose Waste. The Dispose Waste function is subdivided into the following level four functions: (1) Interim Store Solidified Waste, (2) Dispose Immobilized LLW, and (3) Close Operable Units.

The level-three Manage Tank Waste function includes the current tank waste monitoring activities, SST stabilization and isolation, and tank waste characterization. SST waste retrieval is part of the level three Retrieve Waste function. SST farm or operable unit closure is part of the level three function Close Operable Units. Depending on the closure alternative selected, this function may include disassembly and removal of the SSTs or activities such as tank dome filling and surface barrier installation, soil and/or groundwater cleanup, and any postclosure monitoring. Detailed function breakdowns, requirement allocation, and architectures have not been developed for all of the previously described functions.

1.5 SCOPE AND OVERVIEW

The SST-CWP has been prepared to address the principal topical areas identified in Tri-Party Agreement Milestone M-45-06 (i.e., regulatory pathway, operable unit characterization, waste retrieval, technology development, and a strategy for achieving closure). These topics are addressed in Chapters 3.0 through 8.0. Additionally, appendices provide additional information on the SSTs and tank farms, site geology and hydrology, and SST interim operations (stabilization and surveillance).

Chapter 2.0 of the SST-CWP provides a brief description of the environmental setting, SST System, the origin and characteristics of SST waste, and ancillary equipment that will be remediated as part of SST operable unit closure. The discussion in Chapter 2.0 is augmented by five appendices. The SST operable unit includes the SSTs, ancillary equipment, and contaminated soil within the boundary of the tank farm. Appendix C of the Tri-Party Agreement will be revised as appropriate to address the need for either adding or deleting ancillary equipment to each of the SST Operable Units. The DST TSDs will be updated at the same time to ensure consistency. The physical boundaries of contaminated soil will be defined prior to preparing any closure plans and/or permit applications for closing the SST TSDs.

Appendix 2A provides a description of the hydrogeology of the Hanford Site, including information on the unsaturated sediments (vadose zone) beneath the 200 Areas Plateau. The groundwater beneath the tank farms is not included in the SST operable units. The characterization of the vadose zone is important in understanding the transport of leaked waste. Appendix 2B provides a description of each SST, tank farm, and the nature of the waste contained in each tank, as well as figures that show the location and layout of each tank farm. Appendix 2C provides a description of the interim tank farm stabilization, surveillance, and ongoing safety activities. Appendix 2D provides information on the temperature monitoring schedule for the 'watchlist' tanks, and Appendix 2E provides information on the waste routing or transfer of waste in support of emergency pumping operations.

Chapter 3.0 provides a discussion of the laws and regulations applicable to closure of the SST farm operable units. A discussion of SST waste classification and the proposed regulatory pathway for closure is provided in Chapter 3.0. As discussed in Chapter 3, closure of the SSTs will be in accordance with applicable portions of WAC 173-303, "Dangerous Waste Regulations." This requires removal or decontamination of all hazardous waste residues from tank systems at closure, but allows closure of tank systems as landfills if the owner or operator demonstrates that not all contaminated soil can be practically removed or decontaminated. For tanks that are completely decontaminated by waste retrieval, removal of the emptied tanks and excavation and treatment or removal of contaminated soils (clean closure) may be viable alternatives. The Hanford Facility *Dangerous Waste Portion of the Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste* (RCRA Permit) (Ecology 1994) provides for a "modified closure" approach that could be used in the event that all waste cannot be removed from tank systems at closure. Chapter 3.0 addresses regulatory requirements relevant to these alternatives and combinations of alternatives.

Regulatory issues include the classification of residual waste and contaminated soil, and the closure of tank farm operable units containing residual waste as landfills.

Chapter 4.0 provides a summary description of the ongoing characterization activities that best align with the proposed regulatory pathway for closure. A summary discussion of the ongoing waste characterization program in support of waste retrieval, and plans for postretrieval characterization of residual waste in tanks, DQO, and quality control (QC) are included. Additionally, a description of the work performed to map and characterize past tank leaks is provided as well as a summary of the ongoing activity to monitor leaks and transport characteristics in the soil media outside the tanks. Identified issues include: the use of existing information to adequately characterize tank waste, the need to collect and 'representativeness' of soil and groundwater data, and the desirability of an in situ characterization of contaminated soil and leak detection using an improved borehole logging system.

Chapter 5.0 describes aspects of the SST waste retrieval program, including retrieval strategy, technology, and sequence, potential tank leakage during retrieval, and considerations of deployment of subsurface barriers. A description of the Tri-Party Agreement milestones identified for both demonstrating and implementing SST waste retrieval is included. The sequence and schedule for retrieval activities are summarized. Identified issues include: a proposal to use cost/benefit analysis as a basis for making decisions regarding retrieval; the degree of tank leakage permitted during retrieval; retrieval efficiency; and the handling of residual waste, tank hulls, and other tank contents subsequent to retrieval.

Chapter 6.0 will ultimately provide a description of the closure strategy. The vision is to compile this chapter over the next few iterations of the CPW. In effect, this chapter will evolve as various decisions are made regarding closure. When completed, this chapter will address the requirements of WAC 173-303-610. At the present time, Chapter 6 represents a "place holder" for future work.

Chapter 7.0 outlines a risk management strategy that will be used to assist the formulation of closure decisions. The strategy assumes that closure decisions will be based on the risk to human health and the environment. This chapter provides a description of the methods and proposes a process that complements both the regulatory pathway and the characterization activities. The methodology includes aspects of safety analysis, risk assessment, and performance assessment. Issues include: the selection and use of interim and final closure criteria; methods used to compare short-term and long-term risk; and the selection and specification of data that will be used during risk and performance assessments. The decision on the closure of the tank farms must be consistent with plans for closure of the 200 Areas.

Chapter 8.0 provides a summary of the programs that are underway or have been planned to develop technologies to support closure. This includes technology development for retrieving waste, the use of surface and subsurface

barriers (leak mitigation devices), leak detection, treatment and stabilization of contaminated soil, and the immobilization of residual waste in tanks. These activities are considered common to all disposal alternatives and will support the implementation of all future decisions. Issues include: the performance testing of the Hanford Engineered Surface Barrier; the deployment of subsurface barriers; and future development and deployment of leak detection and vadose zone monitoring systems. The chapter on technology will be updated every two years and will be retained so long as technology development needs that are in support of waste disposal activities continue.

Chapter 9.0 lists references cited throughout this CWP. All references listed here, which are not available from other sources, will be made available for review, on request, to any regulatory agency or public commentor. References can be obtained by contacting the following:

Administrative Records Specialist
Public Access Room H6-08
Westinghouse Hanford Company
P.O. Box 1970
Richland, Washington 99352

1.6 UNRESOLVED CLOSURE ISSUES

Tri-Party Agreement Milestone M-45-06 requires that the SST-CWP identify known issues and explain how those issues are being addressed. The principal benefit of the SST-CWP to both DOE and Ecology may be its use in identifying and resolving issues before submittal of the first SST closure plan. Issues affecting hydrogeology, SST interim operations, waste retrieval, waste characterization, technology development, regulatory compliance, and closure strategy are addressed to varying degrees in Chapters 3.0 through 8.0 and Appendix 2A. These specific issues are addressed in Appendix 1A in a format that provides relevant background information, resolution strategy, impacts, reference documentation, and status. The issues are identified in Table 1-2. The order in which these issues are listed should not be misconstrued as reflective of importance. The listing simply reflects the sequential ordering that they appear in the text. Furthermore, the list is by no means complete and reflects input from the various authors of the work plan. It is assumed that the list will be revised and that the order or relative importance of the various issues will be defined in the future.

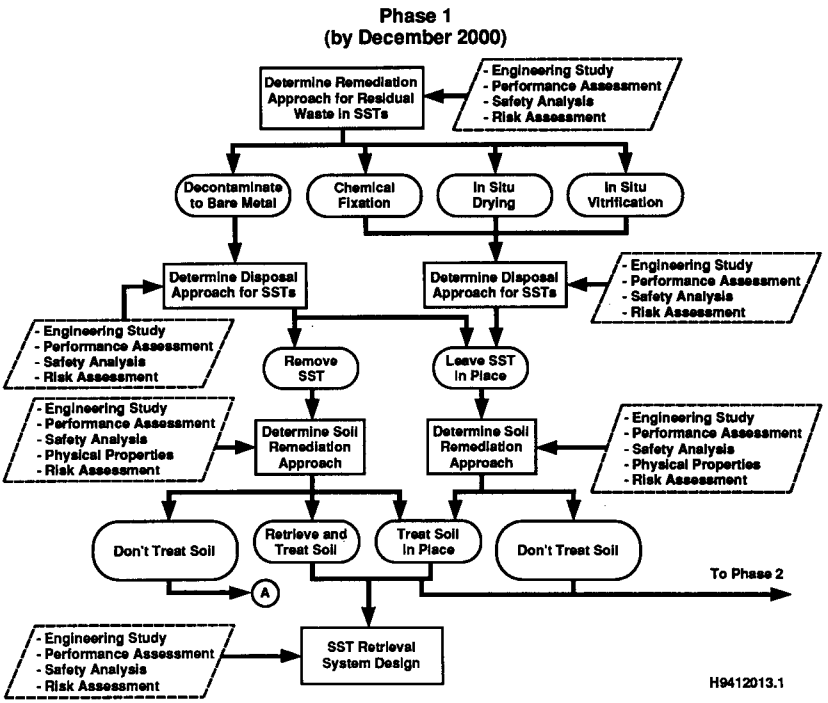

Figure 1-1. A Decision Logic to Support Tank Farm Closure. (sheet 1 of 2)

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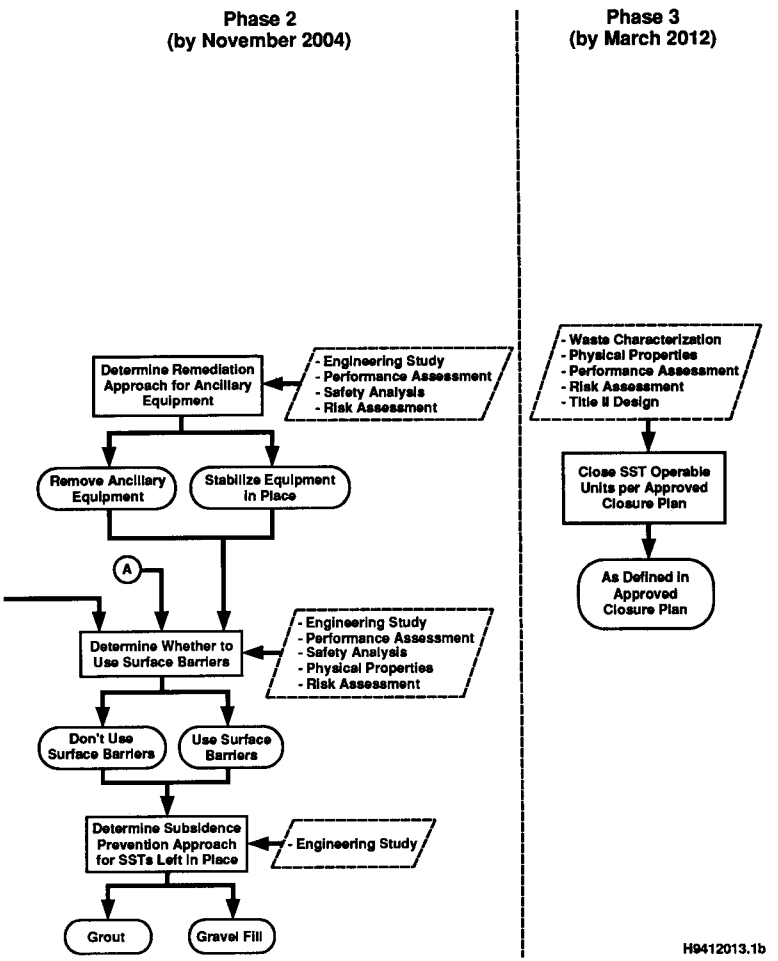

Figure 1-1. A Decision Logic to Support Tank Farm Closure. (sheet 2 of 2)

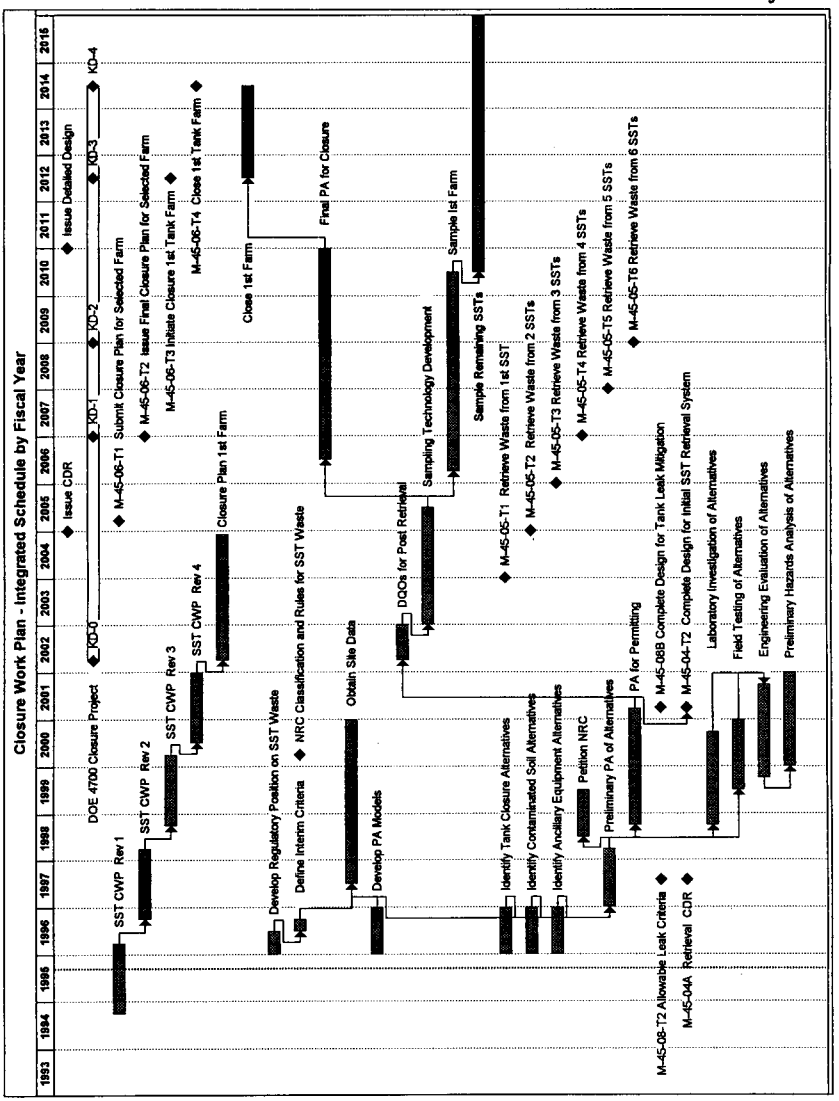

Figure 1-2. An Integrated Schedule to Support Tank Farm Closure.

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Table 1-1. Single-Shell Tank Operable Units.

SST Operable Unit	Area	SST Tank Farm
200-BP-7	200 East	241-B Farm (16 SSTs) 241-BX Farm (12 SSTs) 241-BY Farm (12 SSTs)
200-PO-3	200 East	241-A Farm (6 SSTs) 241-AX Farm (4 SSTs) 241-C Farm (16 SSTs)
200-RO-4	200 West	241-S Farm (12 SSTs) 241-SX Farm (15 SSTs)
200-TP-5	200 West	241-TX Farm (18 SSTs) 241-TY Farm (6 SSTs)
200-TP-6	200 West	241-T Farm (16 SSTs)
200-UP-3	200 West	241-U Farm (16 SSTs)

Table 1-2. Closure Issues. (sheet 1 of 3)

Chapter	Number	Description of Closure Issue
2	N/A	No closure issues.
3	3.01	Closure of Tank Farms with Residual Contamination as Landfills (May single-shell tank [SST] farms be closed as landfills, in accordance with *Washington Administrative Code* 173-303-640(8)(b)?).
	3.02	Classification of Radioactive Residual Constituents (May SSTs, residual waste in SSTs, ancillary equipment, residual waste in ancillary equipment, and contaminated soils be classified as low-level waste?).
	3.03	Absence of Regulations for Near-Surface Disposal of High-Level Radioactive Waste (If the U.S. Nuclear Regulatory Commission classifies residual SST waste as high-level waste, what closure preparation activities should be undertaken in the absence of regulations for near-surface disposal of high-level waste?).
	3.04	Potential Conflicts between the *Atomic Energy Act of 1954* and the *Resource Conservation and Recovery Act of 1976* (strategy for dealing with potential conflicts between regulations for radioactive waste versus regulations for hazardous chemical waste).
4	4.01	Use of Characterization Information to Adequately Characterize Tank Waste.
	4.02	Representativeness of Sampled Sediments and Groundwater (Level of confidence that sediment and groundwater samples are sufficiently representative for the purposes for which they are obtained).
	4.03	Tank Leak Plume Migration (uncertainties of contaminant plume boundaries and rates of migration).
	4.04	Adequacy of Groundwater Flow and Contaminant Transport Data (sensitivity of results to input data, and sufficiency of input data to support predictions).
	4.05	Borehole Logging to Support SST Waste Retrieval and Disposal Activities.
5	5.01	Approach for Evaluating Cost/Benefit Tradeoffs (What cost/benefit criteria will be applied in selection of appropriate waste retrieval technologies?).
	5.02	Retrieval Efficiency (Uncertainties associated with criterion (criteria) for percent waste retrieval required for closure).

Table 1-2. Closure Issues. (sheet 2 of 3)

	Chapter	Number	Description of Closure Issue
1		5.03	Leakage During Retrieval (How much leakage is likely, how much is acceptable?).
2		5.04	Cost/Benefit Tradeoffs for Leak Mitigation Devices (What criteria will be used in determining whether subsurface barriers will be deployed?).
3		5.05	Equipment and Materials Disposed of in Tanks (Will retrieval of equipment and hazardous or radioactive materials disposed of in tanks be required for either retrieval or closure?).
4	6	6.01	Closure Permit Application (How should the closure permit application, and permit, be packaged to support progressive and prolonged schedule for closure of SST farms?).
5	7	7.01	Identification of Data and Information Needs (What information and data are required to support performance assessments and risk assessments).
6		7.02	Integration of Numerical Modeling and Risk Assessment with other Hanford Site Remediation Programs (What methodology will be used to quantify the long-term risk associated with disposing of waste and how will this risk be assigned and apportioned across the Hanford Site?).
7		7.03	Interim Performance Criteria for Operable Unit Closed with Residual Waste (Until quantitative criteria for performance of closed waste sites are promulgated in regulations, what criteria should be used in systems engineering screening, and design optimization of alternatives?).
8		7.04	Tradeoffs Between Increase in Short-Term Risk and Reduction in Long-Term Risk (What criteria will be used to balance increase in worker risk versus decrease in long-term risk to the public in selecting approaches for closure of SST farms?).

Table 1-2. Closure Issues. (sheet 3 of 3)

Chapter	Number	Description of Closure Issue
	7.05	In-Place Disposal Alternative for Single-Shell Tank Waste (The Hanford Defense Waste-Environmental Impact Statement showed in-place disposal of SST waste to have lower risk to workers and to the public, as well as being more cost effective than ex-tank disposal alternatives. The Tank Waste Remediation System-Environmental Impact Statement will reevaluate the in-place disposal option. What engineering and technology development activities should proceed to maintain this as a viable closure alternative?).
8	8.01	Religious Significance of Basalt Riprap in Hanford Surface Barriers.
	8.02	Potential for Differential Settlement of the Surface Barrier Across a Tank Farm.
	8.03	Potential for Surface Barrier Subsidence to Occur Over Tanks (There is a need to evaluate the effects associated with a major subsidence to occur in the tank farms).
	8.04	Surface Barriers (Should the monitoring and testing of the prototype barrier be completed?).
	8.05	Subsurface Barriers (Should subsurface barriers be used to contain potential leakage during retrieval operations?).
	8.06	Technical and Regulatory Basis for Leak Detection and Monitoring to Support Single-Shell Tank Waste Retrieval and Disposal (There is a need to define the goals and objectives of the leak detection and monitoring system).

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CONTENTS

2.0 HANFORD SITE AND TANK FARM DESCRIPTION 2-1

2.1 HANFORD SITE 2-1

2.2 SINGLE-SHELL TANK SYSTEM 2-2

2.3 ANCILLARY STRUCTURES 2-4

2.4 DEFINITION OF ANCILLARY STRUCTURES 2-5

FIGURE

2-1. Location of the Hanford Site F2-1

2.0 HANFORD SITE AND TANK FARM DESCRIPTION

This chapter provides a brief description of the site, history, and characteristics of the SSTs and tank farms. A description of the ancillary equipment also is provided.

2.1 HANFORD SITE

The Hanford Site (Figure 2-1) is an approximately 560-square-mile (1450-square-kilometer) DOE installation occupying a semiarid region near the Columbia River in south-central Washington State. In 1943, the U.S. Army Corps of Engineers selected the area to produce nuclear materials, mainly plutonium, in support of the World War II effort. Since that time, the area has been dedicated to the production of nuclear materials and electricity, diverse research, and waste management activities. Hanford Site facilities, first built and run by the U.S. Army Corps of Engineers (Manhattan Project), have been operated by the Atomic Energy Commission (AEC) (1947 to 1974) and its successors, the Energy Research and Development Administration (ERDA) (1974 to 1977), and the DOE (1977 to present).

Eight reactors were built in the 100 Areas in the 1940's and 1950's, which produced plutonium until 1971 when the last reactor was shut down. Companion fuel fabrication plants (300 Area), chemical processing plants (200 Areas), and waste management facilities were constructed and operated. One dual-purpose plutonium production/steam generation reactor, the N Reactor, began operation in 1963 and operated until 1988. The steam was used by the Washington Public Power Supply System (Supply System) to generate electricity.

Irradiated fuel discharged from the reactors was processed to recover uranium and plutonium. The processing resulted in the accumulation of a wide variety of radioactive and chemical waste. Since the 1940's, most of the Hanford Site's nuclear defense waste has been stored in underground storage tanks on the 200 Areas Plateau.

All tanks and facilities associated with regulated waste that are part of the SST-CWP are located in or adjacent to the 200 East and 200 West Areas. The 200 Areas are located 22 miles (35 kilometers) from the nearest residential community of Richland, Washington, and at least 5 miles (8 kilometers) from the Columbia River.

The 200 Areas Plateau ranges in elevation from 620 to 800 feet (189 to 244 meters) above mean sea level (MSL). Normal Columbia River elevations range from 390 feet (119 meters), where the river enters the Hanford Site near the Priest Rapids Dam, to 340 feet (104 meters) where it leaves the Hanford Site near the 300 Area. The terrain is relatively flat. The sediments in the central part of the Hanford Site, including the 200 Areas Plateau, have undergone minimal erosion since formation by flood water deposits about 13,000 years ago. The unconfined aquifer, contained within the sediments, underlies the waste sites by 180 to 330 feet (55 to 101 meters) in the 200 Areas. The dominant plants on the 200 Areas Plateau are sagebrush,

rabbitbrush, cheatgrass, Sandberg's bluegrass, and tumbleweed. The average annual rainfall at the Hanford Site is 6.3 inches (13.5 centimeters) per year. Because of the aridity, the productivity of both plants and animals is relatively low.

As will be discussed in Chapter 3.0, the SSTs are classified as RCRA storage facilities. Groundwater and subsurface soil monitoring have been implemented at each tank farm. A discussion of the groundwater monitoring program, vadose zone characteristics, and general geology of the 200 Areas Plateau is provided in Appendix 2A. The interrelationship of these parameters (groundwater monitoring, vadose zone characteristics, and geology) combined with the transport characteristics of the waste stored in the SSTs, provides the basis for understanding the mechanisms that control the fate of the waste that either has escaped or may escape engineered containment. Because the primary objective of the closure strategy is to protect future human health and the environment by limiting the amount of contamination that will enter the groundwater, the potential flow and transport of contaminants is an important consideration. The HDW-EIS (DOE 1987a) contains a more complete description of the Hanford Site.

2.2 SINGLE-SHELL TANK SYSTEM

A total of 149 SSTs were constructed between 1943 and 1964. These tanks range in size from 55,000 to 1 million gallons (208,000 to 3.8 million liters). The 149 SSTs are located in 12 tank farms.

The SSTs are constructed of carbon-steel that is American Society for Testing and Materials (ASTM) A283 Grade C or ASTM A201 Grade C (241-AX Farm), which lines the bottom and sides of a reinforced concrete shell. The bottoms of most tanks are slightly dished. The tanks are below grade with at least 6 feet (1.83 meters) of soil cover, which provides shielding, thereby minimizing radiation exposure to operating personnel. Inlet and overflow lines are located near the top of the liner. Most of the 500,000- and 750,000-gallon (1.9- and 2.84-million liter) tanks were built in 'cascades' of three or four tanks. Waste was transferred to the first tank of the cascade and allowed to overflow into successive tanks of the cascade through piping in the side walls. Access to the tanks is provided by risers penetrating the dome of the tanks. Risers vary in diameter from 4 to 42 inches (10.2 centimeters to 1.07 meters).

The carbon-steel liners used in the SSTs that were built at the Hanford Site were not stress relieved after fabrication. The hot, alkaline radioactive waste mixture of liquid plus sludge has induced stress-corrosion cracking of the steel, and over the years, leakage has been suspected or confirmed in a number of these tanks. There are 67 assumed leakers located in the 12 tank farms (Hanlon 1994).

Forced ventilation provides cooling for tanks containing materials that, through radioactive decay, generate heat that could exceed the established concrete temperature limits. Single-stage, high-efficiency particulate air (HEPA) filters allow atmospheric breathing for tanks that do not require

cooling. Gases generated by radiolytic decomposition disperse in this manner. A description of the individual tanks and tank farms is provided in Appendix 2B.

Most of the waste in the SSTs is in the form of sludge, salt cake, and pumpable and nonpumpable liquids. Sludge consists of the solids (i.e., hydrous metal oxides) precipitated from the neutralization of acid waste before their transfer to the SSTs. Salt cake is made up of the various salts formed from the evaporation of water from the waste. Pumpable liquid exists as supernatant and interstitial liquid in the tanks. Because of a combination of physical properties (i.e., density of liquid, viscosity of liquid, compressibility of liquid, porosity of solid, permeability of solid, compressibility of solid, and field capacity of the media [or the maximum amount of liquid a freely drained media can store]).

The SST waste consists primarily of sodium hydroxide; sodium salts of nitrate, nitrite, carbonate, aluminate, and phosphate; and hydrous oxides of aluminum, iron, and manganese. The radioactive components consist of fission product radionuclides such as strontium-90, cesium-137, and iodine-129, and actinide elements such as uranium, neptunium, plutonium, thorium, and americium. The HDW-EIS (DOE 1987a) contains a more complete description of tank contents.

The SSTs contain mostly inorganic waste, although relatively small amounts of plant solvents were added during fuel reprocessing. Water-soluble complexing agents and carboxylic acids were added in the B Plant waste fractionation process.

The majority of the waste stored in SSTs was generated by the following chemical processing operations: the bismuth phosphate ($BiPO_4$) process, the reduction/oxidation (REDOX) process, the plutonium-uranium extraction (PUREX) process, the tributyl phosphate (TBP) process, and the B Plant waste fractionation process. The $BiPO_4$ process was a carrier precipitation chemical separation scheme for the recovery of plutonium from irradiated reactor fuels, and the TBP solvent extraction process was designed to recover uranium from waste generated by the $BiPO_4$ process. These were the first chemical processing operations at the Hanford Site.

The REDOX and PUREX processes are the second- and third-generation chemical facilities that recovered plutonium, uranium, and neptunium from irradiated reactor fuel. The PUREX process uses solvent extraction with TBP to separate uranium and plutonium. Both processes used various reducing and oxidizing agents (e.g., dichromate, ferrous sulfamate, hydroxylamine, hydrazine, nitrite) to control the valence state of the actinides.

Early reactor fuels were clad with aluminum. The N Reactor fuels were clad with zircaloy, a zirconium alloy. Chemical removal of the fuel cladding produced decladding waste with high concentrations of these metals. The B Plant waste fractionation process separated heat-generating strontium-90 and cesium-137 isotopes from the fuel reprocessing waste. The strontium-90 was separated using a di-2-ethylhexyl phosphoric acid solvent extraction process. This process used various complexing agents (i.e., ethylenediaminetetraacetic

acid [EDTA], hydroxyethylethylenediaminetriacetic acid [HEDTA], and citrate) to prevent transition metal extraction. The cesium-137 isotope was purified by ion exchange. Both strontium-90 and cesium-137 were later converted to fluoride and chloride salts and encapsulated in the Waste Encapsulation and Storage Facility. Before transfer to the SSTs, sodium hydroxide or sodium carbonate was added to make the waste from these processes alkaline and to minimize tank corrosion. Thus, the processing of the irradiated fuels has produced alkaline solids and liquids containing radionuclides and hazardous chemical constituents.

Other waste that was sent to the SSTs in smaller volumes includes research and development program waste, facility and equipment decontamination waste, laboratory waste, and Plutonium Finishing Plant (PFP) waste. The PFP uses a TBP solvent extraction process to further purify the plutonium product from the PUREX Plant or from plutonium scrap. The TBP in the PFP process is diluted in carbon tetrachloride, whereas the TBP in the PUREX process is diluted in normal paraffin hydrocarbons (NPH), which are similar to kerosene with carbon-10 to carbon-14 hydrocarbon chains.

Waste management operations have created a complex intermingling of the tank waste. Nonradioactive chemicals have been added to the tanks to enhance storage capabilities, while varying amounts of waste and heat-producing radionuclides have been removed. Additionally, natural processes have caused settling, stratification, and segregation of waste components. Waste was also cascaded (i.e., allowed to gravity-flow from one tank to another) through a series of tanks; cooling and precipitation of radionuclides and solids occurred in each tank of the cascade. As a result, it is difficult to estimate the character of the waste contained in the tanks through operation records.

A summary description of the ongoing interim stabilization and surveillance activities is provided in Appendix 2C. Appendices 2D and 2E provide additional information on tank farm surveillance and safety activities. Appendix 2D provides information on the schedule for monitoring temperature in the identified watchlist tanks and Appendix 2E provides information on the routing of waste to support the emergency pumping activities.

2.3 ANCILLARY STRUCTURES

The SST farm operable units (Table 1-1) are regulated as part of the treatment, storage, and/or disposal (TSD) unit, according to the 1994 Amendment to the Tri-Party Agreement (Ecology et al. 1994). These units include pipes, diversion boxes, vaults, catch tanks, septic tanks, unplanned releases (UPR) (e.g., spills), cribs, French drains, condensate tanks, valve pits, diverter stations, and contaminated soil from leaks in the SST system. Definitions of these ancillary structures can be found in Section 2.4.

2.4 DEFINITION OF ANCILLARY STRUCTURES

Catch Tank--Catch tanks are small-capacity SSTs associated with diversion boxes and diverter stations. The catch tanks are designed to receive any transfer line leakage from the boxes or adjacent pipe encasements. The catch tank waste forms are transferred to storage tanks.

Condensate Tank--Condensate tanks are used to collect condensate drainage water from tanks. The condensate tank waste is transferred to storage tanks.

Crib--Cribs are buried structures (often wood or concrete) filled with aggregate that hold or disperse liquids and/or solutions for percolation into the ground.

Diverter Station--Diverter stations are a gravity-flow means of routing waste to storage tanks.

Diversion Box--A diversion box is a belowgrade concrete enclosure containing the remotely maintained jumpers and spare nozzles for diversion of waste solution to storage tank farms. The diversion boxes also serve to collect any waste leakage from such connections.

French Drain--French drains are large-diameter pipes buried vertically, normally less than 45.9 feet (14 meters) deep, filled with rocks to allow the percolation of small, intermittent flows of liquid waste into the soil.

Pipes--Extensive piping interties exist within and among tank farms in the 200 East and 200 West Areas so that waste can be transferred to or from any tank in the system. Within the tank farms, certain tanks require pumpout jumpers or short lengths of aboveground piping installation before pumping can be initiated.

Septic Tank--Septic tanks are used for nonchemical waste. Some of these tanks, however, may be contaminated.

Unplanned Release--Unplanned releases (spills) are the release of contaminated solutions to Hanford Site soils outside of engineered systems, which are caused by pipeline failure or overflow. Unplanned releases are not the same as leaks from SSTs.

Valve Pit--Valve pits are a form of diversion box. They are associated with flush pits and are used to transfer water or steam into the system.

Vault--Vaults are shielded enclosures used to collect, clarify, and allow physical and chemical modification of contents before such contents are transferred elsewhere.

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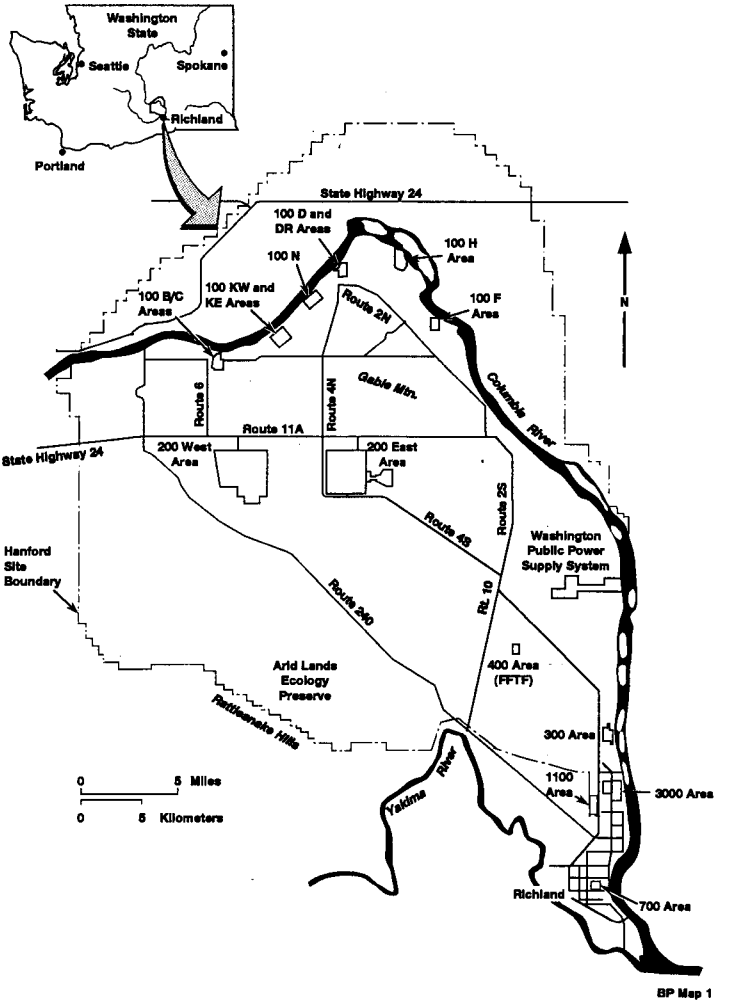

Figure 2-1. Location of the Hanford Site.

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CONTENTS

3.0 REGULATORY PROCESS 3-1

3.1 APPLICABLE LAWS AND REGULATIONS 3-1
3.1.1 *Resource Conservation and Recovery Act of 1976* 3-2
3.1.2 *National Environmental Policy Act of 1969* 3-5
3.1.3 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* 3-6
3.1.4 *Atomic Energy Act of 1954*, As Amended 3-6
3.1.5 *Clean Air Act* 3-9
3.1.6 *Safe Drinking Water Act of 1974* 3-10
3.1.7 State Regulations 3-10

3.2 CLASSIFICATION OF SINGLE-SHELL TANK WASTE 3-11

3.3 CLOSURE REQUIREMENTS AND OPTIONS 3-13
3.3.1 Closure Requirements 3-13
3.3.2 Closure Scenarios 3-15

3.4 REGULATORY ISSUES 3-18
3.4.1 Closure of Single-Shell Tanks 3-18
3.4.2 Classification of Radioactive Residual Constituents . . 3-18
3.4.3 Gaps in Radiological Regulations for Near-Surface Disposal 3-18
3.4.4 Potential Conflicts Between the *Atomic Energy Act of 1954* and *Resource Conservation Recovery Act of 1976* . . 3-19

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3.0 REGULATORY PROCESS

Both Federal and State laws are applicable to the closure of the SSTs. The authorities for regulation of mixed waste managed in the SSTs are derived from the AEA for the radioactive component, and from RCRA and the *Washington Hazardous Waste Management Act of 1976* (HWMA) for the hazardous component. Ecology regulates the SSTs as hazardous waste storage tanks under *Washington Administrative Code* (WAC) 173-303. The SSTs must be closed in accordance with applicable portions of WAC 173-303. Radioactive waste also must be managed in accordance with the AEA. These authorities may impose different requirements; potential RCRA/AEA conflicts should be addressed as they are identified. Additionally, other laws, such as NEPA, the *Clean Air Act*, and the *Safe Drinking Water Act of 1974* are relevant to the closure of the SSTs.

Closure/postclosure planning in accordance with the provisions for RCRA landfills must be provided for RCRA tank systems without secondary containment. Previous analyses that address the closure of RCRA tank systems under the RCRA landfill provisions may be found in Smith (1993) and in Smith et al. (1991). The current strategy for SST closure is in accordance with the following sequence: (1) provide for tank waste retrieval in accordance with Tri-Party Agreement Milestone M-45-00, (2) provide for closure plan development/approval and for closure pursuant to Milestone M-45-06, and (3) commence postclosure actions as necessary. Additionally, the radioactive component of associated mixed waste must be managed pursuant to Chapter V of DOE Order 5820.2A, "Decommissioning of Radioactively Contaminated Facilities" (DOE 1988c). EPA has authority under the provisions of the RCRA and the AEA, Ecology has authority under the provisions of RCRA, and DOE has authority under the provisions of the AEA.

This chapter addresses regulations pertinent to the management of SST waste, including closure of the SSTs as TSD units under RCRA. Additionally, this chapter addresses certain regulatory developments that are in progress that likely will be finalized before implementation of SST closure activities. Section 3.1 provides information on applicable laws and regulations and available information on developing regulations. Section 3.2 discusses classification of the radioactive component with regard to potential NRC licensing requirements. Section 3.3 describes the particular regulatory pathway process and considerations that apply to the different closure alternatives. Section 3.4 identifies issues remaining, and provides guidance on resolution.

3.1 APPLICABLE LAWS AND REGULATIONS

Various laws are relevant to the management of waste in SSTs. These laws are the following:

- *Resource Conservation and Recovery Act* (RCRA)
- *National Environmental Policy Act* (NEPA)

- *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA)
- *Atomic Energy Act* (AEA)
- *Clean Air Act*
- *Safe Drinking Water Act*.

Each of these laws will be addressed in more detail with emphasis on the applicability/impact to SST closure activities.

3.1.1 *Resource Conservation and Recovery Act of 1976*

The RCRA was passed in 1976 to provide for proper waste management. Subtitle C of RCRA consists of Sections 3001-3023, in which Congress addresses hazardous waste. EPA is the administrative agency delegated the authority to develop and to promulgate regulations for hazardous waste management. The Federal regulations governing hazardous waste management are codified in 40 CFR 260-271. A large portion of this authority has been further delegated by EPA to Ecology, who regulates hazardous waste management through the Statewide "Dangerous Waste Regulations," WAC 173-303. These regulations are applicable to dangerous waste management activities at the Hanford Site, including Hanford Site TSD unit activities. In accordance with the Tri-Party Agreement (Ecology et al. 1994), the Hanford Facility is considered as a single RCRA TSD facility.

3.1.1.1 Single-Shell Tank Regulatory Requirements. The SSTs are regulated as RCRA hazardous waste storage tank systems (i.e., they are RCRA TSD units) and, therefore, constitute a portion of the Hanford Facility. These tanks are subject to the operating standards and permit requirements of RCRA Sections 3004 and 3005, respectively. Ecology uses WAC 173-303 to implement these requirements in the state of Washington. The TSD units that were in operation on the effective date of the governing regulations could continue operation without a final status permit by fulfilling certain notification and submittal requirements. These facilities were granted 'interim status' to operate pursuant to applicable regulations until the regulatory authority determines that the process must begin for issuance of a final status permit by requiring the owner/operator to submit a Part B permit application. The Hanford Facility *Dangerous Waste Portion of the Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste* (RCRA Permit) (Ecology 1994) was issued and has been effective since September 28, 1994. The Hanford Facility RCRA Permit addresses some TSD units, but not SSTs.

The Hanford Facility RCRA Permit governs activities at TSD units that have been evaluated through the Part B permit application process. Through this process, Ecology establishes final status standards for the unit. Once approved, the closure plans will be incorporated into the Hanford Facility RCRA Permit. At this time, five units have been incorporated into the permit for final status operation; all other active units continue to be regulated

under interim status. Eventually, all TSD units at the Hanford Site, for which continued dangerous waste management is desired, will be converted from interim status to final status. Some TSD units (e.g., the SSTs) will not be used for continued dangerous waste management. Such TSD units must undergo 'TSD unit closure' in lieu of final status permitting. The Tri-Party Agreement stipulates that all TSD units must be closed pursuant to WAC 173-303-610, irrespective of permit status. WAC 173-303-610 refers to WAC 173-303-640 for supplemental closure requirements for tank systems. WAC 173-303-640(8) requires the owner or operator of a tank system to remove or decontaminate all waste residues, contaminated containment system components, contaminated soils, and contaminated equipment, at the time of closure, but allows closure of tank systems as a landfill if the owner or operator demonstrates that not all the contaminated soil can be practically removed or decontaminated. Section 6.3.2 of the Tri-Party Agreement outlines the process that will be used if a TSD unit is closed as a land disposal unit if clean closure cannot be satisfied.

Levels of retrieval have been specified in Tri-Party Agreement Milestone M-45-00. In addition to these levels of retrieval, a process for closing TSDs is presented in Section 6.3 of the Tri-Party Agreement. As shown in Figures 6-1 and 6-2 of the Tri-Party Agreement, the process for both clean closure and closure as a landfill are diagrammed. Closure as a landfill will require that a permit application be prepared by the owner or operator and submitted to Ecology for approval. Once approved, the TSD will be closed as a landfill in accordance with the closure and post-closure requirements that are provided in the permit.

The Tri-Party Agreement (Ecology et al. 1994) requires that all units located within the boundary of each SST tank farm be closed pursuant to WAC 173-303-610, including contaminated soil and ancillary equipment that were previously identified for cleanup under RCRA corrective action authority. This reclassification as ancillary equipment to the TSD unit has been done in an attempt to ensure the application of a consistent closure approach. Therefore, the closure of all units within the boundary of a given SST farm will be addressed in the closure plan along with the SSTs for the tank farm. The Tri-Party Agreement will be amended as appropriate to include all ancillary equipment impacted by this decision. Additionally, the physical boundaries of contaminated soil will be defined prior to preparing any closure plans or prior to preparing any permit applications for closing the SST TSDs as landfill(s).

3.1.1.2 Part A Permit Application. The Part A permit application is used by the regulatory agency to grant interim status for facilities that have complied with notification and submittal requirements in accordance with regulatory time frames. The SSTs are storing hazardous waste pursuant to the interim status authority of RCRA Section 3005(e). Under this authority, existing TSD unit owners/operators that have been granted interim status may temporarily continue hazardous waste management activities without a final status permit. Part A permit applications do not require public comment, and interim status is automatically granted on meeting the requirements pursuant to WAC-173-303-805. New TSD facilities normally cannot be granted interim status; both a Part A and a Part B permit application must be submitted for

such facilities. The regulator must then issue the permit before construction of the facility. The DOE, Richland Operations Office (DOE-RL) submitted a Part A permit application addressing SSTs to Ecology on March 1, 1988, and has been granted RCRA interim status.

3.1.1.3 Part B Permit Application. The Part B permit application is used by the regulatory agency to issue final status permits for TSD units. The Part B permit application is used to establish permit conditions related to operation and closure (including postclosure care where applicable). A closure plan must be submitted with the Part B permit application. The plan must describe procedures that will be used by the owner/operator to remove dangerous waste and associated contaminated soil and equipment from TSD units at the facility. If the owner/operator is unable to remove all waste (and associated soils and equipment) from the TSD unit, postclosure care will be required, which includes additional permitting. Because DOE-RL does not intend to seek final operating status for SSTs, they will be closed under interim status. Therefore, submittal of a Part B permit application for SSTs is unnecessary. A postclosure permit will be required if the TSD is closed as a landfill. If the SSTs are clean closed, an approved closure plan is required.

3.1.1.4 Interim Status Closure. Technically, the interim status standards of WAC 173-303-400 specify interim status closure in accordance with the Federal regulations of 40 CFR 265, Subpart G. However, because the Tri-Party Agreement stipulates closure in accordance with WAC 173-303-610 irrespective of permit status, TSD unit closure at the Hanford Site under interim status is identical to closure under final status. A written plan for closure of the SSTs must be approved by Ecology. This plan will be reviewed by Ecology in a manner similar to the Part B permit application process.

According to Tri-Party Agreement Milestone M-45-06, the SST-CWP will be used as a roadmap for closure of SSTs. It is recognized that there are uncertainties in the SST closure process, and it is expected that the SST-CWP will evolve and become the SST closure/postclosure plan(s) that will be submitted for Ecology's approval. Section 3.3 provides a discussion of the various regulatory considerations and processes that will be followed for three closure alternatives that bound the range of closure options.

3.1.2 *National Environmental Policy Act of 1969*

The TWRS program is conducted in concert with the Tri-Party Agreement. The program includes the following: (1) resolution of tank waste safety issues; (2) management of tank waste and tank farm activities that includes the upgrading and construction of facilities and infrastructure; (3) tank farm waste retrieval, conditioning (e.g., evaporation/dilution), pretreatment (e.g., radionuclide separation), and immobilization (e.g., vitrification); (4) storage of immobilized high-activity waste; (5) storage/disposal of low-activity and incidental waste; (6) management of encapsulated strontium and cesium; and (7) technology development.

Closing the SST operable units will require NEPA documentation. A ROD issued in 1988 for the HDW-EIS (53 FR 12449) committed to preparing a supplemental EIS once additional information is received on critical parameters that affect the decision on final disposition of the SST tank waste. On January 28, 1994, DOE announced its intention to prepare two EISs in response to activities associated with the treatment, storage, and disposal of waste contained in the 149 SSTs and 28 DSTs (DOE 1994). The first EIS will address the proposed TWRS overall strategy; the second EIS will address actions to resolve safety issues associated with waste storage.

In March 1993, DOE completed a rebaselining of the TWRS program to ensure that the program to remediate tank waste was comprehensive, integrated, and technically feasible. Subsequently, the Tri-Party Agreement was renegotiated. The revised agreement committed to constructing additional tanks and other actions associated with the rebaselining of the TWRS program. Because these actions constitute a Federal expenditure of funds and could potentially affect the environment, DOE developed a strategy that would provide for appropriate NEPA reviews of the planned actions. A TWRS-EIS will address the overall strategy to treat, store, and dispose of Hanford Site high-activity waste (DOE-RL 1994e).

DOE also has considered the need for additional actions to support resolution of safety issues associated with tank waste storage. These will be addressed in the Safe Interim Storage (SIS) EIS. Actions considered include construction of new storage tanks, the cross-site transfer system, initial waste retrieval systems for DSTs, and other actions to mitigate tank safety issues.

In the HDW-EIS ROD (53 FR 12449), DOE deferred final disposal decisions for the tank waste stored in the SSTs pending further evaluation in a supplemental EIS. DOE will meet regulatory requirements through the retrieval, processing, and treatment of this waste. These activities will be integrated with similar activities associated with the high-activity waste stored in the DSTs. As such, the TWRS-EIS (DOE-RL 1994e) will address DOE's proposal for the management, TSD of waste currently stored in the 149 SSTs and 28 DSTs. DOE recognizes that these actions may require additional NEPA documentation; therefore, DOE will conduct appropriate reviews to determine the additional NEPA documentation required to support tank closure activities.

3.1.3 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*

The CERCLA provides a mechanism for response to hazardous substances released to the environment from facilities or vessels. As previously stated, within the boundary of a given tank farm, the SSTs, contaminated soil, and ancillary equipment will be closed under RCRA authority. In order to avoid duplication of effort under CERCLA, the radionuclide component of mixed waste will be addressed as part of the closure action for units closed as a landfill pursuant to the Tri-Party Agreement Action Plan, Section 6.3.2.

3.1.4 *Atomic Energy Act of 1954*, As Amended

The AEA establishes the authority of the Federal government to regulate the production and use of source, byproduct, and special nuclear material. This responsibility was originally under the sole purview of the AEC. In 1970, the responsibility for establishing generally applicable environmental standards for the protection of the environment from radioactive materials was transferred to EPA. EPA also assumed the previous responsibility of the Federal Radiation Council (established in 1959) to provide guidance to the President on radiation matters affecting health. Responsibility for implementation and licensing remained with the AEC.

In 1974, the *Energy Reorganization Act of 1974* (ERA) established the ERDA and the NRC, with licensing of commercial nuclear activities as the responsibility of NRC and remaining activities the responsibility of ERDA. In 1977, the DOE Organization Act created DOE and transferred ERDA activities to DOE.

Regulations applicable to SSTs under the AEA are issued by both EPA and DOE, and the pertinent rules are given as follows. The NRC regulatory responsibility for commercial facilities does not affect DOE, except for HLW disposal. The NRC has licensing authority under the ERA for disposal facilities for all HLW, including that produced by DOE facilities. Because the current strategy includes separation of SST waste to the degree necessary that the residuals would be non-HLW, licensing is not expected to be required. However, it will be necessary to negotiate with the NRC to determine the degree of retrieval and separation required to determine that the residue is not HLW and therefore not subject to licensing (Section 3.2).

3.1.4.1 40 CFR 191. Management of transuranic (TRU) and HLW is regulated under Subpart A of Final Rule 40 CFR 191, "Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes." The regulation controls public exposures from operations involving HLW and applies to tank farm operations. The dose limits are 25 millirem per year to the whole body, 75 millirem per year to the thyroid, and 25 millirem per year to any other organ. These are different from the limits, in terms of effective dose equivalent (EDE), used in more modern regulations, and will require maintenance of two different dose calculation systems.

Disposal of TRU and HLW is regulated under Subpart B, which was remanded for reconsideration [*NRDC vs. U.S. EPA*, 824 F 2d 1258 (1st Cir. 1987)]. EPA reissued the disposal standards (58 FR 66398, December 20, 1993) for applicability to all disposal facilities for TRU and HLW, except Yucca Mountain. Standards include total releases from the facility, an individual protection limit, and a groundwater protection standard, all applicable for 10,000 years after disposal. The standard for Yucca Mountain will not be proposed until after a study is completed by the National Academy of Sciences scheduled to be completed during 1995.

The reissued standard applies to the Waste Isolation Pilot Plant (WIPP) and any other disposal facility, including tank residuals, if those residuals are determined to be TRU or HLW. The strategy includes removing enough waste so that the residue will not be HLW; but it is possible that residues in some tanks will be TRU waste. For TRU waste, EPA will be both the regulating agency and the implementing agency. It will first be necessary to characterize the intended residues sufficiently to determine whether those residues might be TRU waste. Then, the determination would be made by negotiation with EPA in the same manner that the non-HLW determination is to be negotiated with the NRC.

If the residuals are determined to be TRU waste, and the decision is made to proceed with disposal in place, the rule requires a performance assessment to project compliance with those limits. The individual protection requirement includes a dose limit of 15 millirem per year EDE, which is stated to be the approximate equivalent of a 25 millirem per year organ dose limit. The groundwater limit is the current Maximum Contaminant Levels (MCL) from the drinking water standards (40 CFR 141).

3.1.4.2 40 CFR 193. EPA is developing a "Proposed Rule for Management of LLW" as 40 CFR 193. The latest review draft was issued in April, 1989. More recent information has been provided in EPA Symposia papers and briefings to DOE elements. The Proposed Rule is planned to be issued in early 1995 and will contain limits on exposure to offsite individuals and on groundwater concentrations. Although the draft included a section on waste that would be considered "Below Regulatory Concern," this section has been removed. The draft also included a section on naturally occurring and accelerator-produced radioactive material (NARM); this section has also been removed.

The offsite exposure limit in the Proposed Rule is expected to be 15 millirem per year EDE through all pathways. The groundwater limit is expected to be the MCLs, which are currently 4 millirem per year for beta/gamma-emitters, with specific concentration limits for some alpha-emitters. These include existing plumes. A case would have to be made regarding existing plumes should any new releases show up long after the existing plume passes. Composite effects from radionuclides in all tanks and other waste sites will have to be considered, so that the projected total groundwater concentrations will meet the MCLs. The time period for compliance was not stated in the 1989 draft; however, it is believed that 1,000 years is being considered.

The Proposed Rule would apply as long as the site is to be restricted from public use. If the site is to be released for public use, the following provisions of 40 CFR 196 would apply.

3.1.4.3 40 CFR 196. EPA is developing a "Radiation Site Cleanup Regulation" as 40 CFR 196, which is directed toward remediation for unrestricted release of sites. The latest draft was issued on May 11, 1994. The individual protection requirement is 15 millirem per year EDE through all pathways (presumably to an onsite resident) for unrestricted release. There is also a special category that includes "selected active control measures," for sites that cannot meet the unrestricted use limit, presumably because a credible

occupancy scenario would lead to a higher projected dose. In this case, the operator may remediate to a level corresponding to 15 millirem per year, assuming the controls are in place, subject to a condition that the projected dose will not exceed 75 millirem per year, if the controls were not in place. Both limits apply for 1,000 years after disposal, but there is no indication of how to maintain the active controls for that length of time.

The groundwater standard is the MCLs for 1,000 years. Again, there is an escape clause, "if the implementing agency determines compliance to be technically impractical from an engineering perspective". In such a case, active controls may be supplied to ensure that the water is not consumed. It is recommended that this clause not serve as the basis for decision-making, because substantial modification is expected.

3.1.4.4 40 CFR 194. EPA is developing "Criteria for the Certification and Determination of the WIPP's Compliance with Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes" as 40 CFR 194. This is an implementing rule for applying the standards in 40 CFR 191 to the WIPP only. The rule follows from the Waste Isolation Pilot Plant *Land Withdrawal Act*, which specifies EPA as the permitting authority for the WIPP. However, there is a potential gap in the regulations for TRU waste that is not disposed of in WIPP. The repromulgated 40 CFR 191 is stated to apply to WIPP and any other facility, except Yucca Mountain. However, 40 CFR 194 applies only to WIPP, so there are no compliance criteria for other facilities (such as residues in SSTs). If the residues in some SSTs are determined to be TRU waste, new rulemaking might be needed to develop compliance criteria. It is possible that DOE will develop such criteria, because there is no separate law (e.g., the WIPP *Land Withdrawal Act*) to specify who does this.

3.1.4.5 10 CFR 835. Worker radiation protection is regulated by 10 CFR 835, "Occupational Radiation Protection, Final Rule." This rule establishes the primary limit of 5 rem per year, with a number of modifications for special cases. It also covers a variety of topics, such as monitoring, entry control, posting records, facility designs, emergency exposures, and release of materials and equipment. An appendix on Derived Air Concentrations is included in 10 CFR 835.

3.1.4.6 DOE Order 5400.5 (DOE 1990). Public radiation protection is regulated by DOE Order 5400.5, *Radiation Protection of the Public and the Environment*. This establishes the general public dose limit for all pathways of 100 millirem per year EDE and the air pathway limit of 10 millirem per year. Additional detailed requirements are provided for specific situations, sources, and liquid discharges, and tables of Derived Concentration Guides for air and water are included. This order is to be replaced by 10 CFR 835, which was issued as a proposed rule on March 25, 1993. The provisions are the same.

3.1.4.7 DOE Order 5820.2A (DOE 1988c). The primary DOE regulation on radioactive waste is DOE Order 5820.2A, *Radioactive Waste Management*. Individual chapters cover each waste type: Chapter I for HLW, Chapter II for LLW, and Chapter III for LLW. Chapter I addresses design, storage operations, and disposal, with the disposal section deferring to the *Nuclear Waste Policy*

Act of 1982 for requirements. Chapter II addresses classification, packaging, and shipping to WIPP, because disposal of retrievably stored TRU waste is planned for WIPP. Separate planning is required for disposal of old buried TRU waste. The requirements in Chapter III for LLW are stated as Performance Objectives (PO) and include a public individual dose limit of 25 millirem per year EDE and an intruder dose limit of 100 millirem per year. Groundwater protection refers to protecting, "ground water resources, consistent with Federal, State and local requirements," but no numerical limits are given. A radiological performance assessment (PA) is required to establish compliance with the POs. The Order is currently being revised, with similar, but more detailed, requirements. The revised order will contain sections on hazardous and mixed waste. However, the section on decommissioning will be removed, because that topic is covered in a different order.

A key clause states that the order does not apply to waste disposed of before issuance of the order (September 26, 1988). Management of old sites is deferred to RCRA and CERCLA. However, this clause may be revised to include old waste inventories in PAs for contiguous existing or new facilities. The composite effects of nearby facilities may be included.

3.1.4.8 DOE RLID 5820.2A (DOE-RL 1993k). This implementing directive was issued by DOE-RL to supplement the requirements in DOE Order 5820.2A (DOE 1988c). More details are included in this directive, including a groundwater PO for LLW (i.e., 4 millirem per year EDE), a definition of the point of compliance (i.e., 100 meters from the edge of the disposal facility after the period of active institutional control), a limit on the time period for compliance (i.e., 1,000 years), and a long-term protection requirement expressed as a population collective dose limit of 500 person-rem per year.

3.1.5 *Clean Air Act*

Radioactive emissions to air are regulated under the "National Emission Standards for Hazardous Air Pollutants, Final Rule, 40 CFR 61" (54 FR 51654). The basic limit is 10 millirem per year EDE to a member of the public through the air pathway only.

3.1.6 *Safe Drinking Water Act of 1974*

Concentration limits for radionuclides in drinking water are contained in the "National Primary Drinking Water Regulations," 40 CFR 141. The standards are expressed as MCLs, which include specific concentrations for radium-226/228 (i.e., 5 picocuries per liter combined), gross alpha (i.e., excluding radon and uranium - 15 picocuries per liter), and concentrations corresponding to 4 millirem per year to whole body or any organ (listed in an appendix). Again, the old organ dose system will be used to determine compliance.

New MCLs are being considered ("National Primary Drinking Water Regulations: Radionuclides, Notice of Proposed Rulemaking," 56 FR 33050, July 18, 1991). These MCLs would be based on 4 millirem per year EDE. The

concentration limits would be substantially higher for organs having small weighting factors in the determination of weighted whole-body dose. For example, the thyroid weighting factor is 0.05, and the proposed MCL for iodine-129 would be 100 picocuries per liter, compared to the current value of 1 picocurie per liter. Limits for radium-226/228 would be raised to 20 picocuries per liter, and a new limit for uranium (i.e., 20 picocuries per liter) is added.

The limits were developed for application to public drinking water supplies at the point of use. However, some of the developing rules are attempting to apply the same limits to groundwater that does, or could, serve as a water supply. These limits may also be considered as applicable or relevant and appropriate requirements (ARAR) for CERCLA remediations.

3.1.7 State Regulations

Washington State has been granted authority by EPA to administer their own RCRA program in lieu of the Federal program. Therefore, State RCRA regulations are applicable at the Hanford Site. The SSTs will be closed in accordance with State requirements as addressed in the Tri-Party Agreement and the Hanford Facility RCRA Permit (DOE-RL 1995).

3.1.7.1 "Dangerous Waste Regulations," WAC 173-303. The standards that are applicable to dangerous waste management activities at the Hanford Site are contained in the "Dangerous Waste Regulations". Dangerous waste generated at the Hanford Site must be designated and managed pursuant to WAC 173-303. The SSTs are subject to the interim status standards of WAC 173-303-400. However, as stated previously, the SSTs will not be permitted for final status but will instead undergo interim status closure. The Tri-Party Agreement requires that all TSD units, irrespective of permit status, be closed under WAC 173-303-610. A discussion of the closure requirements and a range of closure options or scenarios that bound the closure alternatives is discussed in Section 3.3.

3.1.7.2 "The Model Toxics Control Act Cleanup Regulation," WAC 173-340. The MTCA regulations are used by Ecology to take those actions or to require others to take those actions necessary to investigate and remedy releases of hazardous substances that may pose a threat to human health or the environment. The Tri-Party Agreement provides for cleanup of the Hanford Site under RCRA and CERCLA authorities. In particular, a January 1994 amendment to the Tri-Party Agreement requires that the SSTs (including all units within the boundary of a given tank farm) be closed as RCRA TSD units in accordance with WAC 173-303-610, which in turn requires calculation of numeric cleanup levels using WAC 173-340. *Washington Administrative Code* 173-303-610(2)(b)(i) requires that removal or decontamination of soils, groundwater, surface water, and air must ensure that the levels of dangerous waste or dangerous waste constituents or residues do not exceed the numeric cleanup levels calculated using residential exposure assumptions according to WAC 173-340. As will be discussed in Section 3.3, the application of MTCA standards will be applied to both "clean closures" and "modified closures" as defined in the Hanford Facility RCRA Permit.

3.2 CLASSIFICATION OF SINGLE-SHELL TANK WASTE

Much of the waste in SSTs came from reprocessing of spent fuel and may be considered HLW, unless demonstrated otherwise. However, some of the waste came from non-HLW sources (e.g., the phosphate/sulphate waste that has already been solidified in the grout vaults) and other waste from nonreprocessing sources. Some of this waste may be identifiable in non-HLW tanks, but much of it has been mixed to the point that the classification is uncertain. DOE plans to retrieve the tank waste; separate it into HLW, TRU waste, and LLW fractions; immobilize by vitrification; dispose of the HLW/TRU fraction in an offsite geologic repository; and dispose of the LLW fraction onsite. It is important to establish the criteria for defining each class of waste so that retrieval and processing criteria can be established.

The current waste class definitions start with the definition of HLW in 10 CFR 50, Appendix F, is as follows:

> "Those aqueous wastes resulting from operation of the first cycle extraction system or equivalent, and the concentrated wastes from subsequent extraction cycles or equivalent in a facility for reprocessing irradiated reactor fuels."

This definition is based on the source of the waste, rather than radiological properties. However, the regulatory history in the rulemaking shows that the intent was to capture the major fraction of the total radioactivity for disposal in a geological repository. Authority to regulate was shifted from the AEC to the NRC by the *Energy Authorization Act of 1974*, which created the NRC and gave them the authority to license disposal facilities for HLW.

The definition of HLW was later refined in the *Nuclear Waste Policy Act of 1982* as follows:

> "(A) The highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing, and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and (B) other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation."

This definition remains source-based, but adds derived solids, confirms the intent to require geologic disposal of highly radioactive materials, and restates NRC's role in determining what is HLW and what is not.

The HLW fraction of SSTs cannot be determined without consultation with the NRC. However, it is possible to obtain substantial guidance from the NRC's past action on DSTs. DOE has requested a determination of the classification of DST waste that was to be solidified in grout and disposed of in near-surface grout (Rizzo 1989, Appendix 3A). DOE proposed that the bulk of the key radionuclides be separated for disposal in a geologic repository, such that only 2 to 3 percent of the HLW inventory that originally entered the tanks would be disposed of in the grout facility as LLW. DOE also stated that

the concentrations of radionuclides in the grout would be comparable to Class C LLW, as defined in 10 CFR 61 for cesium and TRU, and to Class A or B for the remainder.

The NRC replied that the criteria were appropriate for classification of the grout feed as LLW, and, therefore, the grout facility would not be subject to licensing (Bernero 1989, Appendix 3A). The reply cautioned that the inventory estimates might be uncertain because they were based partly on modeling rather than actual waste analyses. Thus, it would be necessary to provide sampling and analysis data and to notify the NRC if the inventories were significantly higher than the estimates. The NRC also cautioned that their action should not be interpreted as a precedent. This indicates that further proposals and discussion will be necessary, including substantial inventory characterization, to determine the appropriate classification of SSTs.

Removal of 99 percent of the waste from the SSTs should be sufficient to satisfy the NRC that the residues are incidental waste, and thus non-HLW. The initiation of dialogue to confirm this position with the NRC should be a priority for the program. It is possible that this activity is carried on through the NEPA process, because the NRC is likely to review and comment. The designation as non-HLW should also apply to empty tanks and associated contaminated soil provided the waste has been removed to the maximum or greatest extent technically and economically feasible. The dialogue with NRC should include specific discussion of this point.

Designation as TRU waste or LLW is the responsibility of DOE. The DOE definition of TRU waste is as follows:

> "Without regard to source or form, waste that is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay."

This designation can be made whenever the waste is adequately characterized to determine the concentrations, with the condition that the waste has been designated as non-HLW. The remainder that is not HLW or TRU waste is LLW.

Designation for hazardous characteristics is determined by RCRA. The high-level mixed waste must be vitrified pursuant to the land disposal restrictions of RCRA (40 CFR 268). The residues, empty tanks, and contaminated soil will have to be closed under RCRA rules.

Once the designations have been made, the applicable radiological rules for non-HLW will be the following:

- TRU waste: EPA rules 40 CFR 191 and 194 (when issued), DOE Order 5820.2A (or 5820.2B, when issued), and DOE-RL (1993k).

- LLW: EPA rule 40 CFR 193 (when issued), DOE Order 5820.2A (or 5820.2B, when issued), and DOE-RL (1993k). If the sites are cleaned to the point where unrestricted release could be considered, EPA rule 40 CFR 196 (when issued) will apply.

It is also possible that the State issues rules for waste management and disposal by the time the action is taken. Those rules would have to be considered. EPA is planning a general rule on waste management (no number assigned yet), and this rule likely would apply. The NRC rules will not apply once the designation as non-HLW has been made.

3.3 CLOSURE REQUIREMENTS AND OPTIONS

In this section, the closure requirements as regulated through the Ecology's Dangerous Waste Regulations (WAC 173-303) and the conditions of the Hanford Facility RCRA Permit are discussed. Three possible closure scenarios (clean closure, a landfill closure, and modified closure) will be discussed. It is believed that these closure scenarios bracket the various options available for closure.

3.3.1 Closure Requirements

The Tri-Party Agreement requires that all TSD units, irrespective of permit status, be closed under WAC 173-303-610. The general closure performance standards for tank systems as required through this provision are summarized as follows:

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

(a)(i) Minimizes the need for further maintenance;

(ii) Controls, minimizes or eliminates to the extent necessary to protect human health and the environment, postclosure escape of dangerous waste, dangerous constituents, leachate, contaminated run-off, or dangerous waste decomposition products to the ground, surface water, or atmosphere; and

(iii) Returns the land to the appearance and use of surrounding land areas to the degree possible given the nature of the previous dangerous waste activity." The requirements under WAC 173-303-610(b) will be discussed later in this section.

Additionally, for tanks systems, WAC 173-303-640(8)(a) requires that:

"At closure of a tank system, the owner or operator must remove all waste residues, contaminated containment system components (liner, etc.), contaminated soils, and structures and equipment contaminated with waste, and manage them as dangerous waste ....."

The specific requirements for both the contaminated soil component and the structural component are discussed below.

3.3.1.1 Contaminated soil. The basic condition and premise is that at the time of closure all contaminated soil that can be removed must be removed. In the event that all contaminated soil cannot be removed; there are provisions in the State of Washington regulations that allow the contaminated soil to be left provided this action will not pose any risk to human health and the environment. The conditions are discussed in two sections of the WAC. As required in WAC 173-303-610(b)(i):

> For soils, ground water, surface water, and air, the numeric cleanup levels calculated using residential exposure assumptions according to the MTCA will be applied. The numerical cleanup levels will be calculated according to MTCA Method B although MTCA Method A may used if appropriate.

Secondly, as required in WAC 173-303-640(8)(b):

> If the owner or operator demonstrates that not all contaminated soils can be practically removed or decontaminated as required in (WAC 173-303-640(8)(a)), then the owner or operator must close the tank and perform post-closure care requirements that apply to landfills.

Additionally, the Hanford Facility RCRA Permit provides a condition that allows closure based on the application of MTCA Method C. Closure under this condition shall be deemed a "modified closure." More discussion of the "modified closure" condition is found in the following section.

3.3.1.2 Structural Component. With regard to structures, equipment, bases, liners, etc., clean closure standards can be set by the department on a case-by-case basis so long as the standard is protective of human health and the environment (WAC 173-303-610(2)(b)(ii). It is assumed that these standards would be established using a "contained in" determination as discussed in "Guidance for Clean Closure of Dangerous Waste Facilities" (Ecology 1994).

The Hanford Facility RCRA Permit includes, under Section II.K, additional conditions that allow closure of TSD units located on the Hanford Site. Basically, this condition defines "clean closure" as the status of a TSD unit that has been closed to the cleanup levels prescribed by WAC 173-303-610(b) provided certification of such closure has been accepted by Ecology; and provided a provision for "modified closure." In principle, the modified closure provision provides for closure of a TSD unit using Method C of MTCA rather than Method B. In so doing, the assessment of risk is compared to industrial standards rather than residential standards. Additional conditions associated with modified closures require the following:

- The permittee shall maintain institutional controls in accordance with WAC 173-340-440, which restricts access to the unit for a minimum of five (5) years following completion of closure.

- The permittee shall provide periodic assessments of the TSD unit to determine the effectiveness of closure. The periodic assessment

will include, as a minimum, a compliance monitoring plan in accordance with WAC 173-340-410.

- The permittee shall specify the specific activities that will be followed in a postclosure permit application. The primary purpose of these activities is to monitor concentration in the soil and groundwater to demonstrate that these concentrations are maintained below allowable levels.

As stated previously, if the TSD unit is not closed under the conditions of "clean closure" or "modified closure," it will be closed as a landfill in accordance with Condition II.K.4 of the Hanford Facility RCRA Permit. Both the Tri-Party Agreement and the Hanford Facility RCRA Permit allow closure as a landfill. The procedure for closure of a TSD is provided in Figures 6-1 and 6-2 of the Tri-Party Agreement.

3.3.2 Closure Scenarios

In this section, three scenarios for closure are discussed. Two of these scenarios are intended to bound the problem (clean closure and closure as a landfill) whereas the third scenario (modified closure) provides a description of tank closure consistent with the "retrieval goal" outlined in the Tri-Party Agreement Milestone M-45-00. A brief discussion of each scenario follows.

3.3.2.1 Clean Closure. General closure performance standards were discussed in Section 3.1.1. In addition to compliance with these standards, clean closure requires the removal or decontamination of all dangerous waste, waste residues and equipment, bases, liners, soil/subsoils and other material containing or contaminated with dangerous waste or waste residue. Removal and decontamination will be considered complete when the concentrations of dangerous waste, dangerous waste constituents, and dangerous waste residues throughout the closing unit and throughout any areas affected by the releases from the closing unit do not exceed numeric cleanup levels determined using residential exposure assumptions according to MTCA Regulations and all structures, equipment, bases, liners, and the materials containing or contaminated with dangerous wastes, constituents, or residues have met specific removal and decontamination standards approved by Ecology in accordance with WAC 173-303-610(2)(b)(ii) (Ecology 1994).

At the present time, numeric cleanup levels determined using the MTCA methodology have not been established. Similarly, although DOE has established specific cleanup goals for retrieving waste from the SSTs; as will be discussed in Section 3.3.2.2, these goals were not established as a basis for defining clean closure conditions. To satisfy this need, the specific removal and decontamination performance standard must be developed in such a manner that (WAC 173-303-610);

(2)(a)(i) Minimizes the need for further maintenance;

(ii) Controls, minimizes or eliminates to the extent necessary to protect human health and the environment, postclosure escape

of dangerous waste, dangerous constituents, leachate, contaminated run-off, or dangerous waste decomposition products to the ground, surface water, groundwater, or the atmosphere; and

(iii) Returns the land to the appearance and use of surrounding land areas to the degree possible given the nature of the previous waste activity.

Once these standards have been established, they will be incorporated in the closure plan.

At the time of closure, the owner or operator must remove or decontaminate all waste residues and contaminated containment system components (liner, etc.). Ecology has adopted the "Alternative Treatment Standards for Hazardous Debris," as promulgated by EPA (Ecology 1994). Furthermore, Ecology recognizes that not all materials requiring decontamination during closure will meet the regulatory definition of hazardous debris. Ecology believes the Alternative Treatment Standard represents the best demonstrated available technology (BDAT) for material typically subject for closure decontamination regardless of the regulatory status of the material in question. Treatment may include extraction, destruction, or immobilization. The method of treatment will be described in a permit application. The draft permit will be reviewed by the general public and must be approved by DOE. Once approved, the permit will be included in the Hanford Facility RCRA Permit.

3.3.2.2 Modified Closure. Tri-Party Agreement Milestone M-45-00 (Ecology et.al. 1994) established an objective of retrieving "as much waste as technically possible, with tank residues not to exceed 360 cubic feet (10,200 liters) in each of the 100 series tanks, 30 cubic feet (850 liters) in the 200 series tanks, or the limit of waste retrieval technology capability, whichever is less." The Tri-Party Agreement allows an exception to this level of cleanup on a tank-by-tank basis if supported by detailed justification. The justification will address the protection of human health and the environment.

Contaminated soil and groundwater closure performance standards are provided as Condition II.K in the Hanford Facility RCRA Permit. Performance standards for the three conditions (clean closure, modified closure, and closure as a landfill) are discussed as part of Condition II.K.

It is assumed under this scenario that the "clean closure" performance standard cannot be satisfied. The conditions that govern a "modified closure" are provided as Conditions II.K.3.a. through II.K.3.c. and include:

II.K.3.a. For "modified closures," the Permittees shall provide institutional controls in accordance with WAC 173-340-440 which restricts access to the TSD unit for a minimum of five (5) years following completion of closure. The specific details and duration of institutional controls shall be

specified in Parts III or V of the Permit for a particular TSD unit.

II.K.3.b. For "modified closures," the Permittee shall provide periodic assessments of the TSD unit to determine the effectiveness of the closure. The specific details of the periodic assessment shall be specified in Parts III or V of this Permit. This periodic assessment shall include, as a minimum, a compliance monitoring plan in accordance with WAC 173-340-410 that will address the assessment requirements on a unit by unit basis. At least one (1) assessment activity shall take place after a period of five (5) years from the completion of closure, which will demonstrate whether the soils and groundwater have been maintained at or below the allowable concentrations as specified in Parts III or V of the Permit. Should the required assessment activities identify contamination above the allowable limits as specified in Parts II or V, the TSD unit must be further remediated or the requirements of II.K.4 must be followed. Should the required assessment activities demonstrate that contamination has diminished or remained the same, the Permittees may request that DOE reduce or eliminate the assessment activities and/or institutional controls.

II.K.3.c For "modified closures," the Permittees shall specify the specific activities required by this Condition in a postclosure permit application.

3.3.2.3 Landfill Closure.

For any TSD unit for which Hanford Facility RCRA Permit Conditions II.K.1, II.K.2, or II.K.3., are not chosen as the closure option, closing the TSD unit as a landfill under condition II.K.4 may be selected. Closure and postclosure of the TSD unit as a landfill must follow the procedures and requirements specified in WAC 173-303-610 and WAC 173-303-665. It is assumed that this condition applies to both contaminated media (soil above the groundwater table) and the structural components (i.e., tank, auxiliary equipment).

3.4 REGULATORY ISSUES

This section provides a discussion of four regulatory issues. Additional information on each issue is provided in Appendix 1A.

3.4.1 Closure of Single-Shell Tanks

The SST-CWP will be used as a roadmap for closure of the SSTs in accordance with WAC 173-303-610, the Tri-Party Agreement, and the Hanford Facility RCRA Permit. As uncertainties are resolved through this work plan, the appropriate course of action for achieving closure will be determined. If information related to waste retrieval and other potential impediments reveal that clean closure cannot be practicably achieved, closure/postclosure as a landfill will be pursued.

3.4.2 Classification of Radioactive Residual Constituents

It is important to establish that any residual radioactive waste and contaminated soil remaining after retrieval is acceptable for near-surface disposal as LLW.

The strategy is to open a dialogue with the NRC on their definition of HLW and how they view the retrieval plans in relation to that definition. Characterization is the crucial first step; establishing the residual fraction of total activity remaining is the second. The past precedent of NRC action on the DSTs indicates that the planned 99 percent retrieval will be satisfactory, but that must be confirmed with the NRC.

The impact, if not resolved, would be that the residues designate as HLW, which is not considered appropriate for near-surface disposal. Furthermore, the NRC has no regulatory structure in place for HLW disposed of anywhere but in a geological repository.

3.4.3 Gaps in Radiological Regulations for Near-Surface Disposal

All regulations for LLW disposal are not in place. EPA is developing an LLW rule (40 CFR 193), but it is not yet final. A rule for residual radioactivity for unrestricted release is also in preparation. The controlling DOE Order 5820.2A is being revised for reissue as DOE Order 5820.2B. Performance objectives are not the same in these developing rules.

The drafts will be reviewed closely and comment provided to obtain reasonable, yet conservative POs, which are consistent throughout the rules. The regulatory analysis element of the program will seek out the direction of these rules by analyzing drafts provided for interagency review, studying presentations and papers by the developers, and personal contacts with agency staff, as directed by DOE. Projections of potential requirements and impacts will be prepared to guide program management as the rules proceed. The program also will support participation in DOE Technical Working Groups that are revising DOE Order 5820.2A and other rules, where possible.

3.4.4 Potential Conflicts Between the *Atomic Energy Act of 1954* and *Resource Conservation Recovery Act of 1976*

The AEA and RCRA have different requirements for radiological and chemical constituents, which may conflict in some cases.

The strategy is to identify all regulatory requirements as early as possible in the process and determine their effect on system design to see if any conflicts are unresolvable. Any potential inconsistencies will need to be brought to the attention of Ecology and EPA; resolution may be needed before design can be completed.

The impact of nonresolution could be as serious as a complete redesign or even suspension of activities until resolution can be obtained.

CONTENTS

4.0 OPERABLE UNITS CHARACTERIZATION 4-1

4.1 CURRENT TANK WASTE INFORMATION 4-1

4.2 PRE-RETRIEVAL CHARACTERIZATION OF WASTE IN SINGLE-SHELL TANKS 4-3
4.2.1 Pre-Retrieval Waste Characterization Objectives 4-3
4.2.2 Waste Characterization Process 4-4
4.2.3 Quality Assurance and Quality Control 4-9

4.3 POSTRETRIEVAL CHARACTERIZATION OF IN-TANK RESIDUAL WASTE . . . 4-9
4.3.1 Postretrieval Waste Characterization Objectives 4-9
4.3.2 Strategy for Postretrieval Characterization 4-10

4.4 CHARACTERIZATION OF PLUMES OF LEAKED WASTE 4-11
4.4.1 241-BX-102 Tank 4-12
4.4.2 241-T-106 Tank 4-12
4.4.3 241-A-105 Tank 4-14
4.4.4 241-C-105 and 241-C-106 Tanks 4-14
4.4.5 Future Characterization Activities 4-14
4.4.6 Hydrogeologic Issues 4-15

4.5 SINGLE-SHELL TANK LEAK DETECTION SYSTEM 4-17
4.5.1 Single-Shell Tank Internal Leak Detection 4-18
4.5.2 Single-Shell Tank External Leak Detection 4-22
4.5.3 Borehole Logging 4-25
4.5.4 Quality Assurance and Quality Control for Leak Detection 4-26

FIGURE

4-1 Single-Shell Tank Surveillance Instrumentation F4-1

TABLES

4-1 Documentation of Tank Characterization Information T4-1
4-2 Tri-Party Agreement Milestones for Tank Waste Characterization T4-2.1
4-3 Single-Shell Tank Surveillance Devices and Techniques T4-3
4-4 Single-Shell Tank Leak Detection Strategy T4-4
4-5 Sensor Probes Deployed in Drywells T4-5
4-6 Sensor Probes Deployed in Laterals T4-6

4.0 OPERABLE UNITS CHARACTERIZATION

The waste tank characterization and tank leak or plume characterization activities are discussed in this chapter. The detection systems used for both in-tank and ex-tank leak detection are also discussed. In the near term, characterization activities are designed to support surveillance and retrieval activities. In the long term, characterization activities will be used to support closure activities.

4.1 CURRENT TANK WASTE INFORMATION

SST tank waste is classified as mixed waste, meaning that it contains both radioactive and dangerous waste. Chemical constituents of the waste are primarily sodium hydroxide; sodium salts of nitrate, nitrite, carbonate, aluminate, and phosphate; and hydrous oxides of aluminum, iron, and manganese. The radioactive components consist primarily of fission products such as strontium-90 and cesium-137 and actinide elements such as uranium, plutonium, thorium, and americium.

The salt cake was generated through the evaporator campaigns in which the strontium and cesium was removed; the resulting concentrate supernatant from the SSTs was evaporated into a more concentrated form and sent back to the tanks. This concentrated waste crystallized, forming a salt cake that settled in the tank. Salt cake is much harder than sludge and often forms a layer on the top of the waste. Salt crystals adhere to the walls of a tank or on instruments in the tank, and at times forms solid agglomerates; it contains high quantities of soluble sodium salts, such as sodium nitrate and sodium nitrite.

The sludge was formed from direct transfers of neutralized process waste to the SSTs. The processes that transferred waste to SSTs include the bismuth phosphate, REDOX, PUREX, uranium recovery, strontium semiworks, ferrocyanide scavenging, and other smaller waste sources (e.g., research and development, facility and equipment decontamination, and laboratory waste). The solids consist primarily of insoluble species such as metal hydroxides and bismuth phosphate and some soluble species such as sodium salts. Sludge has a more pliable consistency than salt cake.

There are many sources of characterization information for the SSTs. Each of these sources contribute to the overall understanding of the waste characteristics of the tanks. There are varying degrees of quality and reliability with each of these sources. The purpose of SST characterization is to use these sources in a well-defined strategy to produce a characterization 'best estimate' of the contents of each of the tanks. This 'best estimate' will be developed in the tank characterization reports. Characterization sources used in the tank characterization reports are discussed as follows.

The processing history of a tank provides information on the tank contents. Knowledge of the waste streams transferred to SSTs and the volumes and types of waste transferred from tank to tank can lead to an estimate of tank contents. The *Historical Tank Content Estimate* reports (Brevick 1994a,b) provide an historical characterization estimate of the tank contents for each tank. To date, these historical tank content estimates have been made for 109 of the 149 SSTs. These estimates are based on the historical knowledge of waste transfers in and out of the tanks and also on the knowledge of the process chemistry for the waste transferred in the tanks.

Waste transfers in and out of the tanks are tracked through a large data set called the *Waste Status and Transaction Record* summary reports (Agnew 1994b,c), hereafter referred to as the transaction record. The transaction record reports record the types and volumes of waste that are transferred into or out of the tanks (through pumping, sluicing, or cascading). The transaction record is used in a model called the tank layering model to predict the solid waste types and volumes of waste that have accumulated in the tank. The tank layering model is described in the *Historical Tank Content Estimate* reports.

The final piece of information needed to develop the historical tank content estimates is the *Hanford Defined Waste* document (Agnew 1994a). The Hanford Defined Waste document outlines the chemical composition of each of the types of waste given in the tank layering model. Finally, the estimates of the tank contents are developed using the tank layering model (volume of each waste type), and the Hanford Defined Waste document (composition of each waste type). The *Historical Tank Content Estimate* reports, on completion, will replace the computer model Tracks Radioactive Components (TRAC); TRAC was a computer model that developed process and/or transaction record-based estimates, which was never completed.

The other major source of characterization information is sample analysis data. Documents containing tank sample analysis results have been collected and are indexed in a database (Eberlein 1994). A tank characterization report reviews, summarizes, and interprets the available historical knowledge regarding a waste tank and integrates that knowledge with the information from the sampling and analysis of the tank. When representative sampling of a tank is attempted (i.e., two or more full-depth core or auger samples, or supernatant samples from different risers and waste depths), the evaluation includes a statistical analysis of the data to estimate the mean (bulk) concentration of the tank waste as well as the variances observed in the data. The tank characterization report provides the Characterization Program's 'best estimate' of the tank contents. Together, the tank characterization reports will provide an overall waste inventory of chemicals and radionuclides for the tank farms on the Hanford Site. Of the 23 tank characterization reports issued to date, 13 are for SSTs. Table 4-1 provides a list of *Historical Tank Content Estimate* reports and tank characterization reports (SSTs only) issued to date.

Other sources of characterization data prepared by other programs for specific uses include the *Radionuclide and Chemical Inventories for the Single-Shell Tanks* (Van Vleet 1993) and normalized information from the TRAC

model (Boomer et al. 1993). The SST inventory and concentration estimates in Van Vleet (1993) were developed for use in accident analyses. The most recent sample analyses are used to determine the tank concentrations and inventories. In the absence of sample analyses, TRAC estimates are used. Normalized TRAC takes the total SST inventory used in the HDW-EIS (DOE 1987a) (with a few adjustments) and uses the constituent distribution of TRAC to estimate the concentration and inventory of the chemicals and radionuclides in each SST.

4.2 PRE-RETRIEVAL CHARACTERIZATION OF WASTE IN SINGLE-SHELL TANKS

This section describes current tank waste characterization objectives and activities. Included is a discussion of DQOs, characterization documentation, sampling and analysis, data evaluation, data management, and quality assurance (QA)/QC considerations.

4.2.1 Pre-Retrieval Waste Characterization Objectives

The objective of the Characterization Program is to characterize the tank waste to provide the data necessary to store the waste safely and to enable waste retrieval, processing, and disposal activities to proceed. Characterization provides a key part of the information needed to: (1) identify and resolve safety issues; (2) ensure safe interim storage; and (3) meet the TWRS mission objective to dispose of the waste stored in the Hanford Site SSTs and DSTs.

Other information that supports the characterization of tank waste is the analysis of historical data on waste sources, waste transfer and processing data, and waste tank monitoring and/or ongoing tank surveillance data. Where applicable, information from chemical and physical modeling of tank contents and waste simulant and other studies will be used to provide comprehensive information on the contents and expected behavior of the waste.

The Characterization Program will provide the following:

- Characterization data to support the resolution of unreviewed safety questions and other safety issues associated with watchlist tanks
- Characterization data to support the identification of safety issues associated with current nonwatchlist tanks
- Characterization data necessary for the safe operation of the tank farms
- Characterization data required to support continued operations of the 242-A Evaporator

- Characterization data required to maintain the permit status and support continued operations of the DST storage facility

- Characterization data required for development of retrieval, pretreatment, and vitrification technologies.

The Characterization Program also will comply with the Tri-Party Agreement Milestone M-44-00, which requires the issuance of 177 tank characterization reports based on process knowledge, previous characterization data, and validated empirical data (Ecology et al. 1994). Table 4-2 lists the Tri-Party Agreement milestones for tank waste characterization and a schedule for completion of these activities.

The current tank waste characterization efforts are focused on the needs of the TWRS. Closure-related tank waste characterization needs must be determined and integrated into the Characterization Program. Data will be needed to assess short- and long-term risk and to evaluate the performance of closure alternatives.

4.2.2 Waste Characterization Process

4.2.2.1 Background. The selection of waste removal, treatment, and final disposal options; the need to safely store the waste; and the resolution of safety issues require accurate knowledge of the tank contents to satisfy the myriad technical and regulatory information needs of the data users. Under the originally negotiated terms of Tri-Party Agreement Milestone M-10 (Ecology et al. 1990), each SST would be sampled and characterized so that final waste disposal decisions could be made. Characterization of the contents of the SSTs would then support a decision either to leave the tank waste in place, or to retrieve and process the waste into a glass or grout form (i.e., the leave or retrieve decision). To satisfy this task, sampling and analysis of two core samples from each SST was planned to provide a database with which to identify tanks for either the leave or the retrieve option (Winters et al. 1990).

The two vertical, full-depth samples were intended to identify SSTs that should be retrieved and those that potentially could be disposed of in place; it was assumed that any tanks to be disposed of in place would then require more extensive characterization to support their classification. For the characterization efforts under Milestone M-10, the constituents and waste properties to be analyzed were selected based on the following considerations (Winters et al. 1990):

- A review of potentially applicable state and Federal regulations (including RCRA)

- Performance assessments of the waste matrices and the final waste forms

- Development of technologies such as retrieval, vitrification, and grout.

The regulatory- and risk-based analytes were later refined using analyte prioritization and concentration threshold work (Buck et al. 1991). Long- and short-term risk scenarios were evaluated and used to identify the waste constituents that were the greatest contributors to risk; these constituents were then identified for analysis. Similarly, waste constituents were compared to a form of the toxicity equivalency concentration in the "Dangerous Waste Regulations" (WAC 173-303) and low-level radioactive waste classifications of 10 CFR 61 to identify those constituents that had the greatest influence on the classification of the waste.

Since these early efforts, there have been several changes in the philosophy and overall direction of tank waste remediation and characterization, which have resulted in a redirection of the Characterization Program. The most significant changes are the following:

- Replacement of leave/retrieve option with the decision to retrieve SST waste
- Rejection of the treatment of the waste to a final grout form in favor of high-level and low-level glass fractions; process development continues for vitrification options
- Renegotiation of the Tri-Party Agreement, resulting in deletion of Milestone M-10-00 and the addition of Milestone M-44-00. Among the requirements of Milestone M-44 is the completion of 177 tank characterization reports (one for each SST and DST) by September 1999
- Acceleration of the resolution of the unresolved safety questions (USQ) and other safety issues pertaining to the Hanford Site waste tanks and tank farms as a result of concerns raised by the *Defense Nuclear Facilities Safety Board* (Conway 1993) about the stability and reactivity of the tank waste.

4.2.2.2 Current Waste Characterization Process. Characterization information from various sources will be collected and evaluated to provide information necessary to meet characterization program objectives. One main source of tank waste characterization information is the results of the sampling and analysis of the waste. Other information that supports the characterization of tank waste includes the analysis of historical data on waste sources, waste transfer and processing data, and waste tank monitoring and/or ongoing tank surveillance data. Where applicable, information from chemical and physical modeling of tank contents and waste simulant and other studies will be used to provide comprehensive information on the contents and expected behavior of the waste.

The strategy for characterizing the tank waste includes the following:

- Use of the DQO process to define requirements of the characterization data based on both use and user needs

- Use of all available sources of characterization information to meet user requirements rather than relying on sampling and analysis

- Iteration of the DQO process as necessary to ensure cost-effective resolution of TWRS issues.

4.2.2.2.1 Data Quality Objectives. The overall strategy for implementing DQO efforts in the TWRS is to divide the universe of relevant data needs into a finite number of DQO efforts with focused data needs. Thus, the various DQO efforts have been divided into issue- and process-based activities. Issue-based DQO efforts are focused on a unique safety or regulatory issues such as ferrocyanide tanks or RCRA sampling of DSTs. The process-based DQO efforts address specific waste handling processes such as tank retrieval, pretreatment, and HLW or LLW vitrification. Each DQO effort results in a DQO document, which identifies the required decision inputs. Using the DQO documents, the Characterization Program can work with the TWRS programs to determine, on a tank-by-tank basis, the best way to satisfy the data needs. If the data needs cannot be met in a cost-effective manner, the programs may choose to revise the precision/ accuracy and/or levels of confidence to pursue more cost-effective alternatives.

The DQOs will be included in the SST closure plan(s), RCRA permit application, and any other relevant plans that may be used to describe sampling and analyses requirements. The preparation of all DQOs will comply with Ecology and EPA guidance documents for QA/QC of data. All DQOs will be prepared in a workshop setting that includes contractor, DOE-RL, and Ecology representatives. All DQOs will be included in the closure plans and permit applications that will be made available to stakeholders and approved by Ecology.

4.2.2.2.2 Characterization Planning. Prepared characterization planning documentation includes a sampling priority list, sampling schedule, tank waste analysis plan, and tank characterization plans.

A sampling priority list is a list of all tanks to be sampled for a given fiscal year in order of priority. It is developed by the Characterization Program, with input from the TWRS program elements, by assessing programmatic needs and priorities. From the sampling priority list, a sampling schedule (Stanton 1994) is generated that reflects the priority list to the extent possible given a number of scheduling constraints. Compliance with the *Defense Nuclear Facilities Safety Board Recommendation 93-5* (Conway 1993) requires that the watchlist tanks, and others with identified safety problems, receive the highest priority in the sampling schedule.

The tank waste analysis plan (Haller 1994) is a high-level document that establishes the framework and process for conducting the characterization of all tank waste. The scope of the tank waste analysis plan will cover all aspects of tank waste analysis that are generic to multiple DSTs and SSTs. The tank waste analysis plan identifies sampling and analysis activities projected for the fiscal year and the tank characterization plans and tank characterization reports to be prepared for the year. The tank waste analysis

plan is updated annually as required by Tri-Party Agreement Milestones M-44-01 and M-44-02.

Tank characterization plans are specific to each tank being sampled. The tank characterization plans integrate the results of the various issue- and process-based DQO efforts and identify what, if any, samples are required to support the data needs of the programs. Appendices to the tank characterization plan will identify the sampling methodology, number of samples to be taken, analyses to be performed, and the sampling and analysis QA/QC requirements.

4.2.2.2.3 Tank Sampling Methods. The types of sampling efforts that support the various TWRS activities include push-mode and rotary-mode core sampling, grab sampling, auger sampling, and various types of tank vapor sampling. Each of these sampling methods is briefly described as follows.

Two types of core sampling methodologies, push mode and rotary mode, are used to obtain solid and/or liquid samples of waste in the tanks. The equipment includes specially designed core sampling trucks and sampling devices. The sampler bit is either pushed or rotated through the waste to obtain a cylindrical section of the tank contents below the riser used for sampling. Each sampler can contain a waste segment that measures approximately 2.5 centimeters (1 inch) in diameter and 48 centimeters (18.9 inches) in length. A number of segments can be taken from a tank to obtain a full-depth core sample of the waste. The waste, approximately 2 centimeters (.8 inch) from the bottom during push-mode sampling and approximately 2.5 centimeters (1 inch) from the bottom during rotary-mode sampling, cannot be sampled with these systems. Push-mode core sampling can be used to sample liquid and soft waste while the rotary-mode core sampling is required for hard waste types.

Auger samples are taken using a stainless-steel, hand-turned auger bit contained in a sleeve in a method similar to wood boring or ice auguring. Auger sampling is limited to approximately the first 20 centimeters (7.9 inches) of solids on the tank waste surface and, therefore, is used only to obtain solid samples from the waste surface or to sample tanks with limited amounts of waste.

Liquid or soft slurry samples can be obtained from various depths in a tank using a sample bottle contained in a weighted holder. The bottle is stoppered and lowered to the desired level; the bottle is then unstoppered, filled with sample, and retrieved from the tank.

Vapor sampling is performed using sorbent tubes or evacuated containers (SUMMA[2] canisters and Whitey cylinders).

4.2.2.2.4 Sample Analysis. Analysis of most tank waste samples are performed at the Westinghouse Hanford 222-S Laboratory or Pacific Northwest National Laboratory's (PNNL) 325 Analytical Chemistry Laboratory. Additional

[2]SUMMA is a trademark of the Oregon Graduate Institute.

analytical support will be provided by the Idaho National Engineering Laboratory. The laboratories receive, prepare, and analyze the samples and report the analytical results in accordance with the requirements of the tank characterization plans and appropriate laboratory requirements (e.g., procedures, QA plans).

The samples are received at the laboratory in their shipping containers and are placed into a hot cell. Aliquots are taken from the samples and analyzed directly, homogenized, and/or combined depending on the requirements documented in the tank characterization plans. Depending on which DQOs are applicable to a set of samples, the analyses performed may range from a short list of safety screening analytes to a wide array of chemical, radiochemical, and physical/rheological analyses.

Development is underway to perform some analyses of the samples using hot cell sample scanning techniques. In situ analytical methods, which will supplement the laboratory analysis, are also being developed.

4.2.2.2.5 Data Evaluation. The sampling and analysis data, historical sample analyses, tank surveillance data, and process information are evaluated and provided to the TWRS programs; the data are also used to prepare a 'best estimate' of each tank's contents. Historical information on the processes that generated the various waste types, and on the transfers into and out of tanks, is used to develop historical tank contents estimates (Brevick 1994a,b). Data from the sampling and analysis of the tank waste are evaluated along with historical information, and a 'best estimate' of each tank's contents is documented in tank characterization reports. The data evaluation process and the sources of characterization information are discussed more fully in Section 4.1.

4.2.2.2.6 Data Management. Characterization information is collected and made available in both paper and electronic format. The Tank Characterization Database has been developed and partially loaded with analytical data. The Tank Characterization Database also contains tank inventory estimates from the historical tank contents estimates documents, tank characterization reports, and TRAC. The Tank Characterization Database is accessible through the Hanford Environmental Information System (HEIS) and the Tank Waste Information Network System. As of September 30, 1994, data for 23 tanks (including 13 SSTs) have been entered into the database. In accordance with Tri-Party Agreement Milestones M-44-08 through M-44-12, data for the remaining tanks will be entered into the database.

The Tank Characterization Resource Center maintains copies of tank characterization reports, laboratory sample analysis reports, and other tank characterization documentation. The holdings of the resource center are indexed in a database and a list is issued semi-annually as the *Characterization Data Catalog* (Eberlein 1994).

4.2.3 Quality Assurance and Quality Control

The Characterization Program's QA program is described in the *TWRS Characterization Program Quality Assurance Program Plan* (Whelan 1994). This document identifies the Characterization Program requirements and provides implementation guidance for all activities funded by the Characterization Program. The Characterization Program meets the requirements of DOE Order 5700.6C (DOE 1991b) by complying with WHC-CM-4-2. The *TWRS Characterization Program Quality Assurance Program Plan* was developed to standard American Society of Mechanical Engineers/Nuclear Quality Assurance (ASME/NQA-1) (ASME 1989), which meets the majority of the requirements of the DOE order. Those additional requirements for which ASME/NQA-1 has been interpreted as not meeting the DOE order are also addressed in the *TWRS Characterization Program Quality Assurance Program Plan*. The Characterization Program must satisfy the quality requirements of the Tri-Party Agreement (Ecology et al. 1994), and the Hanford Facility RCRA Permit conditions as specified in II.E (Ecology 1994).

Laboratory QA and QC are discussed in the *Hanford Analytical Services Quality Assurance Plan* (DOE-RL 1994b). This document is the principal DOE Level document for the management and control of technical quality for all laboratories doing work for the DOE-RL. The *Hanford Analytical Services Quality Assurance Plan* incorporated the guidelines and requirements of the Tri-Party Agreement, DOE Order 5700.6C (DOE 1991b), and nationally accepted standards for the operation of environmental laboratories. It takes precedence over all onsite contractor and commercial laboratory documents in support of the Tri-Party Agreement work. It also reflects requirements for validation and verification procedures to meet DQOs.

Additionally, certain sampling and analysis QA/QC requirements may be specified by the DQO documents, which define customer needs and requirements for sampling and analysis.

4.3 POSTRETRIEVAL CHARACTERIZATION OF IN-TANK RESIDUAL WASTE

Following the retrieval of waste from the SSTs, it is expected that characterization of the residual waste will be required before closure. This section provides a brief discussion of postretrieval characterization because specific requirements for postretrieval characterization have not been developed.

4.3.1 Postretrieval Waste Characterization Objectives

After waste has been retrieved from SSTs, any remaining residual waste will be characterized. The objective is to adequately characterize the tanks to ensure that tank cleanout criteria are met and to provide data for modeling long-term performance of closed tank farms.

Tank cleanout criteria are expected to be based on the amount of waste removed and the risk associated with the waste remaining in the SSTs. Risk-based criteria have not yet been developed. Current criteria for the retrieval of waste from SSTs are documented in the Tri-Party Agreement (Ecology et al. 1994). Tri-Party Agreement Milestone M-45-00, "Complete closure of all SST farms," states:

> Closure will follow retrieval of as much tank waste as technically possible, with tank waste residues not to exceed 10,200 liters (360 cubic feet [cu. ft.]) in each of the 100 series tanks, 850 liters (30 cu. ft.) in each of the 200 series tanks, or the limit of waste retrieval technology capability, whichever is less. If the DOE believes that waste retrieval to these levels is not possible for a tank, then DOE will submit a detailed explanation to EPA and Ecology explaining why these levels cannot be achieved, and specifying the quantities of waste that the DOE proposes to leave in the tank. The request will be approved or disapproved by EPA and Ecology on a tank-by-tank basis. Procedures for modifying the retrieval criteria listed above, and for processing waiver requests are outlined in the appendix to this change request.

The subjects of interim performance criteria for closure, long-term versus short-term risk, and waste retrieval criteria are discussed in Chapter 7.0, Sections 7.2.2, 7.2.3, and 7.2.4, respectively.

4.3.2 Strategy for Postretrieval Characterization

The process of characterizing the waste remaining in the SSTs after retrieval operations is expected to be similar to the current characterization process. The DQO process will determine the characterization requirements for the tank residues; the DQOs will be used to develop sampling and analysis plans and schedules; the waste will be sampled and analyzed (including in situ analysis); the results will be evaluated along with pertinent process and historical information to estimate the tank contents; and a data management system will be used to collect, store, and distribute the information.

After retrieving the SST waste, the current criteria require that no more than 10.2 cubic meters (360 cu. ft.) of waste remain; this is less than 2.5 centimeters (1 inch) of waste in the 22.9-meter (75-foot)-diameter tanks. The requirements are similar for the smaller 208,000-liter (55,000-gallon) SSTs. Current sampling methods are not capable of sampling such small amounts of waste. Additionally, the waste may not be entirely on the bottom of the tank, but may be deposited on the tank walls or on in-tank equipment. Performing postretrieval characterization will require new sampling techniques as well as in situ methods to determine the amount of waste remaining in a tank and the characteristics of that waste. Technology development efforts planned or underway to support postretrieval characterization are discussed in Chapter 8.0, Section 8.4. Characterization requirements must be identified to ensure that appropriate characterization technologies will be developed and available when needed.

4.4 CHARACTERIZATION OF PLUMES OF LEAKED WASTE

To monitor the SSTs, in-tank liquid levels and gross gamma logging in vadose zone boreholes (called drywells) adjacent to the SSTs, and leak detection laterals beneath the 241-A Tank Farm and 9 of the tanks in the 241-SX Tank Farm have been used. The drywells were located around the tanks to help detect or confirm leaks so that waste in a tank could be transferred to a storage facility if there was a loss of containment. This monitoring has led to the designation of 67 SSTs as confirmed or suspected leakers (Hanlon 1994).

Many of the tanks have been declared assumed leakers based on data from in-tank monitoring of liquid levels that do not support total tank integrity with 100-percent confidence. Although the data may be suspect, the procedural requirement is to declare a tank with suspect data an assumed leaker, even though no confirmatory data from monitoring the drywells have been obtained to indicate that contaminants have reached the soils surrounding the tank.

Given the uncertainty of the measurement of liquid level along with dynamic processes occurring with the waste in the tanks because of physical and chemical changes, fluctuations of the liquid level measurement data are possible that do not reflect loss of liquid and thus, loss of integrity of a tank.

The volumes of leaks are estimated from the in-tank liquid measurement data based on a loss of 10,400 liters per 2.5 centimeters (2,750 gallons per 1 inch) drop in liquid level. Many of these volumes are small enough that the probability of detecting the leak, should waste have escaped the tank, is extremely low. Confirmation of a leak of less than 37,850 liters (10,000 gallons) from gross gamma surveillance monitoring of drywells is rare.

The magnitude and extent of contamination in the soils around most assumed leaking tanks is unknown, but has been estimated by Boomer et al. (1993). Only the two largest leaks have been investigated by drilling and sampling to determine the extent of the leaked waste. Some estimates can be provided by comparing the drywell logging records from the same or adjacent tanks. Sudden increases in activity in gross gamma surveillance logs that appear simultaneously at similar depth, or in sequence following the declaration of a tank as an assumed leaker, allow some interpretation as to the size and spread of leaked waste.

When the integrity of a tank was lost, the contained waste was transferred to another tank. There was no intention to monitor the extent of the leaked plume using the drywells and gross gamma surveillance logging. The surveillance data provide some historical information about the onset and movement/decay history following a leak. The number and location of drywells, the frequency of logging, and summary tables of drywell logs are found in Welty (1988).

Plumes of gamma-emitting radioactive waste constituents have been mapped in the vadose zone for the two largest tank leaks at the 241-BX-102 and 241-T-106 Tanks (Womack and Larkin 1971; Routson et al. 1979). These two

cases are discussed in the following sections. Both leaks have been confirmed by drilling and sampling as well as by geophysical logging in the drywells adjacent each tank. Gross gamma surveillance logging of the drywells and leak detection laterals have detected sudden increases of activity in a number of drywells surrounding other assumed leaking tanks, but not all of them. There are also thermocouples (TC) installed beneath some tanks. A discussion of the 241-A-105, 241-C-105, and 241-C-106 leak studies also is provided. Tanks 241-C-105 and 241-C-106 are considered sound tanks.

A contractor has been selected to conduct a valid baseline characterization of the vadose zone surrounding the SSTs using a spectral gamma logging system. Work is scheduled to begin in April 1995 and will consist of logging 720 drywells during a two-year period. This activity, including the validation of data, is scheduled to be completed by September 30, 1997. Once the baseline is established and procedures have been defined and tested, the responsibility will be assigned to Tank Farm Operations.

4.4.1 241-BX-102 Tank

Tank 241-BX-102 was confirmed as a leaker in 1970 based on liquid level history, drywell radiation profiles, and soil sampling and analyses. Approximately 264,950 liters (70,000 gallons) of liquid waste containing 51 kilocuries of cesium-137 were released to the glaciofluvial sediments of the Hanford formation surrounding the tank (Womack and Larkin 1971). The leaked waste spread over an approximate horizontal surface area of 1,040 square meters (11,195 square feet) and was mostly contained by a silt lens at a depth of 23 meters (75.5 feet) below grade. Some cesium-137 was reported to a depth of 36.6 meters (120 feet). All waste reportedly was contained in the vadose zone approximately 41 meters (134.5 feet) above the 1971 water table.

Contaminated groundwater was found in Well 2-E33-27 (adjacent to the 241-BX-102 Tank) during the investigation. Levels of cesium-137 were higher in samples of groundwater taken in this well than in wells monitoring the 216-BY cribs to the north, leading the investigators to conclude that the higher levels in Well 2-E33-27 were because of the spread of contaminants during drilling of the well. Well 2-E33-27 was drilled with a single string of 15-centimeter (6-inch)-diameter casing that was driven to groundwater through the plume of leaked contaminants.

4.4.2 241-T-106 Tank

On June 8, 1973, the 241-T-106 Tank, located in the 241-T Tank Farm, was confirmed as leaking. Approximately 435,000 liters (115,000 gallons) of liquid containing 40,000 curies of cesium-137, 14,000 curies of strontium-90, 6 curies of plutonium and americium, and 297,000 curies of various fission products with half-lives of less than 5 years were released to the glaciofluvial Hanford formation sediments surrounding the tank (AEC 1973;

Brown et al. 1979; Routson et al. 1979). The plume of waste leaked from the 241-T-106 Tank coalesced with an earlier leak from the adjacent 241-T-103 Tank. The extent of this composite plume was mapped (ARHCO 1973).

Subsequently, studies were conducted to monitor and assess the potential for migration of radioactivity to points of potential uptake. Monitoring boreholes (drywells) were drilled to provide access for in situ instrumentation. The boreholes also were used to collect sediment samples for geologic and radionuclide analysis, for in situ total gamma logging (gross gamma logging) to monitor changes in the leak plume, and for in situ gamma energy analysis measurements (high-resolution spectral gamma-ray logging) to determine species and concentrations of radionuclides in the leak plume.

The data were analyzed and also used for computer modeling to predict future changes in the plume (Brown et al. 1979). Routson et al. (1979) concluded that gamma-emitting contaminants had stabilized in the soils at a depth of 33 meters (108 feet) below grade and 29 meters (95 feet) above the 1979 water table. The areal extent of the plume grew slightly between 1973 and 1978, but the majority of contaminant transport occurred shortly after the leak.

Transport modeling of the 241-T-106 Tank leak suggests that the plume from the 241-T-106 Tank leak may have reached groundwater (Smoot et al. 1989). However, as stated by the authors, the assumptions and input data for this modeling are suspect. A five-layer stratigraphic model was employed for this analysis. Properties were assigned to these layers consistent with the Grout Treatment Performance Assessment analysis since both reside in a similar geologic structure (i.e., the Hanford formation). As a result, the anisotropy of flow and the high values for unsaturated hydraulic conductivity that may exist in the field were not reflected in the model and may have contributed to a result that disagrees with the depth of penetration of the waste from the 1993 limited field investigation.

A limited field investigation consisting of a single borehole (WHC 1992) was conducted in 1993 in response to a U.S. General Accounting Office (GAO) audit (GAO 1989). Borehole 2-W10-196 was drilled with multiple casing strings to a depth of 62.6 meters (180 feet) through the plume of waste leaked from the 241-T-106 Tank in 1973. Sampling and analyses of soil samples as well as surveys using the Radiologic Logging System (RLS) were performed during construction. Another RLS survey was performed in early 1994. In this borehole, waste from the 241-T-106 Tank leak is still confined in the vadose zone at least 18.3 meters (60 feet) above the present water table (Caggiano and Anderson 1994; Freeman-Pollard et al. 1994). Because of radioactive decay of ruthenium-106 (the isotope used to map the maximum extent of the plume during 1978), direct comparisons with the 1978 data are not possible.

4.4.3 241-A-105 Tank

Following a sudden steam release from the 241-A-105 Tank in January 1965 and subsequent sluicing and transfer operations, spray cooling water was added to the tank to maintain temperatures of the waste to prevent degradation of the concrete. Water was added periodically from 1971 to 1978 to maintain in-tank liquid levels. Approximately 2,308,850 liters (610,000 gallons) of water was added during this time (WHC 1991b). Between 1,430,730 and 1,551,850 liters (378,000 and 410,000 gallons) of this water evaporated and were vented through the exhaust ventilation system (Allen 1991).

However, increased activity in some drywells and laterals indicates that at least some of this cooling water escaped from the tank. Available data are not adequate to determine whether any of the leaked fluid reached groundwater (Caggiano 1991). The same constituents (at lower activities/concentrations) were discharged as part of high-volume liquid effluents to nearby cribs and French drains. As there is no unique indicator of waste that would trace waste in groundwater to the 241-A-105 (or any other) Tank, the constituents in groundwater could have come from discharges to nearby liquid effluent facilities. Leaks of gamma-emitting radionuclides from the 241-A-105 Tank were reported in 1963 and 1965. Since 1963, the 241-A-105 Tank has been designated an assumed leaker (Hanlon 1994).

4.4.4 241-C-105 and 241-C-106 Tanks

Concern has also been raised as to whether cooling water added to the 241-C-105 and 241-C-106 Tanks may have leaked in a manner similar to the leak of cooling water from the 241-A-105 Tank. Historic gross gamma surveillance monitoring in drywells around these two tanks has not revealed any loss of integrity (Welty 1988), but questions have been raised as to whether all of the cooling water added to the tank was vaporized and was exhausted via the ventilation system. Analysis of historic gross gamma logs and logging with the RLS in a number of drywells surrounding these tanks indicated that neither of these two tanks was actively leaking (Brodeur 1993). Contamination arising from surface spills, a cascade line leak between the 241-C-104 and 241-C-105 Tanks, and other tanks in the 241-C Tank Farm was confirmed. Logs reflecting some cesium-137 contamination around the 241-C-106 Tank were traced to the 241-C-103 and 241-C-109 Tanks as the probable source.

4.4.5 Future Characterization Activities

The RCRA regulations stipulate that an underground tank (i.e., TSD unit) includes the tank, the waste therein, and any waste leaked to the surrounding soil. Closure of the SSTs will therefore necessitate closure of the tanks as well as the soils contaminated by tank leaks. Characterization of the magnitude, extent, and mobility of the plumes of leaked waste is needed to evaluate the various remedial action alternatives for closure of the soils contaminated by waste leaked from the SSTs.

Without data on the nature and extent of the contaminants and their mobility, it will not be possible to assess the risk associated with the various closure options. Therefore, a program for characterization of the plumes of leaked waste will commence. Whether each plume from an assumed leaking tank, bounding worst cases, or examples of leaked waste from selected tanks will be characterized remains to be determined. However, planning for this effort should begin soon, as the 1993 limited field investigation of the leak plume at the 241-T-106 Tank demonstrated the potentially high cost and lengthy schedule associated with such projects. The plan to baseline 720 drywells discussed in Section 4.4 is intended to initiate this process.

4.4.6 Hydrogeologic Issues

4.4.6.1 Tank Leak Plume Migration. Data on the migration of tank leak plumes in soil are minimal. Only plumes from the 241-T-106 and 241-BX-102 Tanks leak, the two largest known leaks, have been investigated (Chapter 7.0, Section 7.4). The extent of the 241-BX-102 Plume was investigated in 1971 and has not been investigated since to determine any change in the past 24 years. The 241-T-106 Plume was characterized in 1973 and 1978 and a limited field investigation was conducted in 1993 (Freeman-Pollard et al. 1994; Caggiano and Anderson 1994). These investigations demonstrate that the leaked waste from these largest known leaks at the SSTs appears to be contained in the vadose zone well above groundwater. The rate and direction of movement of these waste plumes, if any, remains to be verified in a manner that allows for clear decisions regarding the closure of these facilities. If these large leaks are contained in the vadose zone, smaller leaks may also be contained within the vadose zone, but there are no reliable data on which to base such a conclusion. Almost no data exist on the extent and magnitude of plumes of waste leaked to soils from the other 65 leaking tanks.

Contaminants are also present around the SSTs that relate to tank farm operations, but do not necessarily relate to releases because of the failed integrity of an underground tank. The failure or improper sealing of cascade, inlet, and/or transfer lines that carried waste have also resulted in releases to soils. The leaked waste adds to the volume of contaminants present in tank farms and needs to be considered in planning for the remediation of the soils surrounding the SSTs.

A program of vadose zone characterization and monitoring (Section 4.5.3) as recommended in the *Westinghouse Hanford Vadose Zone Strategy* (WHC 1994) would accomplish the objective of providing data on the magnitude, extent, and mobility of contaminants in the soils (Appendix 1A, Issue 4.03). The intent is to develop a coordinated program to employ various forms of geophysical logging in existing wells and boreholes. Initially, the selected boreholes would be logged with a spectral gamma logging system (with either a high-purity germanium iodide or sodium iodide crystal) and appropriate and suitable neutron probes to develop a baseline of gamma-emitting radionuclides and moisture. Logging at subsequent intervals would determine whether there was any change to this baseline, the magnitude of this change, and whether it represents waste migration. Using a system of calibrated probes, this system would provide reliable and defensible data on the flux of gamma-emitting

radionuclides and moisture that could be used as input to computer models for prediction of anticipated future changes. Some limited soil gas sampling for volatile organic constituents through access ports in boreholes might also be possible.

Determining the future mobility of the leaked waste and its projected movement to assess risk is best accomplished through validated and verified computer models of moisture and contaminant transport. Therefore, the development and running of appropriate computer models and the input data on soil properties are critical to the success of modeling as a tool to demonstrate the fate and transport of contaminants and the ultimate risk to public health and safety (Chapter 7.0, Section 7.1). Obtaining data on the rate and migration of some plumes through geophysical logging in boreholes (or other appropriate means) is needed to develop and refine the equations on which these models are based.

Soil characteristics (i.e., the thickness and extent of the various strata, the effective porosity and permeability of the units, the unsaturated hydraulic conductivity along with the volume percent moisture and its flux through the strata) are key input data. The mineralogy of the sediments, grain size distribution, sorption characteristics, and waste/soil interaction are also key to the success of modeling the fate and the transport of contaminants. The rate and volume of infiltrating natural and artificial recharge are essential parameters because liquid is the most probable means of mobilizing and transporting soluble contaminant species.

Acquisition of these data, as appropriate, to perform fate and transport modeling will be needed to effectively demonstrate that the magnitude, extent, and mobility of the waste are adequately understood in a manner that allows assessment of risk to the public health and safety (Issue 4.04, Appendix 1A).

4.4.6.2 Groundwater Flow and Contaminant Transport. For any waste that infiltrates through the entire vadose zone to enter groundwater, the rate and direction of contaminant movement are key components in any assessment of risk to the public health and safety. Groundwater is a pathway that could carry contaminants to the Columbia River, which is used by communities downstream of the Hanford Site as a source of public drinking water and also for crop irrigation. Ultimately, the significant factors are: (1) the amount and concentration of contaminants that reach the Columbia River, (2) how long it takes for the contaminants to arrive at the river once they reach groundwater, and (3) in what concentrations/activities. The greater the path length, the longer it will take for contaminants to reach the river; thus, the greater the opportunity for dispersion and dilution, and the greater potential for decay to the stable state (for radionuclides). Environmental monitoring indicates that several plumes of contaminants emanating from the 200 East Area have reached the Columbia River (PNL 1994). Plumes of other contaminants in groundwater heading toward the Columbia River have also been mapped (Ford 1993).

Closure of the SSTs as sources and the contaminated soils in which they are buried may be treated separately from closure of the groundwater. Groundwater operable units in both the 200 West and 200 East Areas are being

characterized separately from the source operable units for the purpose of closure. The separation is because the plumes of contaminants in the groundwater have spread beneath and beyond the many source facilities that may have contributed to groundwater contamination. Plumes of contaminants in groundwater beneath the SSTs may well have originated from discharges to unlined cribs, ditches, ponds, reverse wells, or French drains in the vicinity of SST farms. Remediation of these plumes may better be achieved in their entirety than attempting to distinguish the portion of a plume that may be attributable to any single-source facility and closure of that segment. Therefore, remediation of the groundwater may be considered separately and on a different schedule than closure of the SSTs, in a manner similar to separate closure of the 200-BP-1 source operable unit and the groundwater beneath it (200-BP-5 Operable Unit). Although the TPA allows for the remediation of the groundwater as either a separate activity or an activity in conjunction with a TSD closure/post-closure plan, there is insufficient data to make a decision on the appropriate plan of action at this time.

Modeling will be used to determine the fate of contaminants that infiltrate to groundwater. Key input data to flow and transport models for the saturated zone include: the characteristics of the aquifer (saturated hydraulic conductivity and transmissivity of the various strata/units and facies, sorption); characteristics of the contaminants (solubility, density); anisotropy of flow (horizontal to vertical ratio); and the geometry of any preferred routes (e.g., buried channels of highly transmissive materials). These are data also required for the planning and design of remedial measures and to ensure that restoration has been successful. Although the restoration of contaminated groundwater is the responsibility of Environmental Restoration Contract (ERC), the responsibility for collection and maintenance of groundwater data has not been assigned to a single contractor on the Hanford Site. It is assumed that this responsibility will be assigned to the ERC within the next few months. However, regardless of which contractor will maintain this database, these data will be available for risk and performance assessment modeling. If additional information and or data is required to complete these analysis, the responsibility for collection of this information will be assigned to tank farms. The nature and extent of these data needs have not been defined.

Although considerable information and data have been collected on the transport of contaminants in the soil and water beneath the Hanford Site, the adequacy of these data to support regulatory decisions as summarized in Issue 4.04 (Appendix 1A) remain to be determined.

4.5 SINGLE-SHELL TANK LEAK DETECTION SYSTEM

Surveillance of the 149 SSTs at the Hanford Site consists of monitoring each tank with both internal and external instrumentation. Waste surface level and interstitial liquid are monitored by in-tank devices. Drywells and laterals have been used to supplement leak detection and monitoring outside of tanks. Although the drywells continue to be used for purposes of leak detection, the laterals are not in service. Internal devices are used for primary surveillance. Current external devices generally are employed in a

secondary surveillance role. Where internal instrumentation is no longer functional (e.g., when the tank has been stabilized by pumping out all free liquid), external devices are used in the primary surveillance role.

Internal tank monitoring devices detect and record changes in waste surface and interstitial liquid levels. Changes in liquid levels are evaluated as indications of a tank leak. Readings outside of established ranges are investigated to determine the reason for the change. Internal tank temperatures and psychometric data are recorded to account for evaporative losses of liquid inside tanks. Photography is also used to investigate the inside of tanks and look for changes. Table 4-3 provides a summary of devices and techniques used for internal and external surveillance of SSTs.

Drywells, laterals, and leak detection pits provide access for devices that monitor conditions external to the tanks. External devices are used to monitor changes, such as moisture and radiation levels, in the vadose zone outside of tanks. Changes in these conditions might also indicate a tank leak or leak plume movement. Data anomalies from external monitoring could lead to investigations to determine the reason for change.

The current criteria (Table 4-4) for SST leak detection has evolved from discussions between Westinghouse Hanford and the DOE-RL (Schofield 1994). Table 4-4 forms a basis for the current, revised leak detection plan for SSTs.

The following sections provide brief descriptions of the currently used SST surveillance systems. Discussions in these sections provide additional information to that which is provided in Appendix 2C, pertaining to surveillance during interim stabilization operations. Figure 4-1 shows the typical configuration of surveillance devices in relationship to SSTs. A more complete description of monitoring equipment configuration, bases for action and response, and monitoring frequency requirements can be found in Schofield (1994).

4.5.1 Single-Shell Tank Internal Leak Detection

The preferred methods of SST leak detection involve in-tank measurement of liquid level, regardless of tank waste conditions (liquid surface or interstitial liquid). Internal surface-level measurements are obtained using direct and indirect methods that sense changes in a tank's liquid level. Direct methods actually 'touch' the waste surface. Indirect methods are taken using devices that are deployed within sealed LOWs that are inserted into a tank and reach below the surface of the waste.

The accuracy of surface-level measurement devices, when used on a liquid surface, is superior to measurements obtained via Liquid Observation Wells (LOW) (Section 4.5.1.7). However, certain waste conditions can render currently used surface-level measurement equipment ineffective as leak detection tools. Photography is desired at some frequency to ensure that surface-level measurement devices used for leak detection are working effectively. Three methods are being used for direct solid and liquid waste surface-level measurement: a manual tape system, automatic gauge (Food

Instrument Corporation [FIC] or Enraf-Nonius 854 Advanced Technology Gauge [ENRAF]), and portable 'zip cord' (Section 4.5.1.4). These methods/devices are described in the following sections.

4.5.1.1 Manual Tape System. The manual tape consists of a reel-mounted, calibrated, steel tape with an electrically conductive plummet attached. The tape length is custom set for each tank. The tape, plummet, waste, tank wall, and a portable conductivity meter make up a simple resistance circuit. Contact with a liquid or moist surface as the plummet is lowered completes the circuit. The tape then directly 'reads' the depth of the waste in the tank. The reading is recorded on a datasheet. A special 'slack tape' technique is employed to obtain measurements in tanks with a nonconductive solid surface. 'Pencil'-type plummets are used predominantly for measuring liquid surfaces. A 'doughnut' plummet is used for measuring sludge or moist salt cake levels.

Tape plummets are prone to salt buildup, which can provide readings that make the level in a tank appear abnormally higher. Trending and photography are used to detect salt buildup. Flushing with water or chemicals removes the salt.

A reading of 1.27 centimeters ($\pm$1/2 inch) in tanks with a liquid surface has been established as an action limit that would alert a potential problem. A reading of 2.54 centimeters ($\pm$1 inch) is cause for a formal response or investigation. For SSTs with floating solids, a specification limit of 5.08 centimeters ($\pm$2 inches) has been established. Greater variations in data are typical of SSTs with a solid, conductive (moist) surface suspended in liquid or in which liquid levels varied. The specification limit from these SSTs was set at 7.62 centimeters ($\pm$3 inches).

4.5.1.2 Automatic Gauges (FIC). Automatic FIC-type gauges use an electrically conductive plummet suspended on a calibrated steel tape, similar to the manual tape. This system, like the manual tape device, requires moisture to complete a circuit and obtain a reading. A control system automatically adjusts the plummet position to make contact at the air/waste interface every 60 to 90 seconds. Instead of taking readings directly from a tape, the system increments are counter driven by a wheel that is cycled by the moving tape. The FIC gauge automatically records contact with the surface and is normally interfaced with the Computer Automated Surveillance System (CASS). Automatic gauges, like the manual versions, are prone to salt buildup.

Surface measurements from FICs, in tanks with a nonconductive surface, provide little useful leak detection information, but still are valuable in detecting intrusions. In the intrusion mode, the plummet is set above the waste level and an alarm is generated when liquid rises and makes contact with the plummet. Similar to the manual tape device, the FIC gauge can be used to obtain 'slack tape' readings from tanks with nonconductive waste surfaces.

In tanks with an entirely liquid surface, the specification limit for FIC readings is 1.27 centimeters ($\pm$0.5 inch). For SSTs with floating solids, the specification limit is 2.54 centimeters ($\pm$1 inch). The specification limit

for readings from tanks with a solid, conductive surface is 7.62 centimeters (±3 inches).

4.5.1.3 Automatic Gauges (ENRAF). By June 1994, displacer (weighted wire) gauges ENRAF were installed in two SSTs (i.e., 241-S-103 and 241-S-107) as part of a planned upgrade project for the level detection equipment in tank farms. Future use of this technology is anticipated.

The displacer gauge uses a weight suspended on a stainless-steel wire. The device detects the change in the apparent weight of the displacer by buoyancy or by contact with a solid. The device operates in an 'automatic' mode, using a stepper motor to pay out the wire that provides the depth measurement. The displacer stays partly submerged or in contact with the surface and can compensate for crystal growth on the weight. Electronics compensate for buoyancy differences caused by different waste densities.

The accuracy of the Advanced Technology Gauge (ATG) device is still under development and will be assigned after a suitable period of testing. Accuracy is expected to be in the range of 2.54 mm (±0.1 inch).

4.5.1.4 Zip Cords. A zip cord is an insulated wire with an electrically conductive probe on one end. Zip cords are normally used for taking temporary level readings when other level measurement equipment is out of service, or when there is a question concerning the normal reading from other devices. The cord is prepared by measuring it against a tape measure and putting marks or small strips of tape around the cord at incremental distances along its length. The principle of operation is the same as with the manual tape device. The tank's reference elevation is used to obtain a comparative measurement of waste height. The difference between the reference elevation for the zip cord and that used for the installed tank level measurement equipment is added to or subtracted from the zip cord reading to obtain a waste level reading. Properly set up, deployed, and read, the zip cord can be expected to have similar specification limits to the manual tape device.

4.5.1.5 Visual Inspection. Visual inspection is provided by in-tank, still photography and video inspection. In-tank photography has been used for many years, but only recently has video inspection been used to any extent. Single-frame photography is the preferred method for most tank inspections. However, video imaging is usually faster, provides the ability to observe the tank contents during inspection, and allows the viewer to focus in on items of interest as they are detected. Video imaging is also used for some general inspections. Photos are used largely to determine surface conditions in a tank, help troubleshoot problems with erratic level readings, spot intrusions, or provide backup information when investigating possible tank leaks.

In-tank, still photographs and video are obtained by lowering a camera with a lighting unit into the tank vapor/head space through a riser. For video photography, the image is displayed on a local screen or monitor and can also be recorded on tape for subsequent viewing and archiving.

The ability to determine a surface-level change from photo or video image is based on the judgement of the viewer and the presence of reference points

in the picture. Therefore, the accuracy of liquid level changes determined from photos or video images can range from less than 2.54 to 15.24 centimeters (1 to 6 inches) or more. In-tank photos and video scanning are used for information only. There are no precision-based specification limits for their use at this time.

4.5.1.6 Dip Tubes. Dip tube, weight factor/specific gravity (SpG) measurement systems have been used at the Hanford Site since the 1940's. They are reliable and accurate under normal conditions, but are not used as routine measurement systems in tank farms because the high SpG conditions in most of the waste tanks would result in frequent pluggage of the sensing tubes. Dip tube measurement systems are used in a limited number of cases where surface-level measurements cannot be obtained, LOWs are not available, and dip tube systems have been installed for salt well jet pumping.

In a typical dip tube arrangement, three dip tubes extend into the tank. One reaches almost to the bottom of the tank, one is positioned a set distance above the bottom (normally 25.4 centimeters [10 inches]), and a third is at the top of the vapor space. A differential pressure (DP) is obtained between the bottom and top tubes to give a weight factor indication for the tank. The DP is across the lower two tubes and is used to sense the SpG of the solution. The liquid level is calculated from these data (i.e., weight factor divided by SpG). An error range of 6.86 centimeters ($\pm$2.7 inches) is generally applied to salt well dip tube readings.

4.5.1.7 Liquid Observation Wells. The LOWs are in-tank, closed-bottom drywells made of either steel, fiberglass, or fiberglass-reinforced plastic tubes, with a 7.62-centimeter (3-inch) inside diameter (ID). The LOWs are inserted through tank risers to a position near the tank bottom, and are left there to provide permanent, dry 'observation' of the waste. The LOWs have been installed in 58 of the 149 SSTs.

4.5.1.8 Neutron Probe. Neutron probes are used for sensing tank liquid levels through the wall of a LOW. Neutron probes consist of a fast neutron source and a slow (or thermal) neutron detector. The source/detector (neutron probe) is attached to a cable and lowered into a LOW to obtain readings. The probe is connected, via a conductor inside a supporting cable (wires), to electronics in a mobile van located on the surface. After going through a field scaling procedure, the probe is withdrawn from the LOW at a controlled rate generating a data plot of count rate versus distance from the tank bottom. This profile is used to provide an indication of liquid level. The neutron count rate, obtained by this technique, is a relative value that is not used to directly measure liquid concentration. Trending of changes between current and previous readings provides a relative measurement that is used to estimate the distribution of liquid within the tank. Since mid-1993, all LOW neutron probe scans are read by computer and the interstitial liquid level (ILL) is determined by calculation.

The primary feature of neutron probe data used for leak detection is calibrated accuracy rather than qualitative differences or relative differences between individual readings. The newer methods of calculating ILL give a smaller standard deviation and thus permit a smaller specification

limit, which can mean earlier detection of tank leaks. Unofficial estimates place the accuracy to be within 2.54 centimeters (±1.0 inch), but this has not been formally demonstrated. The replacement LOW vans are specified to have an accuracy of 0.254 centimeter (±0.1 inch) (see Appendix 2C for information on replacement LOW vans).

4.5.1.9 Gamma Probe. The gamma probe is a lead-shielded, highly collimated Geiger-Mueller (GM) detector. Gamma probe operation is similar to that of the neutron probe. The GM tube is lowered to the bottom of a LOW and a gross gamma count rate versus depth obtained as the probe is withdrawn.

The major gamma-emitting radionuclide in the SST liquid phase is cesium-137. Cesium is very soluble in the aqueous (i.e., water) phase, so a plot of gamma count rate versus depth can indicate the distribution of liquid in a tank similar to a neutron probe. However, the nature of the gross gamma method is less exact on gamma scans from LOWs than neutron probe scans. This normally makes gamma scans from LOWs less accurate than neutron probes in determining an ILL. Thus, gamma scans are normally used for information purposes only or to help back up LOW neutron readings. As discussed in Section 4.4, spectral gamma logging will be substituted for the gross gamma approach.

4.5.1.10 Temperature Measurements. Safety requirements necessitate installation of TC trees in all SSTs with a heat load of greater than 8.6 kilowatts (40,000 British thermal units [BTUs]) per hour. Thermocouples are read by tank farm operators on a regular frequency or obtained automatically on the CASS. Data are also recorded from TCs installed in tanks with heat loads less than 8.6 kilowatts (40,000 BTUs) per hour, but the TCs are not replaced after failure. Temperature data are also used to provide additional information during investigations regarding possible leakage.

4.5.1.11 Psychrometics. Psychrometric information (temperature and pressure) is used as an investigative tool to assist in resolving measurement anomalies. Ventilation and air balance personnel take psychrometric surveys on all SST active ventilation systems on a schedule provided for ventilation and air balance by Tank Farm Process Engineering. These surveys provide information on waste tank cooling and evaporative losses. Availability of access ports for psychometric measurements is limited.

4.5.2 Single-Shell Tank External Leak Detection

External leak detection devices are deployed in external drywells, laterals, and leak detection pits (LDP). These devices are used to detect gamma radiation and moisture levels that may have changed. Historically, such external techniques have been used because of a tank leak. The ability to detect tank leakage, however, with current external monitoring equipment is less than that afforded by in-tank measurement equipment.

Drywells and laterals have been installed around the exterior of selected SSTs: 132 SSTs have drywells, 16 SSTs are equipped with laterals, and LDPs have been installed in 4 SSTs in the AX Tank Farm. Laterals are horizontal

shafts located under some tanks. Drywells are vertical shafts arranged around the tank circumference. Drywells can be used to track contamination in the vadose zone, but this capability is not considered part of the leak detection effort.

The role of external devices, operated within laterals and drywells as temporary or backup methods for leak detection, is based on the extent of deployment of these systems and the nature of the data they provide. The data from these systems, using current technology, are not as complete or conclusive as that provided from in-tank methods. This is due in part to the coverage provided (i.e., number of drywells, laterals, and LDPs), and also to detection and range limitations of the sensors that are employed. However, when in-tank leak detection methods cannot be used or are not available, some degree of leak survey capability does exist by using external sensors to observe any increased presence of gamma-emitting radionuclides or moisture in the soil around a tank.

Conclusions and decision-making based on external sensor data are somewhat less compelling than information derived from in-tank devices. For example, in a hypothetical situation, a drop in liquid level or a rise in external tank radiation levels would indicate possible tank leakage. If properly functioning internal devices show no change in liquid level, the tank would be considered sound. If an external device, however, provided a similar steady-state reading for radiation level, it would not be inferred that the tank is sound solely from that information.

4.5.2.1 Drywells. Drywells are used to deploy instruments that can detect changes in radiation levels and moisture content of the soil around the tanks. Drywells are vertical boreholes with 15.2- or 20.3-cm (6- or 8-inch)-diameter carbon steel casings, positioned radially around SSTs. A typical drywell installation will extend 15.2 and 76.2 meters (50 and 250 feet) below grade. Drywells do not penetrate to the water table. Monitoring in drywells is generally carried out between 15.2 and 45.7 meters (50 and 150 feet) deep. The information for drywell monitoring is used, together with primary sensor data, to aid in detecting leakage. The effectiveness of drywell-deployed devices depends, among other things, on the following:

- Proximity of the drywell to the leak
- Proximity of other leaking tanks to the drywell
- Radiation background or moisture level around the drywell
- Liquid migration behavior in the soil (i.e., soil characteristics)
- Radionuclide absorption in the soil
- Size of the leak
- Magnitude of the measured characteristic (i.e., the concentration of the radionuclide in the leaked waste solution and the energy level of its gamma emission)

- Sensitivity of the sensing device
- Total measurement precision
- Monitoring frequency
- Logging speed.

Because of these limitations, drywells and laterals are not used as primary means of leak detection monitoring for a tank. Drywell and lateral data are used to provide information during tank investigations, and can also be used to provide backup leak survey data when primary leak detection equipment on a tank is inoperable or not yet installed.

Periodic monitoring is performed using four gamma or neutron probes that are lowered into drywells (Table 4-5). These instruments provide scan profiles of radiation and moisture in the soil. Tank leakage is revealed by trending data from successive scans. Probes are lowered to the bottom of the drywell and are withdrawn at a constant rate, while the probe sends a signal to a portable van containing electronics and a cable retrieval system. A profile scan is automatically generated from the data. It is assumed that in the future, spectral gamma logging will be substituted for gross gamma logging.

Drywells are also used for monitoring the migration of radionuclides that have entered the vadose zone from a waste tank, crib, or other facility. The requirements for vadose zone monitoring, however, are considerably different than those for providing backup leak surveys or investigating potential tank leakage.

4.5.2.2 Leak Detection Laterals. The laterals are similar to drywells but provide a better means of monitoring for the presence of activity in the soil beneath a tank. Laterals, like drywells, were installed (retrofit) in the tank farm after construction. Laterals are 10.2 centimeter (4-inch)-diameter horizontal steel pipes installed below the concrete tank base, into which 7.62 centimeter (3-inch)-diameter tubing is inserted. The tubes rise to instrument enclosures through vertical caissons adjacent to the tanks. The horizontal portions extend in a fan-like manner 2.44 to 3.05 meters (8 to 10 feet) beneath the tank (from common caissons) and reach beyond the far side perimeter of the tank. They have been installed under 6 tanks in the 241-A Tank Farm and under 10 tanks in the 241-SX Tank Farm.

GM radiation detectors are forced pneumatically from the caisson to the end of the tube, and then retracted by a cable drive mechanism. A radiation profile is obtained during withdrawal. Probes deployed into laterals monitor changes in radiation levels of the soil beneath the tanks. Data are gathered by operators in computer-equipped vans and are transmitted to a central computer via the CASS. Graphs of the monitoring data are visually compared to baseline data to determine if changes in radiation levels or profiles have taken place and to detect data trends. Two probes with different shielding are deployed in laterals (GM-'Green' and -'Red'), as described in Table 4-6.

4.5.2.3 Leak Detection Pits. Leak detection pits collect any liquid that might accumulate beneath a tank bottom. The only SSTs with leak detection pits are those in the AX Tank Farm. Liquid is collected from channels under the tank and is drained to a collection pit for each tank. These tanks are monitored for weight factor, SpG, and gamma activity. Either a liquid level rise, an SpG above 1.0, or an increase in gamma levels could indicate a possible tank leak. Data from leak detection pit devices are recorded manually and transmitted to the surveillance analysis organization for evaluation.

4.5.3 Borehole Logging

There is a relationship between borehole logging, in and around the tank farms, and SST surveillance. Borehole logging, leak detection, and leak plume monitoring all contribute information that is used during retrieval/disposal activities and for remediation decisions. Careful analysis of past data, and data gathered from borehole logging of radionuclide activity, can build a picture of the configuration of previously leaked contaminants in the soil, and can display the migration paths followed in the past. The so-called leak plumes of past leaks are not neat, geometric volumes, as might be expected, but rather are layered to reflect grain-size distribution of soils, their aptitudes, and their discontinuities. Once this picture has been carefully constructed from empirical data, a qualitative estimate can be made to predict where and how quickly any leaked fluids from retrieval or other operations may be detected from the borehole system in place around the various tanks. Characterization of the tank farms soils, using borehole-deployed techniques, can also provide baseline data needed to determine operating criteria/specifications, and assist in the interpretation of data from leak detection devices.

An activity to obtain borehole logging data for the SST tank farms was initiated in fiscal year 1995. Two high-resolution spectral gamma-ray logging systems have been newly fabricated and delivered to the Hanford Site to log drywells throughout the tank farms. These systems will 'baseline log' the gamma-ray-emitting radionuclides in the vadose zone around the drywells surrounding the tanks. The information gathered from this baseline logging effort will characterize both the radionuclide contaminants and the soil in the tank farms. Migration paths of past leaks will also be determined, as best they can be, given the configuration of the present boreholes. As the characterization for each farm is developed, a farm-specific monitoring program will be identified and logging frequencies for long-term monitoring for each well will be determined (and probably carried out with less costly sodium iodide spectral logging systems). Information gathered during monitoring logging will detect any migration, if it occurs, of the present contaminants that adhere to the soils.

Additional subsurface access may be required for some areas where knowledge of the migration paths may be crucial. Subsurface access is possible using cone penetrometers or well casing tipped with driving points and emplaced with a pile driver (in situ characterization probe) and can

provide subsurface access economically and without bringing any contaminants to the surface, such as occurs during well drilling.

By careful collection of the data and correlating the data to soil texture and layering through professional work, the subsurface patterns and pathways of past leaks can be understood and judiciously used to help evaluate the monitoring potential for leaks that may occur during retrieval operations. Considering the present amount of contamination, minor leaks during operations may do nothing more than add an insignificant amount to that already present. A new leak could only redistribute what is already present in the soil. A thorough borehole logging/monitoring program could determine the potential level of change to take place in the vadose zone with a given leak.

Also initiated in fiscal year 1995 was an activity to determine the functions and requirements (F&R) for SST external leak detection and monitoring. Currently, there is no direct link between these two activities. As the requirements for leak detection and monitoring (LDM) become more clear, the role of borehole logging to support SST surveillance, before and during remediation action, could be pursued. This possibility is further discussed in Issue 4.05, "Borehole Logging to Support SST Waste Retrieval and Disposal Activities" (Appendix 1A).

There is also potential to deploy new or enhanced LDM technologies using the existing boreholes. Hundreds of boreholes already in place in the tank farms could be used to obtain surveillance data without further construction or excavation. Coverage of the total soil area of the tank farms from existing boreholes is not perfect, but the boreholes are available, accessible, and inexpensive to use, and could be adapted for new methods of data gathering.

4.5.4 Quality Assurance and Quality Control for Leak Detection

The QA and QC for SST surveillance is achieved through the use of primary leak detection devices, established monitoring intervals, and statistical comparison of current readings with previous or dictated norms. Administrative guidance describes the technical bases for monitoring, the process that should be followed to obtain surveillance data, the criteria for out-of-range readings, and the course(s) of action to take when an out-of-specification reading occurs.

Surveillance data are obtained from SST leak detection or survey equipment following established monitoring frequencies. Monitoring entails taking successive liquid level and/or radiation level readings and comparing them to baseline values. Specification limits are set for permissible deviations from the baseline values. When a reading falls outside of an established specification limit, which could indicate that a leak or intrusion has occurred, an investigation is initiated to determine the cause of the out-of-specification reading.

Schofield (1994b) lists recommendations for specification limits to be used for tank farms leak detection and monitoring. A basis for each specification limit is also provided. This reference also discusses guidelines regarding 'good practice', and ways to improve the quality of leak detection within the tank farms. Specification limits stated in Schofield (1994b) are formally implemented by instructions in the *Tank Farm Leak Detection Operating Specification Document (OSD)* (Schofield 1994a). This OSD is the official document describing the implementation of tank farm leak detection criteria and also describes the appropriate response(s) to take whenever a specification limit is exceeded. The OSD instructions have higher authority than the technical bases. The use of the technical bases, and compliance with the operating specification document, provide QA and QC for waste tank leak detection and monitoring efforts.

Leak detection for SSTs is performed by monitoring for decreases in the tank (waste) surface level, or ILL. A survey, for SSTs, refers to external monitoring from drywells or laterals. These methods are sometimes used as backup to primary leak detection methods, but are not classified as leak detection for purposes of compliance. Specification limits are limits set on leak detection or survey methods. Specification limits on data measurements are those that set an action point, at which time tank leak evaluation investigations must be initiated. For SSTs, there normally is an alert limit below the specification limit, at which time evaluation is started. Specification limits on data measurement frequencies stipulate the maximum time intervals permitted between successive measurements.

Operating specifications are technical limits established to prevent injury to personnel, or damage to a facility or the environment. Schofield (1994a) provides specification limits and recovery actions for the 200 Area Leak Detection Surveillance Program at the Hanford Site (as required by Section 5.23.2: Administrative Control, in WHC-SD-WM-OSR-005 for SSTs [Dougherty 1994]). Specification limits are provided for monitoring frequencies of primary leak detection devices, and for permissible deviations of readings from established baselines or previous readings.

Specification limits include three major informational topics: Technical Bases, Detection/Control, and Recovery Action. The Technical Basis includes the reasoning behind the stated specification limits. These are primarily descriptive and do not state requirements. The Detection and Control section describes general activities that can provide effective monitoring for compliance to the specification limits. This section describes options for attaining compliance, but does not state mandatory requirements. This section also describes what constitutes an OSD violation, and specifies actions that should be taken when specification limits are not met. Required actions to take, in the event an OSD violation has occurred, are provided in the section pertaining to Recovery Action.

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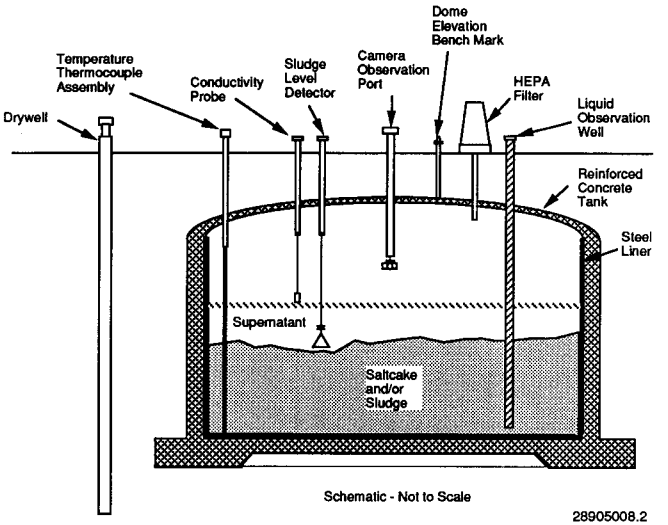

Figure 4-1. Single-Shell Tank Surveillance Instrumentation.

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Table 4-1. Documentation of Tank Characterization Information.

Tank	Document	Document Number, Date
241-S, -SX, -U Farm tanks	*Historical Tank Content Estimate Report for the Southwest Quadrant of the Hanford 200 West Area*	WHC-SD-WM-ER-352, Revision 0, 1994
241-A, -AX, -B, -BX, -BY, and -C Farm tanks	*Historical Tank Content Estimate Report for the Southwest Quadrant of the Hanford 200 East Area*	WHC-SD-WM-ER-349, Revision 0, 1994
241-B-110	*Tank Characterization Report for Single-Shell Tank 241-B-110*	WHC-SD-WM-ER-368, Revision 0, 1994
241-B-111	*Tank Characterization Report for Single-Shell Tank 241-B-111*	PNL-10099, Revision 0, 1994
241-B-201	*Tank Characterization Report for Single-Shell Tank 241-B-201*	PNL-10100, Revision 0, 1994
241-BX-107	*Tank Characterization Report for Single-Shell Tank 241-BX-107*	WHC-EP-0739, Revision 0, 1994
241-C-109	*Tank Characterization Report for Single-Shell Tank 241-C-109*	WHC-EP-0668, Revision 0, 1993
241-C-110	*Tank Characterization Report for Single-Shell Tank 241-C-110*	WHC-SD-WM-ER-367, Revision 0, 1994
241-C-112	*Tank Characterization Data Report - Tank 241-C-112*	WHC-EP-0640, Revision 1, 1993
241-S-104	*Tank Characterization Report for Single-Shell Tank 241-S-104*	WHC-SD-WM-ER-370, Revision 0, 1994
241-T-102	*Tank Characterization Report for Single-Shell Tank T-102*	PNL-10101, Revision 0, 1994
241-T-104	*Tank Characterization Report for Single-Shell Tank 241-T-104*	WHC-SD-WM-ER-372, Revision 0, 1994
241-T-105	*Tank Characterization Report for Single-Shell Tank 241-T-105*	WHC-SD-WM-ER-369, Revision 0, 1994
241-T-107	*Tank Characterization Report for Single-Shell Tank 241-T-107*	WHC-SD-WM-ER-382, Revision 0, 1994
241-T-111	*Tank Characterization Report for Single-Shell Tank 241-T-111*	WHC-EP-0806, Revision 0, 1994
241-U-110	*Tank Characterization Report for Single-Shell Tank 241-U-110*	WHC-EP-0643, Revision 1, 1993

Table 4-2. Tri-Party Agreement Milestones for Tank Waste Characterization. (sheet 1 of 2)

Milestone number	Milestone description	Milestone date
M-44-00	Issue TCRs based on process knowledge, prior characterization data, and validated empirical data acquired after May 1989 for 177 Hanford Site HLW tanks.	9/30/99
M-44-01	Submit a draft copy of the TWRS TWAP's and TCP's revisions, updates, and additions annually to Ecology and EPA	5/31/94 and annually through 1999
M-44-02	Submit TWAP annually to Ecology and EPA for approval.	8/31/94 and annually through 1999
M-44-03	Submit three TCRs for initial evaluation and approval.	10/31/93
M-44-04	Complete input of characterization information for three HLW tanks to electronic database(s).	1/31/94
M-44-05	Issue 20 TCRs in accordance with the approved TCPs. If and approved TCP is not issued, the TCRs must be approved by Ecology and EPA.	9/30/94
M-44-06	Complete input of characterization information for three HLW tanks to electronic database(s).	9/30/94
M-44-07	Complete all fiscal year 1992 and 1993 core sample analyses and complete validation of the resulting data.	3/31/94
M-44-08	Issue 30 TCRs in accordance with the approved TCPs. Complete input of characterization information for 30 HLW tanks to electronic database(s).	9/30/95
M-44-09	Issue 40 TCRs in accordance with the approved TCPs. Complete input of characterization information for 40 HLW tanks to electronic database(s).	9/30/96
M-44-10	Issue 40 TCRs in accordance with the approved TCPs. Complete input of characterization information for 40 HLW tanks to electronic database(s).	9/30/97

Table 4-2. Tri-Party Agreement Milestones for Tank Waste Characterization. (sheet 2 of 2)

	Milestone number	Milestone description	Milestone date
1	M-44-11	Issue 30 TCRs in accordance with the approved TCPs. Complete input of characterization information for 30 HLW tanks to electronic database(s).	9/30/98
2	M-44-12	Issue 14 TCRs in accordance with the approved TCPs. Complete input of characterization information for 14 HLW tanks to electronic database(s).	9/30/99

3 Ecology = Washington State Department of Ecology.
4 EPA = U.S. Environmental Protection Agency.
5 HLW = high-level waste.
6 TCP = Tank Characterization Plan.
7 TCR = Tank Characterization Reports.
8 TWAP = Tank Waste Analysis Plan.
9

Table 4-3. Single-Shell Tank Surveillance Devices and Techniques.

Internal	- Surface-Level Measurements (Manual tapes, automatic gauges, zip cords, and dip tubes)
	- ILL measurements (Gamma and neutron probes)
	- LOWs
	- Temperature measurements
	- Psychometrics
	- Photographic/visual inspection
External	- Drywells
	- Laterals
	- Leak detection pits

ILL = interstitial liquid level.
LOW = Liquid Observation Wells.

Table 4-4. Single-Shell Tank Leak Detection Strategy.

1.	The liquid level in tanks with liquid or semi-liquid surfaces where the surface-level measurement device is touching a surface that will vary with changes in the liquid level will be monitored with surface-level measurement devices. These devices provide the primary leak detection method for these tanks. When the surface-level measurement equipment is out of service, backup leak detection for these tanks will be provided by LOWs. If LOWs do not exist, no formal means of leak detection will be assumed to exist. Backup leak surveys for unstabilized SSTs will be provided by level readings or radiation measurements via leak detection pits, or radiation measurements from laterals or drywells, in that order, until the primary leak detection device is returned to service or an LOW is installed.
2.	The liquid level in tanks with solid or semi-liquid surfaces, where the surface level measurement device is touching a surface that does not vary with the liquid level will be monitored with LOWs. These are designated the primary leak detection device for these tanks. If LOWs are out of service or do not exist and the tanks are unstabilized, backup leak surveys will be provided by (liquid) level readings or radiation measurements via leak detection pits, or radiation measurements from laterals or drywells, in that order, until the LOW equipment is fixed or LOWs installed. If LOWs are out of service or do not exist and the tanks are stabilized, no formal backup leak surveys are required until the LOWs are placed in service.
3.	LOWs will not be installed in tanks with less than 61 centimeters (2 feet) of total waste (because of inability to effectively measure the bottom 61 centimeters [2 feet] of tank with an LOW).
4.	Tanks using surface-level measurement devices as the primary leak detection device should be photographed on a set frequency, or when waste surface conditions are known to have changed, to verify that the surface-level measurement device is effectively measuring liquid level.
5.	For tanks that represent unique situations where the above criteria may not effectively apply (e.g., C-106 Tank), a leak detection method shall be put in place that will provide an equivalent degree of protection.

LOW = Liquid Observation Wells.

Table 4-5. Sensor Probes Deployed in Drywells.

Probe Type	Comment
Gross Count Scintillation #4 or S Probe	Gamma probe--Primary drywell-deployed probe. Noted for sensitivity. Data sent to computer.
Probe Type 1: High Sensitivity Geiger-Muller- 'Green GM'	Gamma probe--When used for leak survey support, scans are used for information purposes only, and to look for trends. Used when background exceeds range for 'S' Probe.
Probe Type 2: High Level Geiger-Muller- 'Red GM'	Gamma probe--Primarily used for leak plume monitoring of past SST leaks.
Probe Type 3: High Parity Germanium Detector	Gamma probe--Primarily used for plume characterization and monitoring of past SST leaks.
Probe Type 4: Soil Moisture Monitor - Neutron	Neutron probe--Measures moisture content of soil around drywell.

Table 4-6. Sensor Probes Deployed in Laterals.

Probe Type	Comment
Type 1: Geiger-Muller Green Probe	Data used primarily for information and to detect trends. Comparisons made to previous readings; soil radionuclide concentrations are not measured.
Type 2: Geiger-Muller Green Probe	Only in SX Tank Farm (two locations); less sensitive than other probes.
Geiger-Muller Red Probe	Leak plume migration tracking only; not used for leak surveys.

CONTENTS

5.0 SINGLE-SHELL TANK WASTE RETRIEVAL 5-1

5.1 RETRIEVAL REQUIREMENTS OF THE TRI-PARTY AGREEMENT 5-1

5.2 STRATEGY FOR RETRIEVAL OF IN-TANK WASTE 5-2

5.3 RETRIEVAL SEQUENCE AND SCHEDULE 5-3

FIGURES

5-1 Past Practice Sluicing F5-1
5-2 Limited-Flexibility Sluicing Enhancement F5-2
5-3 First-Generation Arm-Based Retrieval System F5-3
5-4 Bridge-Mounted Confinement Module--Elevation F5-4

5.0 SINGLE-SHELL TANK WASTE RETRIEVAL

This chapter briefly summarizes current requirements for retrieval of SST waste and outlines the retrieval strategy. Section 5.1 identifies the Tri-Party Agreement milestones being used to implement work needed to achieve compliance with applicable laws and regulations previously described in Chapter 3.0. Section 5.2 outlines the strategy for retrieval of in-tank waste, including the assumptions that underlie the strategy. Section 5.3 provides a schedule of performance based on Tri-Party Agreement milestones for the sequence of tasks needed to close the SST farms.

5.1 RETRIEVAL REQUIREMENTS OF THE TRI-PARTY AGREEMENT

The January 1994 amendment to the Tri-Party Agreement (Ecology et al. 1994) identified and defined major, interim, and target milestones for retrieval of SST waste. Interim and target milestones are defined as milestones that support and are subordinate to major milestones. Major and interim milestones are enforceable under the terms of the Tri-Party Agreement; target milestones are not.

Tri-Party Agreement Major Milestone M-45-00 requires retrieval of SST waste and identifies September 30, 2024, as the date for completing closure of all SST farms. Interim and target milestones for SST waste retrieval and SST farm closure are as follows:

- Milestone M-45-01 was met by issuing a summary of the work needed to develop SST retrieval technology and complete scale-model testing (Shen 1994)

- Milestone M-45-02 requires issuance (beginning in fiscal year 1996 and continuing at the end of each year thereafter through 2017) of the plans for performing the sequence of tasks that will result in retrieval of DST and SST waste, and the basis for those plans

- Milestone M-45-03-T01 requires that the capability of selected technologies to remove 99 percent (by volume) of the waste in a SST be demonstrated. The demonstration will be in Tank C-106 at the C Tank Farm of the 200 East Area. Capabilities of the two principal waste retrieval technologies, hydraulic and mechanical, will be demonstrated, respectively, by October 1997 and June 2002

- Milestone M-45-04A requires the conceptual design of the first waste retrieval system for an entire SST farm to be completed by April 1997; Milestone M-45-04-T01 requires construction and testing of the first system by November 2003

- Milestone M-45-05 requires retrieval of waste from all remaining SSTs. It is implemented by a series of target milestones that establish interim dates for completing retrieval of the wastes remaining after completion of Milestone M-45-03-T01. These interim

target milestones require waste retrieval from 1 SST to begin by December 2003, from 2 additional SSTs by September 2004, from 3 additional SSTs by September 2005 and, eventually, from 20 SSTs per year by the end of each fiscal year from 2015 through 2017

- Milestone M-45-06 requires completion of closure of all SST farms. It is implemented by a series of target milestones that establish dates for submittal (by November 2004) and approval (by September 2006) of a closure plan for the first SST operable unit or tank farm to be closed, and for initiation of closure actions on the first operable unit or tank farm (by March 2012). The milestone additionally requires periodic revision and reissuance of this SST CWP.

5.2 STRATEGY FOR RETRIEVAL OF IN-TANK WASTE

A major technical challenge in closing the SST farms is to retrieve waste from tanks known to have leaked in the past without causing significant additional leakage of waste to the soil. In most SSTs, planned waste retrieval will be by hydraulic sluicing. Other methods of waste retrieval are planned for use in tanks classified as leakers.

In implementing the waste retrieval plans for non-leaking tanks or tanks that have leaked, sluicing jets would be directed to dislodge, break up, and erode the sludges and salt cake. The resultant slurry would be transferred out of a SST to a double-shell receiver tank by pumping it through transfer lines. After the solids in the receiver tank have settled, the supernatant would be recycled back to the sluicing jets in the SST to repeat the process until the waste removal criterion was achieved.

Hydraulic sluicing was used in the A and AX tank farms in the 1960s and 1970s to recover strontium. The sluicing (Figure 5-1) transferred slurry from the SST being sluiced to receiver tanks in the AR vault or to other SSTs. The sluicer nozzles in these recovery operations had rotational (i.e, pan and tilt) capability, but otherwise had no vertical positioning flexibility once they were deployed through tank risers. Past-practice sluicing technology of this type will be used in the first phase of the retrieval demonstration in Tank C-106 (Milestone M-45-03) as part of Project W-320.

Limited-flexibility sluicing enhancement (Figure 5-2) is a variation of past-practice sluicing that deploys sluicers with flexibility in vertical positioning. In this concept, the sluicer nozzles are mounted through existing risers around the edge of a tank. The hydraulic jets are used to flush the waste toward a waste retrieval pump in the center of the tank. The sluicer nozzle initially is positioned such that the hydraulic jet does not strike the tank wall or wash waste away from the wall. Because waste material is removed lastly from the circumference of the tank, the potential for leakage of waste through failures in the tank wall likely will be reduced. This method also is likely to be more effective than past-practice sluicing

because the nozzles can be positioned in close proximity to the waste and can be aimed from many angles. The marketplace availability of systems and services of this type are being investigated.

Retrieval of waste by the use of a hydraulic scarifier (a type of short-range, high-pressure jet) is another variation of hydraulic methods. In conjunction with a closely-coupled pneumatic conveyance system that is designed to immediately vacuum out the added water and loosened waste, the use of a scarifier could result in significant reduction of the need to add water to tanks to remove the waste. Consequently, this method could have significant advantages over other hydraulic methods in tanks with high leakage potential or in tanks where conventional sluicing is not expected to be effective in dislodging or breaking up hard sludge or salt cake. No development work is being done on this waste removal method.

In some SSTs, deployment of robotic or arm-based waste retrieval systems (Figure 5-3) is planned to minimize the addition of water to the tanks (Krieg et al. 1993). Mechanical retrieval methods of these kinds additionally would facilitate the dismantling, relocation and/or removal of in-tank hardware or debris that would otherwise interfere with retrieval of the waste. Robotic or arm-based retrieval systems provide flexibility in positioning waste mobilization and conveyance equipment directly at the surface of the waste, as well as in performing additional tasks that may be identified during the retrieval process. Retrieval systems of this type could enhance mobilization and conveyance of waste from SSTs by a variety of other methods, including mechanical, hydraulic, or pneumatic processes. Mechanically based retrieval systems are being developed by PNNL as part of work funded by EM-50.

Deployment of waste retrieval methods other than sluicing may require access through openings larger than those provided by the existing tank risers and/or may require operations within a confined environment that is partially external to the tanks. For these systems, waste confinement currently provided by a tank will be expanded by constructing additional confinement external to the tank.

Several concepts have been evaluated for confinement structures needed to mechanically retrieve tank wastes (Boomer et al. 1993). These concepts range from movable structures that confine the space above a single tank to stationary structures that enclose the surface over multiple tanks or an entire tank farm. Because alternatives to sluicing most likely will be used in only about one-third of the SSTs, the single-tank confinement concept is most likely to be implemented. Figure 5-4 illustrates one such concept for an arm-based retrieval system. The concept includes a bridge-like structure for mounting retrieval equipment, supporting the confinement structure, and transferring loads to the soil at the periphery of the SST.

5.3 RETRIEVAL SEQUENCE AND SCHEDULE

Waste will be retrieved from SSTs in a manner that addresses simultaneous needs to resolve safety issues, provide feed to waste processing facilities, and provide adequate interim storage space for wastes being generated,

transported, and processed as a result of other cleanup work at the Hanford Site. For planning purposes, Tri-Party Agreement Milestone M-45-02 requires the issuance of annual updates of the scheduling plans for tank waste retrieval. These updates will identify the SST and DST retrieval sequences and schedules, and their basis.

As the retrieval process proceeds, the relationships between various remediation tasks and the details of schedules for facility operation and operable unit remediation will become better defined. Hence, the planning basis for the sequence and schedule of SST waste retrieval will continue to evolve. The sequence of tank farm closure will, in turn, depend on the tank retrieval sequence and subsequent turnover of tanks and tank farms for closure. Retrieval of tank waste is driven by the need to provide process feed to support the start-up and continued operation of proposed waste processing facilities, to mitigate tank safety issues, and to make space available in the DSTs to support retrieval operations for all SSTs and DSTs located on the Hanford Site.

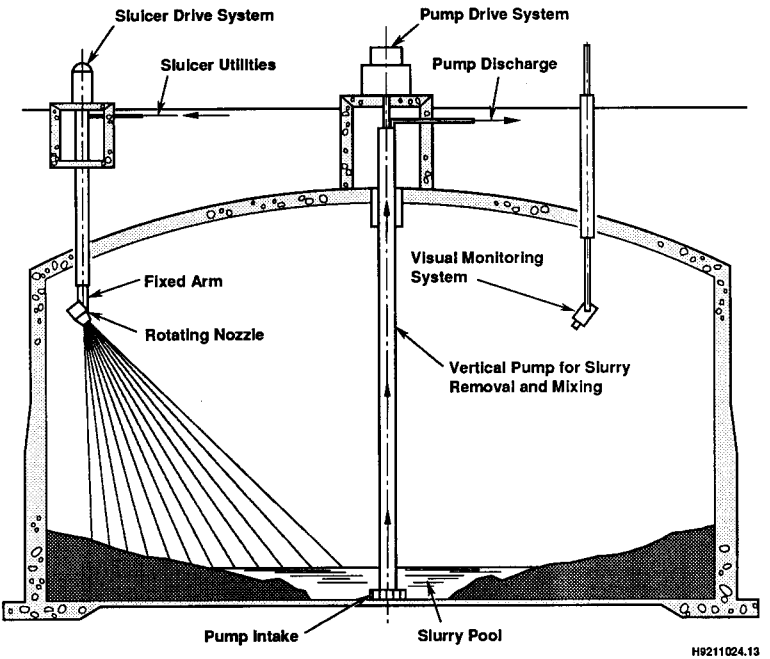

Figure 5-1. Past Practice Sluicing.

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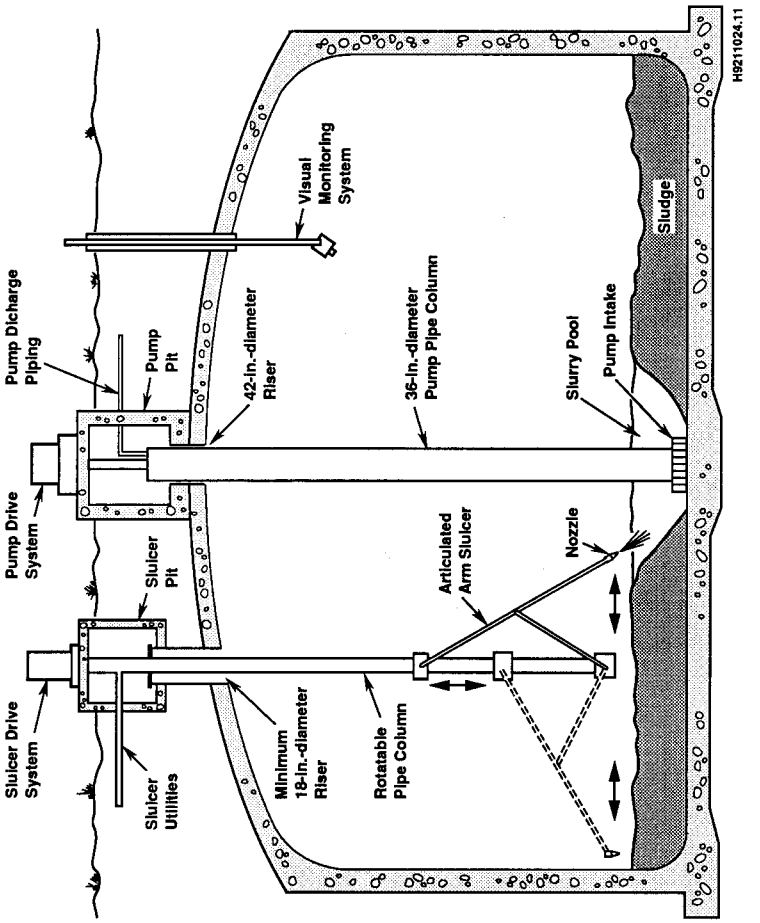

Figure 5-2. Limited-Flexibility Sluicing Enhancement.

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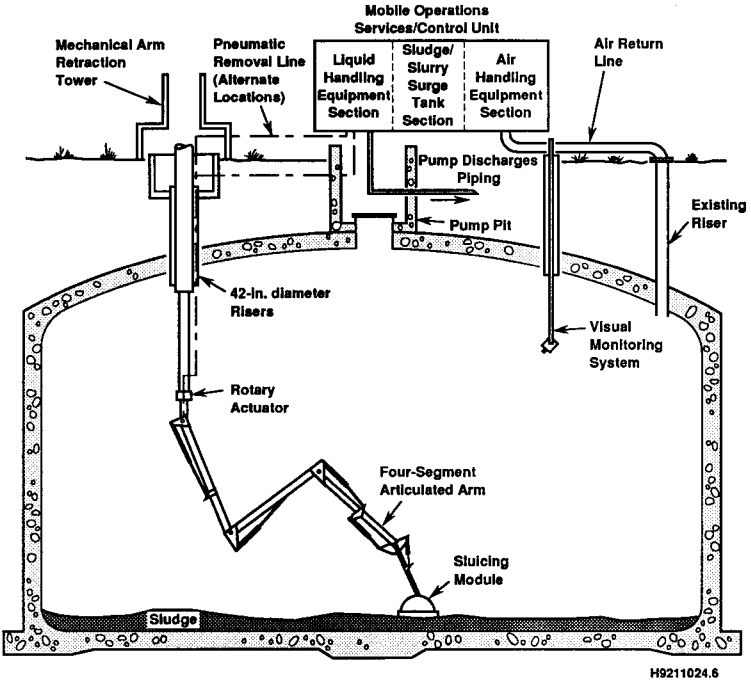

Figure 5-3. First-Generation Arm-Based Retrieval System.

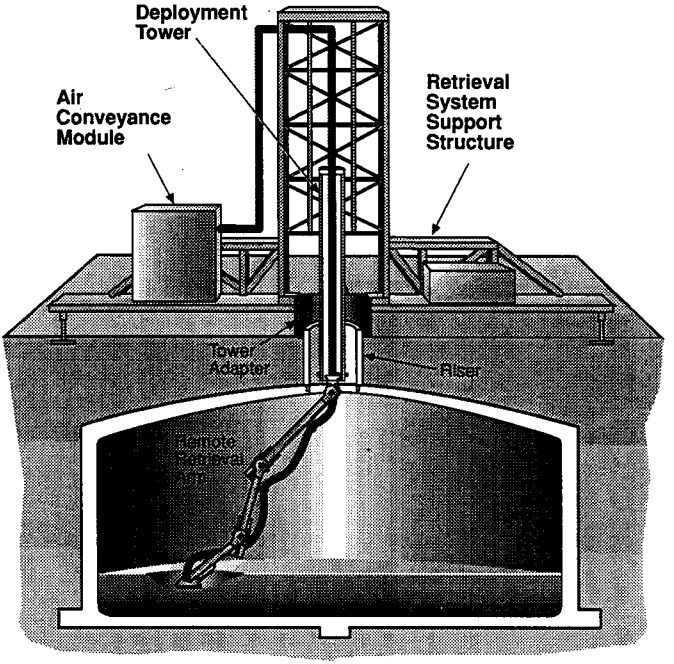

Figure 5-4. Bridge-Mounted Confinement Module--Elevation.

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CONTENTS

6.0 CLOSURE STRATEGY FOR SINGLE-SHELL TANK SYSTEM COMPONENTS 6-1

6.1 CLOSURE STRATEGY 6-1

6.2 CLOSURE PERFORMANCE STANDARDS 6-1

6.3 CLOSURE REQUIREMENTS 6-2

6.4 CLOSURE ACTIVITIES 6-2

6.5 FUTURE USE 6-2

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6.0 CLOSURE STRATEGY FOR SINGLE-SHELL TANK SYSTEM COMPONENTS

6.1 CLOSURE STRATEGY

At the time of closure, the owner or operator of the tank system(s) will either prepare a closure plan or prepare a permit application to close as a landfill. Closure as a landfill will implement the closure and post-closure care conditions provided in Section WAC 173-303-665(6).

A general discussion of the closure options is provided in Section 3.3. The closure plan and/or permit will discuss the performance standards and requirements for the method of closure once the method of closure has been defined. The closure plan and/or permit will discuss the specific actions or activities that will be taken, and will provide a schedule for completing these actions or activities. A variety of closure alternatives exist; the particular closure approach that will be followed has not been defined. As assessment of closure options proceeds and the closure approach is defined, this chapter will be completed. As such, this chapter on closure strategy will continue to evolve over the next few years and will be updated every two years. The schedule for submitting the first closure plan for a selected closure demonstration of an SST operable unit or tank farm is November 30, 2004.

6.2 CLOSURE PERFORMANCE STANDARDS

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

i) Minimizes the need for further maintenance

ii) Controls, minimizes, or eliminates to the extent necessary to protect human health and the environment the postclosure escape of dangerous waste; dangerous constituents; leachate; contaminated run-off; or dangerous waste compositions to the ground, surface water, groundwater, or the atmosphere

iii) Returns the land to the appearance and use of surrounding land areas to the degree possible given the nature of the previous dangerous waste activity.

For tank systems, WAC 173-303-640(8) requires the owner or operator to remove all waste or decontaminate all waste residues; contaminated containment systems components (liner, etc.); and contaminated soils, structures, and equipment, and manage them as dangerous waste. Where closure requirements call for the removal or decontamination of dangerous waste, waste residues, etc., then such removal or decontamination must ensure that the levels of

dangerous waste or dangerous waste constituents or residues do not exceed the following:

- For soils, ground water, surface water, and air, the numeric cleanup levels calculated using residential exposures according to the MTCA Regulations

- For all structures, equipment, bases, liners, etc., clean closure standards shall be set by DOE on a case-by-case basis in accordance with condition 'ii' (stated previously)

- If the owner or operator demonstrates that not all of the contaminated soil can be practically removed or decontaminated, then the owner or operator must close the tank system and perform post-closure care in accordance with landfill requirements.

6.3 CLOSURE REQUIREMENTS

The range of closure alternatives include; clean closure, modified closure, and closure as a land fill unit. These alternatives involve different closure requirements. A discussion of the closure alternatives and requirements are included in Section 3.3 of this CWP.

As discussed in Chapter 3, SST TSD unit closure requirements are included in the WAC 173-303 and 173-340, the Tri-Party Agreement, and the Hanford Facility RCRA Permit. Once a decision on the method of closure for each SST or SST TSD unit has been made, either a closure plan or a permit application as a land disposal unit will be prepared. The specific requirements that regulate this action will be defined at that time.

6.4 CLOSURE ACTIVITIES

The list of closure activities will be specified once the method of closure has been defined.

6.5 FUTURE USE

No future land use or use of tank farm equipment is anticipated at this time.

CONTENTS

7.0 RISK MANAGEMENT 7-1

7.1 RISK ASSESSMENT 7-1
7.1.1 General Risk Conceptual Model 7-2
7.1.2 Data and Information Requirements 7-5
7.1.3 Evaluation of Short-Term and Long-Term Risk 7-5
7.1.4 Uncertainty Analyses 7-7

7.2 RISK MANAGEMENT ISSUES 7-8
7.2.1 Integration of Numerical Modeling and Risk Assessment with Other Hanford Site Remediation Programs 7-9
7.2.2 Interim Performance Criteria and Objectives for Closure with Residual Tank Waste and Soil Contamination 7-10
7.2.3 Tradeoffs Between Reductions in Long-Term Health Risk to the Public and the Environment, and Increases in Risk to Remediation Workers 7-12
7.2.4 Establishment of Waste Retrieval Criteria for Single-Shell Tank Operable Unit Closure 7-13
7.2.5 In-Place Disposal Alternatives for Single-Shell Tank Waste 7-13

7.3 ROLES AND RESPONSIBILITIES 7-14

7.4 PUBLIC VALUES AND PLANS FOR FUTURE INVOLVEMENT 7-15

FIGURES

7-1 Decision Logic: Role of Analyses and Technology in Support of Closure Decisions F7-1.1
7-2 General Risk Conceptual Model F7-2
7-3 Conceptual Model for Terrestrial/Riparian Foodwebs F7-3

7.0 RISK MANAGEMENT

All SST tank system units located within the boundary of each tank farm will be closed in accordance with WAC 173-303-610. The closure process that will be followed is outlined in Section 6.3 of the Tri-Party Agreement. The approved closure plan and/or permit once approved will be included in the Hanford Facility RCRA Permit.

DOE requires that all activities conducted by or for DOE that could result in the release of radioactivity, be assessed for the potential impact of this release to the occupational workforce, and the general public (10 CFR 835 and 10 CFR 834). As a result, ALARA guidelines and radiological dose limits have been established. Over the years, methods have been established to assess the impact of this potential release. As discussed in this chapter, these methods will continue to be used to support the decision making process. To illustrate this process, the decision logic shown as Figure 1 has been enhanced to highlight both the role and purpose for the various analyses. (i.e., risk assessments and performance assessments). The resulting Figure 7-1 is provided as an example to assist the reader to understand the text provided in this chapter. The results from these analyses will be made available to Ecology and may be used by Ecology in setting appropriate performance standards.

7.1 RISK ASSESSMENT METHODOLOGY

Risk to the environment, safety, and health will be identified, evaluated, and compared as part of the decision making process that will result in defining the activities to be performed during closure. The information generated by these analyses will provide the basis for utilizing a risk management approach to making decisions on remediation of SST waste that would best serve both the operational work force and the public. Such a risk management approach considers probability and consequence of alternative actions as a basis for decision making.

For purposes of this work plan, short-term risk is defined as risk associated with the time during which remediation actions are being implemented. Evaluations of short-term risk will focus on assessments of the effects of alternative remediation actions on worker health and safety, but also will include prediction of risk to nonremediation workers, the public, and the environment. Evaluations of short-term risk will include the potential effects of accidents, as well as expected conditions.

Long-term risk is defined as risk to the environment, safety, and health that would result from residual contamination remaining after remediation activities are completed. Long-term risk includes detrimental effects of long-lasting alterations to the environment that would result from remediation of SST waste.

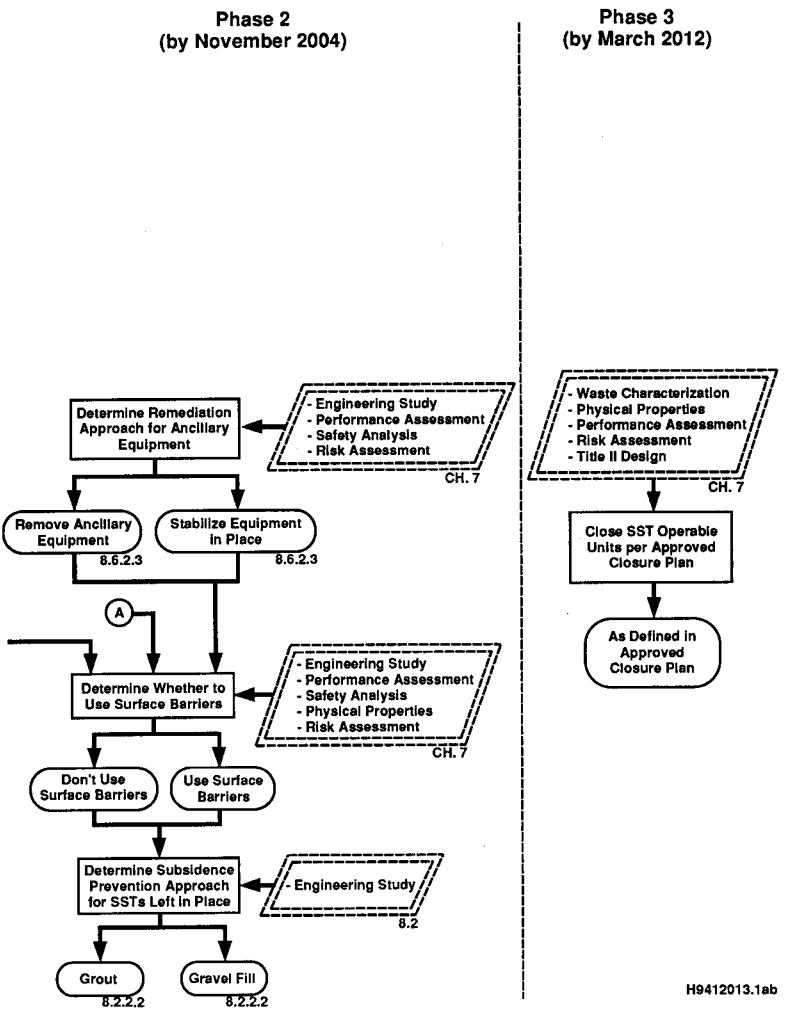

Figure 7-1. Decision Logic: Role of Analyses and Technology in Support of Closure Decisions. (sheet 2 of 2)

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Five media can be included in the exposure pathways: air, soil, groundwater, surface water, and sediments (referred to as river sediments in this section). Transfer of contamination between any of the five media can occur. Though only selected transfers will be discussed in this section, all transfers need to be considered for risk assessments. This section focuses on the exposure routes and transport within each exposure medium.

Exposure routes for radionuclide contaminants transported in air (atmospheric pathway) are: ingestion/uptake, inhalation/respiration, and dermal, and external exposure. Contamination transported through the atmosphere can be deposited on ground and water surfaces creating additional risk. Atmospheric transport is a common pathway analysis for performance assessments required by DOE Order 5820.2A (DOE 1988c).

The following routes can be pathways for human and biota soil exposures: ingestion/uptake, inhalation/respiration, dermal, and external exposure. Soil pathway analyses at the Hanford Site typically consider the upper 15 feet (4.6 meters) because of requirements under "The Model Toxics Control Act Cleanup Regulation" (WAC 173-340). Contaminants have been and can be released to the soil by many mechanisms including previous leaks and spills and disturbance of soil during retrieval activities. After clean-up, residual contaminants in the SSTs may be released to the surrounding soil by diffusion or leaching. If the contaminated soil is not removed at the time of closure, the unit may be closed as a landfill and a sufficiently thick cover will be constructed as required to mitigate the hazard and protect human health and the environment.

Exposure routes for contamination in groundwater medium include: ingestion/uptake, inhalation/respiration, and dermal exposure. Contamination that moves below the vadose zone to an aquifer, and then is extracted via a well, creates an exposure potential for groundwater medium. The consumption of plant and animal products contaminated by irrigation of crops is an example of an exposure route by ingestion. This pathway is a common component of EISs and performance assessments at the Hanford Site.

Important factors to consider for groundwater contamination include the following:

- Contaminant migration within the aquifer is typically orders of magnitude faster than migration within the vadose zone resulting in large numbers of potential contaminant sources spread over large distances
- Heterogeneities of the Hanford Site hydrogeology
- Interaction of contaminant plumes.

These problems may require special approaches such as analyzing transport in the vadose zone independently, then using vadose zone results to create boundary conditions for groundwater analyses.

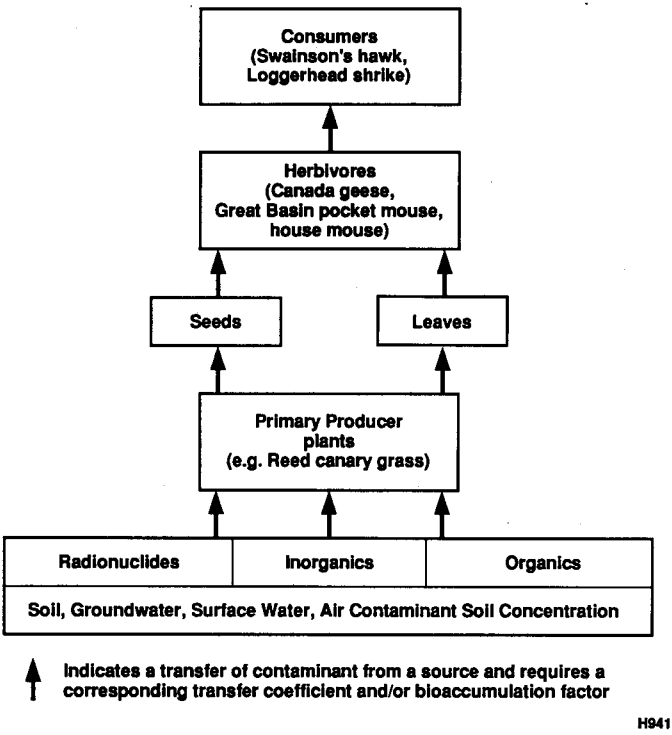

Figure 7-3. Conceptual Model for Terrestrial/Riparian Foodwebs.

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Numeric cleanup levels for soil, groundwater, and surface water will be established using the MTCA methodology (WAC 173-340). Typically, destruction of habitat and exposure to unacceptable levels of radionuclides and hazardous chemicals are the primary considerations for ecological risk at the Hanford Site. The receptors of potential concern are presented in Figure 7-3. Records of radioactive contamination in biota at the 200 Areas confirm that ingestion is the primary pathway for exposure to radionuclides (Johnson 1994).

7.1.2 Data and Information Requirements

The DQO process will be used to guide the collection of data for site risk assessment by clearly defining the role of risk assessment in the decision process, including the following:

- How risk assessment results will be used to make decisions
- What data are needed to support the risk assessment
- How the data will be used
- Ensures that adequate and appropriate data will be collected to support remedial action decisions that are based on risk assessment and its associated uncertainties.

The DQO process will be used to determine the type, quantity, and quality of environmental data sufficient for environmental decision making on the closure of SSTs. In defining the type of data for input into the decision, a conceptual model is developed to identify the existing or potential complete exposure pathways (Section 7.1.1). To determine the data quality and quantity, the risk assessor will assist the decision maker in defining the acceptable level of uncertainty for making site-specific decisions and will use the established target cleanup level, previously collected data and variability, and the acceptable errors. By identifying the DQOs before data collection, a more efficient and cost-effective sampling plan will be developed (DOE 1994). Appendix 7A provides additional details on data and information requirements.

7.1.3 Evaluation of Short-Term and Long-Term Risk

The risk assessment needs to determine if remedies are protective of human health and the environment for both long-term and short-term risk. Different types of risk will be evaluated and compared before closure of the tanks. The scope and purpose of the risk assessment should be updated as the work progresses. Three major project phases are expected: (1) the evaluation of proposed closure alternatives, (2) closure, and (3) postclosure. Contributions to both short-term and long-term risk to human health and the environment for the various closure alternatives will be evaluated under the NEPA process as discussed in Chapter 3.0. In this manner, the decision makers will have a better understanding of the relative importance of the various contributors to overall risk, and will have input from the public and other

The following sections outline the work needed to complete risk assessments. The first step in assessing risk is to identify and define the potential pathways by which risk may occur. Subsequent steps include acquiring data and information needed to calculate and compare the risk, and analyzing consequences, sensitivities, and uncertainties. All risk assessment methods and calculations will be reviewed for technical consistency and validity by the appointees of the Hanford Environmental Dose Overview Panel (HEDOP) (Schreckhise et al. 1993).

7.1.1 General Risk Conceptual Model

The identification and quantification of risk associated with SSTs required the development of information that will specifically characterize contributors to public, worker, or ecological risk. Because a strategy for closure has not been defined, a broad conceptual model of the potential risk is presented.

Components of the risk conceptual model include: hazards, initiating events, and processes; transport media; and, the potential receptors (Figure 7-2). A complete "risk pathway includes a source or release from a source, an exposure point, and an exposure route;" an exposure route is "the way a chemical or physical agent comes in contact with an organism (i.e., by ingestion, inhalation, dermal contact)" (EPA 1989a). Some initiating event creates a hazardous situation that can impact a receptor via air, soil, groundwater, surface water, or river sediment pathway. The details of the conceptual model are discussed in the following sections. Though it is important to form a complete model, the risk evaluation will not examine every pathway.

7.1.1.1 Hazards, Initiating Events, and Processes. The first step in a risk assessment is the identification of the hazards present. Hazards could be radioactive materials, toxic chemicals, or situations of potential physical harm. Once the hazards are identified, an initiator, which causes the hazard to create an undesired effect, is necessary. The presence of the hazard does not necessarily constitute an adverse situation. Initiators can be divided into two categories: (1) natural phenomena and (2) operation/process exposures. Natural phenomena are conditions such as seismic events, high winds, or floods that can cause situations resulting in adverse effects to the receptor. Operation/process exposures are either caused by equipment failure, caused by human error, or received through routine operations. Two possibilities exist when a hazardous event is initiated, an accident has occurred, or contamination has been released. Accident evaluation is presented in Section 7.1.3.1.

7.1.1.2 Contaminant Transport/Transfer and Exposure. When a contaminant is released, the transport of that contaminant to an exposed organism (e.g., exposure pathway) is analyzed. Contaminant transport consists of the movement of a contaminant from the source through a medium to an exposure point. If a contaminant moves between media, transfer occurs. The exposure route is the way exposure to an organism occurs (e.g., ingestion, inhalation, dermal exposure).

also should be given to possible Natural Resource Damage Assessment (NRDA) claims.

Long-term human health risk is a result of contamination remaining onsite after remedial actions are complete and migration of those contaminants through the environment. Contamination may include untreated waste, treatment residuals, and secondary waste from treatment.

Long-term ecological risk is a result of contamination remaining onsite after remediation, ecological stressors that are a result of past practices, and long-term effects of remedial action. Long-term effects can include both adverse effects and mitigative measures. The evaluation should consider the ability of ecological systems to recover from impacts.

The NRDA process was established by CERCLA Section 107(a)(4)(c) and defined in regulations promulgated by the U.S. Department of Interior. The process imposes responsible party liability for "damages for injury to, destruction of, or loss of natural resources." Trustees can use the NRDA process to recover damages from potentially responsible parties for 'residual' injuries not remediated. The NRDA process under CERCLA is used by trustees to assess residual damages for injuries resulting from the releases of hazardous substances. Injury is defined as "a measurable adverse change in the chemical or physical quality or viability of a natural resource." Damage is "the amount of money sought as compensation for the injury to natural resources."

7.1.4 Uncertainty Analyses

Risk presented in a risk assessment is an estimate based on multiple assumptions about exposures, toxicity, and other factors. Uncertainty analyses provide a framework to better interpret estimated results and their value. Qualitative discussions are provided for uncertainty, accompanied by quantitative analyses where appropriate.

7.1.4.1 Exposure Assessment Uncertainties. Key factors for exposure uncertainties involve the description of physical setting, applicability of models and assumptions, and accuracy input parameters as follows:

- Adequacy of land use description
- Likelihood of potential future land use
- Exclusion of chemicals
- Exclusion of pathways
- Model assumptions that impact exposure point concentration and duration
- Use of the upper 95 percent confidence limit as the exposure point concentration for selected pathways

Exposure routes for contamination in surface water medium include: ingestion/uptake, inhalation/respiration, dermal, and external exposure. Dominant surface water bodies at the Hanford Site are the Columbia River, B Pond, and West Lake. The protection of the Columbia River has been a concern for the public, and release of contamination and transport to the river needs to be considered for most risk evaluations. Consumption of contaminated plants and animals living in the surface water is an example of an exposure route by uptake.

Ingestion/uptake and dermal exposure are exposure routes that are available to form pathways for human and biota exposure to river sediment media. Uptake of contaminated river sediments by plants living in the surface water is an example of an exposure route by uptake. The areal extent of river sediments should be clearly defined, especially with respect to bank and beach material. The Columbia River can fluctuate 1.5 meters (5 feet) in one day (DOE-RL 1992i), so the materials exposed during high water conditions are different than those exposed during low water conditions.

The contaminant release and transport in an exposure pathway will be assessed using mathematical models. Existing codes, models, and spreadsheet templates will be used.

Several risk evaluations have been performed for compliance with the CERCLA process at the Hanford Site. This includes baseline and qualitative risk assessments, risk evaluations for remedial alternatives, the *Columbia River Impact Evaluation Plan* (DOE-RL 1992c), and an EIS to assess remedial actions for the Hanford Site. Techniques for pathway analysis established in these reports will be used when appropriate.

7.1.1.3 Receptors. Short-term and long-term risk to human and ecological receptors will be evaluated as needed. Receptors include Hanford Site remediation and nonremediation workers onsite, offsite public, and ecological receptors. Information obtained from past risk, performance, and safety assessments performed at the Hanford Site will be used. Additional data will be collected as needed.

Risk to remediation workers is any risk that occurs while implementing a remedy. These include safety concerns (e.g., construction or transportation accidents), physical stressors (e.g., heat stress), and exposure to hazardous constituents (including both planned and accidental exposures to radionuclides or hazardous chemicals in contaminated media). Short-term risk for workers is the risk remaining after implementation of health and safety measures.

Public receptors include both the general public (off the Hanford Site) and Hanford Site workers not associated with the site-specific remediation. Exposure to contaminants resulting from normal operational releases associated with remediation and potential accidental releases will be considered when developing these pathways in the conceptual model.

The evaluation of ecological risk is less well defined versus human health risk, particularly for arid terrestrial systems. The general formulation of this problem is presented in the HSBRAM (DOE-RL 1993e).

7.2.1 Integration of Numerical Modeling and Risk Assessment with Other Hanford Site Remediation Programs

An unresolved issue that significantly affects the strategy for complying with requirements for closure of SST operable units is how to address questions concerning the source(s) of known groundwater contamination beneath the operable units in assessing risk from SST waste residues.

Groundwater surveillance (e.g., DOE-RL 1994a, DOE-RL 1993a, DOE-RL 1992a) and sampling of sediments in boreholes at the Hanford Site have identified numerous plumes of contaminated groundwater and areas of contaminated soil above the water table. Many contaminated areas originated from the past practice of discharging untreated effluents containing process chemicals and by-product radionuclides to the soil column. Other contaminated areas can be attributed to accidental spills. Although 67 of the 149 SSTs are believed to have leaked (Hanlon 1994), there is no indication from investigations to date that tank-leak contaminants have yet reached the water table (DOE-RL 1994a). Nevertheless, many of the tank farms are underlain by groundwater that has been contaminated from sources other than SST operable units (e.g., the remnant of past discharge of liquid effluent to cribs and ditches).

As indicated in Chapter 3.0, the EPA is developing a proposed rule (40 CFR 193) that is expected to be applied to waste residues likely to remain after closure of the SST operable units. As mentioned previously, cleanup standards for groundwater have been promulgated through MTCA. For groundwater, the most restrictive measure of compliance with radiological contamination in the proposed rule is expected to be an EDE of 4 millirem per year for beta and gamma emitters, and to express limits of concentration for specific alpha emitters.

The limits specified for these measures of compliance will encompass radiation from contaminant sources other than SST waste residues. Hence, the limits specified by the proposed rule will be in terms of maximum allowable radiation levels, irrespective of whether the contamination derives from a single source or multiple sources. Analogous maximum concentration limits for hazardous chemicals will be applied to assess compliance with groundwater quality standards. Other potentially major sources of contamination to which overall sitewide risk may require proportional allocation include onsite disposal of vitrified low-level radioactive waste from SST and DST waste remediation, past practice operable units remediated by the environmental restoration program, solid waste disposal, and any residual high-level or TRU waste.

Without integration of the numerical modeling of contaminant transport and risk assessment work for closure of SST operable units with comparable work for other operable units, the relative contribution needed from each operable unit to achieve overall compliance with groundwater protection criteria will not be known. Consequently, the methods and results of analyses that assess long-term risk to public health and the environment after closure of the SST farms must be integrated with the methods and results of analyses of the risk posed by plumes of groundwater contamination from other sources.

governmental agencies as to how each contribution to risk should be weighted in the decision process.

7.1.3.1 Evaluation of Short-Term Risk. Short-term risk refers to risk that occurs during remediation of a site (DOE-RL 1994h). Short-term risk evaluations should address potential impacts to remediation workers, other nearby populations such as nonremediation workers on the Hanford Site, the general public, and ecological receptors. General considerations of short-term risk assessment include the following:

- The most significant short-term exposure pathways may be different than those identified in an assessment of baseline or long-term risk. For example, direct exposure to contaminated soil or fugitive dust may be insignificant if the site is undisturbed, but can be a concern during excavation activities

- Toxicity values or dose assessment techniques should be applicable for the (generally short) exposure durations

- If the remedy has more than one phase or major component (e.g., excavation followed by treatment), the risk assessment will need to address the potential exposures and cumulative risk from all phases of the remedial action

- Evaluation of short-term risk should consider the impact of physical stressors and hazards (e.g., accidents or habitat destruction).

Worker accident sequence analysis is used to develop the sequence of events that can occur within a given situation. For each accident sequence, the significant contributing factors are identified. This simply may be an identification of preexisting conditions or may require a detailed analysis. When a detailed accident sequence analysis is required, probabilities, frequencies, and consequences are examined and a risk profile generated. Various aggregating schemes are available to make global comparisons of different risk profiles.

The approach to protecting workers from the health risk of hazardous substances is to establish acceptable exposure or dose limits and to enforce compliance using appropriate measurement techniques, inspection, monitoring, and control procedures. This approach is grounded in traditional health physics and industrial hygiene practice. With respect to exposure to radioactive constituents, two primary exposure routes for workers are expected to be: (1) inhalation of radionuclides attached to resuspended particulates (i.e., dust) and (2) exposure to external gamma radiation from photon emitters in contaminated soils (Travis et al. 1993, ICRP 1975).

7.1.3.2 Evaluation of Long-Term Risk. The long-term effectiveness criterion is concerned with the evaluation of risk associated with postremediation site conditions and an alternative's ability to provide protection over time (reliability and permanence). Effectiveness, however, will not be solely judged on the protection of human health and the environment, consideration

assessment, and remediation design activities, and ensure that the activities leading to closure are needed and complementary, and provide a sound, coherent basis for resolving closure issues.

This section describes: (1) how interim performance criteria and objectives will be identified and (2) how they will be applied to determine the contributions needed from the components of SST waste remediation. Evidence of the cumulative effects of these contributions is needed to support a contention that the actions result in compliance with environmental regulations.

7.2.2.1 Objectives and Scope. To make the best decisions for final disposal of SST waste, information is needed on the performances of disposal alternatives in terms of their risk-reduction benefits and costs. The decision-making process will involve identifying, weighing, and balancing often uncertain advantages and disadvantages of disposal alternatives. Some decisions may be difficult because the alternative outcomes are only marginally different; for others, the potential outcomes may dramatically differ.

Once a decision is made, subsequent information will be required to identify the level of performance needed from the contributors to that alternative. This information will indicate the additional benefits, if any, of enhancing the performance of a specified component or of incrementally adding design features or remedial actions to an overall clean-up strategy.

The approach used to identify performance criteria and objectives for SST waste remediation will be based on comparative analyses of the risk resulting from those actions (DOE-RL 1993e). This approach will compare the following:

- The effects on risk reduction of specified technologies or actions leading to SST operable unit closure with their associated costs, and with the risk-reduction costs and benefits of alternatives

- Magnitudes of these risks to naturally occurring (background) and familiar, everyday risks.

7.2.2.2 Use of Comparative Risk Analyses to Define Performance Criteria and Objectives. As discussed in Chapter 3.0, many statutes, regulations, and executive orders may apply to final remediation of SST waste. However, neither the specifics of their applicability nor the final means used to assess compliance can be defined until agreement is reached on the best choice for final remediation.

Because of questions on the details of how these proposed and existing regulations will be implemented, a closure issue is how performance criteria for interim use during the decision-making process are to be identified and applied, and how performance objectives are to be assigned for specific remedial actions and engineered components. Resolution of this issue is needed to answer outstanding questions and make informed decisions. Interim performance criteria and objectives will be required to provide a basis for deciding what remedial actions are needed and what level of performance is

- Accuracy of standard default parameters
- Accuracy of site-specific parameters
- Accuracy of biotransfer factors.

The exposure uncertainty analysis will determine the potential for over- or under-estimating exposures.

7.1.4.2 Toxicity Values and Information Uncertainties. Uncertainties associated with published toxicity values include the following:

- Use of dose-response information from effects observed at high doses to predict the adverse health effects that may occur following exposure to the low levels expected from human contact with the agent in the environment
- Use of data from short-term exposure studies to extrapolate to long-term exposures or vice-versa
- Use of data from animal studies to predict human effects
- Use of data from homogenous animal populations or health human populations to predict effects on the general population.

7.1.4.3 Flow and Transport Modeling Uncertainties. Uncertainties for flow and transport modeling include the following factors:

- Input parameters: source inventories, recharge rates
- Conceptual model simplifications, such as representation of stratigraphy
- Mathematical model limitations caused by using a limited set of physical processes
- Extrapolation of model assumptions thousands of years into future.

7.2 RISK MANAGEMENT ISSUES

There are several major unresolved issues related to application of risk analysis and risk management in developing the strategy for closure of the SST operable units. Most closure issues, which are unresolved questions, can be expressed in terms of what or how much additional information is needed and how or on what basis closure decisions will be made. The following subsections provide additional details pertaining to these issues. The issues are summarized in Appendix 1A.

Consequently, any reductions of long-term risk to public health and the environment will, to some degree, be offset by increased risk to the workforce performing the clean-up actions. The means proposed to implement the closure strategy advanced by this work plan is to base remedial-action decisions on the results of the comparative risk evaluations of how much of the reduction in long-term risk resulting from a given action is offset by a corresponding increase in occupational risk from that action.

The comparisons will be made within the context of the alternative(s) identified by the TWRS-EIS (DOE-RL 1994e). Comparisons will be in terms of the collective risk calculated for the two affected populations, the remediation workforce, and the general public. Risk resulting from various remediation alternatives for SST waste will be predicted and compared as the expected change in mortality and health effects for each affected population.

Occupational risk will include consideration of accidents as well as normal operations. The operations considered will be those that directly affect closure of the six SST operable units. Risk resulting from the performance of each remedial action will be calculated. The risk from all remedial actions that define a remediation alternative will then be summed to provide a cumulative risk estimate.

Evaluation of risk to public health and the environment will include consideration of risk from accidental releases of the waste to the atmosphere and groundwater during retrieval, and expected releases of residual waste after closure of the operable units.

7.2.4 Establishment of Waste Retrieval Criteria for Single-Shell Tank Operable Unit Closure

The answer to the question of how much of the SST waste must be retrieved to ensure compliance with applicable regulations will have major effects on the identity, scope, and costs of SST waste remediation activities. Tri-Party Agreement Milestone M-45-00 requires retrieval of 99 percent of the in-tank waste, pending evaluation of the results of retrieval technology demonstration (Ecology et al. 1989).

Any decision to revise the current waste retrieval goal will depend on: (1) completion of the waste retrieval demonstration and analysis of the results, (2) assessment of the expected effects of various levels of residual waste on groundwater quality, (3) legal requirements, and (4) evaluation of the consequent long-term risk to human health. Hence, finalization of the retrieval goal will require completion of these three studies.

7.2.5 In-Place Disposal Alternatives for Single-Shell Tank Waste

The objective of the in-place stabilization and disposal alternative would be to immobilize and stabilize waste inside the SSTs and to provide enhanced protection to the environment by using a protective barrier and

At many locations, these plumes of contaminated groundwater spatially overlap one another beneath, or downgradient from, one or more SST operable units. Additionally, the contaminant plumes may be temporally coincident at some time in their histories but not at others. In some cases, the existing contaminant plumes beneath SST operable units may have decayed and/or moved downgradient before residual contamination remaining at closure of the operable unit reaches the water table. In these instances, determination of the rates and directions of contaminant travel will be required to ascertain whether allowable limits are likely to be exceeded because of contaminant plume superposition.

Perceived risks differ markedly in the ways in which their outcomes can be considered. For example, risk can be characterized as occupational or public health, short-term or long-term, from radiation or hazardous chemicals, acute or chronic, from routine operations or from accidents, and as causes of injury or illness, genetic damage, or death. The processes of weighing the relative importance and trade-offs of one type of risk versus another will be made by decision makers and stakeholders, not by the risk analysts. Consequently, each type of risk, in terms of the specific means of its measurement and estimated cost of abatement, will be separately defined for consideration by affected parties.

Efforts to assess the overall risk to human health posed by contaminated groundwater beneath the Hanford Site have been initiated. To date, this work principally has focused on formulating conceptual and numerical models of groundwater movement beneath the Hanford Site (e.g., Thorne et al. 1993, and Wurstner and Devary 1993). Future work will integrate these groundwater flow modeling efforts with evaluations of contaminant transport and the consequent risk to human health and the environment. The resultant findings will then be evaluated in terms of the relative cost-effectiveness of alternative risk-reduction opportunities (e.g., Tengs et al. 1994). The risks will be assessed in terms of their relationship to the risk posed by all other contaminants likely to remain after completion of Hanford Site remediation, and the projected costs of remediation alternatives versus the risk-reduction benefits.

7.2.2 Interim Performance Criteria and Objectives for Closure with Residual Tank Waste and Soil Contamination

A major unresolved closure strategy issue for SST operable units is how interim performance criteria and objectives will be identified and assigned to help achieve closure. Interim performance criteria are qualitative guidelines for use during the decision-making period before final decisions on remediation are made. Their purpose is to facilitate comprehensive and consistent comparison of risk, costs, and benefits of alternatives proposed for measures that will be used to make comparisons. Interim performance objectives are the quantitative measures that will be used to make the comparisons. The purpose of this section is to describe the analytical framework proposed to compare the risk, costs, and benefits of alternative technologies proposed for final remediation. Use of the framework will facilitate systematic documentation of the linkage among data collection, risk

DOE and its contractors. The discussion associated with Issue 6.06 (Appendix 1A) describes the anticipated closure permit application process.

7.4 PUBLIC VALUES AND PLANS FOR FUTURE INVOLVEMENT

Appropriate vehicles for including the public in all decisions related to the Hanford Site are included in the Community Action Plan for the Tri-Party Agreement (Ecology et al. 1989). In July 1994, the Secretary of Energy issued guidance on public participation in DOE activities (O'Leary 1994). The DOE policy is that the public is entitled to play a role in departmental decision-making. Actions required of the DOE to implement this policy were described as follows:

- Senior management will ensure that department personnel, other Federal, state, and local officials, tribes, and other stakeholders are appropriately integrated into their planning activities and decision-making processes

- Stakeholders and field managers will determine and identify pre-decisional access points for public input.

All closure plans and permit applications will be made available to the general public and stakeholders for review before their inclusion in the Hanford Facility RCRA Permit.

In January 1994, the DOE adopted interim policy guidance for public involvement in the decision process specifically for the TWRS (Anttonen 1994). The guidance described public involvement activities that would be appropriate at three different levels of public interest. Level 1 is the minimum level of public involvement for any TWRS decision. At this level, public involvement objectives are primarily to keep the general public informed, and to provide opportunities for involvement of groups and individuals who have an active interest in the decision. Level 2, which has the same objectives listed for Level 1, increases the public involvement further by providing opportunities for general public comments. Level 3 is the maximum level of public involvement for any TWRS decision. The basic premise of this level is that the issue is of extremely high public interest. The objectives are identical to those of Level 2; however, much more effort will be expended to ensure that the broader public is informed and included throughout the entire decision-making process.

The guidance stipulates that a public involvement plan will be prepared for each major decision, outlining the level of public involvement judged to be appropriate for that decision. Key decisions for completing development of the tank waste remediation mission scope, requirements, and selection of technical solutions have been identified (Johnson 1994). Johnson (1994) describes the decision process, the schedule for making key decisions, and the plan for obtaining public input.

required from each contributor to those actions to comply with the overall closure requirements. This information also will be needed to avoid independent suboptimization of component performance that may lead to unnecessarily costly solutions or less-than-optimal mitigation of total risk.

The analytical process will consider not only long-term radiologic and toxicologic risk to the public and the environment, but also risk to workers from normal operations and postulated accidents during remediation, as well as other work-related risk. These other remediation-related risks include risk associated with processing and transport of the waste, and risk associated with its disposal elsewhere.

7.2.3 Tradeoffs Between Reductions in Long-Term Health Risk to the Public and the Environment, and Increases in Risk to Remediation Workers

An important issue of the closure strategy is how tradeoffs between health risk to the public and the environment, and increased risk to workers implementing the remedial actions will be evaluated. A related question is how this risk-tradeoff information will be used in the decision-making process for closure of the operable units.

As indicated in Chapter 3.0 (Section 3.1.4) of this plan, worker radiation protection is mandated by 10 CFR 835. The principal compliance limit of 10 CFR 835 is 5 rem per year, with exceptions for specialized types of work. DOE Order 5820.2A (DOE 1988c), as supplemented by DOE Order RLID 5820.2A (DOE-RL 1993k), defines the performance objectives for radioactive waste management in terms of long-term protection of public health and the environment. This order also states that the general process for establishing compliance with the performance objectives will involve conducting radiologic performance assessments.

Closure of the six SST operable units requires that decisions be made on the need for specific remedial actions and the manner in which these waste-cleanup actions will be accomplished and that these actions be documented in either a closure plan or a permit application. It is assumed that tradeoffs between short-term occupational health risk and long-term health risk to the public and the environment will necessarily be a major factor in those decisions regarding the work to be performed in order to comply with worker safety requirements.

SST waste will be retrieved as a means of reducing long-term risk to the public and the environment, the recovered waste will require processing, packaging, transportation, and disposal elsewhere. The population of workers needed to accomplish these tasks likely will receive elevated exposures to radiation and hazardous chemicals. Removal of soil contaminated by leaked tanks and decontamination of ancillary equipment is required unless it can be demonstrated that the soil cannot be practically removed or decontaminated. Workers performing these tasks will likely incur exposures to high levels of radiation and hazardous substances.

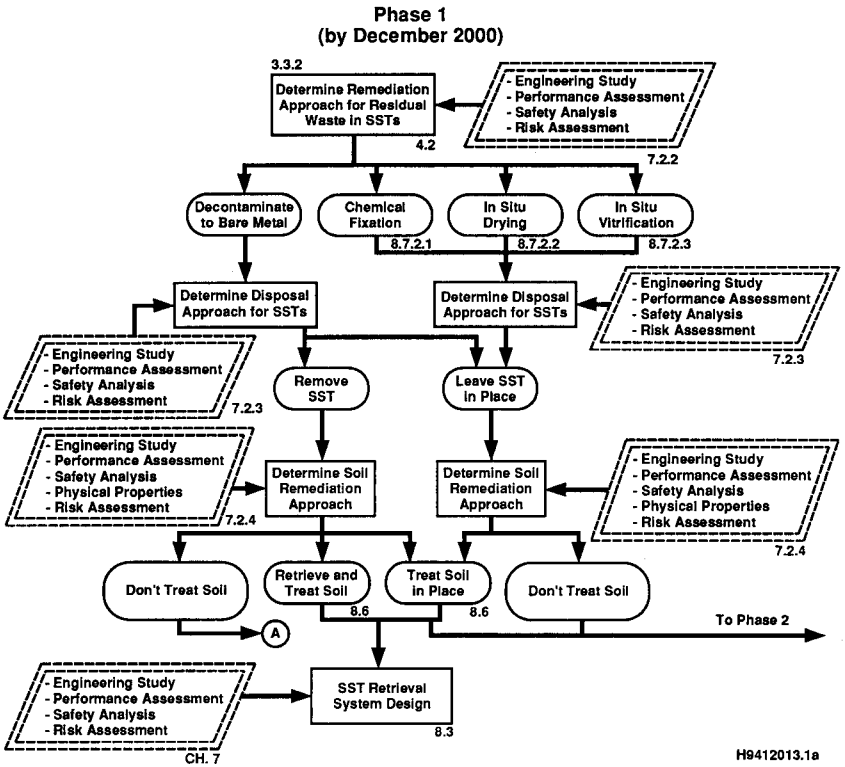

Figure 7-1. Decision Logic: Role of Analyses and Technology in Support of Closure Decisions. (sheet 1 of 2)

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marker system. SST waste would be dried in place. The tanks would be filled with a material suitable for limiting future subsidence. Interim systems for heat removal would be provided, if needed. Though in-place stabilization and disposal would be a permanent disposal action and retrieval would not be anticipated, the fact that the waste was disposed of in this manner would not preclude future generations from intentionally removing the waste for resource recovery or to enhance disposal by some other means.

The in-place disposal alternative is discussed as Issue 6.05 (Appendix 1A). Additional evaluations of this alternative in terms of health risk, technology, and costs are planned.

7.3 ROLES AND RESPONSIBILITIES

Reviewing of the Single-Shell Tank Memorandum of Agreement by the DOE-RL program managers resulted in a statement that they, "...believe that the Hanford mission is best served by amending the Memorandum of Agreement to transfer the ... responsibilities for characterization, assessment, and cleanup of soils and piping for Single-Shell Tank operable units to ... the Office of Waste Management ..." (Wagoner 1994). This recommendation was based primarily on the changes that were made in the 1994 amendments to the Tri-Party Agreement. The implementation of this action places the responsibility for any and all near-term activities associated with the closure of SST farms under the control of the Maintenance and Operations (M&O) contractor.

The responsibility for preparing the CWP was assigned to the TWRS Program Office. The TWRS Program Office was supported by several Westinghouse Hanford (M&O contractor) organizations in completing the CWP. Specifically, TWRS Engineering staff provided engineering and operational subject-matter expertise; Environmental Services staff provided regulatory analysis and permit application services; and the Hanford Technical Services staff provided hydrogeologic and risk assessment services. The M&O contractor will use the services of the Environmental Restoration Contractor (Bechtel Hanford, Inc. (BHI]) and the Research and Development Contractor (PNNL) to implement this work plan.

A team of qualified Hanford Site engineers and scientists prepared this work plan. Approximately half of the participants had prepared previous work plans, thereby providing the necessary continuity and consistency with prior work. The work of this team was coordinated by the Westinghouse Hanford RCRA Closure Plan Group (part of Environmental Services), which has prepared Hanford Site CWPs since 1989.

Although the work has yet to be assigned to implement this CWP, the planning needed to obtain regulatory approval has been defined as discussed in Chapter 3.0. The goal will be to perform closure work in the most cost-effective manner consistent with the Tri-Party Agreement and the Council of Environmental Quality's recommendations, as reflected by the TWRS-EIS (DOE-RL 1994e). Completion of this work will take advantage of the cost saving measures and reduction in duplication that has been performed by the

Figure 7-2. General Risk Conceptual Model.

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CONTENTS

8.0 TECHNOLOGY DEVELOPMENT REQUIRED TO SUPPORT RETRIEVAL AND CLOSURE 8-1

8.1 SINGLE-SHELL TANK WASTE RETRIEVAL 8-1

8.2 SURFACE BARRIER 8-3
8.2.1 Performance of the Hanford Engineered Barrier 8-4
8.2.2 Settlement and Subsidence Considerations 8-6
8.2.3 Graded Approach to Barriers 8-9

8.3 LEAK DETECTION AND MONITORING TECHNOLOGY DEVELOPMENT AND ENGINEERING APPLICATIONS TO SUPPORT CLOSURE 8-11
8.3.1 Leak Detection and Monitoring Functions and Requirements 8-12
8.3.2 Identification and Deployment of LDM Technologies . . . 8-13
8.3.3 Evaluation and Demonstration of Enhanced Surveillance Techniques 8-13

8.4 POSTRETRIEVAL CHARACTERIZATION OF RESIDUAL WASTE 8-16
8.4.1 In Situ Monitoring, Surveillance, and Stratigraphy . . . 8-16
8.4.2 Tank Waste Samples from Multiple Locations 8-17
8.4.3 Deployment Methods for In Situ Sensing 8-17
8.4.4 In Situ Determination of Moisture and Ferrocyanide . . . 8-17
8.4.5 In Situ Measurement of Physical and Rheological Properties 8-18

8.5 CLEANUP OF TANK HULLS, LEAK CONTAMINATED SOIL AND ANCILLARY EQUIPMENT 8-18
8.5.1 Alternatives for Closure of the Tank Hulls, Contaminated Soil and Ancillary Equipment 8-19
8.5.2 Cleanup Methods 8-22

8.6 IMMOBILIZATION AND STABILIZATION OF RESIDUAL WASTE IN TANKS . . 8-27
8.6.1 Residual Waste in Tank and Tank Structure Following Retrieval 8-27
8.6.2 Immobilization and Stabilization 8-28
8.6.3 Immobilization and Stabilization Tank Closure Requirements 8-30
8.6.4 Technology Development 8-31

FIGURE

8-1 Various Single-Shell Tanks F8-1

TABLES

8-1 Typical Single-Shell Tank Retrieval System Requirements T8-1
8-2 Summary of Alternatives T8-2
8-3 Summary of Assumed-Leaker Tanks T8-3.1
8-4 Relative Source Contribution to Carcinogenic Risk T8-4
8-5 Relative Source Contribution to Hazard Index Risk T8-5

8.0 TECHNOLOGY DEVELOPMENT REQUIRED TO SUPPORT RETRIEVAL AND CLOSURE

This chapter provides a summary description of the technology development supporting closure. A brief summary of technology development in support of retrieval also is included. Additional information on the status of retrieval activities can be found in Chapter 5.0. This chapter includes: a discussion of barrier technology (both surface and subsurface); a discussion of leak detection technology; postretrieval characterization; and stabilization and immobilization technologies (e.g., grout and gravel fill) that are under consideration. This chapter will be updated every two years.

8.1 SINGLE-SHELL TANK WASTE RETRIEVAL

In 1992, workshops were conducted at the Hanford Site to formulate technology development strategies for remediating tank waste. The Retrieval Technology Working Group (RTWG) was one of several working groups formed to focus on specific areas of need. The RTWG included representatives from DOE, the private industry, U.S. Bureau of Mines, Lawrence Livermore National Laboratory, Westinghouse Hanford, PNNL, ICF Kaiser Hanford Company (ICF KH), Ecology, and Sandia National Laboratory.

Collectively, the RTWG represented experience in areas such as remote systems, robotics, control system design, sensor system design, conventional mining methods, systems analysis, regulatory analysis, design and construction, hydraulic testing and analysis, and project management. Early in its deliberations, the RTWG adopted a program strategy consisting of the following elements (Krieg et al. 1993):

- Start with known and/or proven technologies (called reference[3] systems). Proven technologies offer the highest probability that the issues can be addressed and system development and deployment accomplished within a reasonable time frame.

- Continue technology development of the reference systems and enhancements[4] to the reference systems.

[3]Reference systems are technologies being investigated that meet program requirements and represent relatively low technical, programmatic, and regulatory risk. Reference systems are based on approaches and concepts that are closest to being considered ready for deployment, or are currently deployed.

[4]Enhancements are generated by identifying technologies that can be built into the reference system to make it better, safer, faster, or cheaper.

- Implement the reference systems on the initial set of tanks. Once the plans for tank waste safety issue resolution, treatment, and disposal are completed, the tank retrieval sequence list will be revised and updated to include any additional tanks to which these retrieval systems are applicable.

- Implement enhancements to the reference retrieval systems when they become available.

- Continue development and evaluation of viable alternatives[5]. The development of alternatives will depend on the available budget and need for alternatives. The need will be driven by the success, or lack of success, or the reference concepts.

- Implement the alternatives as they become available and are needed.

The following is a condensed list of the SST waste retrieval systems recommended by the RTWG:

Reference Systems

- Past practice sluicing retrieval systems (reference hydraulic method)

- Long-reach manipulator arm with mechanical cutter/grabber and confined sluicing end effectors (reference mechanical method).

Enhancements to Reference Systems

- Additional end effectors for arm-based retrieval systems

- Leak mitigation measures for leak collection during past practice sluicing

- Hydraulic mining such as perimeter-jet sluicing and limited mixer-pump retrieval systems.

Alternative Systems

- Stop leak gel/mixer pump retrieval systems

- Hydraulic mining/bore hole mining retrieval systems

- Large tank opening/open pit mining retrieval systems

- Localized melting and waste vaporization retrieval systems.

[5]Alternatives are approaches that differ significantly from the reference system and offer the possibility of major improvements over the reference system, if proven feasible.

The principal features of each of these technologies are described in Krieg et al. (1993). In addition to the technologies listed previously, a number of other concepts were evaluated and determined by the RTWG to be impractical for retrieval of waste from SSTs. These also are identified and briefly described in Krieg et al. (1993).

Tri-Party Agreement Milestone M-45-01 (Ecology et al. 1994) established a requirement to evaluate and select for testing, by September 30, 1994, one or more SST retrieval technologies. To meet this milestone, a summary report was issued describing engineering studies, feature testing, peer reviews, and technology demonstration activities undertaken to develop SST waste retrieval technology and complete scale-model testing (Shen 1994). Shen (1994) summarized the principal design and operating requirements for SST waste retrieval systems, as listed in Table 8-1.

A key element of the SST waste retrieval technology development program, described in Shen (1994), was the integrated technical demonstration in 1991 and 1992 of arm-based retrieval systems using various mobilization and conveyance technologies in a mockup SST test bed. These demonstrations proved the technical feasibility of robotic arm-based retrieval systems capable of performing a variety of in-tank operations. Tests conducted in 1993 and 1994 substantially advanced the understanding of waste dislodging and waste conveyance techniques. As described in Shen (1994), these tests included demonstration of high-pressure water jets for dislodging both sludge and salt cake, and demonstration of jet pumps and blower-powered systems for conveying waste.

The DOE-funded (EM-30, Waste Management Program) SST waste retrieval technology development, as described in the references cited previously, is considered to have advanced to the point that further development and refinement of the reference waste retrieval systems will be conducted by commercial vendors contracted to provide waste retrieval systems for specific SSTs. The first of such contracts will provide the sluicing system under Project W-320 for the in-tank waste retrieval demonstration for C-106 tank, in satisfaction of Tri-Party Agreement Milestone M-45-03-T01, "Complete SST Waste Retrieval Demonstration." The DOE-funded development of enhancements and possible alternatives to the reference waste retrieval technologies will continue as necessary to the point where technology transfer to a commercial vendor is warranted. Several waste retrieval technology development activities under the auspices of the EM-40 Program (Technology Development) in the Tanks Focus Area, Retrieval Projects continue to make retrieval technology data and expertise available to support efforts such as arm-based retrieval.

8.2 SURFACE BARRIER

Contrary to popular belief, surface barrier technology is not a well developed and understood science. The technology is largely unproven and experimental (Daniel 1994). Though the industry continues to engineer surface covers and barriers over waste sites to isolate waste, this practice relies on the technique of 'trial and error' to advance the technology. Because surface

barriers are critical components in isolating hazardous waste sites and controlling the migration of liquid and gas into and out of contaminated areas (i.e., risk management), a more disciplined approach is recommended.

Since issuance of the HDW-EIS in 1987 (DOE 1987a), when the potential value of an effective surface cover was qualitatively presented, a team of Hanford Site engineers and scientists have been working developing the Hanford Engineered Permanent Isolation Surface Barrier (Hanford Engineered Barrier). As a result, the science and practice of constructing an effective, long-term, and maintenance-free barrier for application at the Hanford Site is comparatively well advanced. This work has been defined and peer reviewed (Wing 1994). The monitoring and testing of a prototype barrier is scheduled to be completed in fiscal year 1998, and the technology transfer will be completed shortly thereafter. When this work is completed, the Hanford Engineered Barrier will be available for large-scale deployment at the Hanford Site. Furthermore, completing this work will provide a basis for the future 'downsizing' of the design to better accommodate other applications as deemed appropriate. The concept of downsizing can be applied if all the functions and capabilities that have been incorporated in the Hanford Engineered Barrier are not required to isolate the hazards that are present at a particular waste site. In so doing, a 'graded approach' to the design and construction of surface barriers and covers is proposed for the Hanford Site.

8.2.1 Performance of the Hanford Engineered Barrier

The preliminary performance objectives for the Hanford Engineered Barrier have been documented (Wing 1994) and are summarized as follows:

- Function in a semiarid to subhumid climate
- Limit the recharge of water through the waste to the water table to near-zero amounts (0.05 centimeter [.02 inch] of water per year)
- Be maintenance free
- Minimize the likelihood of plant, animal, and human intrusion
- Limit the exhalation of noxious gases
- Minimize erosion-related problems
- Meet or exceed RCRA cover performance requirements (RCRA Equivalency)
- Isolate waste for a minimum of 1,000 years
- Be regulatory and publicly acceptable.

Evidence of barrier performance will be obtained by conducting laboratory experiments, field tests, numerical modeling, use of analogs, and accelerated stress testing using a prototype test barrier. The design of the prototype

structure is based on information collected over the last several years at the Field Lysimeter Test Facility (FLTF) located on the 200 Areas Plateau and other field-scale and laboratory experimental locations. A synopsis of the work performed to date and future plans has recently been documented (Wing 1994). The design, construction, and testing of the prototype barrier is considered an important element in the evolutionary process because it combines all aspects of the research and development activities that have been performed into a working model. Furthermore, the model is of sufficient size that meaningful data on the constructibility and performance of a full-scale barrier can be collected.

Construction of the prototype structure over the 216-B-57 crib has been directed by the Hanford Environmental Restoration Program and the regulators. This work has been guided by the preparation of a 'treatability test plan' (DOE-RL 1993q). The test plan was augmented by issuing a monitoring and testing plan (Gee et al. 1993) and a program development plan (Wing 1994). As discussed in the monitoring and testing plan, the objectives of the prototype testing are as follows:

- Evaluate the effectiveness of various barrier components individually and as they interact to form a complete engineered system
- Provide large-scale testing of phenomena that are not adequately tested on small-scale field plots, in laboratories, or with lysimeters
- Evaluate multiple, but limited design alternatives for such factors as edge configurations and surface treatments
- Identify instrumentation and measurement systems that enable quantification of barrier performance criteria
- Provide a performance baseline by demonstrating barrier system functionality under stressed and ambient conditions. This involves planning methods to stress the barrier components by simulating extremes in environmental conditions and evaluating the desirability of stressing certain components to failure
- Document the testing and monitoring activities for peer evaluation and critique, regulatory review, and technology transfer
- Obtain 'buy-in' from regulators, end users, and technical peers regarding barrier performance
- Provide a more accurate basis for estimating costs associated with constructing permanent isolation barriers
- Use the information and insights gained from testing activities to direct future barrier development activities.

The prototype design was prepared by ICF KH. An engineering report (Fort et al. 1993) outlines the major design features and provides a schedule for completing the design and construction of the facility. Features included in the design are as follows: two distinct side slope treatments; a surface test area approximately 6,000 square meters that is subdivided into four test sections; catchment facilities (lysimeter pads) located beneath each test section and partitioned side slope treatments to monitor drainage beneath each section; lysimeter pads beneath the composite asphalt layer to monitor drainage; and the construction of a test pad to confirm the permeability of the composite asphalt sublayer. The specific monitoring and testing activities will focus on the following areas of investigation: water infiltration, water erosion, wind erosion, biointrusion, and asphalt testing. A discussion of the test objectives, test description, and anticipated results for each task is available in the testing and monitoring plan (Gee et al. 1993). Additional information on the Hanford Engineered Barrier is provided in Appendix 8A.

8.2.2 Settlement and Subsidence Considerations

This section discusses the importance of settlement and subsidence as they relate to the potential placement of a surface barrier over a tank farm at the time of closure.

8.2.2.1 Settlement. The term 'settlement' refers to a change in ground surface elevation (or other defined datum) in response to the application of a static load, such as the weight of a building structure or a layer of earth fill. Settlement is said to be 'uniform' when all portions of the structure or the fill undergo approximately the same change in elevation. When settlement of a building is nonuniform (i.e., there is 'differential' settlement), shear and flexural stresses develop within the structure, which may lead to visible shifting and cracking of structural and nonstructural elements. Earth fill materials have no strength in tension. Therefore, structures of earthen materials have low shear strength and cannot support flexural stresses. When differential settlement occurs below an earth fill, shearing displacements will take place within the fill to eliminate induced tensile stresses. If the rate of change in settlement with distance across the fill is relatively low, shearing displacements will be taken up by rotational movements between adjacent grains of soil. However, if there is a large amount of differential settlement over a short distance, the deformation within the fill is likely to be confined to a shear plane or zone.

Excessive differential settlement across a tank farm surface barrier could occur because of: (1) compression of fill within the tanks, and/or (2) additional loading of the tank foundations caused by the weight of the tank fill and the weight of the surface barrier. By engineering the properties of the tank fill material, deformation of the fill can be controlled. To do so, the load-deformation response of the fill material to the weight of the surface barrier needs to be established. In an analogous manner, incremental settlement on the tank foundations can be managed to minimize or prevent damage to the surface barrier. For this purpose, it is

necessary to develop an assessment of the loading history and load-deformation response of the subgrade beneath the tank foundations. Regarding the loading history of the subgrade, the following elements should be considered:

- The preexisting loading on the subgrade at the level of the tank footings because of the weight of soil removed for construction of the tanks--As shown in Figure 8-1, the thickness of soil removed varied from 11.3 meters (37 feet) for 1.89-million-liter (0.5-million-gallon) tanks to 15.2 meters (50 feet) for 3.79-million-liter (1-million-gallon) tanks. Assuming a bulk unit weight of about 2 grams per cubic centimeter (125 pounds per cubic foot) (corresponding to a bulk specific gravity of about 2.00) for the soil removed, the subgrade would have been precompressed under a load of approximately 25 to 34 tonnes per square meter (2.3 to 3.2 tons per square foot).

- The loading represented by the existing tanks and footings.

- The maximum weight of contained liquid--The tanks were designed to contain specified volumes of liquid with a specific gravity of 2.00. (Loads could be determined based on heights of liquid column for each tank capacity.)

- The superincumbent weight of existing cover soil, which ranges froma minimum of 6 feet (1.83 meters) over the 1-million-gallon (3.79-million-liter) tanks to 11.75 feet (3.58 meters) over the 55,000-gallon (208,000-liter) tanks--Assuming a bulk unit weight of about 125 pounds per cubic foot (2 grams per cubic centimeter) (corresponding to a bulk specific gravity of about 2.00), the cover soil represents a distributed load ranging from about 0.4 to 0.7 ton per square foot (4 to 7 tonnes per square meter).

- The loading added by backfilling the tanks--The loading on the subgrade will vary with the tank foundation design (i.e., loaded area), the height of the fill, the relative density of the fill (in the case of gravel fill), and the bulk unit weight. A typical unit weight for concrete without reinforcing steel is about 2.16 grams per cubic centimeter (135 pounds per cubic foot). However, light-weight cement/grout formulations (using fly ash, or entrained air) could be used to reduce the weight of grout fill.

- The superimposed weight of the surface barrier--As currently designed, the Hanford Engineered Barrier represents a distributed load of about 12 tonnes per square meter (1.1 ton per square foot).

Differential settlements of the surface barrier across a tank farm is the basis for Issue 8.02 (Appendix 1A).

8.2.2.2 Subsidence. The term 'subsidence' refers to a change in ground surface elevation in response to void volume reduction within the subgrade, as opposed to loading of the ground surface. Subsidence may be initiated by collapse of large individual voids, reduction of void volume within low-

density fill, or biodegradation of organic materials in specific layers. As with settlement, the surface response may be described as uniform or nonuniform. The most exaggerated (i.e., nonuniform) type of subsidence is associated with the collapse of large voids. In such cases, displacement occurs along high-angle shear planes extending upward from the perimeter of the void.

Large subsidence of a surface barrier across a tank farm could occur because of the collapse of unsupported tanks. In recognition of this concern, two alternatives have been considered for providing permanent internal support to individual tanks. Even after the tanks are filled, there could still be a small to moderate amount of subsidence over the tanks under certain conditions. For gravel fill to provide adequate structural support to tanks, the fill must: (1) be placed at a high relative density throughout the tank volume, and (2) support the tank dome without deflection (i.e., head space must be eliminated and fill must be placed with sufficiently high relative density directly under the dome to eliminate potential for dome deflection when the weight of the surface barrier is applied). For grout fill, the chief concern is to eliminate residual head space in the tanks. These concerns must be resolved considering the selected alternative for filling and supporting the tanks.

In the *Tank Waste Technical Options Report* (Boomer et al. 1993), two options were evaluated for stabilization of tanks (i.e., eliminating tank voids with load-bearing fill). The options were to fill the tanks with (1) grout, or (2) gravel. The two options are summarized as follows.

8.2.2.2.1 Fill Tank Void Volume with Grout. According to this option, dry materials (consisting of sand, Portland cement, and fly ash) would be premixed at a batch plant. The dry mix would be transported via truck to one of the two portable mix plants (in 200 East and 200 West Areas), where it would be combined with water and additives (if any) in the correct proportions. Freshly-mixed grout would have a soupy consistency. It would be distributed to the point of use by pumping.

The grout would be introduced into a tank through a dedicated system of distribution pipes. Because of its consistency, the grout would be self-leveling. Tanks would be grouted one at a time. Grout would be introduced in layers of predetermined thickness to optimize the curing process. It is estimated that a 3.79-million-liter (1-million-gallon) tank could be filled in approximately 2 weeks of continuous pumping. However, a longer period may be required to facilitate curing. A portable confinement structure with HEPA filtration would be used during the grouting operation to control radiological contaminants in air displaced from the tanks.

8.2.2.2.2 Fill Tank Void Volume with Gravel. This option calls for introduction of sized, crushed aggregate into tanks using commercial equipment developed for loading bulk solids into cargo ships and large silos. The aggregate would be distributed within the tank by a rotating slinger mechanism (or 'distributor') suspended in the tank from the center riser. The apparatus includes a conveyor system and a hopper situated directly above the distributor. The conveyor would be fed from an adjacent stockpile by a wheel

loader. The equipment is sized for stowing gravel into tanks at a rate of 22.7 tonnes (50 tons) per hour. Some consideration has been given to placement of sacrificial vibrators in critical areas (i.e., areas shrouded by existing hardware or risers) to eliminate voids. As with the previous option, a portable confinement structure with HEPA filtration would be used to control radiological contaminants in air displaced from the tanks during the filling operation.

Mitigation of subsidence of the surface barriers over tanks is the basis for Issue 7.03 (Appendix 1A).

8.2.3 Graded Approach to Barriers

As stated by Daniel (1994), the development of surface barrier technology in the United States has been driven by the promulgation of RCRA regulations. These regulations require that hazardous waste disposal facilities be covered with an engineered cap at the time of closure. The EPA has recommended two cover designs (EPA 1989b) that have been commonly used to close new hazardous waste disposal facilities and for the remediation of the EPA Superfund sites.

However, the application of these designs has resulted in a 'prescriptive' approach to the design and approval of barriers. Specifically, this approach to the design of barriers circumvents the basic purpose and criteria for placement of the cover in the first place. For example, the basic criteria for placement of a cover can be summarized as the need to do the following:

- Provide a low-maintenance cover
- Control, minimize, or eliminate the risk to human health and the environment that would result from the release of the contained hazards.

Though it has been observed that a compacted clay liner covered with soil layers can function as an effective impermeable layer in a temperate climate, it will not be functional in an arid environment. The compacted clay will experience significant drying and cracking in an arid environment. In addition, other observations suggest that the minimum thickness proposed in the standard cover design (61 centimeters [24 inches]) is insufficient in preventing the intrusion of plant roots into the low permeability sublayers in both humid and arid environments.

At the Hanford Site, in addition to the Hanford Engineered Barrier, several other barrier designs have been proposed for use in the closure of waste sites. These include; a family of RCRA Subtitle C covers, a RCRA Subtitle D cover, and a biointrusion cover. A discussion of each barrier is provided in the following paragraphs.

The RCRA Subtitle C cover designs have been designed for use at four locations on the Hanford Site: PUREX, 183-H, Nonradioactive Dangerous Waste Landfill (NRDWL), and low-level burial grounds. Though each of these designs is different, they comply with the technical guidelines issued by the EPA (EPA 1989b) and meet or exceed the design criteria specified in the regulations (10 CFR 61, 40 CFR 264, and WAC 173-303). Of the four designs, the NRDWL design is the most recent development. The NRDWL cover includes six layers and, listed from the top down, includes: a soil thickness of 75 centimeters (29.5 inches), a sand drainage layer of 15 centimeters (5.9 inches), and a geotextile cloth. This design also includes the use of a geosynthetic clay liner (GCL), high density polyethylene (HDPE), and a 60-centimeter (23.6 inches) sand liner beneath the geotextile.

A RCRA Subtitle D cover has recently been designed for the Hanford Solid Waste Landfill. The Solid Waste Landfill design satisfies the criteria specified in the governing regulations. This design consists of a two-layered soil system with a vegetated surface. The total thickness of the barrier as designed is 76 centimeters (30 inches).

In addition to the more typical RCRA designs, a number of conceptual biointrusion barriers have been proposed for use at the Hanford Site. All of the concepts are, however, similar and typically consist of various layers of aggregate and impermeable materials (e.g., asphaltic cement) that overlay a stabilized soil layer that has been treated with organic ligands or polymers that bond the soil into a cohesive media.

To date, with the exception of the Hanford Engineered Barrier, the Hanford Site designs have been driven primarily by regulatory requirements. As a result, the designs are based on performance predictions rather than direct measurements. However, these designs provide a basis from which future designs will evolve. For example, it is assumed that the asphaltic concrete can be used as a substitute for the human-made materials (i.e., HDPE, GCL) when a longer design life and a greater resistance to human and biological intrusion is either desired or required. Also, it is recognized and recommended that the thickness of the barrier be adjusted based on environmental conditions and risk assessment considerations.

In addition, the need for the following information has been cited by Daniel (1994):

- Collect more field data to demonstrate how the use of natural processes (i.e., soils, capillary breaks, vegetation) rather than engineered barriers can be used to limit the percolation of water through the barrier

- Collect more data on the performance of alternative materials to the compacted soil layer

- Determine how much differential settlement surface barriers can withstand before their ability to limit infiltration is compromised

- Document the performance of surface barriers and the individual components or layers.

As presented in Issue 7.04 (Appendix 1A), the performance of the Hanford Engineered Barrier will be directly evaluated by monitoring of the prototype barrier over 216-B-57 Crib. This information will provide a basis for the design of future barriers at the Hanford Site. This information will provide a database that can be used in conjunction with numerical models to predict the performance of various alternative barrier configurations. Aspects of risk and performance assessment modeling will be used to establish the necessary functions of the barrier and to quantify or specify the material type, thickness, and layering sequence for both the various layers and overall structure.

8.3 LEAK DETECTION AND MONITORING TECHNOLOGY DEVELOPMENT AND ENGINEERING APPLICATIONS TO SUPPORT CLOSURE

Primary leak detection techniques currently in use for surveillance of Hanford SSTs are internal methods that record in-tank conditions. Chapter 4.0, Section 4.5 describes the methods and devices that are used for this purpose. Under current, pre-remediation tank farm conditions, these techniques provide adequate and accepted tank status and leak/intrusion information to satisfy existing regulations. The leak detection strategy summarized in Chapter 4.0, represents concurrence from the DOE, Ecology, EPA, and other stakeholders, to accept the current SST (internal) leak detection technologies to meet regulatory requirements. The current approach, however, does not address the need to upgrade or replace existing systems, or search for, and evaluate emerging internal, or external, LDM technologies with improved capabilities. Initiation of remediation activities will change the current operating conditions, and may create situations in which the current surveillance methods and devices are incapable of meeting real or perceived LDM requirements. These future needs are being evaluated within activities that are planned for fiscal year 1995. Topics within planned fiscal year 1995 workscope include the following:

- Determine F&R for SST leak detection and monitoring
- Evaluate present surveillance systems and emerging LDM technologies against established functions and requirements
- Conduct risk assessment, cost benefit, and feasibility review of candidate LDM technologies and develop an implementation plan(s), if indicated by findings
- Evaluate potential expenditures of resources, funds, and time spent on development and application of new technologies, against the capabilities and use of present systems during remediation
- Maintain cognizance of emerging LDM technologies and look for opportunities to evaluate, and possibly deploy, new methods to supplement existing capabilities.

The following sections present information relevant to LDM technology selection and deployment, and describe ongoing and planned LDM-related technology demonstration and testing activities.

8.3.1 Leak Detection and Monitoring Functions and Requirements

Without clearly defined functions and requirements, there is no way to measure the adequacy of existing, or emerging systems and methods, or to evaluate the potential contribution of candidate LDM technologies. A document that addressed functions and requirements for SST leak detection and monitoring (Cruse 1994) was submitted to Ecology in satisfaction of Tri-Party Agreement Milestone M-45-08-T01 ("Provide Preliminary Assessment Report for Projected SST Leakage. Such assessment to project expected environmental contamination and groundwater health risk using existing waste data"). This topic is discussed further in Issue 7.06.

Selection of potential LDM technologies requires a thorough review of established functions and requirements, and a phased approach to evaluate candidate techniques, under realistic field conditions, in order to make deployment decisions. Ideally, the technology evaluation process seeks to develop sufficient initial information to establish confidence that a method will work, as planned, when placed in the field. This is a goal that is supported by the systems engineering approach. Correlation between candidate technologies and Hanford Site LDM needs, however, requires consideration of not only whether the science will 'work,' but other risk and feasibility issues; technical capabilities, implementation and deployment; environmental and regulatory factors; and economic considerations.

Any technology that (1) meets all LDM functions and requirements, (2) successfully completes an initial evaluation and approval process, and then (3) is deployed for service will still, most likely, only be used as a secondary or backup method to internal techniques. Data from any new external LDM methods will be regarded as less conclusive than that provided by existing internal systems. Cross-checks from other corroborating methods will be required to build sufficient operational confidence if a technique is to be used as part of a decision-making process. Even if an 'ideal' external LDM technology could be identified and deployed today, that method would only be used in a secondary role until a reasonable history of performance, and a confidence level, could be established. In fact, under current guidelines, any system deployed in drywells/boreholes or laterals, cannot be used as a primary leak detection system.

8.3.2 Identification and Deployment of LDM Technologies

In the field of leak detection, there are many techniques that operate using a limited number of basic scientific tools. More than 100 candidate LDM techniques exist today in various stages of development and availability (Lewis and Teel 1994). Most 'new' techniques are simply modern, updated, versions of existing LDM science, using more efficient sensors and computing power. Among the currently available LDM technologies there are approximately

30 techniques that have the potential to address Hanford Site needs. Within this group, there are 'families' of LDM technology including borehole geophysics, surface geophysics, borehole-to-borehole geophysics, soil moisture instrumentation, in situ sensors, moisture removal and analysis, and vapor extraction analysis. These technologies are candidates for matchup with SST LDM functions and requirements.

Once LDM technologies are identified, there are major hurdles to cross before consideration for deployment, including a review of data in light of Hanford Site conditions and needs, and an evaluation of feasibility. Success of a technique outside of the Hanford Site does not guarantee success in the tank farms environment. Evaluation and testing of new techniques must include consideration of Hanford Site conditions, including: operational and safety restrictions, restricted drilling and soil access, existing contamination, restricted space, proximity to other tanks and equipment, interference effects from adjacent tanks, and difficult access for maintenance. These conditions will be identified and described within the functions and requirements document. Unknowns regarding leak mechanisms, leak positions, leak volume, and rate of flow also complicate the task of introducing new techniques.

There is a big step between identification of a candidate LDM technology and showing that one will work under Hanford Site conditions. There is a second step to determine if deployment is possible or if the cost of deployment is justifiable. The greatest challenge of leak detection may prove to be the deployment of technology, rather than the identification or development of that technology. Candidate LDM technologies, once shown to satisfy established functions and requirements, would more than likely have to be modified from their off-the-shelf configuration to cope with deployment challenges posed by Hanford Site tank farms. It is also likely that no single technique will provide all the necessary information, and other, companion methods will be needed to back up data or fill gaps in surveillance information. Under such conditions, deployment takes on an even more complicated task in which multiple techniques may have to coexist on the same site, contributing to data, and not detracting from capabilities of other techniques.

8.3.3 Evaluation and Demonstration of Enhanced Surveillance Techniques

Isolated activities are underway to upgrade currently used SST surveillance systems and techniques, and to evaluate new technologies. The following sections provide a brief description of ongoing activities.

8.3.3.1 Acoustic Probe. Salt well pumping and interim stabilization of the SSTs causes the solid surfaces of the waste to become exposed and dry. Loss of surface liquid renders the FIC and manual tape systems ineffective in detecting liquid loss and liquid intrusions. Currently, the only effective methods available to monitor subsurface liquid levels, after tank stabilization, are those that use LOWs. Gamma and neutron probes are deployed in LOWs for this purpose. The precision of these probes is generally limited to 3.05 centimeters ($\pm$0.1 foot) and are further restricted by the angle of

incidence of radiation entering the probe. High frequency acoustic signal techniques could provide assistance with this measurement need.

Acoustic techniques have demonstrated the potential to achieve a higher resolution than currently used, in-tank methods, by sensing the free liquid on the outside of a LOW. Past attempts to develop this method were unsuccessful because of the existence of physical irregularities on the inside surface of LOWs. The rough, irregular, characteristics of the LOWs' surface limited the acoustic transducer's ability to couple (i.e., conduct) energy to the tank contents. This susceptibility to internal surface conditions could be overcome by recent advances in acoustic probe design and the use of broad-band signal generation techniques. Broad-band acoustics, adapted from the geophysics area, are presently being assessed for in-tank and ex-tank liquid sensing and detection, and show potential to overcome the limitations exhibited by other acoustic methods.

A demonstration is currently underway involving the acoustic technique. The TX-114 tank will be fitted with two fiberglass LOWs that will be used to hold source and receiver acoustic probes. Use of two LOWs allows operation of the technique in a 'pitch-and-catch' mode, where the source unit provides the initial signal only and the receiver is dedicated to signal collection.

Previous acoustic methods also required use of polymer LOWs to avoid problems with signal loss/attenuation that resulted in steel LOWs. The new approach is capable of operating from polymer or steel LOWs, or LOWs that may be a combination of metal and polymer. This capability could greatly increase the usefulness of the technique by making currently installed LOWs available for acoustic system deployment.

8.3.3.2 Electrical Resistance Tomography. The Electrical Resistance Tomography (ERT) leak detection technique was tested at a specially prepared, mock-tank, test site in the 200 East Area of the Hanford Site during fiscal year 1994. Demonstration and testing of ERT was carried out in two phases of work. Each phase introduced greater challenges to the technique and provided more and more Hanford Site-like conditions. Phase 1 testing of the ERT technique has been completed (as of August 1994) and Phase 2 testing is ongoing (completion by November 1994). Preliminary data from Phase 1 leak simulation tests have answered basic questions regarding the applicability and potential of the ERT technique to be used as a tool to address Hanford Site leak detection needs. Success at meeting the goals of Phase 1 testing have led to a continuation of support into Phase 2. The technique has shown significant potential as an LDM tool that could play a role in planned SST remediation activities. Following completion of the Phase 2 ERT testing, and evaluation of all data, further demonstration of the technique will be considered. Such future testing activity would be more closely related to actual tank farm or other Hanford Site LDM requirements.

The ERT technique involves application of a relatively simple principle: If a current is applied to soil, the potential difference measured between two points will change if liquids are added to that soil. The degree of change will be greater if the liquids are electrolytes. Leak 'detection' should, therefore, be possible by measuring the potential difference between points in

the soil surrounding the area suspected of containing a leak. Electrical resistance data are collected by using a series of electrode plates placed at different depths below the ground surface in the casing of a borehole.

Resistance data are collected while current is driven through the soil between two adjacent electrodes. The potential difference is then measured, simultaneously, between all other adjacent electrode pairs. This procedure is repeated for all other combinations of adjacent source and receiver electrode positions. Resistance measurement data are stored on a dedicated computer that is part of the ERT support instrumentation.

The ERT data are depicted on tomograms. Tomograms are similar to the data presented by medical diagnostic scans of parts of the body, which show cross-sectional views through different areas. In a similar fashion, ERT tomograms show cross-sectional views, or planes, through the soil beneath a tank and depict the movement of a 'leak' through those planes. The tomographic technique, therefore, is capable of providing a more visual representation of data than obtained with numerical or tabular data alone.

Phase 1 testing goals involved operation of the ERT technique via 16 40-foot (12.2-meter)-deep boreholes, each containing 8 ERT electrodes. Boreholes were drilled in an approximately concentric pattern around a 2/3-scale mockup of a SST. Data were collected during the 'leak' of approximately 4,169 liters (1,100 gallons) of sodium chloride brine solution over a 5-day period. The ERT technique was capable of detecting the presence of the leak at the correct location, at the correct time, discerning the approximate volume of liquid leaked, and following the plume of the leak to the maximum depth of the boreholes. Phase 2 testing involves observation, by ERT, of a 'slower' leak, from a more challenging position on the mock tank. Additional, realistic, difficulties, will be added to the data (e.g., electrical 'noise', cathodic protection) to gain further confidence and information about potential use of the technique in Hanford Site tank farms.

8.3.3.3 Light Duty Utility Arm. The Light Duty Utility Arm (LDUA) is a mobile, remotely controlled, highly dexterous robotic positioning system, designed to access the interiors of underground waste storage tanks. The LDUA is being developed by Westinghouse Hanford and Spar Aerospace Limited (SPAR) under sponsorship of the DOE Office of Technology Development. The LDUA system is highly flexible and adaptive, and provides a platform capable of deploying surveillance, inspection, and waste characterization tools. The system is designed to operate in the highly radioactive environment of waste tanks and can be introduced through existing 30.48-centimeter (12-inch) access riser penetrations.

Hot deployment is planned for fiscal year 1996, in order to support the start of SST remediation activities.

8.4 POSTRETRIEVAL CHARACTERIZATION OF RESIDUAL WASTE

Several technology needs for tank waste characterization have been identified and are documented in the *Tank Waste Remediation System Integrated Technology Plan* (DOE-RL 1994j). While technology needs to support postretrieval, characterization is not specifically addressed; some of the technology development tasks will be applicable to the characterization of the waste remaining in the tanks after retrieval operations are completed. Technology needs for postretrieval characterization need to be identified so that technologies can be made available in a timely manner.

Key technology development deliverables that may be applicable to postretrieval characterization are as follows:

- Technologies for waste surface and volume characterization
- Alternative sampling methods to selectively sample tank waste
- Technologies for in situ sensor placement (cone penetrometer)
- Sensors and methods for in situ measurements (e.g., moisture, ferrocyanide, physical, and rheological properties).

Five technology packages are identified in the integrated technology plan for the above deliverables. They are described briefly in the following sections. Additional information, including cost and schedule, is documented in the integrated technology plan (DOE-RL 1994j). These technologies are intended to complement existing technologies and information (e.g., closed circuit television, still photography, preretrieval sampling and characterization data, process knowledge) that would also be used in analysis, closure engineering development, and closure permitting.

8.4.1 In Situ Monitoring, Surveillance, and Stratigraphy

Several technology initiatives, primarily supported by EM-50 programs, are in progress. The feasibility of applying structure light and laser range-finding technology to detailed surface mapping of tank waste is being investigated. The structured light system may provide high-accuracy detailed surface maps, but because it assumes surface continuity, it is not effective at mapping anomalies such as pipes and deep holes.

The laser range finder is a complementary surface mapping tool that lacks the accuracy capability that the surface light system provides, but it is faster and able to map anomalies. Feasibility studies of applying time domain reflectometry as a means to locate waste material interfaces (e.g., dry solid/wet liquid, organic liquid/water) at depth are being performed. There is also an acoustic monitoring program focused on developing devices to determine waste physical properties during retrieval and to locate objects and discontinuities under the tank.

8.4.2 Tank Waste Samples from Multiple Locations

The ability to sample waste at depth through existing risers, including both selected hot spots and tank bottom residuals sludge and hardpan, is required. Initiatives are proposed to conduct trade and engineering alternative studies to assess both the feasibility of adapting the cone penetrometer technology for tank bottom sampling, and alternative devices (generically referred to as a multi-position sampler) for directional sampling. Examples of alternatives to be investigated include mole devices and adaptation of slant drilling. These systems will be carefully designed to avoid the possibility of breaching containment through penetration of the tank wall or bottom.

8.4.3 Deployment Methods for In Situ Sensing

An in-tank cone penetrometer to be used for sensor deployment is in the planning and design stage. The penetrometer is designed to perform measurements at all waste depths, down to the tank bottom. The penetrometer is planned to be inserted through a 10-centimeter (4-inch)-diameter tank riser using hydraulic pressure provided by the system support truck positioned at the tank riser. The penetrometer itself consists of a tip and a series of hollow segments intended to contain sensors or connections to sensors. The initial sensor package is intended to provide data for the measurement of shear strength, push force, unconfined compressive strength, and pore pressure. Other proposed sensors may provide direct Raman and infrared spectroscopy, spectral gamma, neutron probes, and measurement of moisture and transuranics.

8.4.4 In Situ Determination of Moisture and Ferrocyanide

The primary driver for measurement of the distribution and concentration of moisture, TRUs, and ferrocyanide-containing compounds in waste is to expedite closure of the unreviewed safety questions associated with some of the tanks. In situ characterization technologies also can be employed for other purposes. Deployment of the characterization methods into underground storage tanks will follow the successful demonstration of core sample screening technologies in Hanford Site hot cells.

Copper foil technology is considered relatively mature and adaptable to deployment. This will be a relatively straightforward development for the 'sensing' system, which will be capable of indicating passive and induces neutrons. Moisture detection calibarion will be an early deliverable. Infrared spectroscopy has been successfully demonstrated as a moisture monitoring tool on waste simulants. Following feature tests and qualification in a hot cell environment, it will be ready for technology transfer development for deployment in a penetrometer and/or the LDUA. Raman spectroscopy, when coupled by a radiation-tolerant fiber optic cable, has been demonstrated capable of detecting spectra from real tank waste in a hot cell. From these spectra, it is possible to determine the molecular species present.

This remote chemical analysis capability is also scheduled to be deployed into the tank waste via the cone penetrometer and/or LDUA.

8.4.5 In Situ Measurement of Physical and Rheological Properties

A prototype waveguide sensor for performing in situ measurement of viscosity, density, and temperature using a bench-scale system is under development. Compressive strength of waste will be derived from cone penetrometer readings of tip pressure and friction sleeve resistance during routine deployment operations. The development of a cone penetrometer system for deployment of sensors into Hanford Site underground tanks is targeted for early 1996.

8.5 CLEANUP OF TANK HULLS, LEAK CONTAMINATED SOIL AND ANCILLARY EQUIPMENT

Approximately 67 SSTs have leaked a total volume of 2,271 to 3,407 cubic meters (600,000 to 900,000 gallons) (Hanlon 1994). Table 8-3 provides a listing of the assumed-leaker tanks; the date and volume of material that was leaked from the tank; and a best estimate of the contents of the each tank before the leak. As discussed in Chapter 4.0, the risk of future tank leaks has been reduced using interim stabilization measures.

The ancillary equipment associated with SST operations (e.g., diversion boxes, catch tanks, valve pits, diverter stations, receiver vaults, condensate tanks, French drains, cribs, transfer pipe, equipment leaks, and spill sites) originally were defined in the Tri-Party Agreement as RCRA past practice units. In 1993, the Tri-Party Agreement signatories decided that the ancillary equipment and contaminated soil within the boundaries of the tank farms (assumed to be defined by the fenceline boundaries) would be closed in accordance with WAC 173-303-610. This decision reflects the intent to establish a consistent approach for closure of the TSD units (SSTs) and the RCRA past practice units (the contiguous ancillary equipment and spills) in order toreduce duplication of effort, and thereby reduce time and cost. The Tri-Party Agreement signatories recognize that this reclassification of ancillary equipment is strictly for application of a consistent closure approach and does not impose additional requirements as defined under RCRA interim status (e.g., waste tank integrity testing, provision for secondary containment).

The methods and techniques used to investigate and characterize the contamination in the vadose zone are provided in Chapter 4.0 and Appendix 2A. The methods used to characterize the waste contained in the SSTs were presented in Chapter 4.0. Additionally, an investigation was completed recently in response to a finding from a GAO audit and is summarized in the following paragraphs.

In 1989, the GAO reviewed the DOE's efforts to monitor the movement of leaked waste from SSTs and to assess the environmental impact of the tank leaks. The GAO audit (GAO 1989) concluded that the DOE had not collected adequate data on which informed management decisions could be made or program

priorities established concerning SST hazards or remedial actions. The GAO also stated that the DOE had not provided convincing evidence that the environmental impacts from SST leaks were extremely low to nonexistent. The GAO recommended that the DOE conduct a program to assess the risk of groundwater contamination from leaked mobile and long-lived constituents that have not been monitored directly.

In 1993, an approximate 60-meter (197-foot) borehole (299-W10-196) was drilled 2 meters (6.6 feet) from the side of 241-T-106 Tank. The borehole provided additional data on the location of the leaked constituents. This information will be compared with past data (the leak was characterized in 1973 and 1978) to both determine the relative mobility of the leaked constituents and collaborate previous data on the nature and extent of contamination. Based on data obtained from the 299-W10-196 Borehole, contaminated soil existed down to and slightly below the upper Ringold. A final report on this study is scheduled to be issued by BHI in the near future.

Borehole 299-W10-196 is the first in a proposed series of boreholes drilled or extended to gather data on the contents and extent of tank and ancillary equipment leaks. Continued contaminated soil and ancillary equipment investigations are planned in the future subject to available funding. Additional discussion on the 241-T-106 Borehole characterization activities can be found in Chapter 4.0, Section 4.4.

8.5.1 Alternatives for Closure of the Tank Hulls, Contaminated Soil and Ancillary Equipment

When they are no longer needed to support operations and retrieval, SST systems components and ancillary equipment will be closed in a manner that conforms to the closure performance standards in WAC 173-303-610(2)(a). The standards require that the method of closure provides the following:

- Minimize the need for further maintenance
- Control, minimize, or eliminate postclosure escape of dangerous waste, dangerous constituents, dangerous leachate, contaminated runoff, or decomposition products of dangerous waste to the ground, surface water, groundwater, or the atmosphere to the extent necessary to protect human health and the environment
- Return the land to the appearance and use of surrounding land areas to the degree possible given the nature of the previous dangerous waste activity.

The following three options are available for disposition of the SST system, ancillary equipment, and contaminated soil:

- Retrieval of the SST system, ancillary equipment, and contaminated soil

- Disposal of the SST system, ancillary equipment, and contaminated soil in place

- A combination of the previous options.

Option 1 assumes that all SST system, ancillary equipment, and contaminated soil will be retrieved and disposed of appropriately. If retrieval of the SST system components is determined to be viable, the associated activities would be evaluated to ensure that the occupational health risk did not exceed accepted standards.

Option 2 is based on the assumption that in situ disposal of the SST system, ancillary equipment, and contaminated soil would not exceed negotiated cleanup criteria, and would not permit the escape of residual dangerous and/or radioactive constituents to the ground, surface water, groundwater, or the atmosphere in excess of allowable limits.

8.5.1.1 Retrieval of SST System and Ancillary Equipment. The SST system (tank hulls and internal hardware), and ancillary equipment, could require excavation/removal, packaging, and transportation to an approved disposal site and/or facility. The techniques used to remove the equipment would be governed by the equipment type, location, and integrity, and the radiation levels near, on, and within the equipment. For example, non- to low-level radioactive steel equipment could be disassembled (via plasma torches, arc saws, rod and cable cutting tools) while highly radioactive equipment would require the deployment of remote removal, packaging, and transportation techniques (i.e., robotics). It is uncertain how the residues in the SST shells can be retrieved and what specialized development activities (i.e., reduction of the radioactivity inside the SSTs) would need to be performed in the tanks before dismantling the SST liners (refer to Issue 3.01).

8.5.1.2 Retrieval and Remediation of Contaminated Soil. Before retrieval of the soils, an assessment on the nature and extent of the contamination within the soils would need to be quantified. The information obtained from the assessment would be used to assist decision makers in comparing retrieval and/or treatment options.

The extent of the soil contamination could be determined via existing and future three-dimensional plume maps using the techniques discussed in Chapter 4.0 and Appendix 2A. The data obtained from existing dry wells, cone penetrometers, and a limited number of new deep vadose zone wells could also be used to fill in any geophysical, chemical and radiological, and performance/risk assessment data gaps.

The same mechanical retrieval equipment used to excavate the SST contents discussed in Chapter 5.0 might be used to excavate contaminated soil. It is assumed that much of the contaminated soil will require noncontact and remotely operated systems. Thus, the retrieval equipment would be capable of both digging and lifting soils and debris (e.g., contaminated timbers or piping) out of the excavation area. The retrieved contaminated soils and debris would then be packaged for disposal or would undergo treatment.

Presently, there are several potential alternatives for the treatment (remediation) of the excavated contaminated SST soils. These alternatives are discussed in Section 8.5.2.

8.5.1.3 In-Place Disposal of the SST System and Ancillary Equipment. Retrieval of regulated tanks, waste, and/or ancillary equipment may not be necessary if performance/risk assessments show that the in-place disposal alternative adequately prevents hazardous chemical and radionuclide transport to the biosphere, or if can be demonstrated that the cost associated with retrieval is prohibitively expensive.

In this scenario, void spaces within the SSTs would be filled (i.e., grout) to prevent dome collapse and future migration of residual in-tank waste. The ancillary equipment would also be filled to prevent migration of residual waste residing within the equipment.

8.5.1.4 In-Place Disposal of Contaminated Soils. It is assumed that in-place disposal would include the use of a surface barrier (Section 8.2), possibly in conjunction with in situ treatment of the contaminated soil. Because the SST soils consist of radioactive mixed waste contamination, treatment would consist of fixing the waste in place to reduce the mobility of the contaminants via a barrier that would be placed over the SST system, ancillary equipment, and contaminated soil. The decision to treat the soils, in addition to barrier construction, would be based on the results of the performance/risk assessment. If, after reviewing the results of the performance/risk assessment, it is decided that significantly better long-term (greater than 1,000 years) performance can be obtained by treating the soils, treatment methods would be employed before barrier construction. Possible treatment techniques for fixing waste in place include organic and inorganic grouting and in situ vitrification.

As discussed in Section 8.2, the Hanford Site barrier development team has been organized to develop and demonstrate the performance of protective barrier and warning marker systems for a period of time that extends beyond the institutional control period. The current focus of development efforts is to design protective barrier and warning marker systems that will function in an arid to semiarid climate (e.g., the Hanford Site), limit the infiltration and percolation of water through the waste zone to near-zero amounts, are maintenance free, and will last more than a 1,000 years.

Because the barrier needs to perform for 1,000 years without maintenance, natural construction materials (e.g., fine soil, sand, gravel, cobble, crushed basalt riprap, clay, asphalt) have been selected to optimize barrier performance and longevity. These natural construction materials, most of which exist in large quantities on the Hanford Site, are known to have existed for thousands of years. In contrast to the natural construction materials, the ability of human-made construction materials to survive and function properly for thousands of years is unknown. Because of this uncertainty, human-made construction materials cannot be relied on to perform satisfactorily (or still exist) over several millennia.

Conceptual protective barrier and warning marker system designs are being prepared to satisfy the preliminary performance objectives and control the transport of contaminants via the aforementioned pathways. The barrier and marker system conceptual designs use a number of components integrated into simple and constructible structures. The basis for the conceptual designs will be presented by evaluating how various components of the barrier and marker systems are used to isolate waste from the accessible environment by controlling water infiltration, biointrusion, wind and water erosion, human intrusion, and the release of noxious gases. A more detailed discussion of the surface barrier is provided in Appendix 8A.

Finally, WAC 173-303-610 and -640 require assurance that any contaminants left in place are either immobile or are migrating at such rates that they either would not reach groundwater, or their concentrations would pose no risk to public health and safety if they were to reach groundwater. To accomplish this, a network of groundwater and/or other monitoring wells would be installed. The groundwater and/or other monitoring is expected to continue for at least 30 years and/or beyond, as deemed appropriate by the DOE, regulators, and stakeholders. Also, testing the barrier for assurance that it is performing in accordance with design specifications and regulatory expectations would require vadose zone monitoring.

8.5.1.5 Combined Retrieval and In-Place Disposal of the SST System Components. If performance/risk assessments show that the in-place disposal alternative adequately prevents hazardous chemical and radionuclide transport to the biosphere for some SST system components, while retrieval is best for other SST system components, a combination closure may be implemented.

8.5.2 Cleanup Methods

To date, soil and ancillary equipment cleanup demonstrations and activities have not commenced within the operable units that contain SSTs. Both potential in situ and ex situ treatment and disposal techniques exist for the cleanup of contaminated soil and ancillary equipment.

The potential treatments that might be used to clean up or remediate contaminated soil include both ex situ and in situ methods. Ex situ methods are directed toward physical and chemical separation once the soil has been exhumed. In situ methods rely on soil flushing systems that do not include physical separation.

8.5.2.1 Ex Situ Methods for Soil Cleanup. The methods used to physically separate, wash, and chemically separate contaminated soil require that the contaminated soil be excavated before treatment. Physical and chemical separation processes are classified as follows:

- Soil washing and physical separation
- Separation and chemical extraction
- Separation, washing, and extraction.

The soil washing and physical separation process relies on the governing principle that low radiation levels of contaminated soil can be separated from high radiation levels of contaminated soil on the basis of particle size. Using this process, the contaminated soil is physically scrubbed and separated or segregated by the size of the soil particles. The soil fractions are attrited in order to breakoff and/or scrub the contaminants from the soil particles. Soil washing includes the introduction and use of water under pressure to form jets or sprays that mechanically remove or separate the contaminant from the soil particles.

The separation and chemical extraction process builds on the soil washing and physical separation process. Once the soil is separated into coarse particle fractions, a chemical process is introduced to the wash to strip or extract the contaminants. To remove radionuclides, this could be accomplished by using an acid wash or solvent extraction. Both acid leaching and solvent extraction have been used to extract uranium from ore and to extract radium from uranium mill tailings. Though these processes can be used on unseparated soils, the effectiveness or efficiency of the process is reduced (EPA 1988). Using a chemical extraction process to treat contaminated soils has not been studied at the Hanford Site.

Following the separation step, contaminated soil could be scrubbed with a variety of washing fluids. This wash, followed by a chemical extraction process, would depend on the chemistry of the existing contaminants. Various agents that might be used during the wash include: surfactants, chelating additives, acids, and alkaline solutions. Washing solutions are typically aqueous solutions (caustic lime, slaked lime, or industrial alkali-based washing compounds); acidic aqueous solutions (sulfuric acid, hydrochloric, nitric, citrus, or phosphoric acid); or solutions with either surfactants or chelating agents. Oxidizing agents, such as hydrogen peroxide, and sodium hypochloride could also be introduced. The use of strong chemicals is discouraged because they could create a hazardous by-product that would require treatment.

Two studies have been performed at the Hanford Site to examine the potential for physical separation. One study examined the potential to isolate and treat soil contaminated with uranium near the 300 Area. The system that was developed to physically separate uranium-235 and -238 was successful and met the test objectives without using chemical treatment (DOE-RL 1993b). Specifically, the concentration of uranium was significantly lower in the coarse fraction of the soil (12 picocuries per gram for greater than 0.425 millimeter particles and 94 picocuries per gram for less than 0.425 millimeter particles). In addition, the concentration of copper was reduced in a similar manner.

A second study is ongoing to evaluate the potential for separating cesium from contaminated soil taken from the 116 B-1 trench in the 100 Areas. This system will use physical separation as a first step. The fine fractions will be mechanically scrubbed (attrited) once the material is separated. An electrolyte consisting of citric acid and ammonium citrate will be added to

the wash. Based on bench-scale tests, the citric acid dissolves the iron allowing the cesium to dissolve in solution. Pilot-scale testing will begin in fiscal year 1995.

8.5.2.2 In Situ Methods for Soil Cleanup. An alternative to excavation and treatment of the contaminated soil is to treat the contaminated soil in situ. In situ treatment uses chemical or biological agents or physical manipulation of the soil to either degrade, remove, or immobilize the contaminants. In situ treatment technology is less developed than ex situ treatment technology. In the following sections, biological and chemical in situ treatments are discussed. These two treatments will have limited application during the remediation and closure of the SSTs.

8.5.2.2.1 Biological. Bioreclamation is a technique for treating zones of contamination by microbial degradation. The concept involves altering the environmental conditions to enhance microbial catabolism. The primary application for bioreclamation is to break down organic compounds that are considered hazardous. Microbial degradation can occur through the processes of aerobic digestion, anaerobic digestion, and fermentation. Environmental factors, such as pH, redox potential, oxygen concentration, temperature, and nutrients can and will affect microbial activity. Microorganisms, like all living organisms, require specific inorganic nutrients, carbon, and energy to survive. These factors or elements must be present for bioreclamation to be successful.

A limited number of investigations have been performed at the Hanford Site to test the feasibility of using bioreclamation as a technique for treating waste. Bioremediation in both an ex situ and in situ treatment process has been considered in these investigations. In the removal of carbon tetrachloride from the soil and groundwater in the 200 Areas, the use of bioremediation techniques to break down the carbon tetrachloride in a pump and treat mode of operation has been investigated. To date, most applications at the Hanford Site have addressed the use of bioreclamation to address the breakdown or detoxification of hazardous organic compounds.

The limited characterization of the contaminated soil created by SST tank leaks indicates that the primary hazards result from radionuclides and inorganic metals and compounds. Therefore, it is assumed that bioremediation techniques will be limited to applications that use microbial agents to either release or immobilize the inorganic contaminants.

8.5.2.2.2 Chemical. The in situ chemical treatment of contaminated soils, whereby contaminants are mobilized, is termed 'soil flushing'. Chemical treatment can also be used to immobilize or detoxify the hazard. Flushing agents include surfactants, dilute acids, and water. Detoxification agents include oxidation, reduction, neutralization, and hydrolysis. It is assumed that the characteristics of the SST waste (e.g., heavy metal, salts) would be best addressed using chemicals to either flush or immobilize the hazard.

The feasibility of using in situ treatment technology is governed by: (1) the soil characteristics of the site, (2) the characteristics of the waste, and (3) the site hydrology and geology. Because the application and chemical reaction of chemical treatments are somewhat unpredictable, the use of chemicals must be tested thoroughly before field-scale applications can be performed. Therefore, the use of chemical treatments at the Hanford Site has been discouraged. If the contamination resulting from tank leaks requires removal of the contaminants from the soil, factors such as operator safety and economics may force the use of some form of in situ chemical treatment (i.e., soil flushing).

The feasibility of using various reducing agents to immobilize chromium in Hanford Site soils has been studied by Thornton et al. (1991). In a bench-scale experiment, it has demonstrated that ferrous sulfate and sodium sulfide could be used to immobilize hexavalent chromium in Hanford Site sediments and groundwater.

Vacuum extraction is being used to remove carbon tetrachloride from the soil and groundwater beneath the 200 Areas Plateau. It has been proposed that surfactants be used during the next phase to increase the solubility of the contaminant. Alcohol may be used for this purpose, though no decision has been made.

8.5.2.3 Physical Manipulation. If the contaminants cannot be removed, they might be fixed in place. Monolithic encapsulation or entombment might be accomplished through in situ vitrification, soil heating, soil freezing, or grouting. A passive system would be preferred over an active system. Therefore, it is assumed that either in situ vitrification or in situ grouting would be preferred.

8.5.2.3.1 In Situ Vitrification. In situ vitrification is a thermal treatment technology being developed for remediation of contaminated soils. This process transforms contaminated soils into a leach-resistant, vitreous, and crystalline monolith. The process is applicable to a wide range of soil types and contamination (e.g., hazardous, dangerous, radioactive, mixed waste). Preliminary tests have been performed on the Hanford Site; however, additional investigations need to be conducted at greater depths to determine the feasibility of using in situ vitrification on the SST soils. The stabilization of contaminated soil using in situ vitrification has been demonstrated on the Hanford Site and elsewhere.

8.5.2.3.2 Grouting. Grouting involves the addition of materials (e.g., Portland cement) to the soils in an attempt to fix the mobile radioactive and chemical constituents within the soil, thus preventing further migration of contamination into the soil column or groundwater. Preliminary tests have been performed on mixed waste (located at the Hanford Site) and the results confirm that grouting can serve as a fixative.

A monolithic block of waste could be formed by injecting either a chemical or cementitious grout into the contaminated soil. In situ grouting would likely require a more complete characterization of the contaminated soil before injecting the material. Chemical grouts are better suited for fine-

grained soil with small pores, while cement grouts might be better for coarse-grained material, though both methods could be used. In this case, the cement grout would be applied first, followed by an application of the chemical grout to fill the 'fine' open matrix that may exist.

8.5.2.4 Cleanup of Ancillary Equipment. The ancillary equipment will either be stabilized in place or excavated and removed. Once it has been exhumed, it will either be repackaged and/or processed and readied for disposal, or rehabilitated.

In situ stabilization of ancillary equipment will include the filling of all voids with a solid material. The selection of a solid material will be based on the appropriate functions and requirements. In some cases, it may be necessary to fix or immobilize the contamination present. The immobilization could be augmented by the appropriate sequestering agents, such as zeolites, that could chemically bond with the contaminants. Both chemical and cement grouts could be used for stabilization.

Removed equipment could either be processed and packaged for disposal as dangerous or mixed waste or rehabilitated for reuse. Methods for removing, decontaminating, transporting, treating, storing and/or disposing of contaminated equipment will be described in appropriate detail in future revisions of the *Single-Shell Tank Closure Work Plan.* Equipment designated for disposal as waste would be subject to the land disposal restrictions (LDR) in WAC 173-303-140 if restricted or prohibited constituents are present in/on the equipment. Some type of treatment or decontamination may be necessary prior to disposal to reduce or eliminate the restricted or prohibited constituents. The alternative treatment standards for hazardous debris in Table 1 of 40 CFR 268.45 could be used to determine specific decontamination methods and criteria. Decontamination of waste equipment also may be undertaken for the purpose of radiation reduction, without the intent of meeting the performance standards in 40 CFR 286.45 or of exiting RCRA regulation. Waste equipment that is classified as mixed waste will not necessarily be decontaminated to meet the performance standards in 40 CFR 286.45.

In some cases, it may be desirable and cost effective to rehabilitate the equipment. Techniques such as sand blasting and ice blasting are available for this purpose. Tradeoff studies on the potential reuse of ancillary equipment and the methods that can be used to rehabilitate the equipment are beyond the scope of this CWP.

8.6 IMMOBILIZATION AND STABILIZATION OF RESIDUAL WASTE IN TANKS

Definitions and scope are given for the subject activities in Sections 8.6.1 and 8.6.2. The results of a recent risk analysis are given to show cause for the investigation of immobilization and stabilization technologies described in Section 8.6.3. Past technology assessments are not defined in sufficient detail to determine if these activities are nested beneath top-level technology development issues cited in Section 8.6.4.

8.6.1 Residual Waste in Tank and Tank Structure Following Retrieval

Residue following retrieval may be located in the tank, between the tank steel and concrete foundation, or within the tank concrete.

The residual waste in tanks is the waste left inside the tank's steel structure following waste retrieval. The amount of residual waste allowed by Tri-Party Agreement Milestone M-45-00 is 10.2 cubic meters (360 cubic feet) for 22.85-meter (75-foot)-diameter tanks and 850 liters (30 cubic feet) for 6.1-meter (20-foot)-diameter tanks. This would amount to approximately a 2.5 centimeter (1-inch)-thick layer on the bottom of each tank if all the residual waste settled to the bottom of the tanks. The characteristic of this residual is likely to be the tank 'heel', a hard cement-like crust adhering to the tank bottom and sides, or it may be sludge or liquid.

Any tank that has leaked waste to the sediments through its base is also likely to have a void space between the tank steel and concrete foundation, partially filled with liquid waste. The void space is assumed to exist because of the rough finish of the concrete base and because of warpage induced by welding the sheets of steel that form the steel bottom.

Any tank that has leaked waste to the sediments is assumed to have its concrete shell exposed to contamination by advective and/or diffusive mechanisms. The void space described in Section 8.6.1.1 is assumed to be connected hydraulically to a head of interstitial liquid contained in the tanks. The head of liquid on the concrete is assumed to be the driving force for advection of interstitial liquid waste into the concrete in accordance with Darcy's law.

After retrieval operations are complete, residual waste in the steel tank, residue between the steel tank and concrete foundation, and residue in the concrete shell (foundation), are expected sources for future soil contamination.

8.6.2 Immobilization and Stabilization

If the Tri-Party Agreement goals for waste retrieval can be achieved (i.e., reduction of residual waste volume to within 33.4 cubic meters (360 cubic feet) per tank for series 100 tanks or 2.8 cubic meters (30 cubic feet) per tank for series 200 tanks), the residual waste volumes would be so small that immobilization or stabilization of the residuals as an aspect of closure would not be regarded to contribute materially to closure performance. Conversely, if the Tri-Party Agreement goals for waste retrieval are not achievable, then immobilization and stabilization technologies, such as those discussed in this section, could be incorporated into the closure strategy for SSTs to provide the additional isolation capabilities needed to assure adequate long-term performance of the closure system.

When the terms immobilization and stabilization are applied to the residual waste, they have nearly the same definition because of their common objective to mitigate release of the contaminants to the environment.

Immobilization techniques serve to immobilize contaminants in place or at least greatly slow their migration toward groundwater. The contaminants are not removed, but immobilized. The techniques are broadly placed in two categories: chemical and physical. Chemical immobilization techniques react with contaminants to bind them in place, while physical immobilization techniques change the structure of the area to keep the contaminants from moving.

Stabilization techniques are not applied directly to the residual/residue waste, but are applied to the 'empty' tanks. Filling the tank void space with stabilizing materials (i.e., grout, sand, or gravel) helps maintain the structural integrity of the tank by preventing catastrophic collapse from deterioration, earthquakes, or other external loads, thereby slowing migration of the contaminants out of the structure.

There are no requirements and no technology development plans at this time to immobilize and stabilize residual tank waste (Sections 8.6.3 and 8.6.4). However, if such requirements materialize, it is likely that immobilization and stabilization are based on technologies described in the following sections.

8.6.2.1 Chemical Fixation (Immobilization and Stabilization). In situ chemical stabilization (ISCS) combines the tank waste with chemical adders and grout to provide a stable matrix. In-tank mixing would mechanically combine the SST waste with a grout mixture. Soil immobilization equipment mixes the waste and grout together. The facilities designed for retrieval positions immobilization equipment in the tank.

The goal of grouting is to increase the stability of the waste zone to increase the time required for the material to reach the environment and to slow the rate of release. The grout would reduce the mobility of the waste and would combine with the nitrates to remove the nitrates reactive state. Grout would fill the tank so that the tank interior would make up the waste zone. This filling eliminates the need for the dome filing operation.

The grout mixture includes chemical adders that combine with the components of the salt cake and soluble sludge. Additionally, the presence of more material in the tanks would increase the diffusion path of components that dissolve and move out of the waste zone. Most of the sludge does not require chemical stabilization because the insoluble sludge components would not readily dissolve. The soluble fraction of the sludge also has an increased diffusion path.

The mixing equipment selected (auger with grout injection) ensures complete mixing of the waste and adders. Other mixing concepts may work, but use of these concepts requires further evaluation. The large-opening retrieval system (Chapter 5.0) allows adequate access to the waste to employ the auger system.

8.6.2.2 In Situ Drying. In situ drying is the removal of liquid in the vapor phase from the tank residue. Sludge contains the majority of the interstitial liquid because of capillary pressure. Removal of liquid from the sludge and salt cake requires a technique that introduces energy into the waste. Several methods for liquid removal are considered. These methods include the following:

- Heated air forced through the salt
- Resistance heating
- Alternating-circuit conduction heating
- Electroosmosis
- Induction heating
- Microwave or radio frequency heating.

Heated air has not proven acceptable because of excessive pressure required to force large air volumes through deep layers of dry salt. Resistance heating has not proven acceptable because of the poor heat transfer characteristics of dried salt cake; a dry cylinder of salt forms around any resistive heater. The inner temperature required to drive heat through the encircling dry salt cylinder becomes excessive as the dry salt cylinder radius becomes large in comparison to the heater element radius.

Conducting heat has been demonstrated for small volumes but not for large volumes of material. The power required increases by the square of the radius from the electrode. This leads to excessively high current densities close to the electrodes for large inter-electrode distances. Electroosmosis has not been accepted because of the low mobility of liquid water through salt at low moisture concentrations, and the difficulty in maintaining an effective electric field over large salt volumes. Induction heating is also an undemonstrated technology for million-gallon-waste volumes.

Microwave or radio frequency heating are the most effective ways to introduce energy into the waste. Early development using microwave frequencies shows that dry salt cake attenuated 50 percent of the microwave energy within a few centimeters. Preliminary data indicate that in the radio frequency ban, dried salt cake will be transparent to radio frequency energy. This will allow the radio frequency energy to be transmitted through the dried upper layers of waste with low attenuation down to the lower wet layers.

8.6.2.3 In Situ Vitrification. In situ vitrification (ISV) uses resistive heating to melt the waste in place. The resulting vitrified mass provides a stable matrix for the long-term disposal of the SST waste. The high temperatures from vitrification causes the decomposition of a majority of the waste (nitrates and organics) leaving oxides of nonvolatile species in the matrix.

The high temperature involved in application will cause decomposition of organics and nitrates in the waste. Most nonvolatile components would remain in the glass with a portion of this material carried over in the offgas. This combination phenomena would reduce the hazard of the material. Tests on simulated material has shown the glass to exceed the requirements of toxic concentration leach procedure.

The current full-scale equipment design uses fix electrodes. Technologists have proposed two new design concepts: moving and hot-tipped electrodes. Moving electrodes eliminate expensive electrodes, which require placement before melting begins. Hot-tipped electrodes concentrate power at the bottom of the melt, which improves melt efficiency. The site preparation depends on the containment system employed. The containment system will encompass the entire tank farm, a row of tanks, or a single tank. The larger containments provide more volume to control any releases from operations in the tanks. Regardless of the containment systems employed, the process steps remain unchanged.

8.6.2.4 Discussion. These three techniques are based on the inherent assumption that all in-tank hardware and riser pipes are removed. The decision to remove the in-tank hardware and riser pipes has not been made. Also, each technique requires that the residual waste be penetrated and in some cases agitated. This may be difficult when there is only a small depth of hardened 'heel' left in the tank. Therefore, the application of these techniques is questionable until their technology development is explored.

8.6.3 Immobilization and Stabilization Tank Closure Requirements

Immobilization and stabilization are postretrieval activities whose requirements would come from the tank closure system functional decomposition. A systems requirement for residual/residue tank waste immobilization and stabilization has not been identified at this time. However, a feasibility study of tank leakage mitigation using subsurface barriers was conducted (Cruse et al. 1994a). Using tank residual waste, residue between tank and concrete, residue in concrete, and old and new leaks into the soil, as contaminant source terms, the source risk contributions and hazard index contribution were calculated. The results are given in Tables 8-4 and 8-5. The basis for these results assumes that waste within the confines of the tanks would be mobilized by surface water recharge (i.e., no surface barrier). The results show that tank residual waste relative contribution is 37 percent to the cancer and health index risk. It appears from these results, that stabilization and immobilization of in-tank residues warrant investigation.

8.6.4 Technology Development

Boomer et al. (1993) reported on technology development tasks formulated to resolve key technical issues on disposal system functions. Under the priority 1 task "Evaluate In Situ Tank Farm Closure Processes," subtask "Evaluate Methods for Stabilizing Underground Tank Farm Structures" is identified. This subtask focuses on stabilizing the tank structure with either grout, gravel, or sand. There are no specific tasks identified for immobilizing residual/residue tank waste.

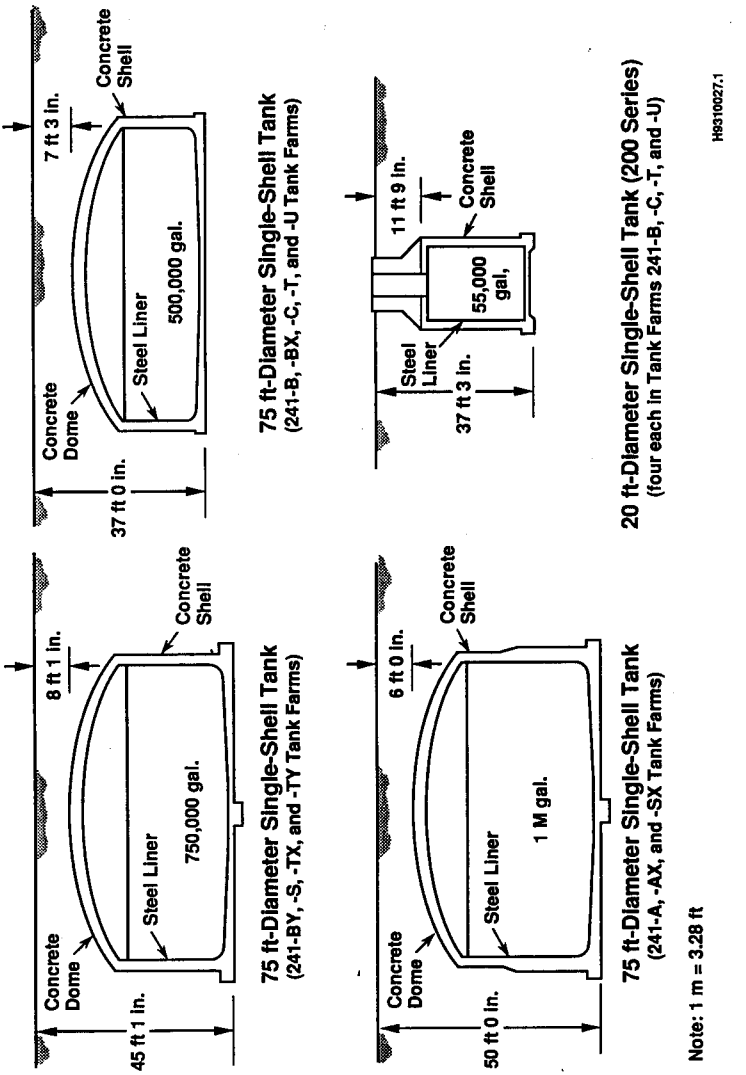

Figure 8-1. Various Single-Shell Tanks.

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Table 8-1. Typical Single-Shell Tank Retrieval System Requirements.

Attribute	Requirement
Radiological release criteria	Shall meet criteria specified in the Hanford Site radiological design manual for releases to the environment (HSRCM-1 1994)
Operating conditions	Must perform intended function under the conditions that exist in the tank
Operating temperature	Must not increase the temperature of the waste above 240 °C (464 °F) at the waste-tool interface
Equipment removal	Shall include features that will allow controlled removal of the equipment from the tank after failure
Decontamination (for equipment removed from the tank)	Shall include features that aid in decontamination and minimize material buildup
Ventilation	Shall not preclude operation of an active ventilation system on tanks in which it is required
Radiation resistance	Materials shall function at a total exposure of 10^7 R gamma
Waste tank confinement	Shall not damage or breach the SST liner
Location of waste	Shall be capable of removing waste from any area within the storage volume of the SST
Removal rate	Average continuous removal rate for undiluted waste shall be 114 liters (30 gallons) per minute
Equipment control	The equipment shall be operated remotely
Pipe cutting capability	Shall be capable of cutting pipes from 1.3 centimeters (0.5 inch) to 107 centimeters (42 inches) in diameter (if required for waste retrieval or closure)
Retrieval capability	Shall provide retrieval for waste from liquids, to thick, stiff sludges, to hard, concrete-like salt cake
Waste transport	Shall be capable of transporting all forms of retrieved waste to the surface of the ground above the SST
Maximum loads	Maximum allowable loads on the soil above the tank dome over a minimum 3-meter (10-foot) radius are 45,400 kilograms (50 tons) for the 200 series tanks 6-meter (20-foot) diameter and 91,000 kilograms (100 tons) for the 100 series tanks 22-meter (75-foot) diameter
Loads against tank	Shall not impose mechanical loads on the tank liner or dome during retrieval
In-tank obstructions	Shall be capable of removing in-tank obstructions and solid debris (if required for waste retrieval or closure)
Waste properties	Shall be capable of pumping abrasive fluids at 114 liters (30 gallons) per minute
Operating time	Shall support the required production rates
Humidity, atmospheric pressure, and temperature	Shall operate at atmospheric pressure, relative humidities up to 100%, and the following temperatures: • Waste contacting: 10 °C to 149 °C (50 °F to 300 °F) • In tank/out of waste: 10 °C to 66 °C (50 °F to 150 °F) • Out of tank: -18 °C to 66 °C (0 °F to 150 °F)
Dose rates	Maximum dose rates to operations personnel shall not exceed 0.2 millirem per hour

NOTE: This dose rate limit is specified to ensure that areas that will be continuously manned during retrieval operations are not required to be posted radiation zones under the Hanford Site radiological control standards (Shen, E. J., 1994, Development and Testing of Single-Shell Tank Waste Retrieval Technologies, Milestone M-45-01 Summary Report, WHC-EP-0807, Westinghouse Hanford Company, Richland, Washington).

Table 8-2. Summary of Alternatives.

Alternative	Waste retrieval type	Assumed tank waste retrieval effectiveness	Subsurface barrier type	Old leaks flushed?	New leaks flushed?	Tanks stabilized?	Surface barrier used?
1. No Action	None	0%	None	No	No	No	No
2. Surface Barrier Only	None	0%	None	No	No	No	Yes
3. Traditional Sluicing (Baseline)	Traditional sluicing	99%	None	No	No	Yes	Yes
4. Robotic Sluicing	Robotic sluicing	99.9%	None	No	No	Yes	Yes
5. Mechanical Retrieval	Mechanical retrieval	95%	None	No	No	Yes	Yes
6. Close-Coupled Chemical Barrier with Flushing	Traditional sluicing	99%	Close-coupled	Yes	Not applicable	Yes	Yes
7. Close-Coupled Chemical Barrier w/o Flushing	Traditional sluicing	99%	40% None 60% Close-Coupled	No	No	Yes	Yes
8. Modified Close-Coupled Chemical Barrier w/o Flushing	Traditional sluicing	99%	Vertical Close-Coupled	No	No	Yes	Yes
9. Box-Shaped Chemical Barrier	Traditional sluicing	99%	Box-shaped chemical	Yes	Yes	Yes	Yes
10. V-Shaped Chemical Barrier	Traditional sluicing	99%	V-shaped chemical	Yes	Yes	Yes	Yes
11. V-Shaped Freeze Wall Barrier	Traditional sluicing	99%	V-shaped freeze wall	Yes	Yes	Yes	Yes
12. Circulating Air Barrier	Traditional sluicing	99%	Circulating air	Yes	Yes	Yes	Yes
13. Clean-Closure w/o Subsurface Barrier	Traditional sluicing & mining	100%	None	No	No	Not applicable	No
14. Clean-Closure with Close-Coupled Chemical Barrier	Traditional sluicing & mining	100%	40% None 60% Close-Coupled	No	No	Not applicable	No

Table 8-3. Summary of Assumed-Leaker Tanks. (sheet 1 of 3)

Tank	Year leaked	Current status	Estimated leak volume (gal)	Waste in tank before leakage
103-A	1987	IS/IP	5,500	DSSF, NCPL, P, IX, B (20,819.7 liter)
104-A	1975	IS/IP	500 to 2,500	PSS, B, P (9463.5 liter)
105-A	1963	IS/IP	10,000 - 277,000	P, IX (37,854 - 1,048,559 liter)
102-AX	1988	IS/IP	3,000	CCPL, B, P (11,356 liter)
104-AX	1977	IS/IP	*	P
101-B	1974	IS/IP	*	BLEB, CWP, EB
103-B	1978	IS/IP	*	EB, CW, TBP, IX, R, BNW, N, LW, DW, OWW, BL
105-B	1978	IS/IP	*	EB, 1C, 2C
107-B	1980	IS/IP	8,000	EB, CW (30,283 liter)
110-B	1981	IS/IP	10,000	FP, 5-6, EB, BL, 2C, 1C, BFSH (37,854 liter)
111-B	1978	IS/IP	*	FP, IX, 2C, 1C, 5-6, EB
112-B	1978	IS/IP	2,000	IX, EB, 2C, 1C, 5-6, FP (7,571 liter)
201-B	1980	IS/IP	1,200	224 (4,542 liter)
203-B	1983	IS/IP	300	224 (1,136 liter)
204-B	1984	IS/IP	400	224 (1,514 liter)
101-BX	1972	IS/IP	*	TBP, CW, EB, BL, OWW, RIX, SIX, IX
102-BX	1971	IS/IP	70,000	TBP, CW, EB, BL, OWW, CW (264,979 liter)
108-BX	1974	IS/IP	2,500	1C, TBP, CW, IX (9,464 liter)
110-BX	1976	IS/PI	*	EB, CW, IX, 1C
111-BX	1984	PI	*	EB, CW, IX, 1C
103-BY	1973	PI	<5,000	EB, TBP, P, CW, OWW (<18,927 liter)
105-BY	1984	PI	*	EB, TBP, CW
106-BY	1984	PI	*	EB, 1C, TBP, CW
107-BY	1984	IS/IP	15,100	EB, 1C, TBP, CW (57,160 liter)
108-BY	1972	IS/IP	<5,000	EB, 1C, TBP, CW (<18,927 liter)
101-C	1980	IS/IP	20,000	TBP, CW, P (75,700 liter)
110-C	1984	PI	2,000	CW, RIX, EB, TBP, 1C, OWW, IX (7,571 liter)
111-C	1968	IS/IP	5,500	EB, HS, CW, FP, SSW, TBP, 1C (20,820 liter)
201-C	1988	IS/IP	550	HS, SSW (2,082 liter)
202-C	1988	IS/IP	450	HS, SSW (1,703 liter)
203-C	1984	IS/IP	400	HS, SSW (1,514 liter)
204-C	1988	IS/IP	350	HS, SSW

Table 8-3. Summary of Assumed-Leaker Tanks. (sheet 2 of 3)

	Tank	Year leaked	Current status	Estimated leak volume (gal)	Waste in tank before leakage
1	104-S	1968	IS/IP	24,000	R, CWR (90,960 liters)
2	104-SX	1988	PI	6,000	EB, PNF, DSSF, RIX, R (22,740 liters)
3	107-SX	1964	IS/IP	<5,000	R (<18,950 liters)
4	108-SX	1962	IS/IP	2,400 to 35,000	R (9,096 to 132,650 liters)
5	109-SX	1965	IS/IP	<10,000	R (37,900 liters)
6	110-SX	1976	IS/IP	5,500	R, RIX, EB, BNW, BL, 224, IX (20,845 liters)
7	111-SX	1974	IS/IP	500 to 2,000	EB, RIX, R (1,895 to 7,580 liters)
8	112-SX	1969	IS/IP	30,000	R (113,700 liters)
9	113-SX	1962	IS/IP	15,000	R (56,850 liters)
10	114-SX	1972	IS/IP	*	R
11	115-SX	1965	IS/IP	50,000	R (189,500 liters)
12	101-T	1973/1992	IS/PI	7,500	BL, R, BNW, EB, CW, DW, 224, RIX, TBP (284,250 liters)
13	103-T	1974	IS/IP	<1,000	CW, R, RIX, EB, BL, IX (<3,790 liters)
14	106-T	1973	IS/IP	115,000	CW, IX/ DW, 2C, 1C, BL (435,850 liters)
15	107-T	1984	PI	*	IX, TBP, CW, 1C
16	108-T	1974	IS/IP	<1,000	1C, TBP, EB, HLO, IX, BNW, BL (3,790 liters)
17	109-T	1974	IS/I1	<1,000	1C, TBP, EB, IX, BL, BNW (3,790 liters)
18	111-T	1984	PI	<1,000	2C, 224 (3,790 liters)
19	105-TX	1977	IS/IP	*	EB, R, IX, OWW
20	107-TX	1984	IS/IP	2,500	EB, R (9,475 liters)
21	110-TX	1977	IS/IP	*	EB, TBP, 1C
22	113-TX	1974	IS/IP	*	EB
23	114-TX	1974	IS/IP	*	EB, 1C
24	115-TX	1977	IS/IP	*	EB, R, DW, CW
25	116-TX	1977	IS/IP	*	EB
26	117-TX	1977	IS/IP	*	EB
27	101-TY	1973	IS/IP	<1,000	R, 1C, TBP (3,790 liters)
28	103-TY	1973	IS/IP	3,000	CW, R, 1C, TBP, DW, IX/ BL, OWW, EB (11,370 liters)
29	104-TY	1981	IS/IP	1,400	TBP, 1C, DW, R, RIX, BL, OWW (5,306 liters)
30	105-TY	1960	IS/IP	35,000	TBP (132,650 liters)
31	106-TY	1959	IS/IP	20,000	TBP (75,800 liters)
32	101-U	1959	IS/IP	30,000	R (113,700 liters)

Table 8-3. Summary of Assumed-Leaker Tanks. (sheet 3 of 3)

Tank	Year leaked	Current status	Estimated leak volume (gal)	Waste in tank before leakage
104-U	1961	IS/IP	55,000	MW, R (208,450 liters)
110-U	1975	IS/IP	5,000 to 8,100	1C, R, CW, LW, BNW (18,950 to 30,699 liters)
112-U	1980	IS/IP	8,500	R, 1C (32,215 liters)

(Reference: Hanlon 1994)
*Statistical average.
Waste type acronyms:
B = B Plant High Level
BL = B Plant Low Level
BLEB = B Plant Low-Level Evaporator Bottoms Feed
BNW = Battelle Northwest Waste
CCPL = Complex Concentrate
CW = Coating Waste
CWP = PUREX High-Level Coating Waste
CWR = REDOX High-Level Coating Waste
DSSF = Double-Shell Slurry Feed
DW = Decontamination Waste
EB = Evaporator Bottoms
FP = Fission Product
HLO = Hanford Laboratory Operations
HS = Hot Semiworks
IP = Intrusion Prevention
IS = Interim Stabilized
IX = Ion Exchange
LW = Laboratory Waste
MW = Metal Waste
N = N Reactor
NCPL = Non-Complexed
OWW = Organic Wash Waste
P = PUREX High Level
PI = Partially Interim Isolated
PNF = Partial Neutralized Feed
PSS = PUREX Sludge Supernate
R = REDOX High Level
RIX = REDOX Ion Exchange
SSW = Strontium Semiworks
TBP = Tributyl phosphate (uranium recovery)
1C = First cycle
2C = Second cycle
224 = 224-U
5-6 = Cell 5 and 6.

Table 8-4. Relative Source Contribution to Carcinogenic Risk (Treat 1994).

Alternative	Source	Cancer risk contribution at peak	Relative contribution (%)
Traditional sluicing (baseline)	Tank Residual	3.9E-06	37
	Between tank and concrete	6.5E-09	0
	In concrete	7.0E-07	7
	Old and new leaks	5.9E-06	56
		1.1E-05	100

Table 8-5. Relative Source Contribution to Hazard Index Risk (Treat 1994).

Alternative	Source	HI contribution at peak	Relative contribution (%)
Traditional sluicing (baseline)	Tank Residual	8.9E-02	37
	Between tank and concrete	2.3E-04	0
	In concrete	1.6E-02	7
	Old and new leaks	1.4E-01	56
		2.4E-01	100

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CONTENTS

9.0 REFERENCES 9-1

9.1 DOCUMENTS 9-1

9.2 CODE OF FEDERAL REGULATIONS 9-21

9.3 FEDERAL AND STATE ACTS 9-23

9.4 REVISED CODE OF WASHINGTON AND WASHINGTON ADMINISTRATIVE CODE 9-24

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9.2 CODE OF FEDERAL REGULATIONS

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40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

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9.3 FEDERAL AND STATE ACTS

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Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601 et seq.

Energy Authorization Act of 1974, 42 USC 5842 et seq.

National Environmental Policy Act of 1969, 42 USC 4321 et seq.

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9.4 REVISED CODE OF WASHINGTON AND WASHINGTON ADMINISTRATIVE CODE

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WAC 173-201, "Water Quality Standards for Surface Waters of the State of Washington," *Washington Administrative Code*, as amended.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

WAC 173-340, "The Model Toxics Control Act Cleanup Regulation," *Washington Administrative Code*, as amended.

APPENDICES

1A CLOSURE ISSUES

2A HYDROGEOLOGIC INVESTIGATIONS

2B DESCRIPTION OF SINGLE-SHELL TANK FARMS AND SINGLE-SHELL TANKS

2C SINGLE-SHELL TANK INTERIM STABILIZATION OPERATIONS AND SURVEILLANCE SYSTEM UPGRADES

2D TEMPERATURE MONITORING SCHEDULES FOR WATCHLIST SINGLE-SHELL TANKS

2E PROPOSED TRANSFER ROUTES FOR EMERGENCY PUMPING OF SINGLE-SHELL TANKS

3A SINGLE-SHELL TANK WASTE CLASSIFICATION: REFERENCED LETTERS

7A DATA AND INFORMATION REQUIREMENTS FOR RISK ASSESSMENTS

8A BARRIER AND MARKER SYSTEM DESIGN CONSIDERATIONS

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APPENDIX 1A

CLOSURE ISSUES

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Number:	Title:	Status:	Addressed in CWP:	Date:
3.01	Closure of Tank Farms with Residual Contamination as Landfills	Open	Section 3.3.1	November 1994

Statement of Issue:

Clean closure of SST farms probably will not be achievable because of the quantities of residual waste expected to remain following retrieval. SST farms probably will need to be closed under WAC 173-303 regulations in accordance with requirements applicable to landfills.

Background:

Information related to the inability to retrieve all waste or other potential impediments must be addressed if and when such information becomes available. If the DOE-RL believes that waste retrieval as specified in Tri-Party Agreement Milestone M-45-00 (Ecology et al. 1994) is not possible for a tank, a detailed explanation must be submitted to the EPA and Ecology explaining why such retrieval cannot be achieved. The explanation must also specify the quantities that the DOE-RL proposes to leave in the tank. Such requests will be evaluated on a case-by-case basis.

Closure in accordance with approved closure plans will commence following completion of retrieval. Closure will be in accordance with WAC 173-303. If it is demonstrated to the satisfaction of Ecology that residues and/or soils cannot be "practicably removed or decontaminated," closure as a landfill will proceed in accordance with the approved closure plan.

Strategy for Resolution:

The SST-CWP will be used as a roadmap for closure of the SSTs in accordance with Tri-Party Agreement Milestone M-45-06. As uncertainties are resolved through this work plan, the appropriate course of action for achieving closure will be determined. If information related to waste retrieval and other potential impediments reveals that clean closure cannot be practicably achieved, approval will be sought from Ecology to pursue closure/postclosure as a landfill.

Impacts if not Resolved, or Resolution is Delayed:

A requirement to retrieve sufficient waste for clean closure of SSTs would add significant additional costs for waste retrieval technology development, and would increase significantly the risk of not meeting existing waste retrieval milestones under the Tri-Party Agreement. Waste retrieval to meet clean closure requirements may not be technologically achievable.

Reference documents:

Ecology, EPA, and DOE, 1994, Hanford Federal Facility Agreement and Consent Order, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

WAC 173-303, "Dangerous Waste Regulations," Washington Administrative Code, as amended.

Number:	Title:	Status:	Addressed in CWP:	Date:
3.02	Classification of Radioactive Residual Constituents	Open	Section 3.3.2	November 1994

Statement of Issue:

The proper radioactive classification needs to be determined for residual waste and contaminated soil.

Background:

It is important to verify that any residual waste and contaminated soil remaining after retrieval will be acceptable for near-surface disposal as LLW.

Strategy for Resolution:

The strategy is to open a dialogue with the NRC on their definition of HLW and how they will view our retrieval plans in relation to that definition. Characterization is the crucial first step; establishing the residual fraction of total activity remaining is the second. The past precedent of NRC action on the DSTs indicates that the planned 99 percent retrieval will be satisfactory, but that must be confirmed with the NRC.

Impacts if not Resolved, or Resolution is Delayed:

The impact, if not resolved, would be that the residues might be designated as HLW, which is not considered appropriate for near-surface disposal. Furthermore, the NRC has no regulatory structure in place for HLW disposed of anywhere but in a geological repository.

Reference documents:

Not applicable.

Number:	Title:	Status:	Addressed in CWP:	Date:
3.03	Absence of Regulations for Near-Surface Disposal of High-Level Radioactive Waste	Open	Section 3.3.3	November 1994

Statement of Issue:

What radiological regulations will apply to disposal of residues, tanks, and contaminated soils as LLW?

Background:

Regulations for LLW disposal are not all in place yet. The EPA is developing an LLW rule (40 CFR 193), but it is not yet final. A rule for residual radioactivity for unrestricted release is also in preparation. The controlling DOE Order 5820.2A (DOE 1988c) is being revised for reissue. Performance objectives are not the same in these developing rules.

Strategy for Resolution:

The strategy is to follow the drafts closely and provide expert review and comment to obtain reasonable, yet conservative, performance objectives, which are consistent among the rules. The regulatory analysis element of the program will seek out the direction of these rules by analyzing drafts provided for interagency review, studying presentations and papers by the developers, and personal contacts with agency staff, as directed by DOE. Projections of potential requirements and impacts will be prepared to guide program management as the rules proceed. The program will also support participation in the DOE Technical Working Groups revising DOE Order 5820.2A and other rules, where possible.

Impacts if not Resolved, or Resolution is Delayed:

To be determined.

Reference documents:

40 CFR 193, "Environmental Standards for the Management, Storage and Land Disposal of Low-Level Radioactive Waste and Naturally Occurring Accelerator-Produced Radioactive Waste," Draft, Code of Federal Regulations, as amended.

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

Number:	Title:	Status:	Addressed in CWP:	Date:
3.04	Potential Conflicts Between the AEA and RCRA	Open	Section 3.3.4	November 1994

Statement of Issue:

Potential conflicts between the requirements of AEA and RCRA could result in the inability to satisfy requirements of both laws.

Background:

The AEA and RCRA have different requirements for radiological and chemical constituents, which may conflict in some cases.

Strategy for Resolution:

The strategy is to identify the totality of regulatory requirements as early as possible in the process and determine their effect on system design to see if any conflicts are unresolvable. If so, negotiations with the regulators, or even legislation, may be needed before design can be completed. Early identification and resolution is necessary to support a successful program.

Impacts if not Resolved, or Resolution is Delayed:

The impact of nonresolution could be as serious as a complete redesign or even suspension of activities until resolution can be obtained.

Reference documents:

Atomic Energy Act of 1954, 42 USC 2011 et seq.

Resource Conservation and Recovery Act of 1976, 42 USC 6901 et seq.

Number:	Title:	Status:	Addressed in CWP:	Date:
4.01	Use of Characterization Information to Adequately Characterize Tank Waste	Open	Sections 4.1	October 17, 1994

Statement of Issue:

How should the different types of characterization information be used to satisfy programmatic characterization requirements?

Background:

Detailed and defensible characterization of the SST waste is required to: (1) guide retrieval, pretreatment, and disposal technology development; (2) address waste stability and reactivity concerns; and (3) satisfy compliance criteria for the various regulatory agencies overseeing activities at the Hanford Site.

Sources of characterization information are tank waste sampling and analysis data (including in situ analysis data), tank surveillance and monitoring data, historical process information, and waste modeling information. In the recent past, emphasis has been placed on the use of sampling and analysis to characterize the tank waste. The characterization information from the different sources are complementary and must be considered together to determine the contents of the tanks.

Strategy for Resolution:

Currently, tank characterization reports (De Lorenzo and Simpson 1994; Schulz et al. 1994) compare analytical results to historical, modeling, and surveillance data to develop estimates of tank inventories. In addition, historical and surveillance information is used to guide sampling and analysis. However, methodologies for the evaluation and interpretation of characterization information to estimate tank contents need to be further developed. Both inductive and deductive reasoning must be employed to adequately understand the tank waste.

In the complex domain of the tank waste, inductive reasoning helps simplify the intricate and sometimes contradictory nature of the data. By looking for patterns among different data sources, models or hypotheses can be formed concerning the tank contents. A process of hypothesis formation, deductively tested expectations, and replacement of outmoded hypotheses is applied. Continued use of this process causes those models or hypotheses with the greatest correspondence with experience to be applied. Other sources of information can be used to fill in gaps left by the model.

Impacts if not Resolved, or Resolution is Delayed:

Defensible characterization information resulting from a synthesis of information from sampling and analysis, tank surveillance and monitoring, historical sources, and tank modeling is needed to support disposal of tank waste, address safety concerns, and comply with regulatory requirements (including those for closure of SSTs).

The inability to resolve this issue may delay other programs, decisions being made without adequate characterization information (greater risk), and/or increase costs. Increased costs may be incurred by the programs if they are required to develop more robust technologies/solutions because of a lack of characterization information. Alternatively, the characterization program may incur increased costs if additional sampling and analysis is required in lieu of fully using other characterization information.

Reference documents:

De Lorenzo, D. S., and B. C. Simpson, 1994, Hanford Site Waste Tank Characterization, WHC-SA-2584-FP, Westinghouse Hanford Company, Richland, Washington.

Schulz, W. W., M. J. Kupfer, G. L. Borsheim, S. J. Everlein, B. C. Simpson, and J. T. Slankas, 1994, Strategy for Sampling Hanford Site Tank Wastes for Development of Disposal Technology, WHC-SD-WM-TA-154, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Number:	Title:	Status:	Addressed in CWP:	Date:
4.02	Representativeness of Soil/Groundwater Sample Data	Open	Section 4.4	October 1994

Statement of Issue:

How representative of in situ conditions are soil/groundwater characterization data (i.e., are sample/analyses results and geophysical logs representative of in situ natural conditions)?

Background:

Risk and performance assessments will be key factors in decisions regarding which specific remedial actions will be taken to close the SSTs. These assessments will be based on computer models that must replicate natural conditions and processes to forecast potential future impacts/consequences of various remedial measures taken to close the SSTs. Data on physical and chemical characteristics of soils and groundwater, contaminants and their mobility, and processes affecting mobility and risk will be key input parameters into such models. These data must accurately characterize the contaminants and the media in which they occur and be representative of natural conditions, not an artifact of the processes/techniques used to acquire them.

Core recovery, sample collection and treatment, handling and transportation, time between collection and analysis, responsible custody of the sample, the method of analysis, the type, frequency of calibration and instrument drift, appropriate correction for background values and data reduction and reporting affect the quality of any subsurface samples obtained during characterization investigations. Failure to adhere to industry protocol, approved practices and procedures in any one of the above elements can lead to data that are not representative of natural conditions.

Infrequent or improper calibration of geophysical logging tools, operator error during logging surveys, improper reduction or analysis of the data, use of other than approved standards, employment of unqualified loggers, and analyses and misinterpretation can introduce error into geophysical logging data.

Strategy for Resolution:

Samples should be collected, handled, transported, analyzed, and data reported according to approved procedures that follow industry protocol and guidance, regulatory requirements and guidance by regulators, professional standards, and oversight organizations (Chapter 4.0, Table 4-6).

Geophysical logging should be conducted with tools of appropriate sensitivity that are properly and frequently calibrated. Furthermore, logging should be conducted by professionals following acceptable procedures based on appropriate industry standards. Data reduction and analysis should be performed by professionals using validated and verified software and following industry standards and protocol.

All data should strive to achieve the DQOs specified in work plans and be of an accuracy and precision that is acceptable and suitable for the intended use.

Impacts if not Resolved, or Resolution is Delayed:

Without representative data on the nature and extent of contaminants, their mobility and transport, and the media in which they occur, risk and performance assessments needed to select remedial measures pursuant to closure of the SSTs may be biased or incomplete. The failure to adequately assess risk and performance of remedial measures could lead to the selection of inappropriate remedial measures or improper design of chosen remedial measures. Either of these consequences could lead to excessive costs and/or increased risk to the public health and safety of workers and increased potential for damage to the environment.

Reference documents:

Not applicable.

Number:	Title:	Status:	Addressed in CWP:	Date:
4.03	Tank Leak Plume Definition and Migration	Open	Section 4.4.5.1	October 1994

Statement of Issue:

Where is the waste leaked and spilled from SSTs and support operations, how far has this waste spread in the soils, how mobile is it in the soils of the Hanford Site, when will these waste plumes reach groundwater (if ever), what will the concentration be on reaching the water table, and will these dates and concentrations on arrival in groundwater pose threats to human health and the environment?

Background:

For closure of a tank system, the owner operator is required to remove or decontaminate all equipment, structures and contaminated soils and manage them as dangerous waste (WAC 173-303-640(8)(a), or, if impractical, close the tank system as a landfill and perform postclosure care as required for closure as a landfill (WAC 173-303-640(8)(b). Any waste leaked to soils from a tank system is considered a part of the tank system and must undergo closure as part of the tank system. Only two leaking tanks (of a total of 67 assumed leaking SSTs) have been investigated, and the full extent of the plume of leaked waste from all 67 of these tanks remains to be defined. In addition, the mobility of the waste and when (if ever) any or all of this waste will reach groundwater remains to be determined. In order to comply with this regulation, it is essential to determine the amount of waste leaked to the soils, the location of the waste in the soils, the mobility of the constituents in the waste plume, and whether the waste represents a potential threat to groundwater and to human health or the environment.

Strategy for Resolution:

All waste constituents leaked from the SSTs to the soils must be characterized to determine the magnitude and extent of contamination, whether any or all of these constituents are mobile, the rate of transport, when (if ever) the waste will reach groundwater, and in what concentration/activity. Baseline data on the current extent of the waste in soils must be determined for each assumed leaking tank. Subsequent monitoring of the waste must be employed to determine whether the waste is mobile and the rate of transport of any or all constituents in the soils. Maximum use should be made of available data and existing access ports that allow remote sensing of the waste in the ground. Geophysical logging in existing boreholes provides a means to accomplish these objectives. Logging with the RLS can determine the location and concentration (activity) of gamma-emitting radionuclides in the soils that have sufficient energy to penetrate borehole casing. Subsequent logging with the RLS can determine the mobility and/or decay of these gamma-emitting contaminants. If any of the mobile gamma-emitting contaminants can be used as a surrogate for nongamma-emitting radionuclides or hazardous waste components, this will accomplish part of this objective. Logging with a pulsed-neutron tool, which is being acquired, can provide can provide an in situ profile of moisture surrounding a borehole. Subsequent logging can determine the moisture flux. Where additional data are needed to determine the maximum extent of any plume of leaked waste in the soil, additional boreholes may have to be constructed to provide access to these tools. There are 780 dry wells located adjacent to SSTs that have been a part of the leak detection system and that can provide access to geophysical logging tools to at least partially characterize the waste in the soils. Application of the spectral gamma logging system to baseline contamination in the vadose zone will provide the basis for defining the extent of contamination. During construction, sampling and analyses of soils can be conducted as needed to determine the extent of the nongamma-emitting radionuclides or the hazardous component as appropriate.

Impacts if not Resolved, or Resolution is Delayed:

Characterization data are needed to evaluate and choose among the various alternatives identified in the Hanford Defense Waste EIS (DOE 1987a) and the Tri-Party Agreement (Ecology et al. 1994). Without a program of detailed characterization of waste leaked to soils from the SSTs, there will be insufficient data on which to base decisions for closure and any remedial action that may be deemed appropriate. If this program of characterization is not begun soon, the data will not be available to allow closure decisions in time to meet the Tri-Party Agreement milestone for closure of the SSTs by the year 2024.

Number:	Title:	Status:	Addressed in CWP:	Date:
4.03	Tank Leak Plume Definition and Migration	Open	Section 4.4.5.1	October 1994

Reference documents:

DOE, 1987a, Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic, and Tank Waste, Hanford Site, Richland, Washington, DOE/EIS-0113, 5 vols., U.S. Department of Energy, Washington, D.C.

Ecology, EPA, and DOE, 1994, Hanford Federal Facility Agreement and Consent Order, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

WAC 173-303, "Dangerous Waste Regulations," Washington Administrative Code, as amended.

Number:	Title:	Status:	Addressed in CMP:	Date:
4.04	Adequacy of Data on Groundwater Flow/Contaminant Transport Data	Open	Section 4.4.5.2	October 1994

Statement of Issue:

Are data adequate to assess the transport of any dissolved contaminant species in groundwater beneath the Hanford Site to support risk assessment(s) related to closure of the SSTs?

Background:

The Columbia River is a direct pathway to receptors for any contaminants by which it is reached. Not only is river water the habitat for many aquatic life forms in the food chain, but it is also a source of drinking water for several communities downstream of the Hanford Site as well as a supply of water for irrigated crops. Groundwater from the unconfined and some confined aquifers beneath the Hanford Site discharges into the Columbia River, and transport of soluble contaminant species in groundwater is the likely pathway to carry contaminants from the Hanford Site to the Columbia River. Characterization of contaminant plumes and the aquifers in which they are moving is required to allow appropriate planning, design, and verification of risk assessments needed to support closure of the SSTs.

Cleanup of the Columbia River and groundwater discharging to the river was an immediate priority for the Hanford Future Site Use Working Group (HFSUWG 1992). Plumes of tritium and nitrate emanating from the 200 East Area are discharging to the Columbia River and have for some time (PNL 1994; Knepp et al. 1994). Plumes of other contaminants are present in groundwater in the 200 East and 200 West Areas (Ford and Trent 1994). These plumes extend beneath many SST farms, but it is not certain whether any waste leaked from the SSTs has reached groundwater and contributed to these plumes. However, during past operations, it is known that the supernatant in the last tank in a series of cascading SSTs was discharged to cribs to make additional tank storage space. Some of this waste may have reached groundwater. Travel times for contaminants in groundwater to reach the Columbia River from the 200 East Area are estimated at 10 to 20 years (Knepp et al. 1994); travel times from the 200 West Area to the Gable Gap area are estimated at about 100 years, with subsequent flow north to the Columbia River. Estimates of time for contaminants in soils to reach groundwater are highly variable and relate to the specific site and the retardation of the contaminant in passage through the vadose zone.

Strategy for Resolution:

Plumes of contaminants in groundwater have integrated contributions from numerous source facilities to the extent that it is nearly impossible to assign specific source facilities responsible for the contaminant species in the saturated zone. Therefore, plumes of contaminants are more effectively treated in total, and groundwater contaminant plumes will be remediated as operable units (e.g., 200-BP-5) by the Environmental Restoration Program (Knepp et al. 1994). Data needed for performance and risk assessments related to closure of the SSTs will be that which is available and that which becomes available as a product of Environmental Restoration (ER) investigations. No specific plans are being made at this time to provide supplemental data that will not be available from either source. Risk assessment and the required data are addressed in Chapter 6.0, Section 6.1. The Hanford Site Groundwater Protection Management Plan (DOE-RL 1994d) addresses issues related to reducing/eliminating contaminants in soils getting to groundwater and specifically deals with unsaturated flow and contaminant transport.

Impacts if not Resolved, or Resolution is Delayed:

Addressed as part of Issues 6.01 (Identification of Data and Information Needs) and 6.02 (Integration of Numerical Modeling and Risk Assessment with Other Hanford Site Remediation Programs).

Number:	Title:	Status:	Addressed in CWP:	Date:
4.04	Adequacy of Data on Groundwater Flow/Contaminant Transport Data	Open	Section 4.4.5.2	October 1996

Reference documents:

DOE-RL, 1994d, Hanford Site Groundwater Protection Management Plan, DOE/RL-89-12, Rev. 2, Draft, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ford, B. H., and S. J. Trent, 1994, Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1993, DOE/RL-93-88, Rev. 0, Section 4.1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

HFSUWG, 1992, The Future For Hanford: Uses and Cleanup - The Final Report of the Hanford Future Site Uses Working Group, Hanford Future Site Uses Working Group, submitted to U.S. Environmental Protection Agency, U.S. Department of Energy, Richland Field Office, and Washington State Department of Ecology.

Knepp, A. J., B. H. Ford, D. K. Tyler, F. N. Hodges, V. G. Johnson, R. E. Peterson, and G. L. Kasza, 1994, Hanford Sitewide Groundwater Remediation Strategy, DOE/RL-94-95, Draft A, U.S. Department of Energy, Richland, Washington.

PNL, 1994, Hanford Site Environmental Report for Calendar Year 1993, PNL-9823, Pacific Northwest Laboratory, Richland, Washington.

Number:	Title:	Status:	Addressed in CWP:	Date:
4.05	Borehole Logging to Support SST Waste Retrieval and Disposal Activities	Open	Section 4.5.3	November 1994

Statement of Issue:

How will the borehole logging activities and data be integrated with SST waste retrieval and disposal activities?

Background:

Borehole logging can provide tank farm soil characteristics and contaminant migration. These techniques are not currently used to provide baseline information.

Borehole logging data can support SST leak detection and surveillance activities. Knowledge on the location and extent of existing tank leaks and plume characteristics can serve as a starting point for external leak detection activities (baseline). Decisions regarding the potential impacts and movement of contaminants can benefit greatly from borehole logging activities performed in the vadose zone. Information on existing plume conditions and soil moisture can be used to determine whether a given leak has sufficient volume and pressure to cause an impact to tank farm operations, cleanup, and the groundwater. Borehole logging information on the soil conditions surrounding the tank farms will contribute to the functions and requirements for leak detection and monitoring technologies.

Strategy for Resolution:

Hundreds of boreholes have been constructed in the tank farms. This system of boreholes is currently used to collect information as a backup to the in-tank monitoring system and leak detection activities discussed in Appendix 2C. It is recommended that the borehole logging activities be coordinated with future SST remediation activities (SST leak detection and soil characterization). In so doing, SST remediation decisions will include consideration of borehole logging data as part of the evaluation and monitoring of SST remedial actions. This data may impact: (1) leak detection during remedial action; (2) determination of LDM technology functions and requirements; (3) selection and deployment of LDM techniques; and (4) interpretation of leak-indicating data from internal or external systems.

Impacts if not Resolved, or Resolution is Delayed:

Borehole logging data, regarding leak plume location and extent in and around the SST tank farms, is needed to support decisions about leak detection and monitoring technology and the importance of 'leak data.' Because of the variability and heterogeneity of soil, the data must be collected in situ. The borehole logging activity provides a means whereby this data can be collected in situ in a relatively nonintrusive manner.

Reference documents:

Not applicable.

Number:	Title:	Status:	Addressed in CWP:	Date:
5.01	Approach for Evaluating Retrieval Cost/Benefit Tradeoffs	Open	Sections 5.1, 5.3, 8.1	October 24, 1994

Statement of Issue:

What basis will be used for evaluating cost/benefit of alternatives for retrieval of waste from SSTs to meet closure requirements, and for selecting the preferred alternatives that will be further developed and deployed?

Background:

Examples of alternatives for retrieval of SST waste to meet closure requirements include: (a) sluicing versus an alternate low-water addition retrieval method such as an arm-based system; (b) sluicing with or without subsurface barriers; and (c) surface transported container versus pipeline transfer of retrieved waste. Ancillary issues include whether or not to build a retrieval system test facility for demonstration and training purposes. The systems engineering process in TWRS is a formalized approach for identifying and translating functions and requirements into a definition of engineered system configuration. This process uses trade studies to evaluate alternatives. Costs and benefits of alternatives are evaluated as part of trade studies as a basis for selection of the preferred alternative. Traditionally, costs are expressed in terms of the quantity of financial resource required, and benefits are defined in terms of satisfying the specified objectives. Other elements of cost associated with implementation of an alternative relate to health and safety risk to workers and the public, consumption of resources, and environmental impacts. For waste remediation and environmental restoration activities, benefits of a proposed action are typically quantified in terms of reduction of risk to the public and environment. Other benefits may include reduction in programmatic risk and risk of noncompliance with regulations, DOE orders, and the Tri-Party Agreement (Ecology et al. 1994). Consequences of such noncompliance could include assessment of civil and criminal penalties.

Strategy for Resolution:

There is currently no formula for combining all the elements of cost and benefit relating to a particular decision into a single numerical cost/benefit measure. It is unlikely that such a measure will be developed. It is hoped that all the elements of cost and benefit that enter into a comparison of alternatives and selection of the preferred alternative be recognized, individually analyzed, and presented to the decision makers. The NEPA requires that environmental consequences of decisions between alternatives be considered in federal agency decision-making on major actions. The TWRS-EIS (59 FR 4052) will, to some extent, address the elements of cost and benefit addressed in deciding on the strategy for remediation of tank waste, including impacts on worker health and safety, short- and long-term impacts on the environment, resource use, and financial costs. This process will also permit an evaluation of differences in some aspects of long-term benefit to the public of the principal alternatives evaluated, by quantification of public health and safety consequences. Within the broad strategy that ultimately will be decided via the TWRS-EIS, there are also details of strategy implementation, examples of which are given above, that will be decided at lower levels of decision-making authority. At this level, the approach used in decision-making will also include consideration of the many elements of cost and benefit that differentiate among alternatives. The only difference will be the degree of rigor and documentation of results of the analysis.

Impacts if not Resolved, or Resolution is Delayed:

This issue is not one that requires a formalized resolution in order to proceed with work. The TWRS systems engineering process puts in place the mechanism for considering the various elements of cost and benefit that need to be considered in deciding among alternatives, and for documenting the results (i.e., the basis for the decision). Accordingly, this issue is considered resolved, as far as the general approach is concerned. Resolution of this issue for the many decisions that will be made in selecting retrieval system configuration and approach will be accomplished as part of the systems engineering process that will be applied in project definition and design.

Number:	Title:	Status:	Addressed in CMP:	Date:
5.01	Approach for Evaluating Retrieval Cost/Benefit Tradeoffs	Open	Sections 5.1, 5.3, 8.1	October 24, 1994

Reference documents:

59 FR 4052, "Intent To Prepare Hanford Tank Waste Remediation System Environmental Impact Statement," Federal Register, Vol. 59, No. 19, pp. 4052-4058, (January 28).

Ecology, EPA, and DOE, 1994, Hanford Federal Facility Agreement and Consent Order, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

National Environmental Policy Act of 1969, 42 USC 4321 et seq.

Number:	Title:	Status:	Addressed in CMP:	Date:
5.02	Percent Waste Retrieval Required for Closure	Open	Sections 5.1, 8.1	October 25, 1994

Statement of Issue:

What degree of waste removal required for closure should be used as the basis for waste retrieval system technology development, retrieval systems engineering, and definition of completion of retrieval operations? How clean is clean enough?

Background:

Tri-Party Agreement Milestone M-45-00 (Ecology et al. 1994) establishes an objective of retrieving "as much waste as technically possible, with tank waste residues not to exceed 360 cubic feet (10,200 liters) in each of the 100 series tanks, 30 cubic feet (850 liters) in each of the 200 series tanks, or the limit of waste retrieval technology capability, whichever is less." These quantities correspond to approximately 1% of the total current SST waste volume, distributed to each SST as indicated. The Tri-Party Agreement allows exceptions to these limits on a tank-by-tank basis, if supported by detailed justification. It is not likely that engineering analysis, laboratory testing, or field testing on waste simulants will provide assurance, at an early stage of retrieval technology development, that the Tri-Party Agreement milestone limits can be met. Also, the Tri-Party Agreement does not address in-tank hardware, metallic lead, and discrete radioactive sources currently in the tanks. Thus, significant program uncertainty will follow the retrieval technology development effort at least until retrieval systems can be deployed and operated in SSTs. Demonstration of SST waste retrieval technology on C-106 tank is scheduled for completion in September 2003 (Tri-Party Agreement Milestone M-45-03-T01). If the current baseline technology (hydraulic sluicing) cannot be demonstrated to meet these criteria, and if Ecology will not relax the criteria, most of the Tri-Party Agreement retrieval milestones will be delayed. Alternatives and enhancements to the baseline retrieval technology will be developed in parallel, to the extent funding is available, and may be capable of meeting the Tri-Party Agreement criteria in the event the baseline technologies cannot. Or, it may be necessary to develop follow-on retrieval/cleanout technologies that will have to be deployed to remove the residual waste, before SSTs can be turned over for closure.

Strategy for Resolution:

Current retrieval program tasks for development of sluicing and alternate retrieval technology will continue. Current waste retrieval program planning is based on deployment of sluicing retrieval systems in most of the SSTs. Sluicing retrieval was estimated in Krieg et al. (1993) to be capable of retrieving, on average, 60 to 80% of the waste in a tank. Programs to investigate and develop enhancements and alternatives to the baseline retrieval technology will be carried forward, at the level permitted by available funding. Peer reviews by individuals from industry, national laboratories, and academia will be conducted periodically to review strategy, and results of analyses and tests, relative to the established criteria. This issue will not be resolved until capability to retrieve sufficient waste to meet Tri-Party Agreement Milestone M-45-00 criteria can be demonstrated through deployment and operation of waste retrieval systems in SSTs.

Impacts if not Resolved, or Resolution is Delayed:

The basis for the current waste retrieval technology development program is to retrieve as much waste as possible, for the given technology that has been identified. The ability to meet the Tri-Party Agreement criteria of 99% retrieval, by tank, or other criteria that may be promulgated through regulations, will not be known until retrieval systems are deployed and operated. If the current criterion is achievable, but future regulatory development or performance assessment to regulatory performance criteria results in stricter criteria, the reference technologies may have to be abandoned, resulting in program delays and increased costs for development of more efficient retrieval technologies. If the 99% retrieval criterion is not changed, but the current reference technologies are found to be inadequate, program uncertainty and risk will increase, pending decision-making on criteria relaxation or development of alternative technologies. If promulgation of regulatory criteria and performance assessment of such criteria demonstrate that less efficient retrieval technologies are acceptable, reallocation of technology development funding for more critical needs may be warranted.

Number:	Title:	Status:	Addressed in CWP:	Date:
5.02	Percent Waste Retrieval Required for Closure	Open	Sections 5.1, 8.1	October 25, 1994

Reference documents:

Ecology, EPA, and DOE, 1994, Hanford Federal Facility Agreement and Consent Order, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Krieg, S. A., R. D. Hodgson, P. K. Bhatia, and E. J. Shen, 1993, Tank Waste Retrieval System - Retrieval Technology Plan, WHC-SD-WM-PLN-060, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Number:	Title:	Status:	Addressed in CWP:	Date:
5.03	Leakage to the Soil During Retrieval	Open	Sections 4.1, 5.1, 5.3, 8.1, 7.3	October 25, 1994

Statement of Issue:

How much, if any, leakage of waste from SSTs to the soil column will be allowable during waste retrieval operations?

Background:

The Final Environmental Impact Statement for Waste Management Operations at the Hanford Site (ERDA 1975) stated that sluicing of sludges in SSTs "is not planned due to the age of the tanks and the possibility of liquid leakage" (Section II.1.1.2.2.2). To provide input to the decision makers in the DOE-RL, EPA, and Ecology during the Tri-Party Agreement (Ecology et al. 1994) negotiations, the Hanford Tank Waste Task Force was chartered to define public values that should influence selection of strategy for remediating Hanford Site tank waste (HTWTF 1993). One of the subject areas addressed was 'Tank Leaks'. The Task Force stated that it was important to "prevent additional leaks without further compounding future remediation efforts". SSTs have been 'stabilized' over the past several years by pumping liquids to the DSTs. Retrieval of waste by sluicing and alternate systems such as robotic arms will involve the addition of various amounts of liquids to SSTs to dislodge and mobilize sludge and salt cake. This increases the potential for leakage, though the risk is much lower with alternates like robotic arm-based systems because water volume additions are much lower than for sluicing. The C-106 tank will be the first SST to be retrieved by sluicing (Lowe 1993). It is estimated that up to 40,000 gallons (151,600 liters) of waste will be leaked to the soil during this retrieval operation. No subsurface barrier is planned to be installed to mitigate the consequences of leakage from this tank. The risk of leakage during retrieval of C-106 tank has been accepted by the DOE-RL and Ecology as preferable to the risk of continuing to store the high-heat waste with regular water additions for cooling until low-water addition alternates such as arm-based retrieval systems are available.

Strategy for Resolution:

The current retrieval strategy is to minimize the risk of leakage by using low water addition methods such as arm-based retrieval systems in known or suspected leaking tanks, except where leaks have occurred only at the previous liquid/air interface. In such cases, sluicing systems could be used as long as the liquid level is maintained significantly below the suspected leakage zones in the tank wall. Chapter 8.0 addresses the planned technology development program that will support this Tri-Party Agreement milestone. Performance assessment of closed tank farms, using numerical models to predict contaminant transport relative to applicable regulations, is expected to provide critical input to the decision on whether, or how much leakage may be permitted during retrieval.

Impacts if not Resolved, or Resolution is Delayed:

Delay in resolution of this issue entails continued programmatic risk. The probability that additional leakage will occur during sluicing retrieval operations is high. If absolutely no leakage of waste during retrieval is permissible, the current reference technology for SST retrieval may have to be abandoned, and the current Tri-Party Agreement retrieval milestones would be in jeopardy. This is a fundamental retrieval system design question.

Reference documents:

Ecology, EPA, and DOE, 1994, Hanford Federal Facility Agreement and Consent Order, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

ERDA, 1975, Final Environmental Impact Statement for Waste Management Operations at the Hanford Site, ERDA-1538, Energy Research and Development Administration, Richland, Washington.

HTWTF, 1993, Final Report Hanford Tank Waste Task Force, The Hanford Tank Waste Task Force, submitted to Washington State Department of Ecology, U.S. Department of Energy, and the U.S. Environmental Protection Agency.

Lowe, S. S., 1993, Engineering Study of Tank Leaks Related to Hydraulic Retrieval of Sludge from Tank 241-C-106, WHC-SD-WM-ES-218, Westinghouse Hanford Company, Richland, Washington.

Number:	Title:	Status:	Addressed in CWP:	Date:
5.04	Cost/Benefit Tradeoffs for Leak Mitigation Devices	Open	Sections 5.3, 8.2	October 25, 1994

Statement of Issue:

What basis will be used for evaluating cost/benefit of alternative leak mitigation methods, for deciding whether these methods will be deployed, and; if these methods of leak mitigation are decided to be used, what basis should be used for selecting the preferred alternative?

Background:

Issue 5.01 provides a general background discussion. Leak mitigation is a specific case that warrants special consideration because the topic is treated under its own Tri-Party Agreement Milestone (M-45-07) (Ecology et al. 1994). In satisfaction of Tri-Party Agreement Milestone M-45-07A, the Feasibility Study of Tank Leakage Mitigation Using Subsurface Barriers was issued (Cruse et al. 1994). This study evaluated functions, feasibility, cost, and performance of a variety of subsurface barrier concepts. The study concluded that deployment of any of the barrier concepts analyzed would result in relatively small incremental risk reduction, at relatively high cost.

Strategy for Resolution:

Refer to Issue 5.01 for a general discussion of resolution strategy. The technology development program described in Chapter 8.0 will support Tri-Party Agreement Milestone M-45-07B, "Reach decision on whether to proceed with demonstration, January 1995," and Tri-Party Agreement Milestone M-45-07C, "Establish new milestones for subsurface barrier implementation, September 1997." These actions are presently under review.

Impacts if not Resolved, or Resolution is Delayed:

The potential use of subsurface barriers and methods of leak mitigation detection are presently under review.

Reference documents:

Cruse, J. M., R. L. Treat, B. B. Peters, R. J. Cameron, W. D. McCormak, T. Trenkler, M. F. Walters, J. K. Rouse, and T. J. McLaughlin, 1994, Feasibility Study of Tank Leakage Mitigation Using Subsurface Barriers, WHC-SD-WM-ES-300, Rev. 0, prepared by Enserch Environmental, Inc., and Bovay Northwest, Inc., for Westinghouse Hanford Company, Richland, Washington.

Ecology, EPA, and DOE, 1994, Hanford Federal Facility Agreement and Consent Order, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Number:	Title:	Status:	Addressed in CWP:	Date:
5.05	Equipment and Materials Disposed of in Tanks	Open	Sections 5.1, 8.1	October 25, 1994

Statement of Issue:

Will equipment and materials (radioactive and hazardous) disposed of in SSTs need to be retrieved to either: (a) permit retrieval of sludge and salt cake; or (b) close tanks in accordance with regulatory requirements?

Background:

In past tank farm operations, a variety of objects, equipment, and materials have been disposed of in some of the SSTs. Some of these items could interfere with waste retrieval operations using sluicing systems or robotic arms, or affect performance of the closed tank farms.

Strategy for Resolution:

Identify and catalog items known to have been disposed of in SSTs. In conjunction with engineering development and project definition of retrieval systems, an assessment will be made of whether such items need to be removed as part of the retrieval process. Arm-based retrieval systems that deploy tools for cutting, grabbing, and lifting should be capable of retrieving such items, if necessary.

Impacts if not Resolved, or Resolution is Delayed:

Tri-Party Agreement milestones for waste retrieval (M-45-05-T01 through -T15) could be impacted (Ecology et al. 1994).

Reference documents:

Ecology, EPA, and DOE, 1994, Hanford Federal Facility Agreement and Consent Order, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Number:	Title:	Status:	Addressed in CWP:	Date:
6.01	Steps Involved in Preparing and Submitting the Closure Plan for Inclusion into the RCRA Facility Permit	Open	Chapters 3.0 and 6.0	November 1994

Statement of Issue:

The closure plan(s) for the SSTs will be included in the RCRA Permit for the Treatment, Storage, and Disposal of Dangerous Waste (RCRA Facility Permit) (Ecology 1994). Inclusion of the closure plan(s) in the RCRA Facility Permit will be the mechanism for formal public review and approval of the closure plan(s).

Background:

The SSTs are considered a TSD unit under RCRA and WAC 173-303. As such, a closure plan needs to be submitted and approved before the final disposition of the SSTs can be realized. This closure plan will be developed to protect human health and environment and will include information to: (1) minimize the need for further maintenance controls, minimize or eliminate risk to the extent necessary to protect human health and the environment, postclosure escape of dangerous waste, dangerous constituents, leachate, contaminated runoff, or dangerous waste decomposition products to the ground, surface water, groundwater or the atmosphere, and; (2) return the land to the appearance and use of surrounding land ares to the degree possible given the nature of the previous waste activity.

Once the closure plan is developed, the regulators have 120 days to review and submit notice of deficiency comments. Once DOE-RL receives the notice of deficiency comments, DOE-RL has 120 days to respond with a response table that identifies comments that are accepted and how the changes will be incorporated; and if the comments are not accepted, the accompanying reasons. The DOE-RL and the regulators then hold issue resolution meetings for up to 8 months to resolve any disputed comments. After issue resolution is completed, the closure plan is revised and resubmitted within 90 days. Ecology has 90 days to furnish any more comments and the DOE-RL has 90 days to issue any necessary page changes.

When the closure plan has been approved by Ecology, the closure plan is then issued to the public for review and comment via the RCRA Facility Permit modification process. To meet the proposed modification process, a closure plan needs to be finalized and submitted to Ecology by December of the year before the permit modification will become effective. The following January, Ecology will issue fact sheets to the public explaining that a permit modification will occur and what will be contained in the modification. In February, Ecology will issue the permit modification, including the closure plan, to the public for review and comment. This review and comment period can take from 45 to 90 days and may include public hearings. Once the public comment period has ended, Ecology will prepare a responsiveness summary for the comments. If deemed necessary, changes to the permit modification, included changing the closure plan, will be completed. The modification will then be issued in June and become effective the following July.

It is prudent not to start major closure activities until Ecology has approved the closure plan and the public has had the opportunity to review and comment.

Strategy for Resolution:

The timing of the submittal of the SST closure plan(s) will need to be coordinated with the RCRA Facility Permit modification process. Coordination of the submittal of the closure plan(s) with the RCRA Facility Permit modification schedule will allow for implementation of the closure plan to proceed as scheduled. In response to the Tri-Party Agreement Milestone M-45-06 (Ecology et al. 1994), a SST-CWP will be prepared and submitted to Ecology for review in May 1995. This plan is scheduled to be issued in January 1996. The closure work plan (CWP) is scheduled to be revised and reissued in January 1998. Preparation and issuance of these work plans before preparing the SST closure plan will provide for an opportunity to resolve and work on long-term lead activities.

Impacts if not Resolved, or Resolution is Delayed:

The only impact will be when closure activities can be implemented. A possibility of up to a 14-month delay could be realized if a closure plan is submitted after the date needed to support a permit modification process. Closure of the SSTs is expected to be an activity that will receive considerable scrutiny. This can only be accommodated if sufficient lead time is built into the closure process.

Number:	Title:	Status:	Addressed in CWP:	Date:
6.01	Steps Involved in Preparing and Submitting the Closure Plan for Inclusion into the RCRA Facility Permit	Open	Chapters 3.0 and 6.0	November 1994

Reference documents:

Ecology, 1994, Dangerous Waste Portion of the Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste, Second Draft, Official Public Comment Version, Washington State Department of Ecology, Olympia, Washington, dated February 2.

Ecology, EPA, and DOE, 1994, Hanford Federal Facility Agreement and Consent Order, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Resource Conservation and Recovery Act of 1976, 42 USC 6901 et seq.

WAC 173-303, "Dangerous Waste Regulations," Washington Administrative Code, as amended.

Number:	Title:	Status:	Addressed in CWP:	Date:
7.01	Identification of Data and Information Needs	Open	Section 7.1, Appendix 7A	October 1994

Statement of Issue:

If data and information required to support risk assessment(s), including safety and performance assessment(s), are not available, work would be delayed until such data and information are obtained.

Background:

Specific data and information are needed to prepare risk assessments, including safety and performance assessments, in support of closure of the SSTs. It is not until the scenarios and performance objectives have been identified that the risk assessment can be developed. Once the risk assessment objectives are established, the level of detail necessary and the specific data and information requirements become apparent (e.g., some risk assessments may not require contaminant transport analysis because the hazard and receptors under consideration are at the same location). A list of risk assessment data and information is given below. Parentheses indicate the amount of information and resource references available. It is recommended that a 'graded approach' supported by appropriate sensitivity analysis be completed to ascertain important assumptions and parameters in the assessment.

Strategy for Resolution:

All risk and performance assessments will use, to the extent possible, existing data and information.

The data and information commonly required are as follows:

General Information:
- Identification of programmatic and sitewide risk that should be managed.

Contaminant Waste Inventory Data (Chapter 4.0):
- Contaminants expected
- Contaminants of potential concern (location, concentration, isotope)
- Evaluation of current and planned disposal facilities with associated waste streams
- Contamination background levels (DOE-RL 1992d, DOE-RL 1994c).

Exposure Assumptions:
- Human and ecological populations potentially exposed
- Length and frequency of contact (HSBRAM, HEDOP)
- Results of modeling and assumptions involved
- Land use
- Number of workers involved in the activity and those in proximity to the activity or process that can be affected by accidents
- Number of hours during which the activity or process occurs.

Toxicity Data (contaminant specific):
- Chemical specification
- Decay and degradation transformation of the chemical in the environment (DOE 1981)
- Regulation of the toxicant
- Volume or mass of contamination
- Potential acute and chronic effects on human and ecological receptors (IRIS).

Accident Sequence Analysis Data:
- Physical layout of the area in which the activity or process takes place (site-specific information)
- Type of ambient conditions in which the activity or process takes place
- Design requirements established by orders, codes, or directives
- Critical design features such as configuration of confinement barriers and remediation equipment
- Degree and types of automatic features that are incorporated in the design of the process or activity.

Number:	Title:	Status:	Addressed in CWP:	Date:
7.01	Identification of Data and Information Needs	Open	Section 7.1, Appendix 7A	October 1994

Strategy for Resolution (cont):

Contaminant Transport Modeling Data for Atmospheric, Soil, Groundwater, Surface Water, and River Sediment Pathways:

- Release concentrations, volume, and velocity as functions of time and location
- Wind direction, wind speed, temperature, and atmospheric stability as functions of time and location (Hanford Site weather station)
- Concentrations, volume, velocity, moisture content (or pressure), and chemical attributes of the solvent as functions of time and location (limited information available)
- Topography, stratigraphy, and lithology
- Vadose zone moisture characteristic information to include unsaturated hydraulic conductivity and moisture content as functions of pressure (limited information available)
- Dry bulk density
- Total, diffusional, and effective porosities (limited information available)
- In situ volumetric moisture content (site-specific information)
- In situ matrix potential (site-specific information)
- Longitudinal and transverse dispersivities (textbook)
- Molecular diffusion coefficients (textbook)
- Sorption distribution coefficients (much information available, but not necessarily appropriate)
- Recharge estimates
- Spatial description of aquifers
- Saturated hydraulic conductivity (site-specific information)
- Specific storativity (limited information available)
- Geometric description of surface water boundaries
- Initial conditions, such as velocities for surface water
- Boundary conditions (site-specific information)
  - Contamination entering surface water
  - Conditions affecting gaining and losing water from natural causes: evaporation, rainfall, leakage, inflow from other surface waters and groundwater
  - Conditions affecting gaining and losing water from humanmade causes: inflow from dammed waters, sewer plant discharges, storm sewer discharges, outflow to irrigation systems and municipal water supplies
- Dispersivities (textbook)
- Mixing factor
- Sorption distribution coefficient for the sediment

Exposure and Toxicity Information

- Direction with respect to programmatic and sitewide risk that should be managed
- Boundary conditions
  - Contamination entering surface water
  - Conditions affecting gaining and losing water from natural causes: evaporation, rainfall, leakage, inflow from other surface waters and groundwater
  - Conditions affecting gaining and losing water from humanmade causes: inflow from dammed waters, sewer plant discharges, storm sewer discharges, outflow to irrigation systems and municipal water supplies
- Dispersivities
- Mixing factor
- Sorption distribution coefficient for the sediment.

Impacts if not Resolved, or Resolution is Delayed:

The project would be delayed or lack specificity in the incomplete area.

Number:	Title:	Status:	Addressed in GWP:	Date:
7.01	Identification of Data and Information Needs	Open	Section 7.1, Appendix 7A	October 1994

Reference documents:

DOE, 1981, Radioactive Decay Data Tables, DOE/TIC-11026, U.S. Department of Energy, Washington, D.C.

DOE-RL, 1992d, Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes, DOE/RL-92-24, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994c, Hanford Site Background Data Applications Guide: Part 1, Soil, DOE/RL-94-72, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

See Appendix 6A, Section 6.1.

Number:	Title:	Status:	Addressed in CWP:	Date:
7.02	Integration of Numerical Modeling and Risk Assessments	Closed	Section 7.2.1	November 1994

Statement of Issue:

How will the chemical and radiological contamination from the residual waste in the SST and the contaminated soil be quantified in terms of long-term public health and environmental risk? How will this risk be related to the risk associated with the stabilization and disposal of other waste on the Hanford Site? How will numerical modeling and risk assessment be used in evaluation of closure alternatives and closure permitting?

Background:

A number of plumes have been identified in the groundwater beneath the Hanford Site. These plumes result from several sources. There is no direct indication from investigations conducted to date that any tank-leak contaminants have reached the groundwater. As stated in Chapter 3.0, the EPA is promulgating cleanup standards for federal facilities. These standards will be applied to the soil and groundwater. An analytical technique will be required to relate the accepted waste residual to these standards. It is likely that the radioactive component of residual waste in tanks, contaminated ancillary equipment, and contaminated soil will be classified by the NRC as incidental LLW. The DOE Order 5820.2A (DOE 1988c) requires that numerical modeling (performance assessment) be conducted for LLW disposal sites to evaluate long-term risk to the public health and safety from disposed waste. The Defense Nuclear Facilities Safety Board, in Recommendation 94-2, criticized the DOE for lack of progress in preparation of performance assessments for its many LLW disposal sites, and for neglecting to provide criteria for consideration of composite and cumulative effects from multiple disposal sites and from all past, present, and future disposal actions in conducting such performance assessments.

Strategy for Resolution:

Numerical models will be used to calculate the concentration of contaminants in the soil and groundwater beneath the SSTs. These analyses will apply the standard suite of Hanford Site models that have been developed and applied over the years. As stated in Issue 6.01, "Identification of Data and Information Needs," data are required to operate these analytical 'tools.' A database has been assembled to support the use of these models. The amount of additional data that will need to be collected to support the operation of these models in support of disposal concept development and the regulatory process is unknown. In the disposal concept development phase, during which costs and benefits of alternatives are compared, simplified numerical modeling techniques will be applied. Following selection of the preferred alternatives, more rigorous numerical modeling techniques will be applied for design optimization and in support of permitting. Composite effects of vitrified LLW disposal, and closure of other proximate waste units will be considered.

Impacts if not Resolved, or Resolution is Delayed:

Without the use and integration of numerical models to simulate contaminant transport and quantify human health risk, the relative contribution from each tank and its effect on the concentration of contamination in both the soils and groundwater will not be known. The results from these analyses will be required for selection of closure alternatives during the concept development phase, and in support of permitting for final closure of the tank farms. Without this information, there will be no basis to predict the performance of the cleanup operation and to assess the potential impacts associated with various cleanup decisions.

Reference documents:

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

Number:	Title:	Status:	Addressed in CWP:	Date:
7.03	Interim Performance Criteria for Operable Unit Closed with Residual Waste	Open	Section 7.2.2	November 9, 1994

Statement of Issue:

Until quantitative performance criteria have been defined for the cleanup and closure of radioactive waste sites, decisions will be made based on the use of interim performance criteria. What methods will be used to assign, evaluate, and control the use of interim performance criteria?

Background:

The Hanford Site scientific community has developed and applied numerical techniques to simulate the effect of proposed actions on human health and the environment. Recently, these techniques have been used to evaluate the consequences associated with deploying various retrieval and disposal scenarios (Boomer et al. 1991). These studies have provided insight to the cost effectiveness associated with various retrieval, processing/treatment, and disposal options. It is assumed that these same analytical techniques will be used to establish and quantify the assignment of interim performance criteria and provide a basis from which decisions will be made regarding waste retrieval and cleanup.

Aspects of systems engineering have been used to define the functions and requirements for the various waste handling systems. These systems include the retrieval, processing, and disposal of SST waste. Aspects of systems engineering and simulation modeling will be used to relate and quantify the performance of the system components.

Strategy for Resolution:

A strategy for the assignment and use of interim performance objectives is presented in Chapter 6.0, Section 6.2.2. It is important to recognize that an iterative process will be used. It is further assumed that the results from all analyses will be reviewed before initiating new analysis and that the results from these analysis will provide a basis for assigning new or revising interim performance criteria.

The overall performance objective for retrieving waste from the SSTs has been defined (Ecology et al. 1994). As stated in Issue 5.02, "Percent Waste Retrieval Required for Closure," the Tri-Party Agreement cleanup criteria is 99 percent. In addition to this criteria, radiation cleanup standards for federal facilities are being promulgated (40 CFR 196) and Ecology has issued cleanup standards for dangerous waste (WAC 173-340). As planned, the waste and contamination that currently exists in the SST tank farms will be removed and processed with the expectation of satisfying these requirements. Because these cleanup requirements are not quantitatively equivalent, analytical methods will be used to establish a relationship between these two and perhaps other applicable or relevant and appropriate requirements (ARAR) as they become defined. Because the various cause and effect relations associated with contaminant concentration, migration in the biosphere, and dose is nonlinear, these relationships will be simulated. Simulation models of several waste retrieval/processing/disposal 'systems' will be assembled and applied. Where interim performance criteria for the various system components has been measured, they will be used. Where interim performance criteria does not exist, they will be assumed. This process can also be worked in reverse. Knowing the desirable end state (i.e., a dose limit or maximum concentration), the simulation models can be used to back calculate an 'interim' performance criteria.

A three-step process for the assignment and use of interim performance criteria is provided in Chapter 6.0, Section 6.2.2. These steps include: (1) the assignment of the desirable end state based on existing regulations; (2) the assignment of interim performance criteria to the components of the various systems and the simulation of system performance; and, (3) the introduction and adjustment of performance measures to account for technology and use of nontechnical parameters.

Impacts if not Resolved, or Resolution is Delayed:

At present, it is not known if any system will satisfy the regulatory requirements. Furthermore, the relative and comparative performance of the various systems and system components is unknown. Resolution of this issue is required if a technical basis is used for the selection of the retrieval/treatment/disposal system.

Number:	Title:	Status:	Addressed in CWP:	Date:
7.03	Interim Performance Criteria for Operable Unit Closed with Residual Waste	Open	Section 7.2.2	November 9, 1994

Reference documents:

40 CFR 196, "Radiation Site Cleanup Regulation," Draft, Code of Federal Regulations, as amended.

Boomer, K. D., S. K. Baker, A. L. Boldt, M. D. Britton, L. E. Engelsman, J. D. Galbraith, J. S. Garfield, K. A. Giese, C. E. Golberg, B. A. Higley, K. J. Hull, L. J. Johnson, R. P. Knight, J. S. Layman, R. M. Marusich, R. J. Parazin, M. G. Piepho, E. J. Slaathaug, T. L. Waldo, and C. E. Worcester, 1991, Systems Engineering Study for the Closure of Single-Shell Tanks, WHC-EP-0405, Draft A, 6 vols., Westinghouse Hanford Company, Richland, Washington.

Ecology, EPA, and DOE, 1994, Hanford Federal Facility Agreement and Consent Order, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

WAC 173-340, "The Model Toxics Control Act Cleanup Regulation," Washington Administrative Code, as amended.

Number:	Title:	Status:	Addressed in CWP:	Date:
7.04	Tradeoff Between Increase in Short-Term Risk and Reduction in Long-Term Risk	Open	Section 7.2.3	November 8, 1994

Statement of Issue:

What criteria will be used in closure decision-making to achieve an optimum balance between increases in short-term risk to workers and to the public, resulting from activities to implement closure alternatives, and associated reductions in long-term risk to the public and the environment?

Background:

The objective of closure is to limit long-term risk to the public and the environment associated with potential exposure to contaminants. Implementation of closure actions that involve worker exposure to contaminants, or that increase the potential for release of contaminants to the environment through normal operations or accidents, entail increased short-term risk to workers, the public, and the environment. The DOE's policy, as stated in DOE Order 5400.5 (DOE 1990), DOE Order 5480.11 (DOE 1991c), and in the "Occupational Radiation Protection, Final Rule" (10 CFR 835), is to conduct its activities so that radiation exposures to both members of the public and workers are maintained ALARA. Compliance with the individual radiation dose limits cited in the aforementioned DOE orders and rule has been held as satisfying the ALARA principle. No guidance has been provided in DOE orders, regulations, or notices on application of the ALARA principle to optimize exposures to workers and the public within the individual protection limits cited, or with respect to collective dose.

Strategy for Resolution:

In evaluating and comparing closure alternatives, collective dose to workers from normal operations, and collective and individual dose and risk to workers and members of the public from postulated accidents will be evaluated. Performance assessment using numerical models will also be used to estimate concentrations of hazardous and radioactive contaminants reaching the accessible environment from the closed SST operable units, and resultant dose and health effects to maximally-exposed individuals and to the collective public. Results of these analyses will be made available to the decision makers as input to the selection of the preferred alternatives.

Impacts if not Resolved, or Resolution is Delayed:

This issue will be resolved in the process of selecting the preferred alternatives for closure. Decision makers will be provided with results of estimates of dose to workers and the public and resulting health effects. Each decision maker will use her/his own set of values in reaching consensus on the optimum balance between short-term risk to workers and the public, and reduction in long-term risk to the public and the environment.

Reference documents:

10 CFR 835, "Occupational Radiation Protection, Final Rule," Code of Federal Regulations, as amended.

DOE, 1990, Radiation Protection of the Public and the Environment, DOE Order 5400.5, U.S. Department of Energy, Washington, D.C.

DOE, 1991c, Radiation Protection for Occupational Workers, DOE Order 5480.11, U.S. Department of Energy, Washington, D.C.

Number:	Title:	Status:	Addressed in CWP:	Date:
7.05	In-Place Disposal Alternative for Single-Shell Tank Waste	Open	Chapter 1.0	September 1994

Statement of Issue:

Is an alternative strategy acceptable for in-place immobilization and stabilization of SST waste; how would the appropriateness of that alternative be evaluated?

Background:

The in-place disposal of SST waste is excluded from the Tri-Party Agreement (Ecology et al. 1994). However the HDW-EIS (59 FR 4052) and tank waste disposal options engineering studies (Boomer et al. 1991, 1993) contain in-place disposal as viable technical closure option.

Strategy for Resolution:

The in-place disposal of SST waste will be included as a closure option in the forthcoming TWRS-EIS (DOE-RL 1994e). Further evaluations for health risk, technology, and costs will be made for comparison purposes with other disposal options.

Impacts if not Resolved, or Resolution is Delayed:

Closure of SST farms will be delayed.

Reference documents:

59 FR 4052, "Intent To Prepare Hanford Tank Waste Remediation System Environmental Impact Statement," Federal Register, Vol. 59, No. 19, pp. 4052-4058, (January 28).

Boomer, K. D., S. K. Baker, A. L. Boldt, M. D. Britton, L. E. Engelsman, J. D. Galbraith, J. S. Garfield, K. A. Giese, C. E. Golberg, B. A. Higley, K. J. Hull, L. J. Johnson, R. P. Knight, J. S. Layman, R. M. Marusich, R. J. Parazin, M. G. Piepho, E. J. Slaathaug, T. L. Waldo, and C. E. Worcester, 1991, Systems Engineering Study for the Closure of Single-Shell Tanks, WHC-EP-0405, Draft A, 6 vols., Westinghouse Hanford Company, Richland, Washington.

Boomer, K. D., S. K. Baker, A. L. Boldt, J. D. Galbraith, J. S. Garfield, C. E. Golberg, B. A. Higley, L. J. Johnson, M. J. Kupfer, R. M. Marusich, R. J. Parazin, A. N. Praga, G. W. Reddick, J. A. Reddick, E. J. Slaathaug, L. M. Swanson, T. L. Waldo, and C. E. Worcester, 1993, Tank Waste Technical Options Report, WHC-EP-0616, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

DOE, 1987a, Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic, and Tank Waste, Hanford Site, Richland, Washington, DOE/EIS-0113, 5 vols., U.S. Department of Energy, Washington, D.C.

DOE-RL, 1994e, Implementation Plan for the Tank Waste Remediation System Environmental Impact Statement, DOE/RL-94-88, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1994, Hanford Federal Facility Agreement and Consent Order, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Number:	Title:	Status:	Addressed in CMP:	Date:
8.01	Religious Significance of Basalt Riprap in Hanford Surface Barriers	Open	Sections 8.2 and Appendix 8A	November 1, 1994

Statement of Issue:

Is the mining of basalt outcroppings on the Hanford Site substantially burdening the Yakama Indian Nation's right to free exercise of religion.

Background:

The basalt outcroppings on the Hanford Site are religiously and culturally significant to the Yakama Indian Nation. In 1993 and 1994, Congress passed and amended the Religious Freedom Restoration Act of 1993. The Religious Freedom Restoration Act was enacted to preclude the government from substantially burdening a person's exercise of religion unless it demonstrates that the application of the burden: (1) is in furtherance of compelling governmental interest; and (2) is the least restrictive means of furthering that compelling governmental interest. At issue are the proposed plans to mine the basalt outcroppings on the Hanford Site. The Yakamas have consented mining small amounts of basalt for use as riprap in the prototype Hanford Site surface barrier constructed over the 216-B-57 crib in 200 East Area, but have strong objections to mining large quantities of basalt needed for construction of surface barriers over tank farms and other waste disposal sites at the Hanford Site.

Strategy for Resolution:

The potential application for placement of the surface barrier over tank farms will be discussed in the TWRS-EIS (59 FR 4052). The design and construction of the prototype barrier includes the use of a layer of basalt to both protect the side slopes and to prevent human and biological intrusion (Wing 1994). Future use of this resource in support of this technology will need to be reviewed and approved by all interested parties. It is assumed that the public will be introduced to the potential use of this resource as part of the EIS review process. In addition, its use will be identified in the SST-CMP and assumed in various risk assessments and performance assessments. A plan to measure the performance of the prototype barrier that includes the use of basalt will be initiated during fiscal year 1995. The potential for substitution of other material(s) for basalt will be investigated.

Impacts if not Resolved, or Resolution is Delayed:

The present design specifies the use of basalt. If other materials are substituted for basalt, the entire design and testing process will be impacted. The nature and extent of this impact is unknown at this time.

Reference documents:

59 FR 4052, "Intent To Prepare Hanford Tank Waste Remediation System Environmental Impact Statement," Federal Register, Vol. 59, No. 19, pp. 4052-4058, (January 28).

Religious Freedom Restoration Act of 1993, Public Law 103-141, 107 STAT 1488 (5 USC 504; 42 USC 1988, 2000066 - 2000066-4), November 16, 1993.

Wing, N. R., 1994, Permanent Isolation Surface Barrier Development Plan, WHC-EP-0673, Westinghouse Hanford Company, Richland, Washington.

Number:	Title:	Status:	Addressed in CWP:	Date:
8.02	Potential for Differential Settlement of the Surface Barrier Across a Tank Farm	Open	Section 8.2	November 1994

Statement of Issue:

When the surface barrier is constructed over tank farms, the soil between the tanks may exhibit one consistent load-deformation response, while the backfilled tanks exhibit a response that is consistent but different. The product of this scenario would be a pattern of differential settlement of the surface barrier depending on the relative stiffness of the tanks and soil between tanks.

Background:

This issue is discussed in Wing (1994). No work has been determined on this activity at the Hanford Site.

Strategy for Resolution:

Settlement over the tanks is determined by the load-deformation response of the tank backfill and the load-deformation response of the tank foundation soils. Settlement of the surface between the tanks is determined by the load-deformation response of the soil column between the tanks. The soil between the tanks is made up of previously excavated soil. The soil between the tanks and the foundation soil under the tanks may be similar in terms of geology, yet different in terms of relative density, loading history, and load-deformation response.

The information needed to resolve this issue would be best obtained by performing standard penetration resistance tests of the soil column between the tanks. However, the load-deformation response of the soil between tanks could be evaluated using other methods, such as the plate bearing test.

When the necessary information has been obtained, settlements over the tanks and between the tanks should be estimated and compared. If the estimates differ significantly, a strategy for minimizing the problem would have to be developed. The solution might take the form of densifying or otherwise stiffening either the fill inside the tanks or the fill outside of and between the tanks, or of placing a temporary surcharge load over the site.

Impacts if not Resolved, or Resolution is Delayed:

If the various load-deformation responses under various portions of the covered area are quantified, settlement of the surface barrier over the tanks cannot be evaluated and the surface barriers cannot be designed appropriately for the settlement condition.

Reference documents:

Wing, N. R., 1994, Permanent Isolation Surface Barrier Development Plan, WHC-EP-0673, Westinghouse Hanford Company, Richland, Washington.

Number:	Title:	Status:	Addressed in CWP:	Date:
8.03	Potential for Surface Barrier Subsidence to Occur Over Tanks	Open	Sections 8.2 and 8.7	November 1994

Statement of Issue:

Without some form of permanent internal support, tank domes (especially of the larger-diameter tanks) are likely to collapse, leading to rupture of the surface barrier, during or after closure because of the weight of existing cover soil and surface barrier materials. Backfilling the tanks with sand, gravel, or grout will mitigate this issue.

If there is residual head space in tanks after backfilling, or if the fill has a low bearing capacity, the potential exists for the tank domes to undergo progressive buckling under the weight of the surface barrier emplaced at closure. In this scenario, a gradual failure mode is envisioned in which the weight of the tank domes and the surcharge load of the surface barrier is gradually transferred to the tank fill, which in turn undergoes compression. Progressive failure will cease when sufficient bearing resistance is developed by the fill. Moderate to minor subsidence of the tank domes would create shallow craters or 'dimples' in the surface barrier. Such features would adversely impact barrier performance (i.e., by creating localized reversals in the slopes of the barrier layers such that lateral drainage from portions of the barrier area is prevented, or possibly by inducing localized shear or flexural stresses that would lead to rupture of the low-permeability asphalt layer of the barrier).

Background:

The issue has been recognized for some time. Stowing equipment for the aggregate fill alternative has been demonstrated (RHO 1983b) in a sub-scale tank mockup. Load-deformation characteristics of the backfill were not determined. A full-scale demonstration of the aggregate fill alternative was planned (RHO 1983a) but not conducted. The grout fill alternative has not been evaluated to an equivalent extent.

Strategy for Resolution:

Two alternative strategies for internal support of tanks have been proposed. One alternative is to fill the tanks with aggregate, using equipment developed for stowing bulk materials into bins, holds, and/or bunkers. The second alternative is to fill the tanks with grout.

To resolve this issue, assessments are needed of the load-deformation responses of the tank domes and the tank fill to the surcharge weight represented by the surface barrier. With these assessments, the minimum required bearing capacity of the tank fill can be established and tank dome deflection predicted. The surface barrier can be designed for the predicted tank dome deflection.

Impacts if not Resolved, or Resolution is Delayed:

A preferred alternative must be selected to support surface barrier design. This is one of a number of programmatic issues that would have to be resolved before closure activities at any individual tank farm site could be initiated.

Reference documents:

RHO, 1983a, Single-Shell Tank In Situ Disposal Demonstration Plan, WHC-SD-RE-PAP-006, Rockwell Hanford Operations, Richland, Washington.

RHO, 1983b, Tank Mock-Up Engineering Study, WHC-SD-WM-ES-020, Rockwell Hanford Operations, Richland, Washington.

Number:	Title:	Status:	Addressed in CWP:	Date:
8.04	Hanford Engineered Surface Barrier	Open	Section 8.2	November 1994

Statement of Issue:

Should the monitoring and testing of the prototype barrier be completed? The performance of the Hanford Engineered Surface Barrier can be quantified once this information is collected.

Background:

The ROD for the HDW-EIS recommended that the DOE sponsor research for the development of an enhanced cover design (53 FR 12449). During fiscal year 1988, a program was initiated in response to this recommendation. Since its inception, the program has had several sponsors and has struggled from year to year to obtain its funding. During fiscal year 1991, the ER Program adopted the program and continued to support the program through fiscal year 1994. During the 3 years, the program was peer reviewed on two separate occasions and a prototype test barrier was constructed for the purpose of collecting construction cost and to test performance. Construction of the prototype barrier was complete in September 1994. A testing program was scheduled to be initiated during fiscal year 1995 and continue through fiscal year 1998. During fiscal year 1995, the ER Program reduced the level of support to the point that the performance testing of the prototype structure cannot be completed.

Strategy for Resolution:

It has been proposed that the responsibility for the program be transferred to Waste Management (Wagoner 1994). However, no decision on the transfer of this responsibility has been made. It is recommended that this responsibility be formally assigned to TWRS.

Impacts if not Resolved, or Resolution is Delayed:

The closure of waste sites will require the use of a cover or surface barrier. The Hanford Engineered Surface Barrier has been designed to satisfy the functions and requirements for closing Hanford Site waste sites (Wing 1993). However, before the barrier can be used, its performance must be quantified. The delay in collecting this data will result in additional cost. In addition, if funding is not provided in the near future, a 'new team' of scientists and engineers will need to be assembled to complete the program.

Reference documents:

53 FR 12449, "Final Environmental Impact Statement for the Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision," Federal Register, Vol. 53, No. 72, pp. 12449-12453, (April 14).

Wagoner, J. D., 1994, Change to Single-Shell Tank Memorandum of Agreement, (letter #40517 to J. E. Baublitz and J. E. Lytle, dated August 12), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Wing, N. R., 1993, Permanent Isolation Surface Barrier: Functional Performance, WHC-EP-0650, Westinghouse Hanford Company, Richland, Washington.

Number:	Title:	Status:	Addressed in CWP:	Date:
8.05	Subsurface Barriers	Closed	n/a	May 1995

Statement of Issue:

Will subsurface barriers be deployed to confine potential leakage of waste from SSTs during waste retrieval operations?

Background:

Tri-Party Agreement Milestone M-45-07-T04 (Ecology et al. 1994) required a decision on whether to proceed with a subsurface barrier program by June 1997. This decision was to be based on the results of subsurface barrier demonstration testing that was scheduled to be completed by March 1997, in accordance with Tri-Party Agreement Milestone M-45-07-T03. A decision to proceed with subsurface barrier demonstration testing will be made pursuant to Tri-Party Agreement Milestone M-45-07B. This milestone was stated completed in TPA Change No. M-45-95-01 dated May 11, 1995, which replaced the balance of the M-45-07 milestones with a new series of milestones under M-45-08 relating to leak detection and mitigation.

Strategy for Resolution:

n/a.

Impacts if not Resolved, or Resolution is Delayed:

n/a.

Reference documents:

Cruse, J. M., R. L. Treat, B. B. Peters, R. J. Cameron, W. D. McCormak, T. Trenkler, M. F. Walters, J. K. Rouse, and T. J. McLaughlin, 1994a, Feasibility Study of Tank Leakage Mitigation Using Subsurface Barriers, WHC-SD-WM-ES-300, Rev. 0, prepared by Enserch Environmental, Inc., and Bovay Northwest, Inc., for Westinghouse Hanford Company, Richland, Washington.

Ecology, EPA, and DOE, 1994, Hanford Federal Facility Agreement and Consent Order, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Federal Facility Agreement and Consent Order Change Control Form, Change Number M-45-95-01, dated May 11, 1995.

Number:	Title:	Status:	Addressed in CMP:	Date:
8.06	Technical and Regulatory Basis for Leak Detection and Monitoring to Support SST Waste Retrieval and Disposal	Open	Section 8.4	May 1995

Statement of Issue:

What is the basis (technical and regulatory) for LDM needed to support SST waste retrieval and disposal?

Background:

The current, primary leak detection devices for SSTs are internal systems. Confidence in these systems comes from years of experience, extensive historical data, and the inherent simplicity of the systems themselves. They are accepted because they are able to get the job done. The parameters within which they operate and the data they produce are accepted because they are considered to represent the best available technology. Faced with current remediation goals however, decisions must be made regarding future changes to LDM needs, and the capabilities and demands on existing systems. The search for, and evaluation of new and improved LDM technologies can only take place with technical and regulatory criteria established.

Related environmental compliance and technical interests cannot be communicated clearly, or worked together efficiently, without a common ground of agreed-to criteria and basis for LDM. Presently, there are no specific, written criteria describing the technical and regulatory basis for LDM to support SST waste retrieval and disposal. Such a basis would identify the technical and informational needs of LDM methods and devices that are/will be needed to support remediation activities.

The present dialog on LDM is based on a widely varied collection of real and imagined 'requirements.' The consequences of this situation include potentially invalid or inappropriate decision-making, nondefensible technical plans and actions, inefficient and possibly unnecessary spending on potential 'solutions', and endless and inconclusive dialog with technology providers/developers attempting to help the Hanford Site solve its LDM 'problems.'

Once a technical basis is in place and accepted by all parties, there is a common point from which remediation dialog, involving LDM, can begin as follows:

- The LDM possibilities and use can be discussed in the context of technically realistic capabilities.
- Potential LDM technical solutions can be sought and evolve.
- The process of technology identification and evaluation becomes more straightforward and rational with performance requirements clearly stated.
- Planned and potential remediation decisions can be evaluated against the costs and risk involved with developing 'required' LDM and other surveillance devices.
- The field of potential technical solutions can be narrowed and defended more easily.
- The results of proposed technical solutions can be evaluated through cost/benefit analysis and risk assessment.

At least three major, interrelated LDM topical areas could be coordinated using a single LDM criteria basis as follows:

- Borehole logging and characterization of the tank farms soil environment
- Leak detection and surveillance of the SSTs during routine/custodial operations and during remedial action
- Leak detection and monitoring technology development and engineering application to support SST remedial action.

In May 1995, a series of milestones under TPA Milestone M-45-08 related to leak detection and mitigation during sluicing retrieval operations in SSTs were added by Federal Facility and Consent Order Change Control No. M-45-95-01.

Number:	Title:	Status:	Addressed in CMP:	Date:
8.06	Technical and Regulatory Basis for Leak Detection and Monitoring to Support SST Waste Retrieval and Disposal	Open	Section 8.4	May 1995

Strategy for Resolution:

Develop functions and requirements for leak detection and monitoring to support SST retrieval and remediation action. Determine functions and requirements (F&R) through a technically facilitated consensus activity between Hanford Site, the DOE-RL, and stakeholder staff.

Impacts if not Resolved, or Resolution is Delayed:

Leak detection and monitoring actions/nonactions related to SST retrieval and remediation cannot be defended without a clearly stated technical and compliance basis (i.e., F&Rs). Should LDM technology be required through findings of a F&R evaluation, engineering applications or technology development activities would be held up until such basis documentation were prepared and released. Without the effort to develop LDM F&Rs, related activities will continue independently and the process of coordination will be delayed. This will have potential impacts on cost efficiency, schedules, increased resource requirements, and duplication of effort.

The current approach and SST surveillance techniques has been accepted for LDM of SSTs during ongoing, routine operations. However, there is no 'current approach' regarding LDM to support SST retrieval and disposal, and there is no basis for LDM technology identification, evaluation, or deployment. Furthermore, without such a basis, there is no way to assess the adequacy of current methods or the need for, and potential of, new or modified techniques.

There is no way to defend the adequacy or appropriateness of current LDM methods and devices to support SST remediation without a technical and regulatory basis on which to compare. In the interim, the lack of new LDM technology, and the perceived need for that technology, could hold remediation actions hostage and prevent or slow progress.

Reference documents:

Federal Facility Agreement and Consent Order Change Control Form, Change Number M-45-95-01, dated May 11, 1995.

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APPENDIX 2A

HYDROGEOLOGICAL INVESTIGATIONS

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CONTENTS

2A.1.0 HYDROGEOLOGICAL INVESTIGATIONS . . . . . APP 2A-1

2A.1.1 FACILITY BACKGROUND . . . . . APP 2A-1

2A.1.2 GEOLOGY OF THE HANFORD SITE . . . . . APP 2A-2
2A.1.2.1 Introduction . . . . . APP 2A-2
2A.1.2.2 Regional Geologic Setting . . . . . APP 2A-3
2A.1.2.3 Geology of the 200 Areas . . . . . APP 2A-4

2A.1.3 HYDROGEOLOGY . . . . . APP 2A-6
2A.1.3.1 Climate and Surface Hydrology . . . . . APP 2A-6
2A.1.3.2 The Vadose Zone . . . . . APP 2A-7
2A.1.3.3 Groundwater Hydrology of the 200 Areas . . . . . APP 2A-15

2A.1.4 GROUNDWATER MONITORING . . . . . APP 2A-18
2A.1.4.1 RCRA Monitoring . . . . . APP 2A-18
2A.1.4.2 Historical Groundwater Monitoring . . . . . APP 2A-22

FIGURES

2A-1	200 East Area Waste Management Area Location Map	APP F2A-1
2A-2	200 West Area Waste Management Area Location Map	APP F2A-2
2A-3	Structural Geology of the Pasco Basin	APP F2A-3
2A-4	Geomorphic Features Surrounding the 200 Areas	APP F2A-4
2A-5	Generalized Stratigraphy of the Hanford Site	APP F2A-5
2A-6	Generalized Stratigraphy of the Suprabasalt Sediments at the Hanford Site	APP F2A-6
2A-7	Legend for Geologic Cross Sections	APP F2A-7
2A-8	North-South Geologic Cross Section Through Western Part of 200 East Area	APP F2A-8
2A-9	West-East Geologic Cross Section Through 200 East Area	APP F2A-9
2A-10	North-South Geologic Cross Section Through Eastern Part of 200 East Area	APP F2A-10
2A-11	North-South Geologic Cross Section Through 200 West Area	APP F2A-11
2A-12	West-East Geologic Cross Section Through 200 West Area	APP F2A-12
2A-13	Generalized Hydrostratigraphy of the 200 East Area	APP F2A-13
2A-14	Generalized Hydrostratigraphy of the 200 West Area	APP F2A-14
2A-15	Liquid Effluent Disposed to Ground at the Hanford Site	APP F2A-15
2A-16	Hindcast Water Table Map of the Hanford Site, January 1944	APP F2A-16
2A-17	200 Areas Water Table Elevation, June 1993	APP F2A-17
2A-18	Hydrographs of 200 East Area SST Groundwater Monitoring Wells	APP F2A-18
2A-19	Hydrographs of Groundwater Monitoring Wells in SST WMAs S-SX and T	APP F2A-19
2A-20	Hydrographs of Groundwater Monitoring Wells in SST WMAs TX-TY and U	APP F2A-20
2A-21	June 1993 Water Table Map for the 200 East Area	APP F2A-21
2A-22	Location Map for Single-Shell Tank Groundwater Monitoring Wells in 200 East Area	APP F2A-22
2A-23	Location Map for Single-Shell Tank Groundwater Monitoring Wells in 200 West Area	APP F2A-23
2A-24	Schematic Diagram of a Completed Groundwater Monitoring Well	APP F2A-24

TABLES

2A-1 Single-Shell Tanks . . . . . APP T2A-1
2A-2 Hydraulic Gradients at Single-Shell Tank Waste Management Areas . . . . . APP T2A-2
2A-3 Groundwater Flow Velocities[a,b,c] in the Unconfined Aquifer Beneath Single-Shell Tank Waste Management Areas . . . . . APP T2A-3
2A-4 Hydraulic Properties in the 200 Areas . . . . . APP T2A-4
2A-5 Wells in the Single-Shell Tank Groundwater Monitoring Network . . . . . APP T2A-5.1
2A-6 Water Level Decline Single-Shell Tank Groundwater Monitoring Wells . . . . . APP T2A-6.1
2A-7 Single-Shell Tank Historical Groundwater Monitoring Wells . . . . . APP T2A-7.1
2A-8 Some Procedures used to Control the Quality of Characterization Data . . . . . APP T2A-8

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2A.1.0 HYDROGEOLOGICAL INVESTIGATIONS

Proposals to dispose of and/or close the SSTs, which are discussed in Chapter 1.0, Section 1.1, summarize closure alternatives presented in the HDW-EIS (DOE 1987a) and the Tri-Party Agreement (Ecology et al. 1994). Soils into which waste was leaked or spilled must also be closed as required by WAC 173-303-610 and 173-303-640. Once leaked or spilled, the waste has escaped engineered containment. The fate and transport of the waste is then a function of the characteristics of the waste, the soils to which it has been released, and the soil/waste interaction. If and when any of the waste reaches groundwater, the concentration and/or activity of any constituents when reaching groundwater, and the fate and transport of these constituents through the saturated media to the Columbia River are a function of the characteristics and processes in the natural system.

Contaminants are present in the soils surrounding many of the assumed leaking SSTs and ancillary facilities. The fate and transport of these released constituents have a significant impact on the risk to public health and safety, and must be addressed as part of any risk or performance assessments conducted in support of evaluating various closure options for the SSTs. Therefore, an understanding of the characteristics of the unsaturated and saturated media and the processes affecting mobility and transport is essential to making decisions regarding closure of the SSTs. This chapter provides background on the natural system and the characteristics and processes that will affect mobility and transport of waste constituents and ultimately the risk presented by the various closure and/or remedial measures that may be evaluated to minimize risk to public health and safety.

The SSTs are actively storing hazardous (as well as radioactive) waste. As such, they are RCRA facilities for which interim-status groundwater monitoring has been instituted in accordance with WAC 173-303-400 (and 40 CFR 265 by reference) and the Tri-Party Agreement (Ecology et al. 1994). A summary of historical (i.e., before the implementation of RCRA at the Hanford Site) and RCRA groundwater monitoring is provided in Section 2A.1.4 to provide background on groundwater quality beneath the SSTs. Chapter 4.0, Section 4.4.6 details some issues relating to the uncertainties of the movement of waste through the unsaturated and saturated media underlying the SSTs and their potential impact on risk and performance assessments (Chapter 6.0, Section 6.1).

2A.1.1 FACILITY BACKGROUND

The SSTs are considered to be actively storing mixed hazardous and radioactive components and are one of many RCRA facilities on the Hanford Site regulated by Ecology under WAC 173-303. Groundwater monitoring as required by 40 CFR 265 (referenced in WAC 173-303-400) for interim status facilities has been implemented at each of these RCRA facilities, including the SSTs. Groundwater monitoring of RCRA facilities on the Hanford Site is addressed in the Tri-Party Agreement (Ecology et al. 1994) and milestones for groundwater monitoring are contained in the Action Plan under Milestone M-24-00.

The RCRA groundwater monitoring at the SSTs began in 1989 with the preparation of a groundwater monitoring plan (Jensen et al. 1989) and the completion of 12 groundwater monitoring wells to satisfy Tri-Party Agreement Milestone M-24-03. Twenty-one additional RCRA standard wells (i.e., wells compliant with construction specifications in WAC 173-160) were constructed at the SSTs in 1990 and 1991. Eleven wells, constructed from 1990 through 1991, satisfied Milestone M-24-07. Ten additional wells were constructed in 1991 to satisfy Milestone M-24-15. Two more wells were added in 1992 to satisfy Milestone M-24-28.

The 149 SSTs are located in 12 tank farms in the 200 Areas of the Hanford Site (Figures 2A-1 and 2A-2). For purposes of groundwater monitoring, the SSTs are within 7 waste management areas, each of which contain between 10 and 40 SSTs (Table 2A-1). Waste management areas A-AX, B-BX-BY, and C are located in the 200 East Area (Figure 2A-1); waste management areas S-SX, T, TX-TY, and U are located in the 200 West Area (Figure 2A-2).

Waste management operations created a complex intermingling of processing plant waste by pumping plant effluent into various tanks. This waste was subsequently transferred to different tanks to accommodate available space, provide feed for evaporators, and remove waste from suspected leaking tanks. Nonradioactive chemicals were added to the tanks while varying amounts of waste- and heat-producing radionuclides were removed. In addition, natural processes caused settling, stratification, and segregation of waste components. Waste also was cascaded (allowed to flow by gravity from one tank to another via lateral connecting pipes) through a series of tanks; cooling and precipitation of radionuclides and solids occurred in each tank of the cascade.

As a result, it is difficult to estimate the composition of the waste in the tanks using operational records. Records of generated waste were minimized for security reasons so that data could not be used to estimate the volume of special nuclear materials produced during the Cold War.

The processes that generated waste stored in the SSTs, the composition of the waste, and the history of operations that produced the waste may be found in Chapters 2.0, 4.0, and 6.0 and in Anderson (1990). Radionuclide and chemical inventories for each of the SSTs were summarized in a 1993 consultant report to Westinghouse Hanford (Van Vleet 1993).

2A.1.2 GEOLOGY OF THE HANFORD SITE

2A.1.2.1 Introduction

The geologic development of the Columbia Plateau, particularly the Pasco Basin, has been studied in detail for the DOE as part of the siting studies for a now-canceled deep geologic repository for high-level nuclear waste. The *Consultation Draft, Site Characterization Plan* (DOE 1988a) summarizes information about the Hanford Site, particularly near the 200 West Area where the candidate repository site was located. Geologic studies of the Columbia

River basalt, which underlies the Columbia Plateau and the Hanford Site, are presented in Reidel and Hooper (1989). Geologic studies to verify the tectonic suitability of sites for nuclear power plants located on the Hanford Site include those for the Washington Public Power Supply System (WPPSS) (1981) and the Skagit/Hanford Project (PSPL 1982). More detailed information is available in the following documents:

- Structural geology, tectonics and volcanism (Caggiano and Duncan 1983; Reidel and Hooper 1989)

- Basalt stratigraphy and chemistry (Swanson et al. 1979; Reidel et al. 1982; Reidel and Hooper 1989)

- Sedimentary units interfingered with and overlying the basalts (Bjornstad 1984, 1985; Fecht et al. 1985; Myers et al. 1979; Myers and Price 1981; Graham et al. 1984; Reidel and Hooper 1989; Lindsey and Gaylord 1989; and Lindsey 1991). Tallman et al. (1979) prepared the first in-depth study of the geology of the 200 Areas.

2A.1.2.2 Regional Geologic Setting

The Hanford Site is in the Pasco Basin, a structural and topographic basin within the Columbia Plateau. The Columbia Plateau is located in an intermountain basin extending from the Bitterroot Mountains to the Cascade Range that is partially filled with a thick sequence of Miocene tholeiitic basalt flows called the Columbia River Basalt Group (Swanson et al. 1979). Flows of the Grande Ronde, Wanapum, and Saddle Mountains basalts are present in the Pasco Basin and were erupted from northwest trending linear vent systems in the interval between 17 and 8 million years ago. Tuffaceous volcaniclastic sediments that developed between eruptions separate many of these basalt flows. These flows have been folded and faulted, creating broad structural and topographic basins separated by asymmetric anticlinal ridges (Figure 2A-3). Primary flow-top breccias and interbeds within this stratigraphic sequence may serve as aquifers of the confined aquifer system.

The thick basalts rest unconformably on older Tertiary sedimentary or volcanic rocks and are in turn overlain by fluvial and lacustrine sediments of the Miocene-Pliocene Ringold and Quaternary Hanford Formations. These Neogene sediments, which consist of sand, gravel, silt, and clay, were deposited in streams or lakes and constitute the supra-basalt (unconfined) aquifer system beneath the Hanford Site. Coarse gravel facies within these units are highly transmissive when saturated; clay- and silt-rich units are not highly transmissive when saturated and may serve as perching horizons or confining or partially confining units for water in the Neogene sediments within the vadose zone. Under unsaturated conditions, finer grained units are often more transmissive (i.e., have higher unsaturated hydraulic conductivity).

2A.1.2.3 Geology of the 200 Areas

The 200 Areas are developed on a gently sloping, low relief surface that has resulted from two geomorphic processes: (1) Pleistocene cataclysmic flooding and (2) Holocene eolian activity. Quaternary cataclysmic flooding from the catastrophic failure of glacially dammed lakes that drained across the Columbia Plateau ended about 13,000 years ago (Mullineaux et al. 1978). These floods, which produced the coulees typical of the Channeled Scablands, led to deposition of sand and gravel in waters hydraulically impounded north of Wallula Gap. Deposition of sand and gravel created Cold Creek bar (Bretz et al. 1956), a prominent flood feature on which the 200 Areas are developed (Figure 2A-4). The northern boundary of the Cold Creek bar is an east-southeast trending erosional channel, which was cut by floodwaters draining from the basin (Bjornstad et al. 1987).

Since the end of the Pleistocene, winds have locally reworked the surficial glaciofluvial sediments, depositing a veneer of eolian sand. Holocene sand dunes are present along the southern boundary of the 200 East Area (Figure 2A-4). Holocene alluvium was deposited along the Cold Creek-Dry Creek alluvial plain, less than 1 mile (1.6 kilometers) southwest of the 200 West Area (Figure 2A-4).

The Cold Creek bar rests unconformably on dipping Columbia River basalts along the flanks of the Cold Creek syncline, which is bounded on the north by the Umtanum Ridge-Gable Mountain anticlinal structure and on the south by the Yakima Ridge anticline (Figure 2A-3). In the 200 Areas, the basalt strata generally dip gently (less than 5 degrees) to the south-southwest, except in the southwest corner of the 200 West Area, where flows are nearly horizontal along the axis of the Cold Creek syncline. While the basalt strata dip southwest, the surface of the basalt slopes generally to the south. The axis of the Cold Creek syncline plunges southeastward.

The generalized stratigraphy of the Hanford Site is shown in Figure 2A-5. Bedrock consists of Miocene tholeiitic basalt flows and tuffaceous sedimentary interbeds, which belong to the Columbia River Basalt Group and the Ellensburg Formation, respectively. The uppermost basalt flow in the 200 Areas is generally the Elephant Mountain Member, which acts as a confining layer to the underlying Rattlesnake Ridge interbed. Overlying Columbia River basalt is the fluvial-lacustrine Ringold Formation, consisting of variably mixed and interbedded gravel, sand, silt, and clay (Figure 2A-6). The thickness of the Ringold Formation ranges from 0 feet (0 meters) in the northern part of the 200 East Area to about 500 feet (152 meters) in the southwest portion of the 200 West Area near the axis of the Cold Creek syncline (DOE 1988a; Tallman et al. 1979). Overlying the Ringold Formation are sands and gravels of the Quaternary Hanford formation that are generally divisible into two major facies: a coarse sand and gravel facies representing high-energy sedimentary environments (channels and bars) and a fine facies representing low-energy sedimentary environments (slackwater deposits in overbank or in protected backwater environments). Sediments of the Hanford formation were deposited during Pleistocene cataclysmic floods.

2A.1.2.3.1 200 East Area. Geologic cross sections through the 200 East Area are provided in Figures 2A-8, -9 and -10. The base of the Neogene section throughout the 200 East Area is the Elephant Mountain Member of the Saddle Mountains Formation. North of the 200 East Area, two boreholes have gone from the Hanford formation directly into the Rattlesnake Ridge interbed, indicating that the Elephant Mountain member has been removed by erosion. The extent of this window through the Elephant Mountain member is unknown. Graham et al. (1984) suggest that the Elephant Mountain member may also be missing in the northeastern part of the 200 East Area based on anomalous barometric efficiency data. The Rattlesnake Ridge interbed is composed of reworked volcanic ash with interbedded fine to coarse grained sand units. The Rattlesnake Ridge unit thickens from a few feet (meters) north of the 200 East Area to more than 65 feet (20 meters) to the south.

Ringold unit A gravel and the overlying lower mud sequence are present in the southern part of the 200 East Area, but thin and pinch out against basalt highs in the central 200 East Area. These are overlain by the Ringold unit E gravels that also thicken to the south. Gravels just above the basalt in the north-central part of the 200 East Area may be either the Ringold unit A or E.

The Hanford formation in the 200 East Area is divisible into three units: Hanford lower gravel, Hanford sand, and Hanford upper gravel. The gravels are generally pebble to cobble gravels, occurring in a medium-to-coarse sand matrix. In the northern part of the 200 East Area, Hanford lower gravels or Hanford sand directly overlies the Elephant Mountain Member of the Columbia River basalt. These units thin onto basalt highs. In places, Hanford lower gravels may be directly overlain by Hanford upper gravels, but without the intervening sand unit, the two are indistinguishable. Each of these units is highly variable. Clastic dikes, as discussed in Section 2A.1.3.2, have been observed cross cutting various units of the Hanford formation in the 200 East Area.

2A.1.2.3.2 200 West Area. Geologic cross sections through the 200 West Area are provided in Figures 2A-11 and 2A-12. Directly overlying the Elephant Mountain Member of Columbia River basalt is the Ringold A unit. This unit consists largely of fluvial gravel with some intercalated sand and silt lenses in the west and south. The unit is present throughout the 200 West Area but thins to the north and pinches out beyond the 200 West Area perimeter fence. Fine sand, silt, and clay of the Lower Mud Sequence of the Ringold overlie Ringold A gravels. The lower mud sequence is thickest in the west central part of the 200 West Area and pinches out in the northeast corner of 200 West. Matrix-supported, pebble and cobble gravel of the Ringold unit E overlies the Lower Mud Sequence and is variably cemented and of variable thickness throughout the 200 West Area. Laminated to thin-bedded silt and fine sand of the upper unit of the Ringold Formation overlies the Ringold unit E and are present only in the western, northern, and central part of the 200 West Area.

Separating the Ringold from the Hanford Formation is the Plio-Pleistocene/Early Palouse unit. The Plio-Pleistocene is a calcareous paleosol that varies in thickness and intactness throughout the area. In places, it is a dense, sometimes blocky and sometimes fractured caliche that may have

erosional windows through it in a number of places. The 'early' Palouse soil is a silt-rich unit that occurs only in the subsurface and is sometimes confused with the silt-dominated facies of the overlying Hanford formation.

The Hanford formation consists of a lower fine and an upper coarse facies, with high degree of textural variation within and among these units. Silt and silty fine sand in fining-upward sequences are common and sometimes interbedded with coarser sands and some gravel. The lower fine unit thickens to the south in the 200 West Area. Clastic dikes are common in this unit. The upper coarse unit of the Hanford formation generally consists of coarse sand and intercalated gravel, with some minor silt units. As with the Hanford fine unit, this sequence is highly variable with regard to texture and clast size. Some fining upward sequences grading from gravel through sand are present in the upper coarse facies.

Additional details on the geology of the 200 Areas and beneath each waste management area may be found in Delaney et al. (1991), Lindsey (1991), and Caggiano and Goodwin (1991).

2A.1.3 HYDROGEOLOGY

2A.1.3.1 Climate and Surface Hydrology

The climate of the Hanford Site is semiarid, with warm, dry summers and cool winters (Stone et al. 1983). Annual precipitation at the Hanford Site has varied from a low of 3 inches (7.5 centimeters) to a high of 11.5 inches (29 centimeters) with a mean of 6.3 inches (16 centimeters) (DOE 1988a). Intense precipitation is rare, with only two occurrences of more than 1 inch (2.5 centimeters) in 24 hours. About 42 percent of annual precipitation occurs between November and February, and about 35 percent of this precipitation may occur as snow. Temperatures frequently drop below freezing during winter nights, but prolonged periods of sub-freezing weather are not common. Sub-zero temperatures (Fahrenheit) may occur for brief periods. Daytime high temperatures in the winter average (for any month) above freezing. The ground may freeze to depths of up to 3 feet (90 centimeters), but the depth of frozen ground commonly does not exceed 1 foot (30 centimeters).

The largest surface water body at the Hanford Site is the Columbia River, which serves as the local and regional discharge point for groundwater and surface water runoff. From Priest Rapids Dam west of the Hanford Site [pool elevation of 488 feet (149 meters)] to the southern edge of the 300 Area, the Columbia River is free flowing before it reaches the 340-foot (104-meter) pool elevation of Lake Wallula upstream from McNary Dam. Changes in Columbia River stage can be rapid and, when raised quickly by release of water from upstream dams, can lead to infiltration of river water into the sediments along channel margins (i.e., bank storage). Conversely, rapid declines in river stage can accelerate the flow of groundwater into the Columbia River. These phenomena are common along the river and have had notable effects on groundwater flow along with rates and directions of contaminant transport in the 100 and

300 Areas of the Hanford Site. The Yakima River flows along the southwestern border of the Hanford Site and affects recharge to the southern part of the Hanford Site.

West Lake is a natural pond along the southern flank of Gable Mountain on the Hanford Site. Waste management ponds have been created during Hanford Site operations that collected low-level liquid effluent from chemical processing facilities since operations began in 1944. Several of these ponds [e.g., the 216-A-25 (Gable Mountain), 216-U-10 (U) and 216-T-4 (T) Ponds] have been decommissioned. Only the 216-B-3 Expansion Ponds remains active.

2A.1.3.2 The Vadose Zone

2A.1.3.2.1 Description of Vadose Zone. The vadose zone is the volume of soils and/or sediments extending from the ground surface to the water table and consists of solid, liquid, and gaseous phases. Grains of minerals and rock fragments of varying sizes are the principal solid elements in the vadose zone. The packing of these grains affects the density of the soil. The void spaces between the grains may be filled with gases or liquids. The grain size distribution of the material affects the closeness of the packing, with finer grains commonly occurring between larger grains or clasts. Precipitation of solutes between the grains can cement them in place and reduce the void space (porosity) available for storage of liquids or gases. Liquids include infiltrating precipitation that may be modified by the addition of soluble species, or any liquid waste discharged to the soils. Gases present in the interstices between grains include air, gaseous products of any biotic decomposition, and any contaminants that may have been volatized (usually organics).

Below the water table, all the voids (interstices and/or fractures) are filled with liquids. Above the water table, the voids are generally not filled with liquids; however, saturated zones may exist above a zone of lower permeability (e.g., a clay unit) in a perched zone. Pressure at the water table equals atmospheric pressure while pressure above the water table is less than atmospheric and fluids are generally held by capillary forces. Water in the saturated zone moves from areas of higher head (water level) to areas of lower head, where the total head is the sum of the pressure and the elevation head. Liquid also moves in the vadose zone where the total soil water potential is the sum of the soil water potential and the elevation potential. Liquid will not flow freely into a well or collection device in the vadose zone without applying suction; therefore, water is not extracted from the vadose zone for human consumption or irrigation. The field capacity of a soil is defined as the volume of liquid that can be held by capillary forces so that it will not drain under the influence of gravity.

Clastic dikes are known to be present in the Hanford formation and their presence could influence fluid and contaminant transport. The dimensions of clastic dikes vary from a width of a few centimeters to several meters. Length can vary from a few meters to tens of meters; depth of dikes can also vary widely. Polygonal patterns indicative of clastic dikes in the subsurface have been observed south of the 200 West Area suggesting their presence within

the 200 West Area. Clastic dikes were found during drilling of boreholes and in excavations in the vicinity of the 216-U-14 ditch (200-UP-2 operable unit) (Singleton and Lindsey 1994) in the Hanford fine and Plio-Pleistocene units, which occur at depths exceeding 100 feet (30 meters). Clastic dikes were also found in excavations in the Hanford formation at the site of the now-canceled grout treatment program east of the 200 East Area. Many form polygonal patterns where they intersect the ground surface. Geometry of clastic dikes in the Pasco Basin was addressed by Black (1979). The effect of clastic dikes on liquid transport varies with the dimensions of the dike, the volume, rate of application, and location (relative to the dike) of any applied liquids, the grain size distribution and stratification of materials within the dike (Fecht et al. 1994). At the extreme, clastic dikes could serve as conduits or barriers for infiltration of liquids.

The vadose zone in the 200 East Area consists of Holocene surficial deposits, the Hanford formation, the Ringold fluvial gravel units A and E, the Ringold lower mud and basalt (Figure 2A-13). In the central to northern part of the 200 East Area where the 241-A, -AX, -B, -BX, -BY, and -C SST farms are located, the Hanford formation and Holocene surficial deposits dominate. The thickness of the vadose zone beneath these tank farms ranges from about 250 to 280 feet (76 to 85 meters). Some perched water has been reported in the vicinity of the 241-BX tank farm, and a silt-rich unit apparently controlled the distribution of leaked contaminants from the 241-BX-102 tank (Womack and Larkin 1971). The contrast in grain sizes and unsaturated hydraulic conductivity between strata within the vadose zone creates capillary barriers that change the direction of liquid infiltration and thus, the anisotropy of fluid transport.

The vadose zone in the 200 West Area is comprised of Holocene surficial deposits, the Hanford formation, the Plio-Pleistocene/'Early Palouse' horizons, the Upper Ringold unit, and the upper parts of the Ringold E unit (Figure 2A-14). All the SST groundwater monitoring wells in the 200 West Area are screened at the top of the water table, which is in the Ringold E unit. The thickness of the vadose zone beneath SST farms in the 200 West Area ranges between about 200 to 220 feet (61 to 67 meters). The caliche in the Plio-Pleistocene and Early Palouse units beneath SST farms in the 200 West Area has served to enhance spreading of infiltrating liquids, including waste. Because of differences in unsaturated hydraulic conductivity, density, and cation exchange capacity, activity from gamma-emitting radionuclides typically increases in caliche horizons. Clastic dikes are known to be present in the Hanford formation in the 200 West Area and could affect infiltration of liquids and contaminants.

2A.1.3.2.2 Vadose Zone Processes. Flow of liquid through the vadose zone is a function of the relationship between recharge rates, moisture content, matric potential, and unsaturated hydraulic conductivity for each hydrostratigraphic unit. Generally, liquid will flow and spread laterally at a much greater rate in the fine-grained units than in coarse-grained units under unsaturated conditions. Fine-grained strata in both the 200 West and East Areas exert significant influences on the rate and direction of infiltration of liquids. Conversely, coarse-grained units may impede the flux of liquids through the vadose zone under unsaturated flow conditions because

of the formation of a capillary pressure barrier between the coarse-grained units and overlying fine-grained units. Waste transport in the vadose zone is a function of the movement of liquid contaminants through the vadose zone as well as physical and chemical characteristics of the media in the vadose zone.

2A.1.3.2.2.1 Waste Interaction With Soils/Boreholes. The mineral composition of the units of the Ringold and Hanford Formations is mostly quartz and feldspar; however, there are minor amounts of mica, chlorite, and montmorillonite present in the fine-grained units or the fine fraction of other units (Routson et al. 1979). Micas and clay minerals, with layered silicate structures, possess greater cation exchange capacities and thus, can sorb radionuclides. In addition, most of the sand grains in the Hanford and Ringold Formations are coated with limonite, a hydrous ferric oxide that also has a high cation exchange capacity. Many of the large cations found in Hanford Site waste streams (e.g., strontium-90, cesium-137, plutonium-238-240, uranium-235-238) are sorbed in Hanford Site soils usually within a few meters of a source; however, there are others (e.g., ruthenium/rhodium-106, technetium-99, tritium) that sorb very little or not at all and move through the soils at the same or close to the same rate as water. The composition of the silt and/or clay fraction and the presence of calcium carbonate (Routson et al. 1981) enhances the cation exchange capacity of Hanford Site soils. Most anions common to waste streams, especially nitrate, also do not sorb readily and are not retarded in passage through Hanford Site soils. Nitrate is easily measured in groundwater and has been used as a surrogate for some of the more mobile constituents in waste streams more difficult and costly to monitor.

The natural background for nonradioactive constituents in Hanford Site soils (DOE-RL 1992d), against which any constituent depth profiles would be compared to evaluate the extent of contamination (DOE-RL 1994c), has been documented. The natural background for radionuclides is presently under study and expected to be released soon. Naturally occurring radionuclides in Hanford soils include potassium-40 and the uranium and thorium decay series.

The chemical composition of the waste stream significantly affects the ability of the Hanford Site soils to sorb radionuclides. Changes in pH or salt content are known to affect sorption. 'High salt' waste seem to retard sorption and thus enhance mobility. Some radionuclides can form complexes with other constituents that greatly increase their mobility in Hanford Site soils. For example, cobalt-60, an activation product common in SST waste, forms a negatively charged cyanide complex, which significantly increases its mobility. Cyanide was added to many Hanford tanks as potassium ferrocyanide to precipitate cesium-137 and strontium-90 during uranium scavenging operations in the 1950's. High salt waste produced during uranium scavenging operations was discharged to cribs and trenches near SST farms.

The carbon steel casing of wells, both dry and groundwater monitoring, has corroded with time. It has been known from the early days of Hanford operations that hydrous iron oxides sorb radionuclides (Brown and Ruppert 1950).

2A.1.3.2.2.2 Vadose Zone Contamination and Remediation. The vadose zone consists of solid, liquid, and gas phases. Contaminants in the vadose zone may exist in the same three states: (1) as precipitated solids in the interstices (i.e., cementing agent) between grains or coating on grains, (2) as liquids coating grains and filling the void spaces between grains, and (3) as gases for those constituents (particularly organics) that have a low vapor pressure. Most of the leaked waste from SSTs is likely in the solid or liquid state. There may be some contaminants in the gaseous phase in areas above the plume of carbon tetrachloride in the 200 West Area or close to cribs where significant quantities of carbon tetrachloride were discharged to the vadose zone. Other organic substances may also be present in the vapor state, but carbon tetrachloride is the most likely to occur because of the volume of this solvent that was discharged to various liquid effluent facilities in the vadose zone. The state in which the contaminants occur in the subsurface and their degree of bonding to the solid phases present in the vadose zone will affect the ease with which they can be recovered using various technologies.

The lateral and vertical continuity as well as the characteristics of the various strata in which the contaminants occur also affects not only contaminant mobility, but their ease of extraction using various remedial measures. Extraction of contaminants in the vapor state depends on the air permeability of the units. Ease of extraction of fluids from the vadose zone depends on the tension with which they are held; however, because the air pressure is less than atmospheric in unsaturated sediments, fluids will not flow to a well or borehole without applying considerable suction. A minimum volume of liquid will be held by capillary forces (the field capacity) and will not drain under gravitational pull. Contaminants held on the surface of grains or by capillary forces in interstices cannot be extracted short of removing and washing the soils. If remedial actions are to be effective, the concentration/activity of the waste species, their magnitude and extent and the physical and chemical characteristics of the vadose zone strata must be known so that appropriate remedial measures can be selected and planning and design of remedial measures undertaken.

2A.1.3.2.3 Recharge Estimates for the Unconfined Aquifer. The major sources of natural recharge to the unconfined aquifer are rainfall and runoff from areas of high relief bordering the Hanford Site, ephemeral streams in the Cold Creek and Dry Creek valleys, and localized areas where river water is influent, which produces temporary bank storage during high stages of the Yakima or Columbia rivers (Graham et al. 1981). Discharge from the unconfined aquifer is primarily to the Columbia River. Where there is a hydraulic connection between the unconfined and confined aquifer systems, recharge to the unconfined aquifer may occur if the head in the confined aquifer exceeds that in the unconfined aquifer. The connection between aquifers may be natural or artificial (i.e., poorly sealed exploration or groundwater monitoring wells). Regardless of origin, the connection produces communication between the aquifers.

Cold and Dry Creeks are ephemeral streams that, when flowing, drain eastward and southward to the Yakima River. These channels are infrequently used for runoff, which infiltrates into the soils through the permeable stream beds. Some recharge is provided to the unconfined aquifer if the water infiltrates the entire thickness of the vadose zone to reach groundwater.

Newcomb et al. (1972) estimated that about 465 acre-feet per year of water may have infiltrated from the influent Cold and Dry Creeks and Rattlesnake Springs, but a significant part of this volume may have been lost by evapotranspiration and not infiltrated to recharge groundwater. Graham et al. (1981) estimated natural recharge from the Cold Creek valley to the 200 Areas to be approximately 1.3×10^6 gallons (4.9×10^6 liters) per day. Recharge and infiltration of precipitation to the unconfined aquifer along influent Cold and Dry Creeks is currently being investigated by the U.S. Geological Survey, Water Resources Division (Tacoma, Washington).

Natural recharge to the unconfined aquifer from precipitation is a function of climate, soil, vegetation, and topography. The SSTs are contained in tank farms in which SSTs are buried in the upper part of the vadose zone above the unconfined aquifer in the 200 Areas plateau. This surface of extremely low relief negates any effects of topography on the rate or volume of recharge. Microtopography around wells, boreholes, and other facilities may localize water during snowmelt, but otherwise has little affect on recharge. The arid climate of the Hanford Site favors evaporation. The generally coarse, permeable soils of the 200 Areas plateau favor infiltration. Where plants and vegetation are present, the uptake of moisture by the roots of the plants and vegetation results in a loss of moisture to the atmosphere by transpiration, and thus a loss of moisture from soils. Moisture that infiltrates below the root zone may slowly drain deeper into the vadose zone and possibly recharge the unconfined aquifer. Thus, the depth of root penetration by elements of the desert flora plays a key role in determining whether infiltrating precipitation is lost by evapotranspiration or continues to infiltrate unimpeded toward groundwater. Rooting depth of deep-rooted plants in the 200 Areas of the Hanford Site was investigated by Klepper et al. (1985).

The relationship between evapotranspiration and infiltration affects recharge to the unconfined aquifer from precipitation. Wallace (1977) estimated that potential evapotranspiration ranged from five to nine times the mean annual precipitation. However, Stone et al. (1983) indicate that precipitation may exceed potential evapotranspiration for the months of November through February. Any excess of precipitation relative to evapotranspiration is available for groundwater recharge if this fluid infiltrates beyond the depth where upward capillary movement occurs [highly variable, but generally about 10 to 20 feet (300 to 600 centimeters) in the 200 Areas plateau] or where it may be assimilated by deeply rooted perennial or annual shrubs/plants [up to 20 feet (600 centimeters)].

2A.1.3.2.3.1 Lysimeter Studies. The mobility of liquid waste after loss of containment from various facilities in the upper part of the vadose zone has led to the use of lysimeters to investigate infiltration of applied liquid, especially precipitation, in Hanford Site soils (e.g., Gee and

Jones 1985; Gee et al. 1989b). Infiltrating liquid is a likely vehicle for the transport of soluble species in Hanford Site soils. Several different types of lysimeters have been installed at several locations on the Hanford Site to investigate the effects of soil type, soil layering, and vegetation on the infiltration of synthetic precipitation (Gee et al. 1992). Infiltration has been found to be highly variable as a function of soil texture, the rate and volume of added precipitation and the presence and type of vegetation (ibid). In general, infiltration is greatest where soils are coarse (mostly coarse sand or larger grain sizes) and vegetation is absent. Sandy soils with shallow-rooted grasses (e.g., cheat grass or native bluegrass) favor infiltration and recharge. In sandy soils with deep-rooted annual (e.g., Russian thistle, tumble mustard) or perennial vegetation (e.g., sagebrush, rabbit bush), evapotranspiration results in the loss of most moisture, with almost no drainage below the root zone and almost no change in storage. Changes to moisture in storage are measured with neutron probes in the lysimeters. In areas of silt loam soils, there is almost no drainage of infiltrating moisture, as the reduced unsaturated hydraulic conductivity along with any vegetation effectively bar deep infiltration and recharge.

Gee and Kirkham (1984), from observation of lysimeters near the 300 Area, found that there may be significant infiltration (and thus recharge to the unconfined aquifer) of natural precipitation where the surface is unvegetated and composed of coarse gravelly material. Where the surface is vegetated and consists of sand and finer material, upward movement by capillarity and evapotranspiration may exceed infiltration and there is essentially no recharge from natural precipitation. Routson and Johnson (1990) concluded from studies of geophysical logging and coring in lysimeters and a burial trench that recharge in the 200 Areas from natural precipitation over a 10-year period is small and may approach zero. Thus, within the Hanford Site, natural recharge rates have been estimated to range from near zero to more than 4 inches (10 centimeters) annually, depending on surface conditions (Gee 1987; Gee et al. 1992; Routson et al. 1988). Negligible recharge occurs in areas of fine-textured sediments and deep-rooted perennial shrubs and annual plants (e.g., in undisturbed portions of the 200 Areas). Higher infiltration occurs in areas having a coarse gravelly surface and no vegetative cover. To minimize eolian erosion of soils in tank farms, the surfaces have been covered with a gravel cover (thus enhancing infiltration). The cover, along with application of herbicides, inhibits the growth of vegetation which could return contaminants in soils to the surface. Contaminated plants could be removed by winds transporting dead vegetation (e.g., tumbleweeds) or ingested by herbivores.

Natural recharge to the unconfined aquifer at the Hanford Site has been overwhelmed by artificial recharge from the disposal of liquid effluents to unlined ponds, trenches, french drains, reverse wells and cribs. Disposal of liquid effluents to the soil column has been occurring at the Hanford Site since 1944, but the volume of liquid effluents discharged to soils has been declining in recent years as operating reactors and processing plants have been terminated. Graham et al. (1981) estimated that artificial recharge may have been ten times greater than natural recharge.

2A.1.3.2.3.2 Changes to the Water Table from Hanford Site Operations. The largest sources of artificial recharge in the central Hanford Site have been three waste ponds designated U Pond (216-U-10), Gable Mountain Pond (216-A-25), and B Pond (216-B-3). The 216-T-4 pond (T Pond), formerly located in the northern part of the 200 West Area, received liquid effluents from 1944 to 1972 and produced a water table mound that affected the rate and direction of groundwater flow. The water table mound beneath T Pond has dissipated and no longer influences the direction of groundwater flow in the 200 West Area. All were located near or in the 200 Areas. Water table mounds created by discharges to the U and B Ponds continue to exert a significant influence on head and the rate and direction of groundwater flow in the unconfined aquifer. U Pond, located in the 200 West Area, and Gable Mountain Pond, located north of the 200 East Area, were decommissioned in 1984 and 1985, respectively. Portions of B Pond will continue to be used for disposal of clean liquid effluent once the facility is clean closed. The Treated Effluent Disposal Basin is planned for construction east of the present 216-B-3 Pond. This pond will receive liquid effluent from the Treated Effluent Disposal Facility that is presently in the planning/design stages and will be located east of the 200 East Area near the Liquid Effluent Receiving Facility.

The total volume of liquid effluents discharged to radioactive disposal facilities in the 200 Areas in 1988 was approximately 2.4×10^{10} gallons (9.1×10^{10} liters) (Coony and Thomas 1989), or a rate of approximately 6.6×10^{7} gallons (2.5×10^{8} liters) per day. The estimated total volume of potentially radioactive liquid effluents discharged to the ground in the 200 and 600 Areas in 1989 was 3.96×10^{9} gallons (1.5×10^{10} liters) (Brown et al. 1990) or about 2.7×10^{6} gallons (1.0×10^{7} liters) per day. Liquid effluent discharged to ground in the 200 Areas and environs in 1992 was 1.44×10^{9} gallons (5.45×10^{9} liters); liquid effluent discharges in 1993 were 1.3×10^{9} gallons (5.14×10^{9} liters). Liquid effluent discharged to ground through June 1994 was 7.93×10^{8} gallons (3.0×10^{9} liters). Volumes of process effluent discharged to the ground at the Hanford Site are shown on Figure 2A-15. Note the greater volume of liquid effluent discharged to the ground in the 200 West Area during early Hanford Site operations corresponding to the operation of the 221-T and 202-S chemical processing plants (both of which are located in the 200 West Area). A significant shift to greater discharges in the 200 East Area occurred in 1956 with the startup of PUREX. With the startup of the 242-A evaporator in March 1994, the volume of liquid effluent discharged to the 216-B-3 Expansion Ponds has doubled. The discharge is now transmitted directly to B Pond via an underground pipe, thereby eliminating evapotranspiration losses in transit along unlined ditches previously used to route liquid effluent to B Pond. Note also the steady decline in liquid effluent discharged to the ground in the last 10 years.

A comparison between the hindcast water table map of the Hanford Site for 1944 (Figure 2A-16) and the 1993 200 Areas water table map (Figure 2A-17) indicates the effect of Hanford Site operations on the hydrologic regime. The water table beneath the former U Pond rose about 70 feet (21 meters) from the pre-Hanford Site state. Since decommissioning of U Pond in 1984, the water table in the 200 West Area has begun to decline. This rapid decline in water

table elevation has led to installation of longer well screens [35 feet (10.7 meters)] at SST waste management areas S-SX and U to increase the longevity of monitoring wells in these areas.

The rise in the water table beneath B Pond from pre-Hanford Site conditions has been about 30 to 40 feet (9.1 to 12.2 meters). Hydrographs showing water level decline in SST wells are shown in Figures 2A-18, -19, and -20. Changes in water level from 1988 to 1993 for the 200 Areas are shown on Figure 8 in Kasza et al. (1994). Kipp and Mudd (1974) review historical water table maps of the Hanford Site through 1973.

2A.1.3.2.3.3 The Effects and Significance of Recharge. Liquid infiltrating into the ground can mobilize contaminants previously discharged to soils. Once mobilized, the soluble contaminants may be transported laterally or migrate to groundwater. Should mobile species encounter a direct pathway to groundwater or to a location deeper in the vadose zone, the rate of transport would exceed that of interstitial fluid transport. Unsealed or poorly sealed wells present such a pathway. Highly mobile species (e.g., technetium-99, tritium, nitrate) may move with the advancing liquid and penetrate deeper into the vadose zone, or potentially reach groundwater. Other constituents react with soils (precipitation or sorption) and move through soils at rates less than that of water. Therefore, the volume of recharge affects the mobility of constituents that have escaped containment. The greater the recharge, the greater the potential for mobility and transport. After ceasing to discharge liquids to the soil, natural recharge remains as the sole mechanism likely to mobilize constituents in residence in the soils. Thus, zero natural recharge would effectively remove the potential for remobilizing contaminants. Providing that field capacity of soils is not exceeded, zero or very low recharge could stabilize contaminants in place, or lead to their slow transport such that they reach groundwater in dilute amounts and create little risk to public health and safety by the time they reach the Columbia River, which is the most likely pathway to the public.

A computer simulation of radionuclide flux rates from a shallow burial trench through the vadose zone to groundwater demonstrates the effects of varying recharge rates. For this model, seven layers comprised of four different soil types with different hydraulic properties were used to model the flux rates for strontium-90, cesium-137, cobalt-60, carbon-14, and chlorine-36 (Khaleel and LeGore 1990). These isotopes represent a wide range of half lives and sorption coefficients. Travel times for water to traverse the vadose zone and reach groundwater were: 9,479 years for a recharge rate of 0.02 inch (0.05 centimeter) per year; 1,085 years for a recharge rate of 0.2 inch (0.5 centimeter) per year and 136 years for a recharge rate of 2.0 inches (5.0 centimeters) per year. This simulation illustrates the significance of differences in recharge rate for travel time of water to groundwater. The simulation also demonstrates the potential benefit derived from efforts to control the recharge rate to immobilize waste in soils during remediation of sites. Constituents with higher sorption coefficients would have even longer travel times to traverse the vadose zone to reach groundwater [provided that they are not complexed with some other constituent(s) that decreases sorption].

Direct measurement of in situ moisture profiles in boreholes in Hanford Site soils has not been possible to date because boreholes are cased. The carbon steel casing used for well construction to maintain the borehole along with the varying air space between the casing and formation has precluded the use of conventional neutron logging tools as used in the petroleum industry. A pulsed neutron logging tool is being procured to test its usefulness in logging for moisture in the Hanford Site borehole environment. As resources allow, this tool and other tools evaluated should be used to obtain moisture profiles in selected drywells at the SSTs as baseline data. Relogging will then provide a clearer picture of moisture flux, which is a key component of contaminant transport models that will be used to assess contaminant mobility and ultimately risk. These computer models may provide significant input to decisions regarding closure of the SSTs.

2A.1.3.3 Groundwater Hydrology of the 200 Areas

Groundwater beneath the Hanford Site occurs under unconfined, semiconfined, and confined conditions. The unconfined aquifer is primarily within the lower portion of the Hanford formation and the Ringold unit E [the middle unit] of the Ringold Formation (Graham et al. 1981). The base of the unconfined aquifer is the basalt surface, or, where present, the clays and silts of the lower mud facies of the Ringold Formation (Figure 2A-5). Where these fine-grained sediments occur, they act as a semiconfining layer for the coarse-grained facies (Ringold A unit) at the base of the Ringold Formation (DOE 1988a). Confined aquifers beneath the Hanford Site include sedimentary interbeds, primary flow top breccias, and interflow zones in units of the Columbia River Basalt Group. Dense interiors within basalt flows of the Columbia River Basalt Group separate these flow tops and interflow zones and serve as aquitards in the confined system.

Most underground waste management facilities at the Hanford Site, including the SSTs, are located in the vadose zone of the unconfined aquifer. The depth to water within the unconfined aquifer in the 200 Areas ranges from approximately 200 feet (61 meters) beneath the former U Pond to approximately 340 feet (104 meters) west of the 200 East Area. The saturated thickness of the unconfined aquifer ranges from 0 feet (0 meters) at the north edge of the 200 East Area (structures cause the top of the basalt to protrude above the water table) to more than 250 feet (76 meters) in the northwest part of the 200 West Area. The June 1993 water table elevations for the unconfined aquifer beneath the 200 Areas are illustrated in Figure 2A-17.

Regional groundwater flow in the 200 Areas is from west to east; however, the U Pond and B Pond mounds have significantly modified this flow. Groundwater flow beneath the 200 West Area is now generally toward the north and the east, away from the U Pond mound, which has shifted eastward and begun to decline since U Pond decommissioning in 1984. Present liquid effluent discharges to the 216-U-14 Ditch and the 216-Z-20 tile field have resulted in a shift of the mound to the northeast. As this mound dissipates, the hydraulic gradient is expected to decrease and lead to a more easterly flow of groundwater as is typical of the regional gradient. The hydraulic gradient in

the 200 West Area is higher than in the 200 East Area and is approximately 0.001. Hydraulic gradients and groundwater flow velocities beneath each SST waste management area are summarized in Tables 2A-2 and 2A-3.

Groundwater flow beneath the 200 East Area is complex. Groundwater flowing eastward from 200 West converges with water flowing west from the water table mound beneath B Pond. The water then divides to flow around the B Pond mound. One component flows northward between Gable Butte and Gable Mountain and another component flows southeast toward the Columbia River (Serkowski et al. 1988). The high transmissivity beneath most of the 200 East Area results in very low hydraulic gradients of about 10^{-3} to 10^{-4}. Minor changes in flow direction and rate may result from changing rates of wastewater discharged into B Pond and other disposal sites. Changing rates of wastewater discharge and a high transmissivity in the unconfined aquifer make it difficult to define flow directions beneath a small site using water table maps of the 200 East Area. For example, a map of water table elevations and water level data for June 1993 (Figure 2A-21) illustrate that the difference in head across the northern part of the 200 East Area between the east and west boundaries is about 1 foot (30 centimeters) (a hydraulic gradient of about 7×10^{-5}). However, contaminant plume maps of the 200 Areas indicate long-term trends in groundwater flow direction in the unconfined aquifer (Serkowski et al. 1988). Long-term direction of groundwater flow in the unconfined aquifer continues to be north-northwest in the extreme north-central portion of the 200 East Area near SST waste management area B-BX-BY. Groundwater flow and contaminant transport near PUREX has been affected by the volume of discharges to PUREX cribs and to B Pond. High volume discharges to PUREX cribs in the past produced a slight mound, with groundwater flowing radially away from this high. Liquid discharges to B Pond have been terminated and shifted to the 3C lobe of B Pond. These discharges are maintaining an areally extensive water table mound whose apex is shifting eastward beneath the 3C lobe with the shift in point of discharge from the original B Pond. Flow from this mound is also radially outward, but the mound also serves to divert eastward-flowing groundwater to the east and southeast around this mound. Modeling suggests that this pattern of groundwater flow will persist at least through 1997 (Johnson et al. 1994).

The principal geologic units (Figures 2A-13 and 2A-14) controlling groundwater flow in the unconfined aquifer in the 200 Areas are, in ascending order, the Elephant Mountain Member (generally the bottom of the unconfined aquifer); the Ringold Formation, which contains both confined, semiconfined, and unconfined aquifer components; and the Hanford formation. Basalt of the Elephant Mountain Member is generally the base of the unconfined or uppermost aquifer near the 200 East Area. However, Graham et al. (1984) and Jensen (1987) speculate that there may be communication between the unconfined aquifer and the Rattlesnake Ridge confined aquifer in the northeast part of the 200 East Area. This interpretation is based on anomalous barometric efficiencies of some wells. There are no geologic data that support such an interpretation (i.e., no boreholes or geophysical surveys that confirm the absence of the Elephant Mountain Member). The head in the unconfined aquifer beneath B Pond exceeds the head in the uppermost confined Rattlesnake Ridge aquifer leading to a zone of downward vertical gradient and flow (Graham et al. 1984; Jensen 1987; Kasza et al. 1991).

The Elephant Mountain Member has been removed by erosion north of the 200 East Area, providing a connection between the unconfined and the uppermost confined aquifer. In wells 699-53-55 and 699-55-55, sediments of the Hanford formation directly overlie the Rattlesnake Ridge interbed. The extent of this window in the Elephant Mountain Member currently is unknown. Thus, the potential for vertical communication and the direction of groundwater and contaminant movement is also unknown. The direction of groundwater flow will generally be from areas of higher head to areas of lower head.

Aquifers in the Ringold Formation exist under both confined and unconfined conditions. In the southern portion of the 200 East Area and much of the 200 West Area, the coarse-grained facies of the basal Ringold unit is overlain by the lower mud sequence of the basal Ringold resulting in confinement of the unit A at the base of the Ringold (Lindsey 1992). In other areas, the fine-grained basal and lower Ringold units are missing, and the coarse-grained basal and/or middle Ringold unit E) constitute the unconfined aquifer. In the northeastern portion of the 200 East Area, the Ringold Formation is absent because it has been completely eroded. Here, the unconfined aquifer is in the Hanford formation, which lies directly on the Elephant Mountain Member of the Columbia River Basalt Group (Tallman et al. 1979).

The textural variations in the unconfined aquifer lead to widely varying hydrogeologic properties (Table 2A-4). The values in Table 2A-4 are generalized; in some locations, hydraulic properties lie outside the ranges given. Although limited in size and volume, clastic dikes are relatively common in the Hanford formation. The wide range in grain sizes, thickness of included strata, and relationship to the surrounding host sediments, could exert significant control over the infiltration and movement of liquids and contaminants.

In the 200 West Area, the unconfined aquifer is primarily in the fluvial gravel facies (FSE unit) of the Ringold, a compact and often partially cemented matrix-supported gravel. Transmissivities range from 300 to 5,400 square feet (28 to 502 square meters) per day (Graham et al. 1981). In the 200 East Area, the unconfined aquifer is in either the unconsolidated Hanford formation, the middle Ringold unit, or both, leading to a wide range of transmissivities from 5 to 135,000 square feet (0.5 to 12,542 square meters) per day. Generally, transmissivities increase from west to east across the 200 Areas as a result of thinning of the Ringold Formation and saturation of the Hanford formation. Analysis of slug test data for some 1989 SST monitoring wells yielded a range of transmissivities from 330 to 5,600 square feet (31 to 529 square meters) per day for 200 East Area and about 530 square feet (49 square meters) per day for wells in waste management area T in the 200 West Area (Newcomer et al. 1990).

The measured storativity values for the unconfined aquifer range from 0.002 to 0.07 (Table 2A-4); the lower values are associated with the lower Ringold unit and the higher values with the Hanford formation (Graham et al. 1981).

The effective porosity of the sediments in the unconfined aquifer ranges from 10 to 30 percent (Graham et al. 1981). The lower value corresponds with sediments of the Ringold lower mud unit, and the upper range approaches the total porosity of the sediments in the Hanford formation.

The water in the unconfined aquifer unaffected by Hanford Site operations is of calcium-bicarbonate, sodium-bicarbonate, and calcium-sulfate types (Graham et al. 1981). Calcium-bicarbonate is the most prevalent chemical type; however, there is considerable variability in chemical composition over the 200 Areas.

Discontinuous perched water occurs in parts of the 200 Areas, often lying above a calcrete horizon in the Plio-Pleistocene unit or above markedly finer-grained sediments in the upper Ringold unit and Hanford formation. The lateral extent of these perched water zones has not been delineated, but they are generally found only near liquid effluent disposal sites where large quantities of water have been discharged to the sediments and where fine-grained sediments occur between the disposal site and the water table.

Hydrogeology beneath each waste management area may be found in Caggiano and Goodwin (1991).

2A.1.4 GROUNDWATER MONITORING

As RCRA facilities actively storing hazardous waste, the SSTs are conducting groundwater monitoring to comply with WAC 173-303-400 (and 40 CFR 265, Subpart F by reference). Groundwater was monitored as part of an operational monitoring program prior to implementation of RCRA, but the wells were not constructed or located in accordance with RCRA requirements. Groundwater is one of several media monitored for compliance with DOE orders by the Environmental Surveillance Program (Schmidt et al. 1993)

2A.1.4.1 RCRA Monitoring

Groundwater around the SSTs is monitored to determine the quality of groundwater beneath the tanks and whether waste leaked from the SSTs have affected groundwater quality in the uppermost aquifer underlying the facilities. Monitoring complies with RCRA interim status standards that are described in 40 CFR 265, Subpart F, and the Ecology's "Dangerous Waste Regulations," WAC 173-303. All SST waste management areas comply with the minimum requirement of at least one upgradient and at least three downgradient wells. Ecology implements interim status groundwater monitoring regulations by reference in WAC 173-303-400 to 40 CFR 265, Subpart F.

The RCRA groundwater monitoring at the SSTs was initiated in 1989 with the preparation of a groundwater monitoring plan (Jensen et al. 1989) and the construction of 12 RCRA-standard groundwater monitoring wells. In all, 35 RCRA-standard groundwater monitoring wells have been constructed in 1989,

1990, 1991, and 1992 at the SSTs (Jensen et al. 1989; Caggiano and Goodwin 1991; WHC 1990; Caggiano 1991, 1993). The wells in the SST network are listed in Table 2A-5 and are illustrated in Figures 2A-22 and 2A-23.

Many older wells constructed of carbon-steel casing that have been perforated to communicate with the aquifer were drilled in and around the tank farms before 1986. In November 1989, Ecology requested that DOE evaluate the potential for conversion of these existing carbon steel wells to wells that comply with specifications for resource protection wells in WAC 173-160 before drilling additional wells. After evaluation, it was concluded that the DOE would not attempt to convert any of the existing wells to RCRA-compliant wells unless specifically requested to do so by Ecology. Reasons for this decision include: inability to backpull single strings of casing that were corroded and tightly adhered to the soils; the potential for formation collapse; the likelihood of spreading contamination; and the opening of direct pathways of contamination to groundwater. Risk of personnel exposure and the costs of disposal of the original carbon-steel casing as mixed waste also affected this decision. Ecology and EPA subsequently issued a joint policy on the use of existing wells at the Hanford Site. In this policy, four categories of wells were designated; only RCRA-standard wells that comply with the specifications in WAC 173-160 can be used to obtain samples for analysis of hazardous constituents in groundwater. Screening wells and radiation monitoring wells can be used to provide supplemental data for groundwater monitoring.

Some of the older wells near the SSTs have been designated as screening wells per the Ecology/EPA policy on existing wells. Water levels are measured monthly in some of these wells as well as in the RCRA-standard wells when access to the wells is permitted.

Sites for new groundwater monitoring wells are proposed in groundwater monitoring plans and engineering change notices (ECN) to those plans. The groundwater monitoring plans and ECNs are submitted to Ecology for concurrence before the initiation of well construction.

New wells are located based on the direction of groundwater flow, the site stratigraphy, hydrogeology, available records of contamination, and other factors affecting safety in drilling operations. The Monitoring Efficiency Model (MEMO) (Jackson et al. 1991) is used to locate new wells to optimize the efficiency of the monitoring network. Given a certain input, MEMO generates a hypothetical plume from a continuously leaking source, allows the plume to migrate and spread, and determines the likelihood that a network of groundwater monitoring wells would intercept the hypothetical plume. The plume generation model is basically the two-dimensional analytical transport model of Domenico and Robbins (1985). The MEMO inputs include data on the characteristics of the sediments (soils), the volume and rate of leaking of contaminants, the direction of groundwater flow, and the coordinates of wells used to monitor the facility. As output, the model provides a map showing where releases from the facility would and would not likely be detected by monitoring wells under the known constraints assumed for the analysis. Cumulatively, MEMO calculates the efficiency of the groundwater monitoring network. Calculations of network efficiency of groundwater monitoring wells

at the SST waste management areas (as well as other details of MEMO and well locations) may be found in Revision 1 of the SST groundwater monitoring plan (Caggiano and Goodwin 1991).

Numerous ancillary and support facilities, as well as aboveground and underground utilities, pipelines, transfer lines, and roads are present around SST waste management areas, which limit sites for groundwater monitoring wells. Before initiating drilling, a visual inspection of the site as well as a check of as-built drawings and maps of facilities and utilities is made. In addition, a ground-penetrating radar survey is made to locate any underground structures/facilities or utilities that may be present. By agreement with Ecology, all new RCRA-standard wells have been located outside the perimeter fences of the tank farms and at least 100 feet (30 meters) from the nearest tank. During drilling, boreholes are geologically and geophysically logged (gross gamma and sometimes spectral gamma) and the boreholes and samples are monitored for radioactive and hazardous waste contamination during drilling to ensure the safety of field personnel. Samples of soils are collected for analysis of moisture and $CaCO_3$ content and some are granulometrically analyzed. Wells are constructed using cable tool methods and generally begin with up to 20 feet (6 meters) of surface casing of 12 inches (30 centimeters) or larger diameter. Drilling proceeds with 10-inch (25-centimeter)-diameter casing to about 150 feet (46 meters), and then 8-inch (20-centimeter)-diameter casing is used to continue the well.

If contamination is encountered, an evaluation is performed to determine whether drilling should continue. If it is safe to proceed, drilling is then resumed, usually with a new drill string of reduced diameter so as not to drive and spread contamination beyond its present location. Wells are completed as 4-inch (10-centimeter)-diameter wells of stainless-steel casing and screen (either continuous wirewrap screen or channel pack) with filter pack surrounding the screen and an annular seal above. Surface seals, a concrete pad, and protective posts complete the well (Figure 2A-24). Wells are developed using a submersible pump and, when completed, a HydroStar[6] sampling pump is installed in each well. Slug tests are performed in most wells. Step drawdown or continuous pumping and recovery tests may be made in some wells, but the length of pumping and the volume of purgewater generated during testing have limited the application of these aquifer testing methods. Data obtained during the drilling and sampling of a well are documented in borehole summary reports (WHC 1990; Caggiano 1992, 1993).

Water levels are measured periodically in the wells and data are reported quarterly to Ecology. Water levels have been measured monthly for at least the first year to ensure that the wells are properly located upgradient and downgradient. Water levels are also measured during sampling (quarterly or semi-annually). Water levels are continuing to decline in the 200 Areas. Water levels are declining more rapidly in the 200 West Area than in the 200 East Area. Declining water levels are summarized in Table 2A-6 and illustrated in hydrographs in Figures 2A-18, 2A-19, and 2A-20.

[6]HydroStar is a trademark of Instrumentation Northwest, Inc., Redmond, Washington.

Wells were sampled quarterly during the first year and analyzed for the list of constituents specified in the groundwater monitoring plan (Caggiano and Goodwin 1991). Samples of groundwater collected from SST wells have been analyzed for drinking water standards, water quality parameters, indicator parameters, and site-specific parameters (gross alpha, gross beta and gamma scans, cesium-137, strontium-90, cobalt-60, iodine-129, total uranium, tritium, and plutonium).

Four (or more) quarters of data on groundwater quality have been obtained and statistical analyses have been performed on the data in accordance with applicable regulations (Chou 1991). Samples of groundwater were taken from 12 RCRA-standard as well as some older wells in waste management areas A-AX, B-BX-BY, C, and T in February 1990 and July and October 1991, and analyzed as specified in the groundwater monitoring plan (Jensen et al. 1989; Caggiano and Goodwin 1991). Wells at all other waste management areas were sampled in October 1991. Analytical results are reported quarterly to Ecology (Smith et al. 1989a, b, c; Smith et al. 1990; Lerch 1990; DOE-RL 1990a; DOE-RL 1990b; DOE-RL 1991b; DOE-RL 1991c; DOE-RL 1991d; DOE-RL 1991e). Sampling of groundwater monitoring wells at the SSTs was suspended in May 1990 pending the availability of another analytical laboratory to replace U.S. Testing Laboratories. Sampling was resumed in July 1991.

Sampling at most SST waste management areas is now occurring semi-annually for indicator parameters and annually for groundwater quality parameters. Quarterly sampling is also occurring at SST waste management areas T and TX-TY because these two sites are now in a groundwater quality assessment monitoring program under interim status because of elevated field-specific conductance. The values for field-specific conductance in downgradient well 2-W10-15 at waste management area T and in downgradient wells 2-W10-17 and 2-14-12 at waste management area TX-TY exceeded the critical mean for field specific conductivity for each waste management area. Verification of this exceedance occurred in March and April 1993, thereby triggering each of these SST waste management area into groundwater quality assessment monitoring under interim status regulations. As required, Ecology has been notified and a groundwater quality assessment monitoring plan has been prepared for these two sites and submitted to Ecology (Caggiano and Chou 1993). These two sites are very close to one another and are located above the same areally extensive plume of high conductivity in groundwater in the northern part of the 200 West Area. Because high conductivity is widespread in the northern part of the 200 West Area [Johnson (1993), Figure 5-37], a single program of investigation is being undertaken to ascertain whether the high conductivity results from the SSTs, or from one of the numerous liquid effluent facilities surrounding these facilities, which received close to 7.6 billion liters of liquid effluent.

Data obtained during RCRA sampling and analyses indicate that the groundwater beneath these two waste management areas contains elevated nitrate, chloride, fluoride, sulfate, sodium, calcium, gross beta, and tritium. The cause of elevated conductivity could be any of these metals or anions, but the specific constituents causing the increased conductivity, and the specific facility or facilities contributing the responsible constituent(s), remain unknown at this time.

Groundwater monitoring activities at the SSTs, including constituents that exceed various regulatory limits, are summarized in annual reports (Smith and Gorst 1990; DOE-RL 1991a; DOE-RL 1992b; DOE-RL 1993c; DOE-RL 1994a). Data obtained from water level measurements and analysis of samples are reported quarterly (Smith et al. 1989a, b, c; Smith et al. 1990; Lerch 1990; DOE-RL 1990a; DOE-RL 1990b; DOE-RL 1991b; DOE-RL 1991c; DOE-RL 1991d; DOE-RL 1991e; DOE-RL 1992e; DOE-RL 1992f; DOE-RL 1992g; DOE-RL 1992h; DOE-RL 1993e; DOE-RL 1993f; DOE-RL 1993g; DOE-RL 1993h; DOE-RL 1993i; DOE-RL 1993j; DOE-RL 1994f; DOE-RL 1994g).

2A.1.4.2 Historical Groundwater Monitoring

2A.1.4.2.1 Historical Monitoring Background. The discharge of liquid waste to the ground at the Hanford Site that contained low levels of radionuclides in dilute chemical solutions led to monitoring of the groundwater to protect human health, to minimize impact on plant and animal species, and to minimize restrictions on land and water use (Brown and Raymond 1962). Decay and sorption of radionuclides during infiltration through the vadose zone to groundwater, and continued decay and sorption during travel through the unconfined aquifer to the Columbia River, supported the practice of ground disposal of low-level liquid waste with isotopes having a half life of three years or less. Groundwater samples were collected by bailer from wells with casing perforated over a lengthy interval of the unconfined aquifer and typically were analyzed for gross beta, uranium, cobalt-60, strontium-90, cesium-137, tritium-3, and ruthenium-106 (ibid).

Groundwater has been intermittently monitored in the vicinity of some SST farms for several decades using groundwater monitoring wells that were constructed to monitor adjacent cribs, trenches, or other liquid waste disposal facilities (Table 2A-7). Groundwater monitoring wells were constructed in some tank farms at various times, usually in response to some event/activity. Some liquid waste disposal facilities were planned originally to accept only about 10 percent of the calculated specific retention of the sediments (soils). Specific retention was calculated as the volume of a prism between the base of a crib/trench (using the area of the facility as the top of the prism) and the water table using a porosity (void ratio) of 10 percent.

Wells were installed and groundwater was monitored to determine whether the liquid waste discharges to a facility 'broke through' to the water table. Once 'breakthrough' occurred, the liquid effluent would be discharged to another liquid waste disposal facility. For the liquid effluent to 'break through to groundwater', the entire vadose zone beneath the facility, to some radius beyond the confines of the facility, would become saturated to hydraulically connect the liquid effluent discharges with groundwater at the water table. However, some of the wells installed to monitor groundwater were not properly sealed and served to provide direct pathways to groundwater, thereby 'short circuiting' the usual process of interstitial infiltration. Retardation of radionuclides in transport through Hanford Site soils by adsorption, precipitation, and ion exchange was part of the original strategy for disposing of liquid effluent to cribs (Healy 1953; Brown and Ruppert 1950). Thus, only the most mobile of contaminants would migrate at

the same rate as water (i.e., unimpeded). In effect, soil and/or waste interaction processes served to segregate waste into components of varying mobility. Those with high sorption coefficients would be retained in the soil or move more slowly than water.

Knowledge about radiochemistry, waste and/or soil interaction, and disposal practices evolved with time, sometimes as a result of some unexpected discoveries. For example, cobalt-60 was expected to sorb relatively close to a source when discharged to soils; however, the discovery of cobalt-60 in groundwater during uranium scavenging operations was unexpected and was found to have resulted from complexing of the cobalt with cyanide, which was added to tanks. The formation of complexes with cobalt-60 greatly enhanced its mobility; ferrocyanide was added to many tanks as part of the uranium scavenging process.

Groundwater monitoring wells at the Hanford Site have been constructed mostly with cable tool drilling. Before 1986, carbon steel casing was used exclusively and was generally perforated over some interval to communicate with the aquifer. Screens were installed in some wells. Monitoring wells constructed along the margins of cribs often had space between the casing and the formation that was not sealed. Thus, some of the wells have acted as direct pathways to groundwater, as liquids could enter the annular space and be transported directly to groundwater. Wells may not have been properly developed and groundwater samples were often taken by bailer without adequate purging to assure that the groundwater in the aquifer (as opposed to water that may have stood in the casing) was being sampled. Corroded carbon steel casing in contact with water may have affected analyses for groundwater quality (especially metals and radionuclides), although there are no quantitative measures to assess this effect.

Historical groundwater monitoring data in HEIS (DOE-RL 1993d) represent all the information available on the changes of groundwater quality with time and should be used with caution because of varying data quality. Techniques for sampling and analyses, including laboratory analytical procedures and/or equipment as well as limits of detection, precision, and accuracy have changed with time.

2A.1.4.2.2 Review of Historical Groundwater Quality Data. Several wells and constituents were examined to detect changes in groundwater quality with time for wells that have been monitored for some duration. Older wells within, as well as close to, some tank farms in both 200 East and 200 West Areas were chosen. For older wells, the constituents most often analyzed for most wells were gross beta, nitrate, and cesium-137. The quality of the data is inconsistent and sporadic. For many wells, there are abundant data in the 1950's, little, if any, data in the 1960's, with monitoring data again appearing from the 1970's to the present. The frequency of sampling also varied; some wells may have been sampled at most annually, while others were sampled once or twice each month. Quality control problems resulted in data gathered within the same year (and sometimes the same quarter) showing orders of magnitude differences in concentration/activity.

Given the nature of the record, the following generalizations may be made.

- Gross beta contamination up to and exceeding 100,000 picocuries per liter in groundwater was reported in some wells near the 241-A and 241-AX tank farms in the mid 1950's--several years before there were any leaking SSTs reported in this area of the Hanford Site. The 241-A-105 tank was reported leaking in 1963 and was the first reported leaking tank in these two tank farms. Nitrate up to a few thousand parts per million and cesium-137 up to several hundred picocuries per liter are reported in wells in this same area in the mid 1950's. The unit of measure for radionuclide contaminants in groundwater in the 1950's was microcurie/milliliter and it is not certain that a conversion has been made in the database. One microcurie is 10^{-6} curies; 1 picocurie is 10^{-12} curies.

- Gross beta contamination up to and exceeding 100,000 picocuries per liter in groundwater was reported in some wells near the 241-B, 241-BX, and 241-BY tank farms in the mid 1950's--years before there were any leaking SSTs reported in this area of the Hanford Site. The 241-BX-102 tank was reported leaking in 1971 and was the first reported leaking tank among these three tank farms. High volumes of liquid effluent were discharged to the 216-BY cribs in this area of the Hanford Site during uranium scavenging operations. The 216-BY cribs are part of the 200-BP-1 operable unit.

- Nitrate up to a few hundred parts per million was reported in some wells near the 241-S and 241-SX tank farms in the early 1960's. The 241-SX-108 tank is the earliest reported leaking tank in these two tank farms and was reported leaking [up to 35,000 gallons (132,000 liters)] in 1962.

- Nitrate up to a few thousand parts per million and gross beta up to a few tens of thousand picocuries per liter were reported in wells in the vicinity of the 241-TX and 241-TY tank farms in the mid 1950's. The earliest known leaking tanks in these two tank farms were the 241-TY-106 and 241-TY-105 tanks that were reported leaking in 1959 and 1960, respectively.

- Gross beta to several tens of thousands of picocuries per liter and cesium-137 to several hundred picocuries per liter are reported for wells in the vicinity of the 241-T tank farm in the mid 1950's. Cobalt-60 to a few hundred picocuries per liter and nitrate to several hundred parts per million are also reported in wells in the same area in the early to mid 1960's. The earliest known leaking tank in the 241-T tank farm is the 241-T-106 tank, which was confirmed as leaking in 1973.

Few, if any, hazardous waste constituents were monitored, as there was no statutory requirements to monitor groundwater before passage of RCRA and its implementation at the Hanford Site. Groundwater monitoring in the early days of the Hanford Site was conducted to support operational decisions regarding the performance of cribs and other facilities. When a facility

ceased to function as intended, waste was diverted to another facility. Characterization to determine the magnitude and extent of contaminants, their mobility, and ultimately risk to potential receptors evolved through regulations passed after many of these facilities ceased to operate. Nitrate was often present in the effluent discharged to unlined cribs, trenches, french drains, and ponds and was monitored as a surrogate for mobile contaminants difficult or expensive to analyze with available equipment/technology in the early days of the Hanford Site.

Historical data on groundwater quality, even with the varying quality of the data because of differences in sampling, analytical, and reporting protocols, suggest that groundwater in the vicinity of most SST farms was contaminated before any leaking tanks were confirmed. This includes surface spills that have occurred in the tank farms. Given that the constituents discharged to cribs, french drains, ponds, and ditches were nearly identical in composition to waste sent to SSTs, the facility responsible for the degradation of groundwater quality is impossible to identify. Clearly, the reprocessing of spent fuels and liquid waste discharges from these reprocessing facilities account for the degradation of groundwater quality in the 200 East and 200 West Areas, but the contaminants in groundwater probably have not leaked directly from the SSTs to reach groundwater.

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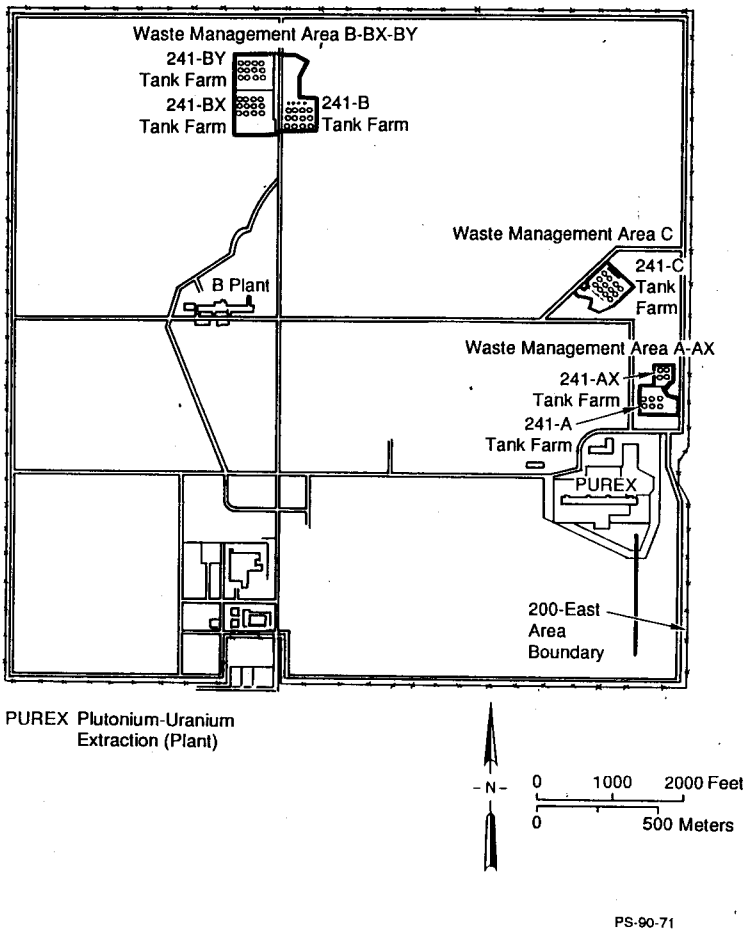


Figure 2A-1. 200 East Area Waste Management Area Location Map.

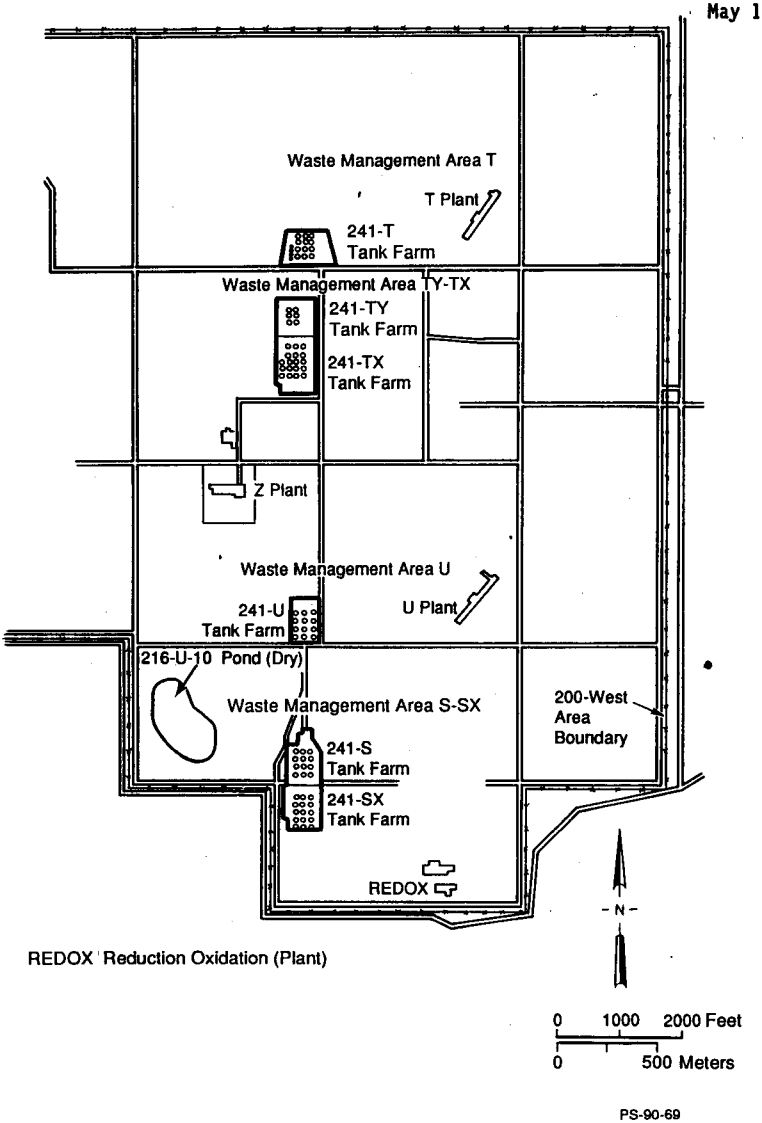


Figure 2A-2. 200 West Area Waste Management Area Location Map.

960516.1532

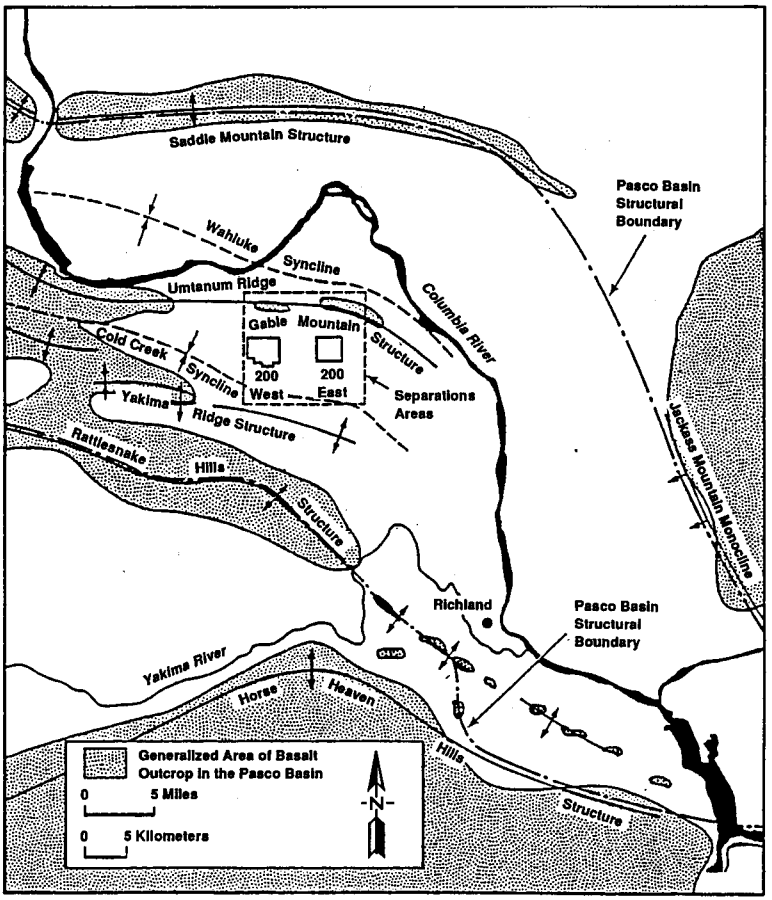


Figure 2A-3. Structural Geology of the Pasco Basin.

960516.1532

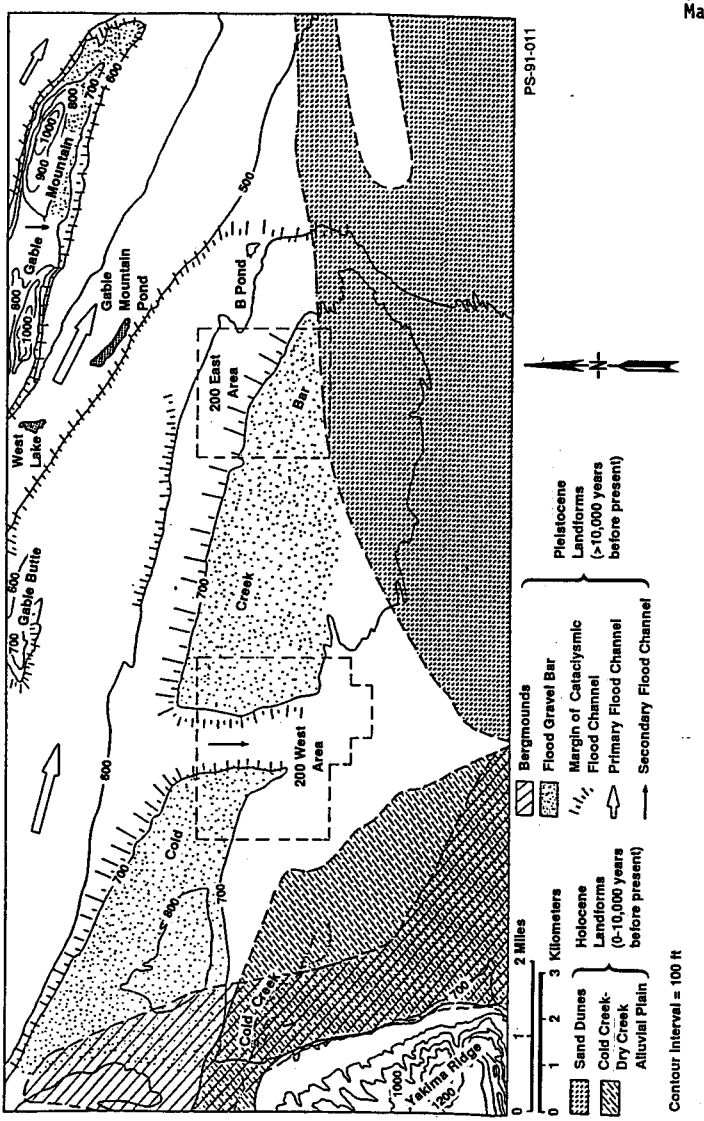
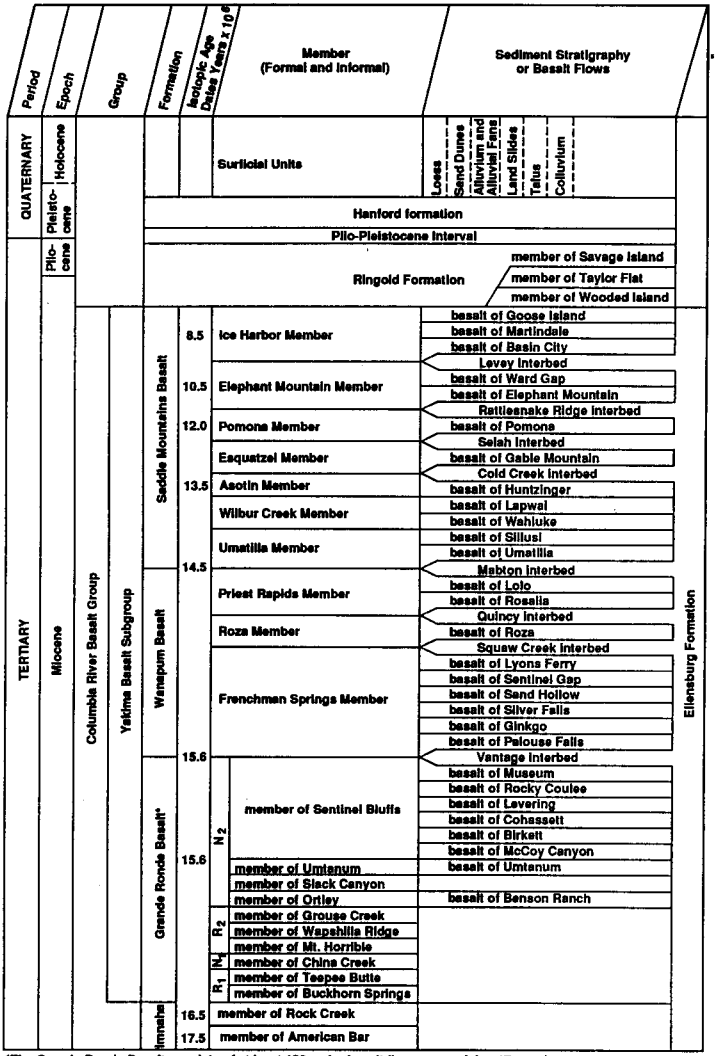


Figure 2A-4. Geomorphic Features Surrounding the 200 Areas.



*The Grande Ronde Basalt consists of at least 120 major basalt flows comprising 17 members. N_2, R_2, N_1, and R_1 are magnetostratigraphic units.

H9102029.8b

Figure 2A-5. Generalized Stratigraphy of the Hanford Site.

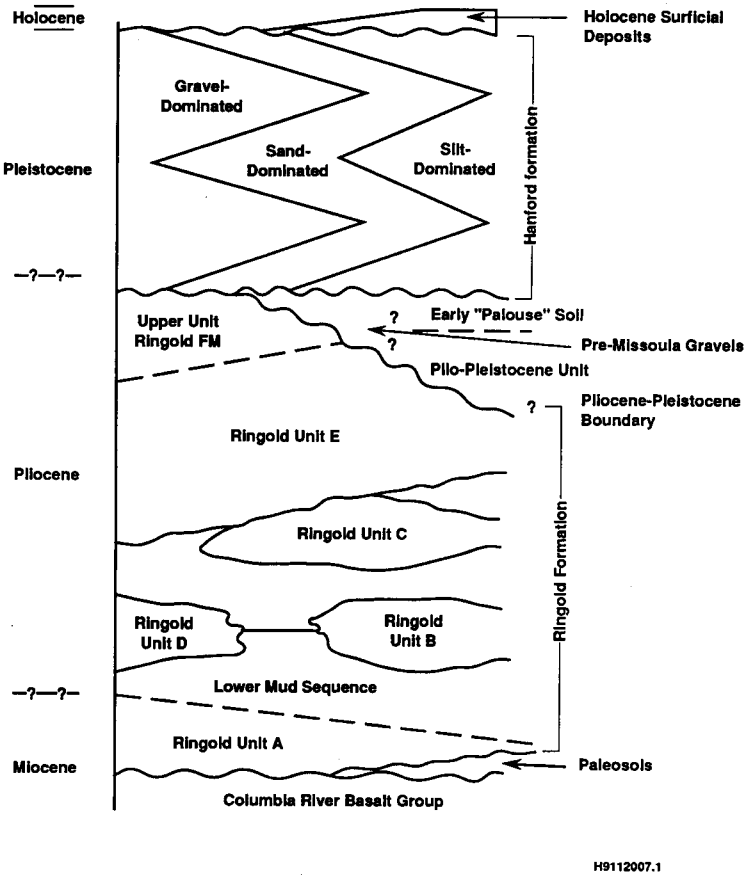
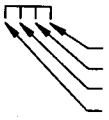


Figure 2A-6. Generalized Stratigraphy of the Suprabasalt Sediments at the Hanford Site.

960516.1532

Explanation

Grain Size Scale, Indicates
Dominant Grain Size in an Interval



- Cobble–boulder Gravel
- Pebble Gravel
- Sand
- Clay/Silt

Additional Lithologic Symbols
Includes Subordinate Lithologies

- Pedogenic Calcium Carbonate
- Paleosols
- Ringold Clast Supported Gravels
- Open Framework Hanford Gravels
- Laminated Muds
- Basalt

Other Symbols

- Formational contact, ? where inferred
- Unit contact, ? where inferred
- Water Table Elevation (December 1991)

Unit Abbreviations

Hc – Upper Coarse Unit, Hanford formation
Hf – Lower Fine Unit, Hanford formation
EP – Early "Palouse" Soil
PP – Plio–Pleistocene Unit
UR – Upper Unit, Ringold Formation
E – Gravel Unit E, Ringold Formation
LM – Lower Mud Sequence, Ringold Formation
A – Gravel Unit A, Ringold Formation

Blank portions of cross section well logs represent sediments (dominantly sand) which do not fit into sediment categories depicted by symbols listed above.

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Figure 2A-7. Legend for Geologic Cross Sections.

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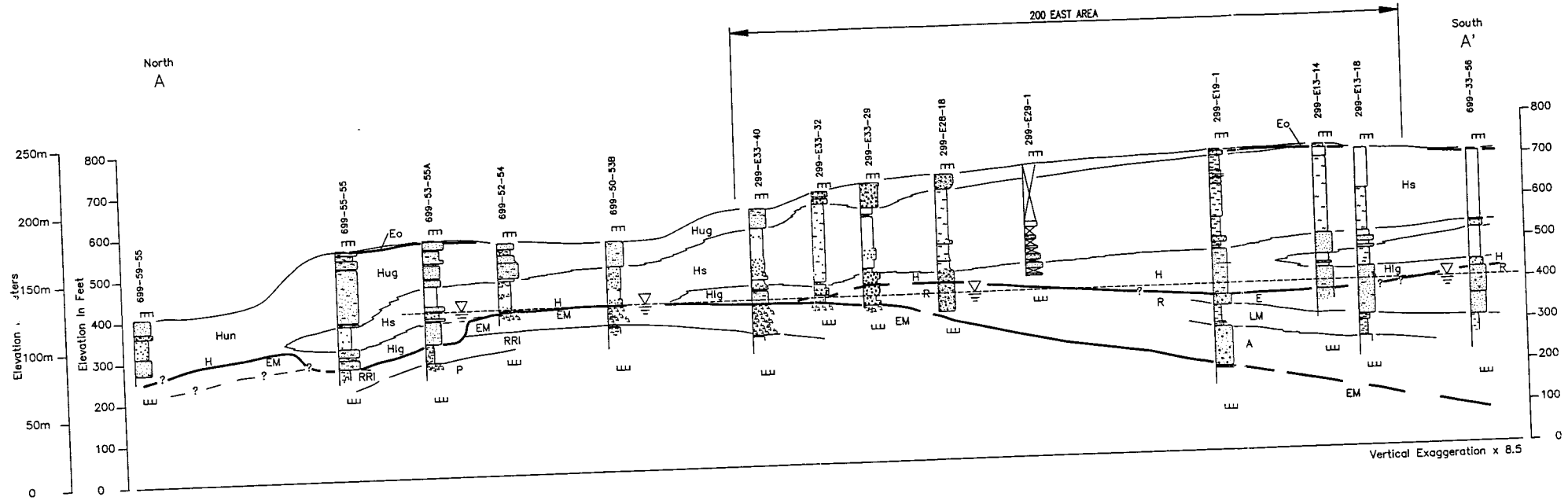

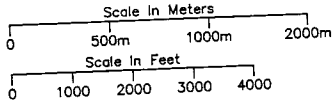

NOTE
Refer to Figure 4.1-8 for cross section location and Figure 4.1-3 for legend. Figure based on Lindsey et al. 1992.

SJT\011794-D

Figure 2A-8. North-South Geologic Cross Section Through Western Part of 200 East Area.

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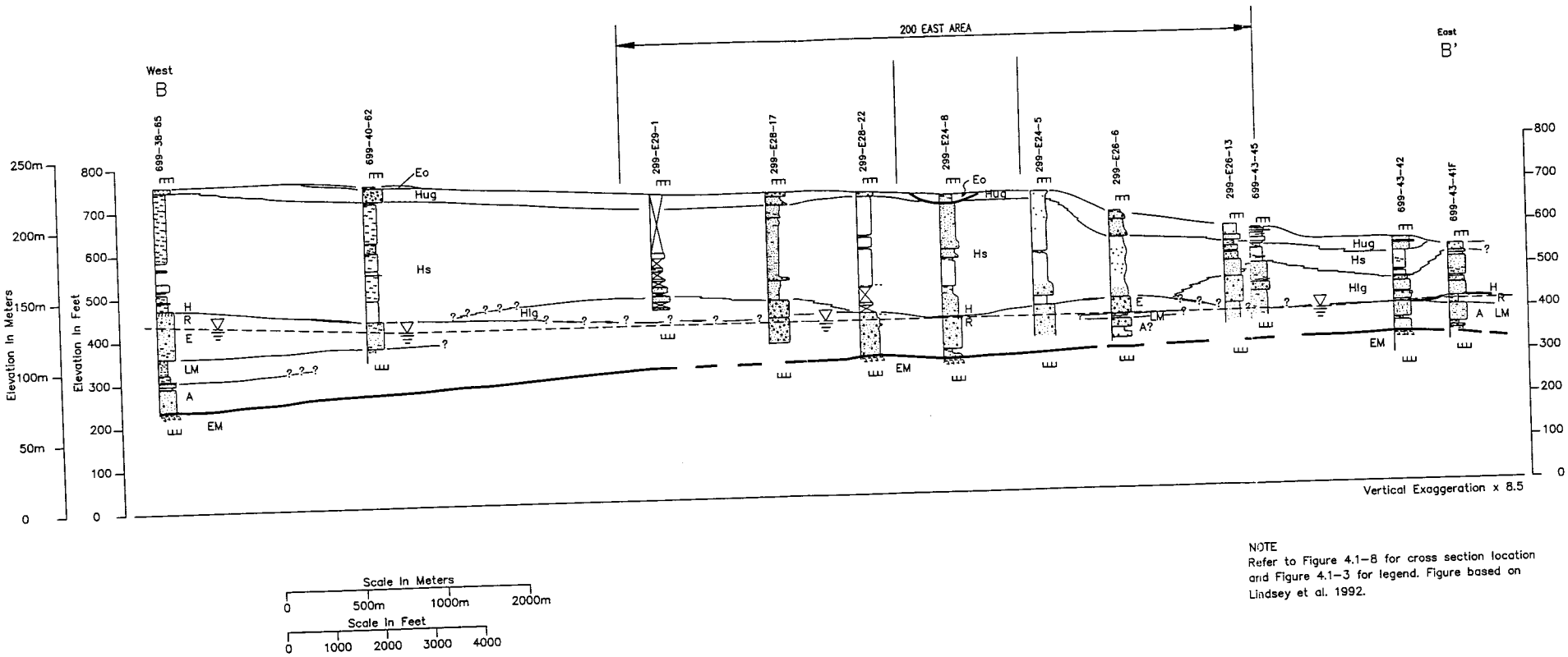

NOTE
Refer to Figure 4.1-8 for cross section location and Figure 4.1-3 for legend. Figure based on Lindsey et al. 1992.

SJT\011794-B

Figure 2A-9. West-East Geologic Cross Section Through 200 East Area.

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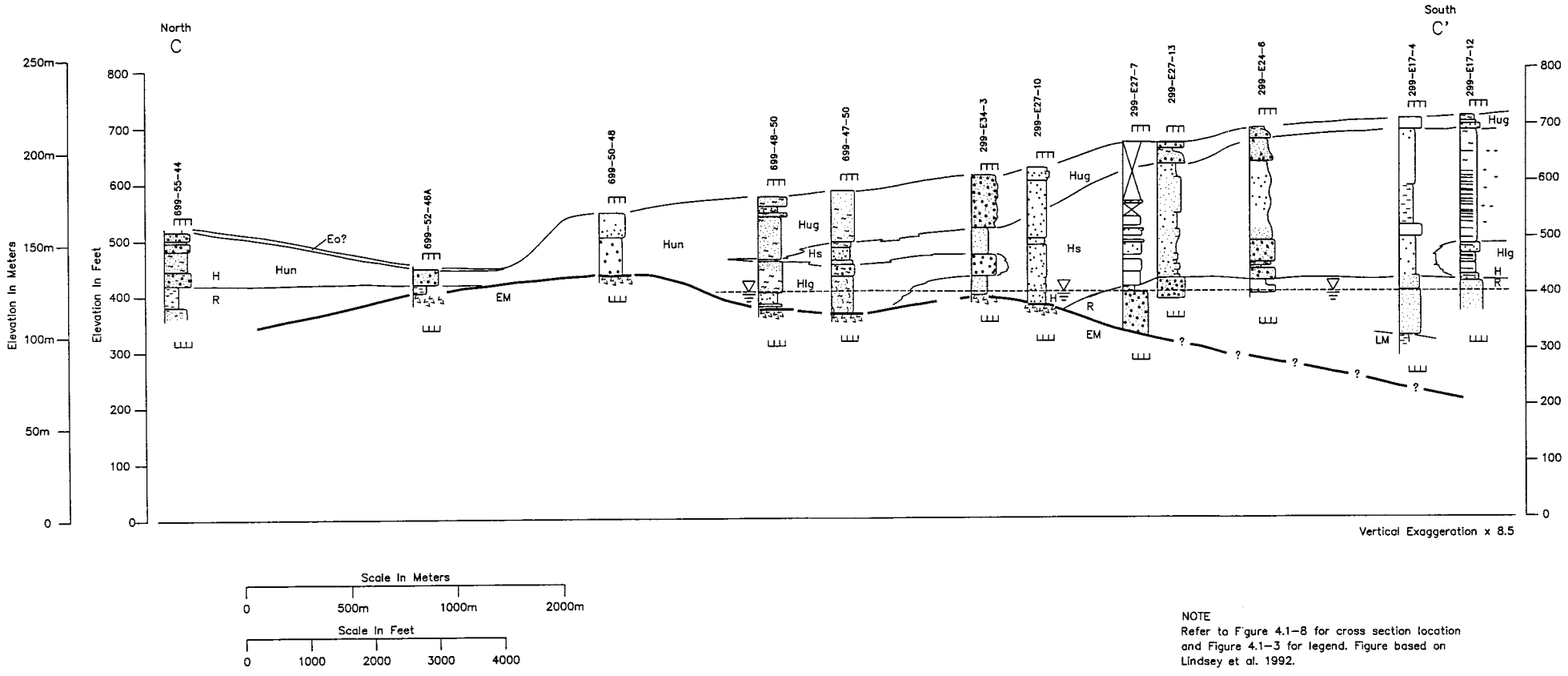

NOTE
Refer to Figure 4.1-8 for cross section location and Figure 4.1-3 for legend. Figure based on Lindsey et al. 1992.

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Figure 2A-10. North-South Geologic Cross Section Through Eastern Part of 200 East Area.

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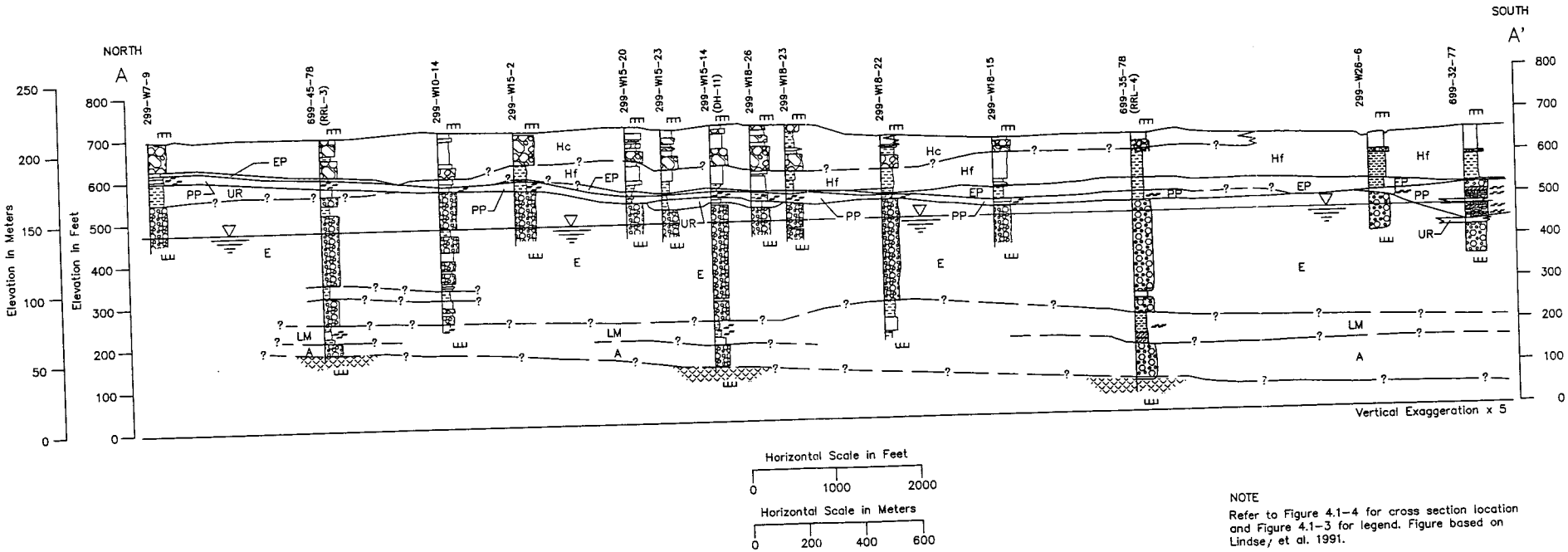

NOTE
Refer to Figure 4.1-4 for cross section location and Figure 4.1-3 for legend. Figure based on Lindsey et al. 1991.

SJT\011894-A

Figure 2A-11. North-South Geologic Cross Section Through 200 West Area.

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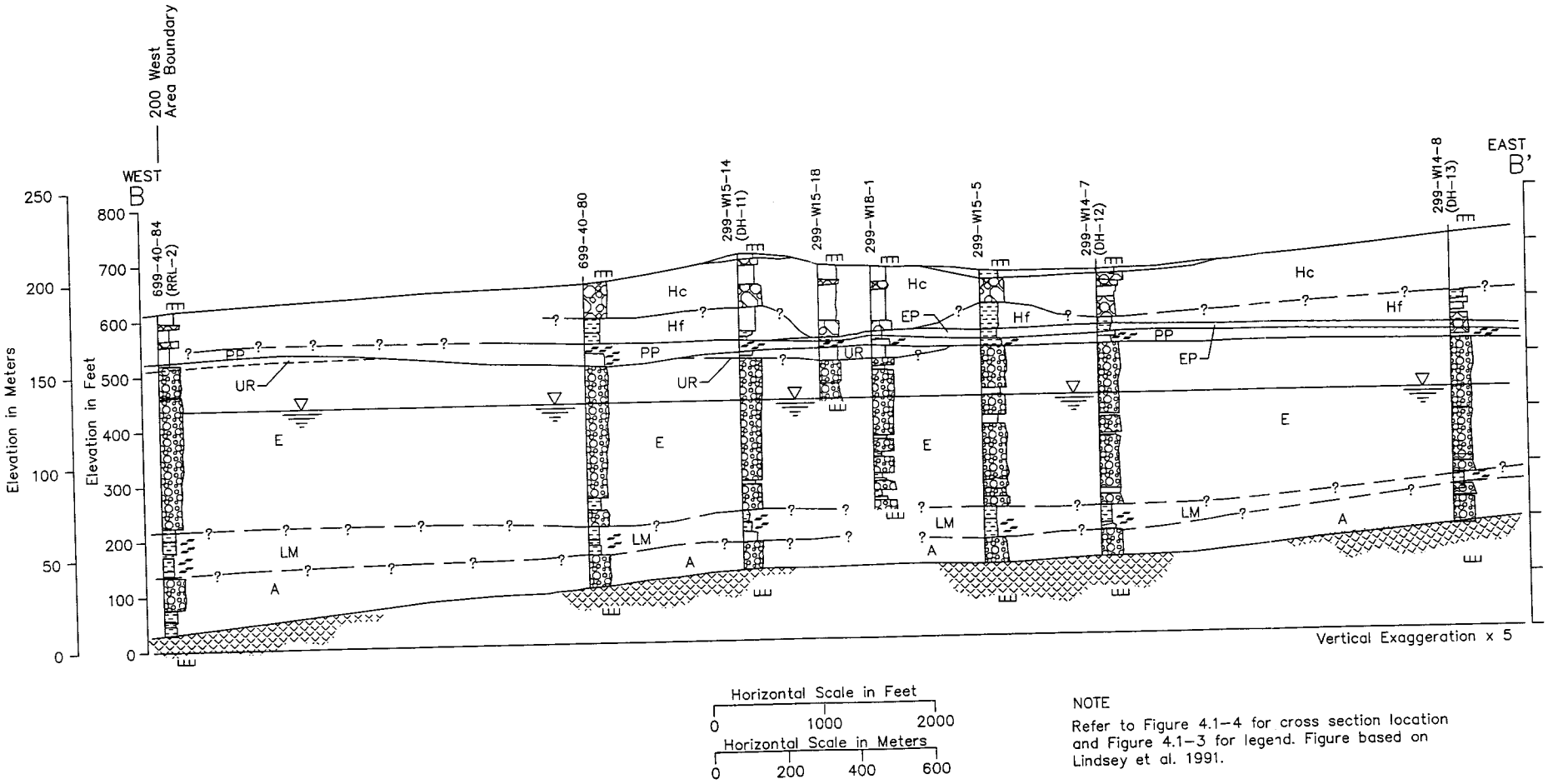

NOTE

Refer to Figure 4.1-4 for cross section location and Figure 4.1-3 for legend. Figure based on Lindsey et al. 1991.

SJT\011494-B

Figure 2A-12. West-East Geologic Cross Section Through 200 West Area.

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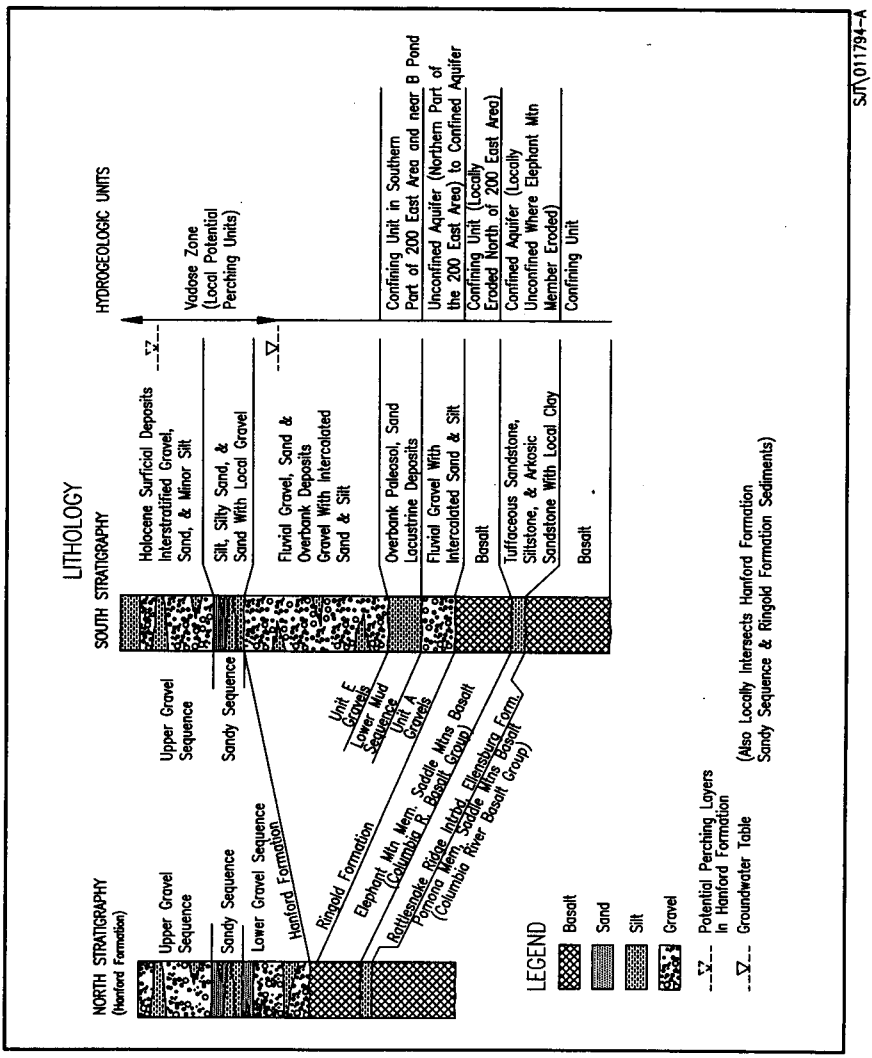

Figure 2A-13. Generalized Hydrostratigraphy of the 200 East Area.

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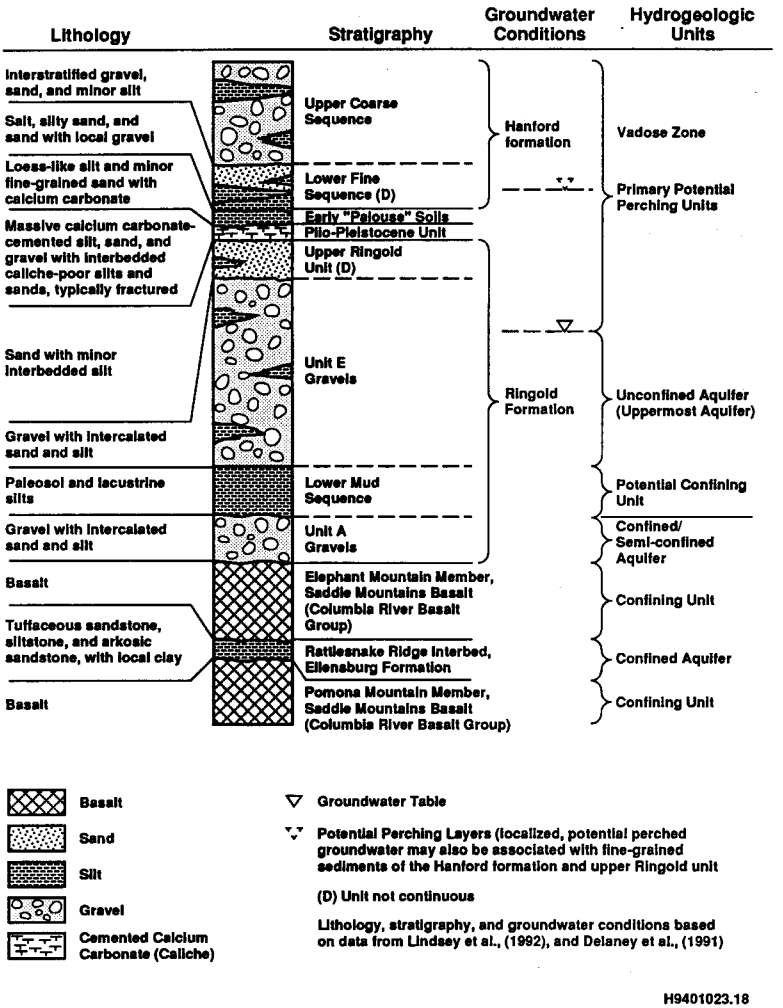


Figure 2A-14. Generalized Hydrostratigraphy of the 200 West Area.

960516.1532

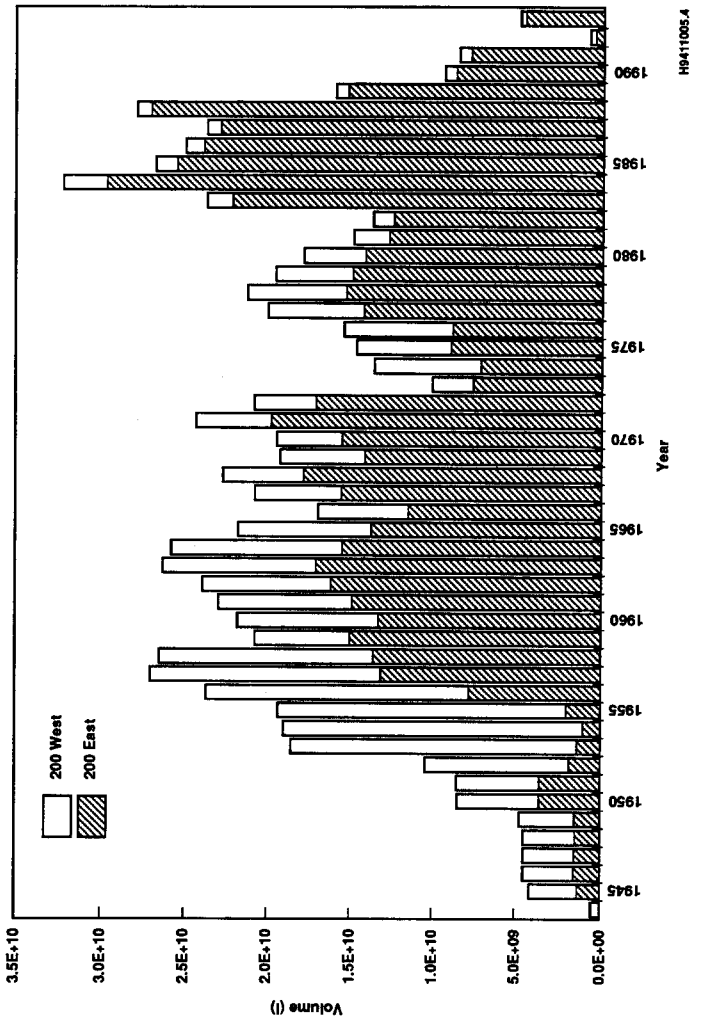


Figure 2A-15. Liquid Effluent Disposed to Ground at the Hanford Site.

960516.1532

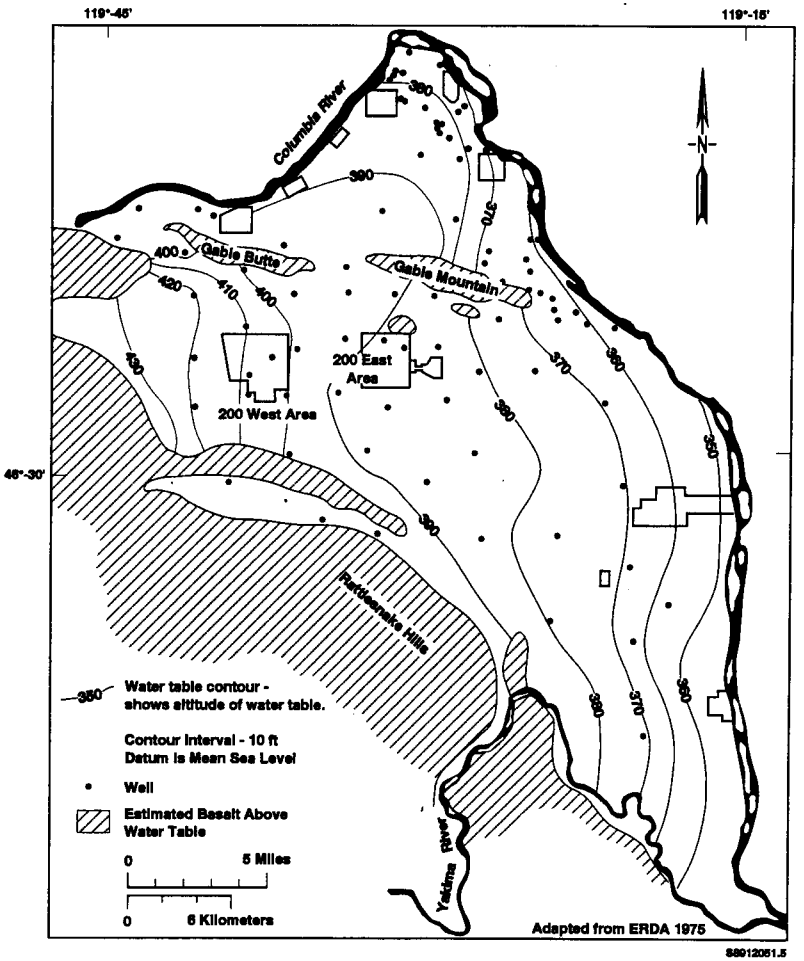
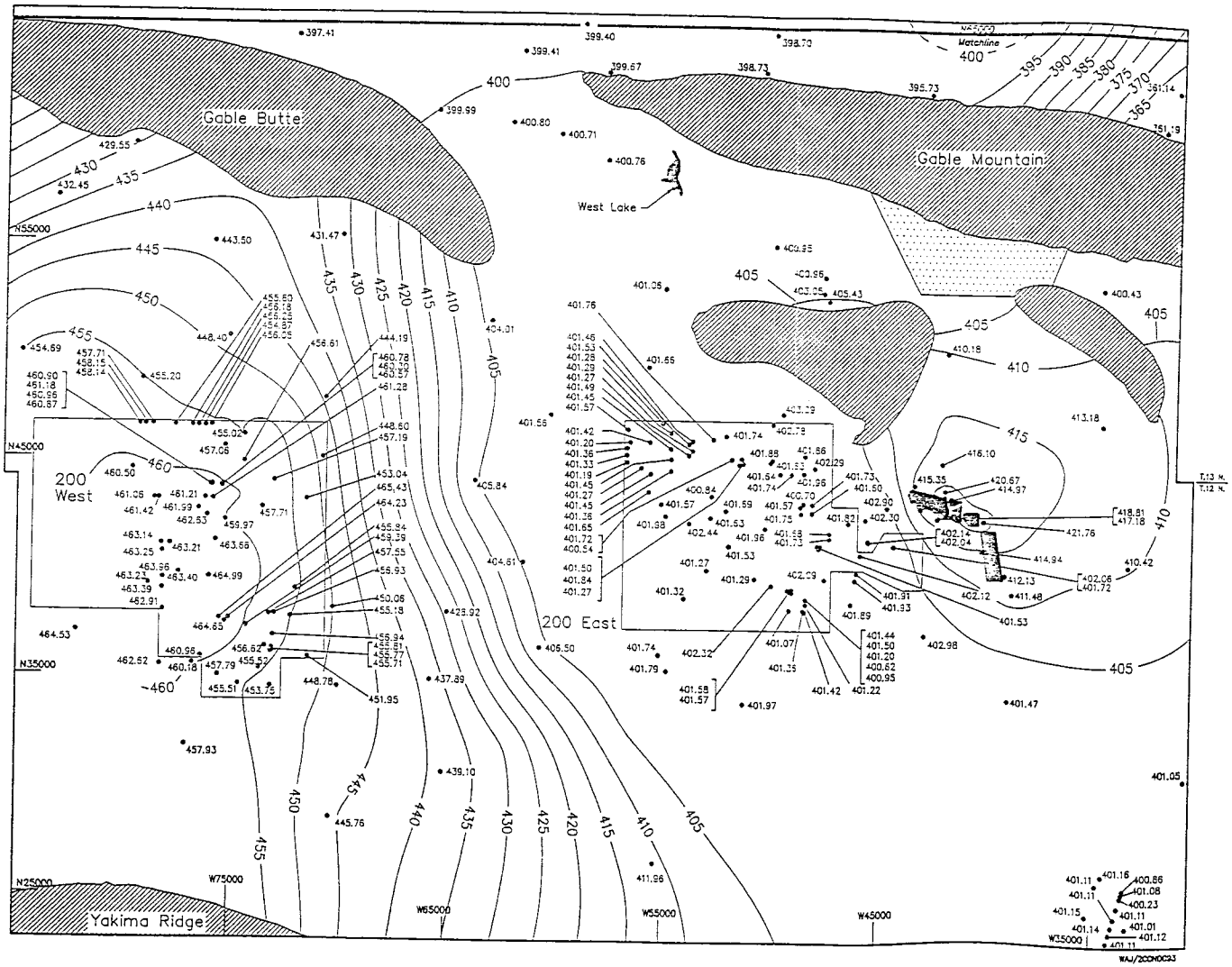


Figure 2A-16. Hindcast Water Table Map of the Hanford Site, January 1944.

960516.1532

Figure 7

200 Areas Water Table Elevation December 1993



206.34 • Water table elevation (feet above mean sea level)

- - - - The dashed line indicates a contour line generated due to unusual data. (Kasza 1990)

400 Groundwater table elevation contour interval = 5 ft

Ponds

Areas where the basalt surface is generally above the water table

Areas of conflicting data.

The 200 Areas water level elevation map has been prepared by the Geohydrologic Support Function, Westinghouse Hanford Company.

Note: To convert to metric, multiply elevation (ft) by 0.3048 to obtain elevation (m).

0 1 Mile

0 1 Kilometer

-N-

Figure 2A-17. 200 Areas Water Table Elevation, June 1993.

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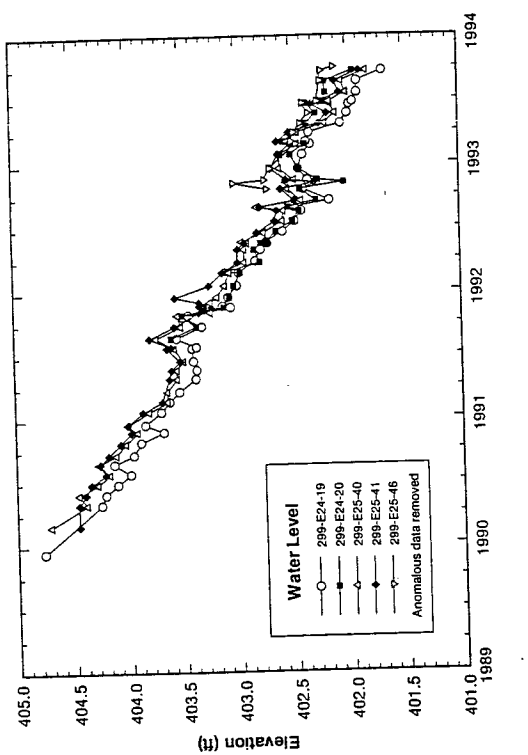

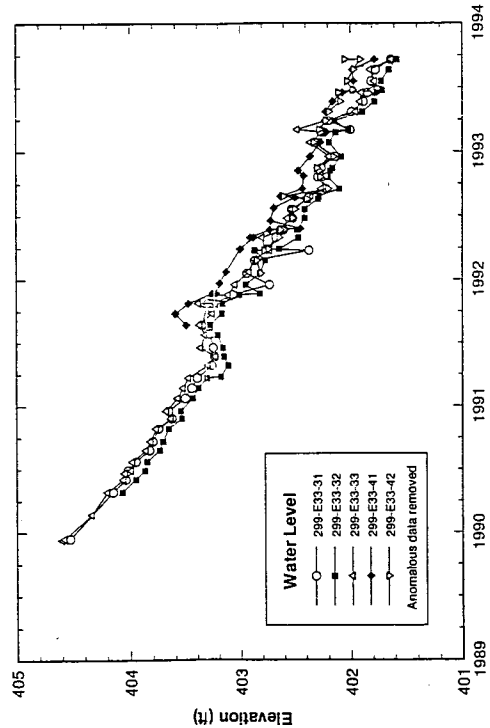

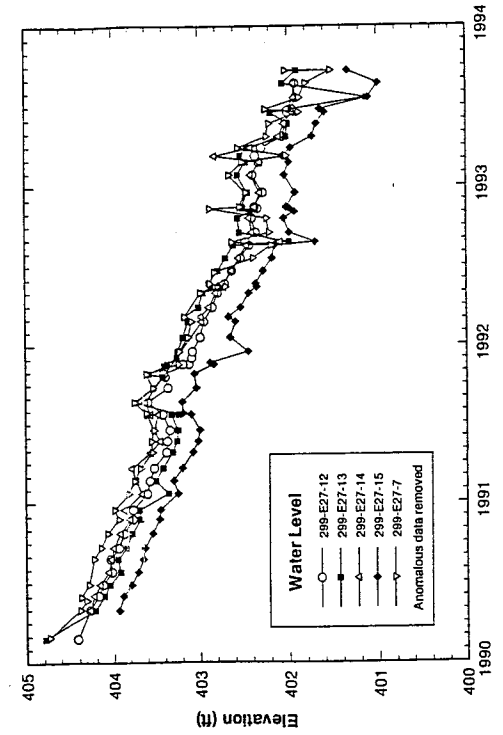

Figure 2A-18. Hydrographs of 200 East Area SST Groundwater Monitoring Wells.

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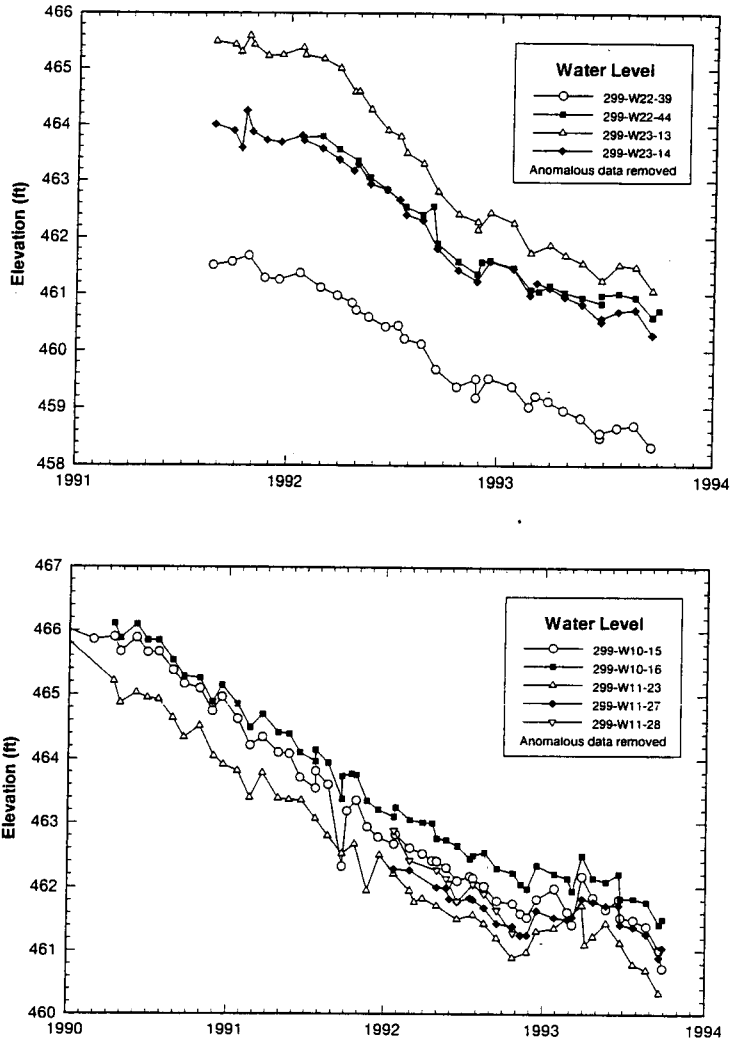

Figure 2A-19. Hydrographs of Groundwater Monitoring Wells in SST WMAs S-SX and T.

960516.1532

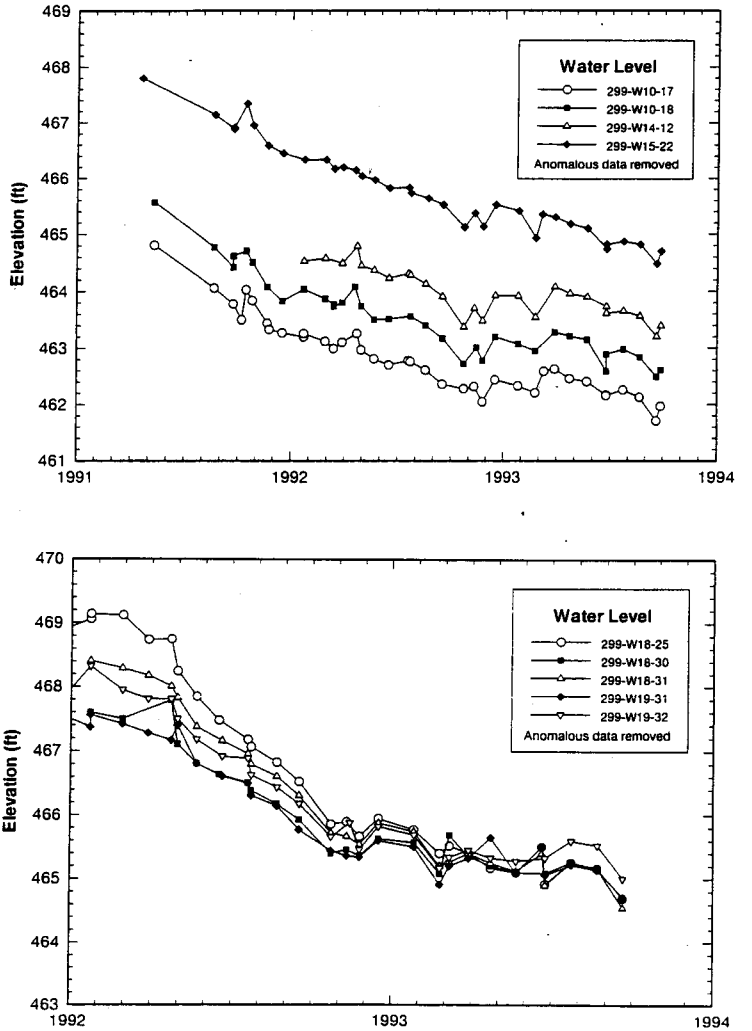

Figure 2A-20. Hydrographs of Groundwater Monitoring Wells in SST WMAs TX-TY and U.

960516.1532

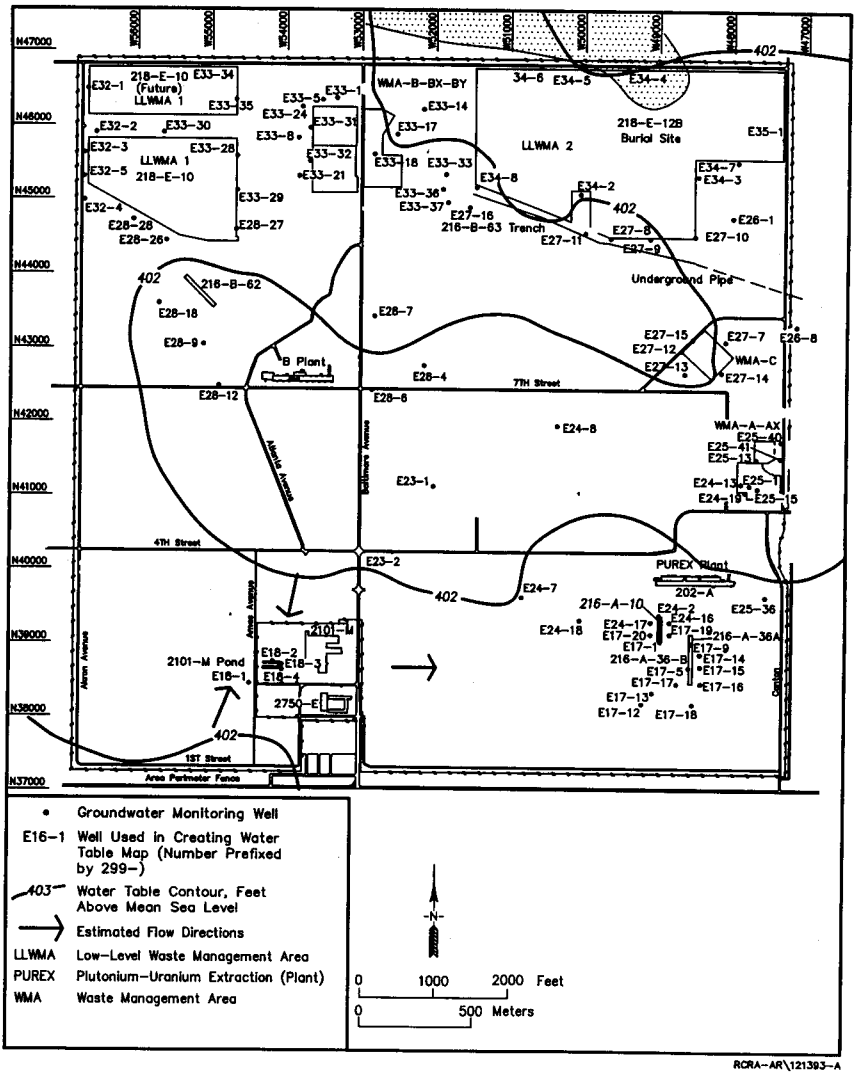

Figure 2A-21. June 1993 Water Table Map for the 200 East Area.

960516.1532

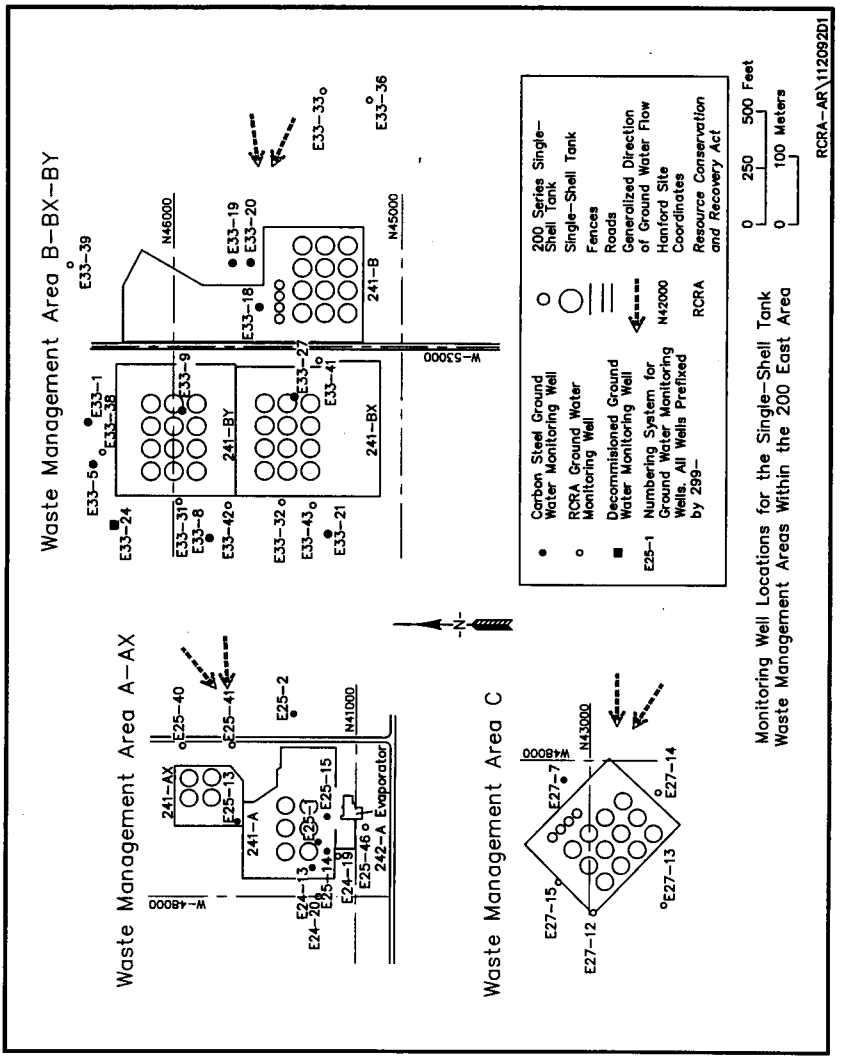

Figure 2A-22. Location Map for Single-Shell Tank Groundwater Monitoring Wells in 200 East Area.

960516.1532

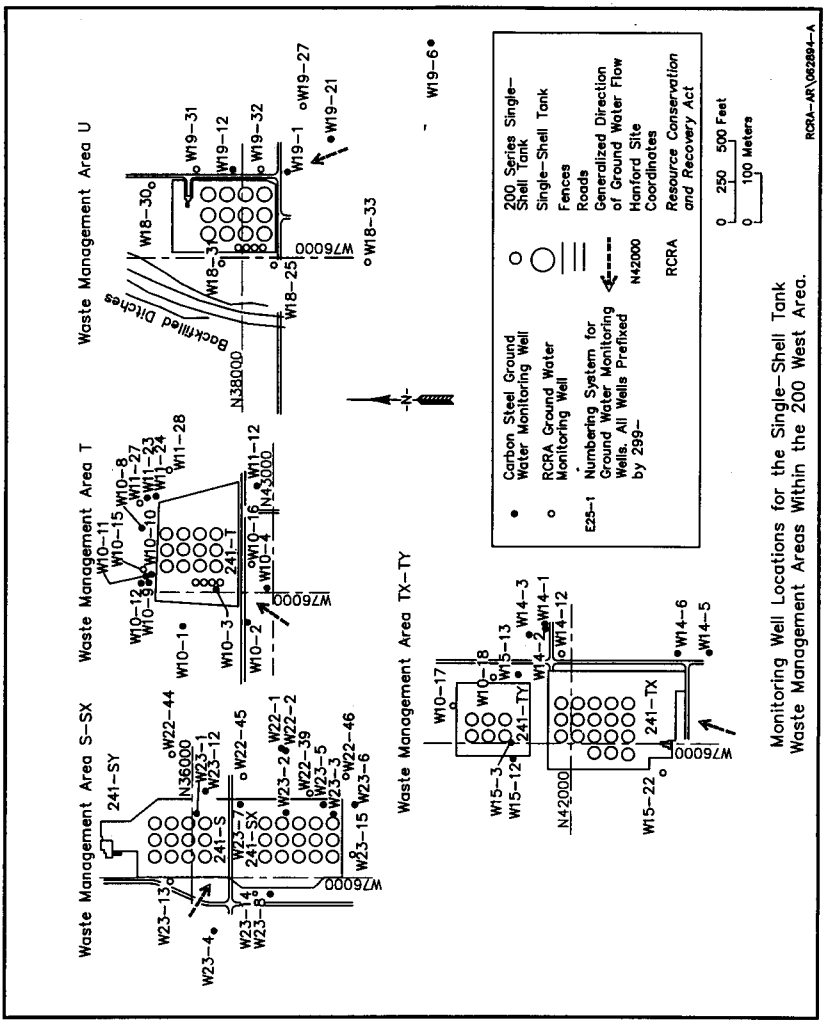

Figure 2A-23. Location Map for Single-Shell Tank Groundwater Monitoring Wells in 200 West Area.

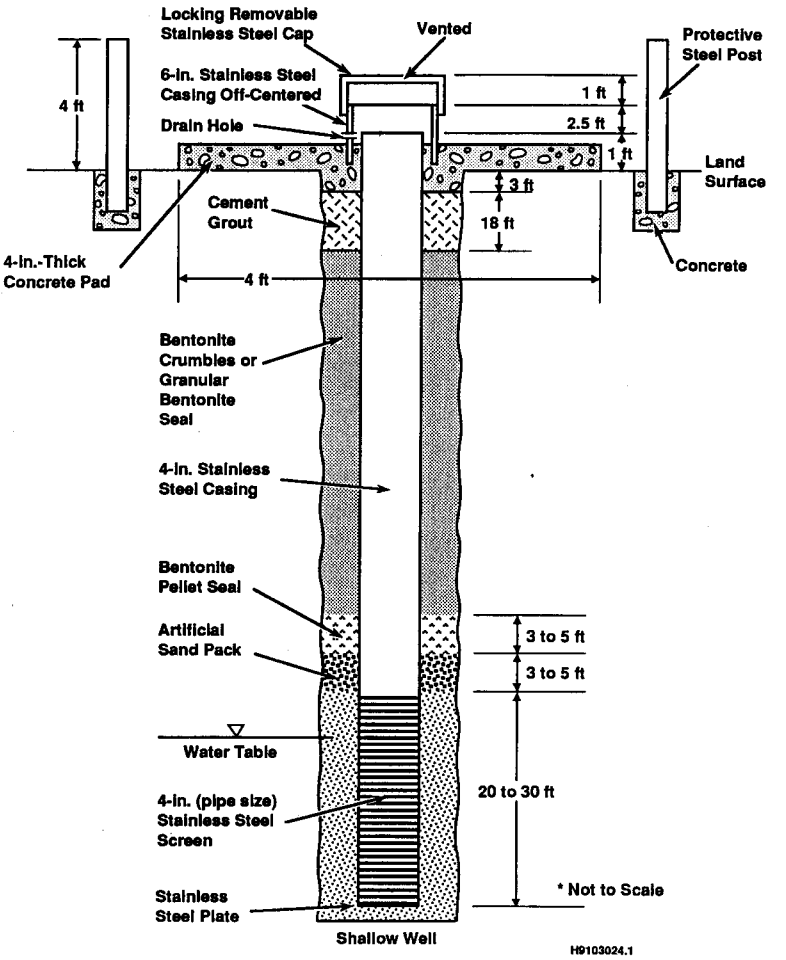

Figure 2A-24. Schematic Diagram of a Completed Groundwater Monitoring Well.

960516.1532

Table 2A-1. Single-Shell Tanks. (sheet 1 of 4)

Tank number	Year of construction	Year removed[a] from service	Operating capacity, liters (gallons)
200 EAST AREA			
Waste Management Area A-AX			
241-A-101	1954-1955	1980	3,785,000 (1,000,000)
241-A-102	1954-1955	1980	3,785,000 (1,000,000)
241-A-103[b]	1954-1955	1980	3,785,000 (1,000,000)
241-A-104[b]	1954-1955	1975	3,785,000 (1,000,000)
241-A-105[b]	1954-1955	1963	3,785,000 (1,000,000)
241-A-106	1954-1955	1980	3,785,000 (1,000,000)
241-AX-101	1963-1964	1980	3,785,000 (1,000,000)
241-AX-102[b]	1963-1964	1980	3,785,000 (1,000,000)
241-AX-103	1963-1964	1980	3,785,000 (1,000,000)
241-AX-104[b]	1963-1964	1978	3,785,000 (1,000,000)
Waste Management Area B-BX-BY			
241-B-101[b]	1943-1944	1974	1,892,500 (500,000)
241-B-102	1943-1944	1978	1,892,500 (500,000)
241-B-103[b]	1943-1944	1978	1,892,500 (500,000)
241-B-104	1943-1944	1972	1,892,500 (500,000)
241-B-105[b]	1943-1944	1978	1,892,500 (500,000)
241-B-106	1943-1944	1977	1,892,500 (500,000)
241-B-107[b]	1943-1944	1969	1,892,500 (500,000)
241-B-108	1943-1944	1977	1,892,500 (500,000)
241-B-109	1943-1944	1977	1,892,500 (500,000)
241-B-110[b]	1943-1944	1971	1,892,500 (500,000)
241-B-111[b]	1943-1944	1976	1,892,500 (500,000)
241-B-112[b]	1943-1944	1977	1,892,500 (500,000)
241-B-201[b]	1943-1944	1971	208,175 (55,000)
241-B-202	1943-1944	1977	208,175 (55,000)
241-B-203[b]	1943-1944	1977	208,175 (55,000)
241-B-204[b]	1943-1944	1977	208,175 (55,000)
241-BX-101[b]	1946-1947	1972	1,892,500 (500,000)
241-BX-102[b]	1946-1947	1971	1,892,500 (500,000)
241-BX-103	1946-1947	1977	1,892,500 (500,000)
241-BX-104	1946-1947	1980	1,892,500 (500,000)
241-BX-105	1946-1947	1980	1,892,500 (500,000)
241-BX-106	1946-1947	1971	1,892,500 (500,000)
241-BX-107	1946-1947	1977	1,892,500 (500,000)
241-BX-108[b]	1946-1947	1974	1,892,500 (500,000)
241-BX-109	1946-1947	1974	1,892,500 (500,000)
241-BX-110[b]	1946-1947	1977	1,892,500 (500,000)
241-BX-111[b]	1946-1947	1977	1,892,500 (500,000)
241-BX-112	1946-1947	1977	1,892,500 (500,000)

Table 2A-1. Single-Shell Tanks. (sheet 2 of 4)

Tank number	Year of construction	Year removed[a] from service	Operating capacity, liters (gallons)	
Waste Management Area B-BX-BY (cont)				
241-BY-101	1948-1949	1971	2,838,750	(750,000)
241-BY-102	1948-1949	1977	2,838,750	(750,000)
241-BY-103[b]	1948-1949	1973	2,838,750	(750,000)
241-BY-104	1948-1949	1977	2,838,750	(750,000)
241-BY-105[b]	1948-1949	1974	2,838,750	(750,000)
241-BY-106[b]	1948-1949	1977	2,838,750	(750,000)
241-BY-107[b]	1948-1949	1974	2,838,750	(750,000)
241-BY-108[b]	1948-1949	1972	2,838,750	(750,000)
241-BY-109	1948-1949	1979	2,838,750	(750,000)
241-BY-110	1948-1949	1979	2,838,750	(750,000)
241-BY-111	1948-1949	1977	2,838,750	(750,000)
241-BY-112	1948-1949	1978	2,838,750	(750,000)
Waste Management Area C				
241-C-101[b]	1943-1944	1970	1,892,500	(500,000)
241-C-102	1943-1944	1976	1,892,500	(500,000)
241-C-103	1943-1944	1979	1,892,500	(500,000)
241-C-104	1943-1944	1980	1,892,500	(500,000)
241-C-105	1943-1944	1979	1,892,500	(500,000)
241-C-106	1943-1944	1979	1,892,500	(500,000)
241-C-107	1943-1944	1978	1,892,500	(500,000)
241-C-108	1943-1944	1976	1,892,500	(500,000)
241-C-109	1943-1944	1976	1,892,500	(500,000)
241-C-110[b]	1943-1944	1976	1,892,500	(500,000)
241-C-111[b]	1943-1944	1978	1,892,500	(500,000)
241-C-112	1943-1944	1976	1,892,500	(500,000)
241-C-201[b]	1943-1944	1977	208,175	(55,000)
241-C-202[b]	1943-1944	1977	208,175	(55,000)
241-C-203[b]	1943-1944	1977	208,175	(55,000)
241-C-204[b]	1943-1944	1977	208,175	(55,000)
200 WEST AREA				
Waste Management Area S-SX				
241-S-101	1950-1951	1980	2,838,750	(750,000)
241-S-102	1950-1951	1980	2,838,750	(750,000)
241-S-103	1950-1951	1980	2,838,750	(750,000)
241-S-104[b]	1950-1951	1968	2,838,750	(750,000)
241-S-105	1950-1951	1974	2,838,750	(750,000)
241-S-106	1950-1951	1980	2,838,750	(750,000)
241-S-107	1950-1951	1980	2,838,750	(750,000)
241-S-108	1950-1951	1979	2,838,750	(750,000)
241-S-109	1950-1951	1979	2,838,750	(750,000)
241-S-110	1950-1951	1979	2,838,750	(750,000)
241-S-111	1950-1951	1972	2,838,750	(750,000)
241-S-112	1950-1951	1974	2,838,750	(750,000)

Table 2A-1. Single-Shell Tanks. (sheet 3 of 4)

Tank number	Year of construction	Year removed[a] from service	Operating capacity, liters (gallons)
Waste Management Area S-SX (cont)			
241-SX-101	1953-1954	1980	3,785,000 (1,000,000)
241-SX-102	1953-1954	1980	3,785,000 (1,000,000)
241-SX-103	1953-1954	1980	3,785,000 (1,000,000)
241-SX-104[b]	1953-1954	1980	3,785,000 (1,000,000)
241-SX-105	1953-1954	1980	3,785,000 (1,000,000)
241-SX-106	1953-1954	1980	3,785,000 (1,000,000)
241-SX-107[b]	1953-1954	1964	3,785,000 (1,000,000)
241-SX-108[b]	1953-1954	1962	3,785,000 (1,000,000)
241-SX-109[b]	1953-1954	1965	3,785,000 (1,000,000)
241-SX-110[b]	1953-1954	1976	3,785,000 (1,000,000)
241-SX-111[b]	1953-1954	1974	3,785,000 (1,000,000)
241-SX-112[b]	1953-1954	1969	3,785,000 (1,000,000)
241-SX-113[b]	1953-1954	1958	3,785,000 (1,000,000)
241-SX-114[b]	1953-1954	1972	3,785,000 (1,000,000)
241-SX-115[b]	1953-1954	1965	3,785,000 (1,000,000)
Waste Management Area T			
241-T-101[b]	1943-1944	1979	1,892,500 (500,000)
241-T-102	1943-1944	1976	1,892,500 (500,000)
241-T-103[b]	1943-1944	1974	1,892,500 (500,000)
241-T-104	1943-1944	1974	1,892,500 (500,000)
241-T-105	1943-1944	1976	1,892,500 (500,000)
241-T-106[b]	1943-1944	1973	1,892,500 (500,000)
241-T-107[b]	1943-1944	1976	1,892,500 (500,000)
241-T-108[b]	1943-1944	1974	1,892,500 (500,000)
241-T-109[b]	1943-1944	1974	1,892,500 (500,000)
241-T-110	1943-1944	1976	1,892,500 (500,000)
241-T-111[b]	1943-1944	1974	1,892,500 (500,000)
241-T-112	1943-1944	1977	1,892,500 (500,000)
241-T-201	1943-1944	1976	208,175 (55,000)
241-T-202	1943-1944	1976	208,175 (55,000)
241-T-203	1943-1944	1976	208,175 (55,000)
241-T-204	1943-1944	1976	208,175 (55,000)
Waste Management Area TX-TY			
241-TX-101	1947-1948	1980	2,838,750 (750,000)
241-TX-102	1947-1948	1977	2,838,750 (750,000)
241-TX-103	1947-1948	1980	2,838,750 (750,000)
241-TX-104	1947-1948	1977	2,838,750 (750,000)
241-TX-105[b]	1947-1948	1977	2,838,750 (750,000)
241-TX-106	1947-1948	1977	2,838,750 (750,000)
241-TX-107[b]	1947-1948	1977	2,838,750 (750,000)

Table 2A-1. Single-Shell Tanks. (sheet 4 of 4)

Tank number	Year of construction	Year removed[a] from service	Operating capacity, liters (gallons)
Waste Management Area TX-TY (cont)			
241-TX-108	1947-1948	1977	2,838,750 (750,000)
241-TX-109	1947-1948	1977	2,838,750 (750,000)
241-TX-110[b]	1947-1948	1977	2,838,750 (750,000)
241-TX-111	1947-1948	1977	2,838,750 (750,000)
241-TX-112	1947-1948	1974	2,838,750 (750,000)
241-TX-113[b]	1947-1948	1971	2,838,750 (750,000)
241-TX-114[b]	1947-1948	1971	2,838,750 (750,000)
241-TX-115[b]	1947-1948	1977	2,838,750 (750,000)
241-TX-116[b]	1947-1948	1969	2,838,750 (750,000)
241-TX-117[b]	1947-1948	1969	2,838,750 (750,000)
241-TX-118	1947-1948	1980	2,838,750 (750,000)
241-TY-101[b]	1951-1952	1973	2,838,750 (750,000)
241-TY-102	1951-1952	1979	2,838,750 (750,000)
241-TY-103[b]	1951-1952	1973	2,838,750 (750,000)
241-TY-104[b]	1951-1952	1974	2,838,750 (750,000)
241-TY-105[b]	1951-1952	1980	2,838,750 (750,000)
241-TY-106[b]	1951-1952	1959	2,838,750 (750,000)
Waste Management Area U			
241-U-101[b]	1943-1944	1960	1,892,500 (500,000)
241-U-102	1943-1944	1979	1,892,500 (500,000)
241-U-103	1943-1944	1978	1,892,500 (500,000)
241-U-104[b]	1943-1944	1961	1,892,500 (500,000)
241-U-105	1943-1944	1978	1,892,500 (500,000)
241-U-106	1943-1944	1977	1,892,500 (500,000)
241-U-107	1943-1944	1980	1,892,500 (500,000)
241-U-108	1943-1944	1979	1,892,500 (500,000)
241-U-109	1943-1944	1978	1,892,500 (500,000)
241-U-110[b]	1943-1944	1975	1,892,500 (500,000)
241-U-111	1943-1944	1980	1,892,500 (500,000)
241-U-112[b]	1943-1944	1970	1,892,500 (500,000)
241-U-201	1943-1944	1977	208,175 (55,000)
241-U-202	1943-1944	1977	208,175 (55,000)
241-U-203	1943-1944	1977	208,175 (55,000)
241-U-204	1943-1944	1977	208,175 (55,000)

[a]The last year the tank was capable of receiving waste; actual date of last waste receipt may have been earlier.

[b]Assumed leaking tank (Hanlon 1994). Date (from WIDS) when tank was taken out of service, which may be long before the tank was officially declared as a confirmed or assumed leaker.

Table 2A-2. Hydraulic Gradients at Single-Shell Tank Waste Management Areas.

WMA	Well number	Date water levels measured	Diff. in head (feet)[a]	Gradient
A-AX	E25-2, E24-19 E25-40, E24-19	6/24/93 6/24/93	0.31 0.21	0.0005 0.0002
B-BX-BY	E33-33, E33-24 E33-33, E33-32	6/23/93 6/23/93	0.28 0.09	0.0001 0.00005
C	E27-14, E27-15 E27-7, E27-12	6/23/93 6/23/93	0.37 0.20	0.0007 0.0004
S-SX	W23-13, W23-2 W23-14, W22-46	6/24/93 6/24/93	1.47 2.28	0.0015 0.0025
T	W10-16, W11-27 W10-16, W10-9	6/24/93 6/24/93	0.41 0.17	0.0005 0.0002
TX-TY	W15-22, W10-17 W15-22, W10-18	6/24/93 6/24/93	2.66 1.93	0.0017 0.0017
U[b]	W18-25, W19-32 W18-31, W18-30	6/24/93 6/24/93	0.41 0.15	0.00066 0.00008

[a]Measurements are made in feet and fractions thereof and are therefore reported in those units. To convert feet to meters, divide by 3.28.

[b]The direction of groundwater flow beneath the Waste Management Area U in June 1993 was reversed from what it has been, i.e., water levels in planned upgradient wells 2-W18-25 and 2-W18-31 were declining faster than in planned downgradient wells 2-W19-32 and 2-W18-30. This reversal began in late spring and may be temporary because of short-term high-volume discharges during late spring to the 216-U-14 Ditch, which is located east of the 241-U Tank Farm. These discharges were related to the final campaign and cleanout of the 221-U Plant. The changes may also be related to the migration of the apex of the groundwater mound eastward beneath the 241-U Tank Farm or to the possible southwestward expansion of a groundwater mound that may be developing beneath the 284-W Powerhouse Pond. Water levels are being monitored carefully and additional wells monitoring the top of the unconfined aquifer in the vicinity of the 241-U Tank Farm have been added to the water level network to provide more data on this apparent change in groundwater flow direction.

Table 2A-3. Groundwater Flow Velocities[a,b,c] in the Unconfined Aquifer Beneath Single-Shell Tank Waste Management Areas.

WMA	Well number	Hydraulic conductivity (m/d [ft/d])	Hydraulic gradient[d]	Effective porosity	Flow velocity (m/d [ft/d])
A-AX	E24-19	33.5 (110)	0.00035	0.20	0.06 (0.19)
		33.5 (110)	0.00035	0.10	0.12 (0.38)
	E25-40	21.3 (70)	0.00035	0.20	0.04 (0.12)
		21.3 (70)	0.00035	0.10	0.08 (0.25)
	E25-41	7.3 (24)	0.00035	0.20	0.01 (0.04)
		7.3 (24)	0.00035	0.10	0.02 (0.08)
B-BX-BY	E33-33	97.5 (320)	0.000075	0.20	0.04 (0.12)
		97.5 (320)	0.000075	0.10	0.07 (0.24)
C	E27-13	54.8 (180)	0.00055	0.20	0.15 (0.50)
		54.8 (180)	0.00055	0.10	0.3 (1.0)
	E27-14	48.7 (160)	0.00055	0.20	0.13 (0.44)
		48.7 (160)	0.00055	0.10	0.27 (0.88)
	E27-15	119 (390)	0.00055	0.20	0.34 (1.1)
		119 (390)	0.00055	0.10	0.64 (2.1)
S-SX	W23-13	27.4 (90)	0.002	0.20	0.27 (0.9)
		27.4 (90)	0.002	0.10	0.55 (1.8)
	W23-14	0.43 (1.4)	0.002	0.20	0.003 (0.01)
		0.43 (1.4)	0.002	0.10	0.009 (0.03)
T	W10-15	10.1 (33)	0.00035	0.20	0.02 (0.06)
		10.1 (33)	0.00035	0.10	0.04 (0.12)
	W10-16	10.1 (33)	0.00035	0.20	0.02 (0.06)
		10.1 (33)	0.00035	0.10	0.04 (0.12)
TX-TY	W15-22	15.2 (50)	0.0017	0.20	0.13 (0.43)
		15.2 (50)	0.0017	0.10	0.26 (0.85)
	W10-18	54.8 (180)	0.0017	0.20	0.46 (1.5)
		54.8 (180)	0.0017	0.10	0.94 (3.1)
U	W18-25	6.1 (20)	0.00037	0.20	0.01 (0.04)
		6.1 (20)	0.00037	0.10	0.02 (0.07)
	W19-31	36.6 (120)	0.00037	0.20	0.07 (0.22)
		36.6 (120)	0.00037	0.10	0.13 (0.44)

[a]Calculated using: $v = Ki/n$, where K = hydraulic conductivity, i = gradient, and n = effective porosity.

[b]Hydraulic conductivities were calculated from results of slug tests performed in wells indicated (Newcomer et al. 1990). Connelly et al. (1992) found that hydraulic conductivities determined from slug tests may be an order of magnitude too low compared with hydraulic conductivities calculated from constant discharge tests.

[c]All of these wells are completed as 4-in. wells with stainless steel screens (0.10 or 0.20 slot) in the uppermost part of the unconfined aquifer beneath each site. Most 200 East Area wells are completed in the Hanford formation; most 200 West Area wells are completed in the Ringold Formation.

[d]Average of two values for hydraulic gradient given in Table 2A-2.

Table 2A-4. Hydraulic Properties in the 200 Areas.[a]

Interval tested	Hydraulic conductivity (foot per day)	Storativity	Porosity (percent)
Hanford formation	2000-10,000	0.07	30
Middle Ringold Unit	9-230	NA	NA
Lower Ringold Unit	1-12	0.002	10

NA = not available.
[a]Graham et al. 1981.

Table 2A-5. Wells in the Single-Shell Tank Groundwater Monitoring Network. (sheet 1 of 4)

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
Waste Management Area A-AX					
299-E24-19[89]	Top of unconfined	S	M	RCRA	--
299-E24-20[90]	Top of unconfined	S	M	RCRA	--
299-E25-40[89]	Top of unconfined	S	M	RCRA	--
299-E24-13[68]	Top of unconfined	--	M	PRE	--
299-E25-1[55]	Top of unconfined	--	M	PRE	--
299-E25-2[55]	Top of unconfined	--	M	PRE	--
299-E25-14[63]	Top of unconfined	--	M	PRE	--
299-E25-15[69]	Top of unconfined	--	M	PRE	--
299-E25-16[69]	Top of unconfined	--	M	PRE	--
299-E25-41[89]	Top of unconfined	S	M	RCRA	--
299-E25-46[92]	Top of unconfined	S	M	RCRA	--
Waste Management Area B-BX-BY					
299-E33-31[89]	Top of unconfined	S	M	RCRA	--
299-E33-32[89]	Top of unconfined	S	M	RCRA	--
299-E33-33[89]	Top of unconfined	S	M	RCRA	--
299-E33-36[90]	Top of unconfined	S	M	RCRA	216-B-63
299-E33-41[90]	Top of unconfined	S	M	RCRA	--
299-E33-38[90]	Top of unconfined	S	M	RCRA	200-BP-1
299-E33-39[90]	Top of unconfined	S	M	RCRA	200-BP-1
299-E33-42[91]	Top of unconfined	S	M	RCRA	--
299-E33-43[91]	Top of unconfined	S	M	RCRA	--
299-E33-1[54]	Top of unconfined	--	M	PRE	--
299-E33-5[55]	Top of unconfined	--	M	PRE	--
299-E33-8[53]	Top of unconfined	--	M	PRE	--
299-E33-18[50]	Top of unconfined	--	M	PRE	--
299-E33-21[57]	Top of unconfined	--	M	PRE	--
299-E33-24[67]*	Top of unconfined	--	M	PRE	--

Table 2A-5. Wells in the Single-Shell Tank Groundwater Monitoring Network.
(sheet 2 of 4)

	Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
1	Waste Management Area C					
2	299-E27-12[89]	Top of unconfined	S	M	RCRA	--
3	299-E27-13[89]	Top of unconfined	S	M	RCRA	--
4	299-E27-14[89]	Top of unconfined	S	M	RCRA	--
5	299-E27-15[89]	Top of unconfined	S	M	RCRA	--
6	299-E27-7[82]	Top of unconfined	S[s]	M	PRE	--
7	Waste Management Area S-SX					
8	299-W22-39[90]	Top of unconfined	S	M	RCRA	--
9	299-W22-44[91]	Top of unconfined	S	M	RCRA	--
10	299-W22-45[92]	Top of unconfined	S	M	RCRA	--
11	299-W22-46[91]	Top of unconfined	S	M	RCRA	--
12	299-W23-13[91]	Top of unconfined	S	M	RCRA	--
13	299-W23-14[90]	Top of unconfined	S	M	RCRA	--
14	299-W23-15[91]	Top of unconfined	S	M	RCRA	--
15	299-W23-1[53]	Top of unconfined	--	M	PRE	--
16	299-W23-2[54]	Top of unconfined	--	M	PRE	--
17	299-W23-3[56]	Top of unconfined	--	M	PRE	--
18	299-W23-4[57]	Top of unconfined	--	M	PRE	--
19	299-W23-5[69]	Top of unconfined	--	M	PRE	--
20	299-W23-6[69]	Top of unconfined	--	M	PRE	--
21	299-W23-7[60]	Top of unconfined	--	M	PRE	--
22	299-W23-8[82]	Top of unconfined	--	M	PRE	--
23	299-W23-12[70]	Top of unconfined	--	M	PRE	--

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Table 2A-5. Wells in the Single-Shell Tank Groundwater Monitoring Network. (sheet 3 of 4)

	Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
1	Waste Management Area T					
2	299-W10-15[89]	Top of unconfined	Q+	M	RCRA	--
3	299-W10-16[89]	Top of unconfined	Q	M	RCRA	--
4	299-W11-27[91]	Top of unconfined	Q	M	RCRA	--
5	299-W11-28[91]	Top of unconfined	Q+	M	RCRA	--
6	299-W10-4[52]	Top of unconfined	--	M	PRE	--
7	299-W10-3[51]	Top of unconfined	--	M	PRE	--
8	299-W10-8[73]	Top of unconfined	--	M	PRE	--
9	299-W10-9[73]	Top of unconfined	--	M	PRE	--
10	299-W10-11[74]	Top of unconfined	--	M	PRE	--
11	299-W10-12[74]	Top of unconfined	--	M	PRE	--
12	299-W11-23[73]	Top of unconfined	--	M	PRE	--
13	299-W11-24[73]	Top of unconfined	--	M	PRE	--
14	299-W10-10[73]	Top of unconfined	--	M	PRE	--
15	Waste Management Area TX-TY					
16	299-W10-17[90]	Top of unconfined	Q	M	RCRA	--
17	299-W10-18[90]	Top of unconfined	Q	M	RCRA	--
18	299-W14-12[91]	Top of unconfined	Q	M	RCRA	--
19	299-W15-22[90]	Top of unconfined	Q	M	RCRA	--
20	299-W15-3[52]	Top of unconfined	--	M	PRE	--
21	299-W15-12[73]	Top of unconfined	--	M	PRE	--
22	299-W15-13[73]	Top of unconfined	--	M	PRE	--

Table 2A-5. Wells in the Single-Shell Tank Groundwater Monitoring Network. (sheet 4 of 4)

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
Waste Management Area U					
299-W18-25[90]	Top of unconfined	Q	M	RCRA	--
299-W18-30[91]	Top of unconfined	Q	M	RCRA	--
299-W18-31[91]	Top of unconfined	Q	M	RCRA	--
299-W19-31[90]	Top of unconfined	Q	M	RCRA	--
299-W19-32[90]	Top of unconfined	Q[+]	M	RCRA	--
299-W19-12[83]	Top of unconfined	Q[s]	M	PRE	--

Notes: Shading denotes upgradient wells. Superscript following well number denotes the year of installation.
M = frequency on a monthly basis.
PRE = well was constructed before *Resource Conservation and Recovery Act* specified standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to *Resource Conservation and Recovery Act*-specified standards.
S = frequency on a semiannual basis.
* = well decommissioned in September 1993.
[+] = well is also sampled semiannually for the Carbon Tetrachloride Expedited Response Action project.
[s] = well is sampled for supporting data.

Table 2A-6. Water Level Decline Single-Shell Tank Groundwater Monitoring Wells. (sheet 1 of 2)

WMA	Well number	6/90 - 6/91 Decline (ft)[a]	6/91 - 6/92 Decline (ft)[a]	6/92 - 6/93 Decline (ft)[a]
A-AX	E24-13	0.95	0.67	0.61
	E24-19	0.71	0.82	0.64
	E25-1	0.96	0.58	0.69
	E25-2	1.05	0.52	0.57
	E25-13	0.95	0.60	0.64
	E25-15	0.94	0.59	0.71
	E25-40	0.80	0.74	0.60
	E25-41	0.83	0.71	0.57
		Avg. 0.90	0.62	0.63
B-BX-BY	E33-8	0.80	0.70	0.63
	E33-18	0.81	--	--
	E33-21	0.77	0.73	0.70
	E33-24	1.11	0.75	1.0
	E33-31	0.77	0.73	0.77
	E33-32	0.71	0.75	0.70
	E33-33	0.61	0.80	0.77
	E33-41			0.75
	E33-42			0.54
	E33-43			0.57
		Avg. 0.80	0.74	0.71
C	E27-7	0.66	0.69	0.58
	E27-12	0.79	0.71	0.68
	E27-13	0.80	0.46	0.81
	E27-14	0.64	0.89	0.62
	E27-15	0.79	0.72	0.64
		Avg. 0.74	0.69	0.67
S-SX	W22-39	NA	1.57	1.93
	W22-44		--	2.01
	W22-45		--	--
	W22-46		--	1.85
	W23-1		1.51	2.16
	W23-2		1.35	2.29
	W23-3		1.30	2.07
	W23-6		1.37	2.12
	W23-7		2.24	2.28
	W23-8		1.58	2.47
	W23-12		1.49	2.56
	W23-13		1.93	2.67
	W23-14		1.58	2.33
	W23-15		--	--
		Avg.	1.59	2.23

Table 2A-6. Water Level Decline Single-Shell Tank Groundwater Monitoring Wells. (sheet 2 of 2)

WMA	Well number	6/90 - 6/91 Decline (ft)[a]	6/91 - 6/92 Decline (ft)[a]	6/92 - 6/93 Decline (ft)[a]
T	W10-3	1.72	1.45	0.76
	W10-8	1.70	1.87	0.52
	W10-9	1.90	--	0.71[b]
	W10-10	1.93	1.59	0.60
	W10-11	1.92	1.59	0.59
	W10-12	1.89	1.58	0.61
	W10-15	1.94	1.62	0.57
	W10-16	1.74	1.47	0.81
	W11-23	1.59	1.86	0.64
	W11-24	1.57	1.82	0.69
	W11-27	--	--	0.69
		Avg. 1.79	1.65	0.64
TX-TY	W10-17	NA	1.46	0.54
	W10-18		1.37	0.62
	W14-12		--	0.62
	W15-3		1.31	1.12
	W15-12		1.48	0.98
	W15-13		1.40	0.85
	W15-22		1.51	1.0
		Avg.	1.42	0.82
U	W18-25	NA	2.08	2.56
	W18-30		--	1.55
	W18-31		--	2.26
	W19-12		1.65	1.80
	W19-31		1.66	1.55
	W19-32		1.63	1.59
		Avg.	1.76	1.89

Notes: *Resource Conservation and Recovery Act* standard wells are shaded; upgradient wells are underlined.

Additional wells are used for measurement of water levels, but measurements were not always made in each well each month. Water level measurements were not initiated until early 1993 in wells constructed in 1992. Changes in water levels in these wells will be reported next year.

[a]Measurements are made in feet and fractions thereof and are therefore reported in those units. To convert feet to meters, divide by 3.28.

[b]Data from July 1992 to June 1993 (June data not available).

NA = not available.

Table 2A-7. Single-Shell Tank Historical Groundwater Monitoring Wells. (sheet 1 of 3)

WMA	Well number[1]	Date completed	Depth[2]	Diameter[3]	Interval[4]	Monitoring dates	Facility
200 EAST AREA							
A-AX	E24-13*	1969	340	4 (8)	270 - 308 (P)	1985-1989	241-A Tank Farm
A-AX	E25-1	1955	310 (322)	4 (8)	280 - 310 (P)	1957-1963	241-A Tank Farm
A-AX	E25-2*	1955	316 (375[5])	6 (8)	275 - 316 (P)	1957-1990	216-A-1, 216-A-7
A-AX	E25-13*	1963	317	4 (8)	256 - 315 (P)	1957-1991	241-AX Tank Farm
A-AX	E25-15	1969	294.5 (340)	4 (8)	270 - 294.5 (P)	--	241-A Tank Farm
A-AX	E25-16	1969	307 (340)	4 (6)	270 - 307 (P)	--	241-A Tank Farm
B-BX-BY	E33-1*[6]	1954	233 (240)	4 (8)	215 - 233 (P)	--	216-B-43 Crib
B-BX-BY	E33-5*[6]	1955	237 (242)	4 (8)	218 - 236 (P)	1955-1991	216-B-47 Crib
B-BX-BY	E33-8*	1953	257	8	230 - 257 (P)	1958-1990	216-B-41 Trench
B-BX-BY	E33-9*	1949	261 (275[7])	4 (8)	252 - 261 (P)	1956-1989	241-BY Tank Farm
B-BX-BY	E33-18*	1950	284 (278)	8	240 - 260 (P)	1951-1989	216-B-7A & B Cribs
B-BX-BY	E33-19	1956	252[8]	8	217 - 248 (P)	1957-1959	216-B-11A & B Reverse Wells
B-BX-BY	E33-20*	1956	254[5]	6 (8)	225 - 251 (P); 239 - 254 (S)	1957-1989	216-B-11A & B Reverse Wells
B-BX-BY	E33-21*	1957	282[9]	8	235 - 275 (P)	1958-1990	216-B-36 Trench
B-BX-BY	E33-24*[10]	1967	256[11]	4 (8)	219 - 241 (P)	1971-1989	216-B-57 Crib
B-BX-BY	E33-27	1970	231 (265)	4 (6)	90 - 231 (P)[12]	1971-1987	216-BX Tank Farm
C	E27-7*	1982	281	6 (8)	241 - 281 (S)	--	241-C Tank Farm
200 WEST AREA							
S-SX	W23-1*	1952	234.5 (262)	4 (6)	180 - 260 (P); 178 - 234.5 (S)	1959-1989	241-S Tank Farm
S-SX	W23-2*	1954	220 (236)	4 (8)	187 - 200 (P)	1955-1989	241-SX Tank Farm
S-SX	W23-3*	1956	232	4 (8)	176 - 228 (P)	1959-1989	241-SX Tank Farm
S-SX	W23-4*	1957	300	8	180 - 295 (P)	1959-1990	216-S-21 Crib

Table 2A-7. Single-Shell Tank Historical Groundwater Monitoring Wells. (sheet 2 of 3)

	WMA	Well number[1]	Date completed	Depth[2]	Diameter[3]	Interval[4]	Monitoring dates	Facility
1	S-SX	W23-5	1969	250	4 (6)	175 - 240 (P); 205 - 238 (S)	1971-1977	241-SX Tank Farm
2	S-SX	W23-6	1969	250	4 (6)	172 - 248 (P)	--	241-SX Tank Farm
3	S-SX	W23-7*	1969	250	4 (6)	170 - 229 (P); 169 - 219 (S)	1971-1989	241-SX Tank Farm
4	S-SX	W23-8	1972	235	6	165 - 230 (P)	1974-1988	241-SX Tank Farm
5	T	W10-1*	1947	305	8	190 - 270 (P)	1955-1994	216-T-5 Crib
6	T	W10-2	1953	230	4 (6)	200 - 228 (P)	1956-1977	216-T-7; 216-T-36 Cribs
7	T	W10-3*	1951	239	8	194 - 230 (P); 181 - 237 (S)	1955-1989	241-T Tank Farm; 216-T-7 Crib
8	T	W10-4	1952	245	8	190 - 245 (P)	1956-1993	216-T-36 Crib
9	T	W10-8	1973	252	6	211 - 251 (S)	1974-1990	241-T Tank Farm
10	T	W10-9	1973	225	6	194 - 214 (S)	1974-1992	241-T Tank Farm
11	T	W10-10	1974	250	6	196 - 248 (P)	--	241-T Tank Farm
12	T	W10-11	1974	250	6	196 - 248 (P)	--	241-T Tank Farm
13	T	W10-12	1974	250	6	196 - 248 (P)	--	241-T Tank Farm
14	T	W11-12	1953	250	8	200 - 250 (P)	--	--
15	T	W11-11	1953	248	8	198 - 246 (P)	1956-1989	216-T-26, -27, -28
16	T	W11-23	1973	252	6	200 - 240 (P)	--	241-T Tank Farm; 216-T Trenches
17	T	W11-24*	1973	250	6	210 - 250 (S)	--	241-T Tank Farm
18	TX-TY	W14-1	1954	240	6 (8)	195 - 230 (P)	--	216-T-26, -27, -28 Cribs
19	TX-TY	W14-2	1955	223	6 (8)	181 - 223 (P)	--	216-T-26, -27, -28 Cribs
20	TX-TY	W14-3	1961	270	6 (8)	208 - 268 (P)	--	216-T-26, -27, -28 Cribs

Table 2A-7. Single-Shell Tank Historical Groundwater Monitoring Wells. (sheet 3 of 3)

	WMA	Well number[1]	Date completed	Depth[2]	Diameter[3]	Interval[4]	Monitoring dates	Facility
1	TX-TY	W14-4	1966	205	5 (6)	[13]	--	--
2	TX-TY	W14-6*	1974	240	6	195 - 225 (P)	--	241-TX Tank Farm
3	TX-TY	W15-3*	1952	245	4 (8)	200 - 236 (P)	1957-1990	241-TY Tank Farm
4	TX-TY	W15-4	1956	217	6 (8)	170 - 216 (P)	--	216-T-19 Crib
5	TX-TY	W15-12	1973	225	6	195 - 215 (P)	--	241-TY Tank Farm
6	TX-TY	W15-13	1973	225	6	197 - 225 (P)	--	241-TY Tank Farm
7	U	W19-1	1957	216 (301)	8	178 - 206 (P)	1959-1994	216-U-14 Ditch
8	U	W19-12	1983	250	6 (8)	210 - 240 (S)	1983-1993	241-U Tank Farm

NOTES:

All wells were constructed using carbon steel casing and materials unless otherwise noted. None of these wells comply with construction specifications in WAC 173-160, and none is considered a Resource Conservation and Recovery Act standard well in the terminology of the Washington State Department of Ecology and the U.S. Environmental Protection Agency. These wells qualify as screening wells or water level wells in the terminology of the Washington State Department of Ecology and the U.S. Environmental Protection Agency and can be used to provide supporting data [e.g., water levels as some (e.g., E25-2, W10-9) have]. Other wells terminating in the unsaturated zone ("dry wells") are not listed, but 780 dry wells (boreholes) surround the single-shell tanks (SST) and others exist along the margins of many of the cribs adjacent to the tank farms. These dry wells have been used as access ports for geophysical logging tools used for surveillance to check function of facilities in support of operations. Most dry wells consist of a single 6-inch carbon steel casing that is not perforated. For data and information relating to dry wells in tank farms or cribs supporting tank farm operations, see Welty (1988).

*Well used for groundwater sampling to determine compliance with control limits established in DOE Order 5400.1 (DOE 1988b) as part of the Hanford Site Operational Environmental Monitoring program.

[1] All well numbers preceded by 299.

[2] Present depth, with original drilled depth in parentheses.

[3] Present completed diameter of casing, with original casing diameter in parentheses. Most of these wells were originally constructed with a single casing and modified some years later. The modification included perforating the outer casing, installing a packer and a narrower diameter casing and grouting between the two to provide some annular seal. This may have been done over the entire borehole, or at selected intervals.

[4] Interval open to aquifer. If followed by (S), well contains a screen; if followed by a (P), casing is perforated.

[5] Top of Columbia River basalt.

[6] This well is one of several wells used to monitor the 216-BY cribs north of the 241-BY Tank Farm. These and the other wells used to monitor these cribs are scheduled to be decommissioned to permit construction of a modified Resource Conservation and Recovery Act barrier atop these cribs as the recommended remedial action in the 200-BP-1 Record of Decision.

[7] Top of Columbia River basalt at 265 feet from driller's log.

[8] Top of Columbia River basalt at 249 feet from driller's log.

[9] Top of Columbia River basalt at 279 feet from driller's log.

[10] Well was decommissioned in September 1993 to permit construction of a barrier over the 216-B-57 crib.

[11] Top of Columbia River basalt at 244 feet from driller's log.

[12] Well filled in to depth of 231 feet and is now above water table. Contamination (up to 10,000 counts per minute) encountered during drilling from 214 feet to bottom of well. Well drilled adjacent to and through plume of waste leaked from 241-BX-102 tank.

[13] No documented record of a perforated or screened interval for this well.

Table 2A-8. Some Procedures used to Control the Quality of Characterization Data.

Procedure manual	Procedure number	Title (subject)
WHC-CM-7-7	EII 3.2	Calibration and Control of Monitoring Instruments
	EII 5.1	Chain of Custody
	EII 5.2	Soil and Sediment Sampling
	EII 5.4	Field Cleaning and/or Decontamination of Equipment
	EII 5.8	Groundwater Sampling
	EII 5.9	Soil-Gas Sampling
	EII 5.11	Sample Packaging and Shipping
	EII 6.6	Resource Protection Well Characterization and Evaluation
	EII 6.7	Documentation of Well Drilling and Completion Operations
	EII 9.1	Geologic Logging
	EII 11.1	Geophysical Logging

EII = Environmental Investigations Instruction.

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APPENDIX 2B

DESCRIPTION OF SINGLE-SHELL TANK FARMS AND SINGLE-SHELL TANKS

CONTENTS

2B.1.0 DESCRIPTION OF SINGLE-SHELL TANK FARMS AND SINGLE-SHELL TANKS . . . . . APP 2B-1

2B.1.1 SINGLE-SHELL TANK FARMS DESCRIPTION . . . . . APP 2B-1
2B.1.1.1 241-A Tank Farm . . . . . APP 2B-1
2B.1.1.2 241-AX Tank Farm . . . . . APP 2B-3
2B.1.1.3 241-C Tank Farm . . . . . APP 2B-5
2B.1.1.4 241-B Tank Farm . . . . . APP 2B-9
2B.1.1.5 241-BX Tank Farm . . . . . APP 2B-13
2B.1.1.6 241-BY Tank Farm . . . . . APP 2B-17
2B.1.1.7 241-S Tank Farm . . . . . APP 2B-21
2B.1.1.8 241-SX Tank Farm . . . . . APP 2B-24
2B.1.1.9 241-T Tank Farm . . . . . APP 2B-31
2B.1.1.10 241-TX Tank Farm . . . . . APP 2B-36
2B.1.1.11 241-TY Tank Farm . . . . . APP 2B-42
2B.1.1.12 241-U Tank Farm . . . . . APP 2B-45

FIGURES

2B-1	241-A Single-Shell Tank Farm Site Plan	APP F2B-1
2B-2	241-AX Single-Shell Tank Farm Site Plan	APP F2B-2
2B-3	241-B Single-Shell Tank Farm Site Plan	APP F2B-3
2B-4	241-BX Single-Shell Tank Farm Site Plan	APP F2B-4
2B-5	241-BY Single-Shell Tank Farm Site Plan	APP F2B-5
2B-6	241-C Single-Shell Tank Farm Site Plan	APP F2B-6
2B-7	241-S Single-Shell Tank Farm Site Plan	APP F2B-7
2B-8	241-SX Single-Shell Tank Farm Site Plan	APP F2B-8
2B-9	241-T Single-Shell Tank Farm Site Plan	APP F2B-9
2B-10	241-TX Single-Shell Tank Farm Site Plan	APP F2B-10
2B-11	241-TY Single-Shell Tank Farm Site Plan	APP F2B-11
2B-12	241-U Single-Shell Tank Farm Site Plan	APP F2B-12
2B-13	Typical Single-Shell Tank	APP F2B-13
2B-14	Cross-Sectional Views of Hanford Single-Shell Tanks	APP F2B-14
2B-15	Typical Transfer System	APP F2B-15
2B-16	241-A Single-Shell Tank Farms	APP F2B-16
2B-17	241-AX Single-Shell Tank Farm	APP F2B-17
2B-18	241-B Single-Shell Tank Farm	APP F2B-18
2B-19	241-BX Single-Shell Tank Farm	APP F2B-19
2B-20	241-BY Single-Shell Tank Farm	APP F2B-20
2B-21	241-C Single-Shell Tank Farm	APP F2B-21
2B-22	241-S Single-Shell Tank Farm	APP F2B-22
2B-23	241-SX Single-Shell Tank Farm	APP F2B-23
2B-24	241-T Single-Shell Tank Farm	APP F2B-24
2B-25	241-TX Single-Shell Tank Farm	APP F2B-25
2B-26	241-TY Single-Shell Tank Farm	APP F2B-26
2B-27	241-U Single-Shell Tank Farm	APP F2B-27

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2B.1.0 DESCRIPTION OF SINGLE-SHELL TANK FARMS AND SINGLE-SHELL TANKS

2B.1.1 SINGLE-SHELL TANK FARMS DESCRIPTION

Between 1943 and 1964, 149 SSTs were built for the storage of radioactive waste. The SSTs are located in 12 tank farms, which each consists of 4 to 18 tanks. Addition of new waste to the SSTs was discontinued in November 1980. A description of the 12 tank farms and individual tanks is provided in this Appendix. Photographs and related graphics for the tank farms are provided in Figures 2B-1 through 2B-27.

The SST volumes vary from 55,000 to 1,000,000 gallons (208,000 liters to 3.8 million liters). One hundred thirty-three of the SSTs are 75 feet (22.86 meters) in diameter and 29.75 to 54 feet (9.07 to 16.46 meters) high (at their highest points), with nominal capacities of 500,000 to 1,000,000 gallons (1.9 to 3.8 million liters). Sixteen of the tanks are smaller units of a similar design 20 feet (6.1 meters) in diameter and 25.5 feet (7.77 meters) high with capacities of 55,000 gallons (208,000 liters). The SST configurations are provided in the Part A. A typical SST is also provided in the Part A.

2B.1.1.1 241-A Tank Farm

The 241-A Tank Farm consists of six buried SSTs that contain mixed waste. The tank farm is located approximately 1,300 feet (400 meters) northeast of the 202-A Building, which is directly south of the 241-AX Tank Farm.

The tanks were placed in service during the mid-1950's and were retired in the early 1970's and 1980's. They are numbered 241-A-101 through 241-A-106. Currently all of the tanks are inactive and each has undergone initial stabilization and has a status of either partial interim isolation or interim isolation (Henderson 1991).

2B.1.1.1.1 241-A-101 Single-Shell Tank. Tank 241-A-101 is classified as an inactive waste management unit. It operated from January 24, 1956 until November 21, 1980. The tank received PUREX carbonate wash waste; PUREX organic wash waste; PUREX HLW; B Plant HLW (waste fractionization); and supernatant containing B Plant HLW, PUREX HLW, double-shell slurry feed (DSSF), and complexed and noncomplexed waste from the 241-A, 241-AX, 241-BX, and 241-SX Tank Farms (Henderson 1991). The tank currently contains 413,000 gallons (1,563,400 liters) of drainable interstitial liquid, no supernatant liquid, and 953,000 gallons (3,607,500 liters) of solids (Hanlon 1994).

The tank is surrounded by 13 active radiation monitoring wells. The tank is equipped with automatic temperature sensors and airlift circulators. This tank is considered 'sound' and is partially interim isolated. This tank has a potential for hydrogen or flammable gas accumulation above its flammability limit and is on the flammable gas watchlist.

2B.1.1.1.2 241-A-102 Single-Shell Tank. Tank 241-A-102 is classified as an inactive waste management unit. It operated from March 22, 1956 until November 21, 1980. The tank received PUREX carbonate wash waste; PUREX HLW; B Plant HLW (waste fractionization); and supernatant containing PUREX HLW, B Plant HLW, PUREX sludge supernatant, evaporator waste, complexed waste, and DSSF from the 241-A, 241-AX, 241-AY, and 241-SX Tank Farms (Henderson 1991). The tank currently contains 2,000 gallons (7,600 liters) of drainable interstitial liquid, 4,000 gallons (15,100 liters) of supernatant liquid, and 41,000 gallons (155,135 liters) of solids (Hanlon 1994).

The tank is surrounded by seven active radiation monitoring wells. The tank is equipped with automatic temperature sensors, airlift circulators, an automatic liquid-level gage, and a radiation detection/temperature measurement system under the tank. This tank is considered 'sound' and is partially interim isolated.

2B.1.1.1.3 241-A-103 Single-Shell Tank. Tank 241-A-103 is classified as an inactive waste management unit. It operated from May 17, 1956 until August 14, 1980. The tank received PUREX carbonate wash waste; PUREX organic wash waste; PUREX HLW; B Plant HLW (waste fractionization); waste fractionization ion exchange waste; and supernatant containing B Plant HLW, waste fractionization ion exchange waste, PUREX HLW, PUREX sludge supernatant, evaporator waste, complexed waste, and DSSF from the 241-A, 241-AX, 241-BY, and 241-C Tank Farms and 244-AR and 244-CR Vaults (Henderson 1991). This tank currently contains 15,000 gallons (56,100 liters) of drainable interstitial liquid, 5,000 gallons (18,700 liters) of supernatant liquid, and 371,000 gallons (1.39 million liters) of solids (Hanlon 1994).

The tank is surrounded by eight active radiation monitoring wells. The tank is equipped with automatic temperature sensors, airlift circulators, and an automatic liquid-level gage. This tank is considered an 'assumed leaker' and is interim isolated.

2B.1.1.1.4 241-A-104 Single-Shell Tank. Tank 241-A-104 is classified as an inactive waste management unit. It operated from 1958 until 1975. The tank received PUREX carbonate wash waste; PUREX organic wash waste; PUREX HLW; B Plant HLW (waste fractionization) and ion exchange waste; and supernatant containing PUREX sludge supernatant from the 241-A Tank Farm and the 244-AR Vault (Henderson 1991). This tank currently contains no drainable interstitial liquid, no supernatant liquid, and 28,000 gallons (106,000 liters) of solids (Hanlon 1994).

The tank is surrounded by eight active radiation monitoring wells. The tank is equipped with automatic temperature sensors, airlift circulators, and an automatic liquid-level gage. This tank is considered an 'assumed leaker' and is interim isolated. This tank is included in the watchlist tanks program and is on the 'high-heat' list.

2B.1.1.1.5 241-A-105 Single-Shell Tank. Tank 241-A-105 is classified as an inactive waste management unit. It operated from 1962 until 1971. The tank received PUREX inorganic wash waste and supernatant containing PUREX HLW from

the 241-A Tank Farm (Henderson 1991). This tank currently contains 4,000 gallons (15,100 liters) of drainable interstitial liquid, no supernatant liquid, and 19,000 gallons (71,900 liters) of solids (Hanlon 1994).

Tank 241-A-105 has a high-heat load of 50,000 British thermal units per hour (14.65 kilowatts). This tank is surrounded by seven active radiation monitoring wells and is equipped with automatic temperature sensors, airlift circulators, and an automatic liquid-level gage. It is considered an 'assumed leaker' and is interim isolated. This tank is included in the watchlist tanks program and is on the 'high-heat' list.

2B.1.1.1.6 241-A-106 Single-Shell Tank. Tank 241-A-106 is classified as an inactive waste management unit. It operated from 1957 until August 14, 1980. The tank received PUREX organic and inorganic wash waste; PUREX carbonate wash waste; PUREX HLW; B Plant HLW; and supernatant containing PUREX HLW, B Plant HLW, and complexed concentrate from the 241-A Tank Farm, the 244-AR Vault, and the B-302 tanks (Henderson 1991). This tank currently contains 7,000 gallons (26,500 liters) of drainable interstitial liquid, no supernatant liquid, and 125,000 gallons (473,000 liters) of solids (Hanlon 1994).

This tank is surrounded by eight active radiation monitoring wells. The tank is equipped with automatic temperature sensors, airlift circulators, and an automatic liquid-level gage. This tank is considered 'sound' and is interim isolated. The tank is included in the 'high-heat' list.

2B.1.1.2 241-AX Tank Farm

The 241-AX Tank Farm consists of four buried SSTs that contain mixed waste. It is located approximately 1,750 feet (530 meters) northeast of the 202-A Building, east of the 241-AY Tank Farm, and between the 241-A and 241-AZ Tank Farms.

Tanks were placed in service during the mid-1960's and retired in the early 1980's. They are numbered 241-AX-101 through 241-AX-104. Currently, all the tanks are inactive and each has undergone initial stabilization and has a status of either partial interim isolated or interim isolated (Henderson 1991).

2B.1.1.2.1 241-AX-101 Single-Shell Tank. Tank 241-AX-101 is classified as an inactive waste management unit. It operated from 1965 until November 12, 1980. The tank received fission product waste; PUREX organic wash waste; PUREX HLW and LLW; B Plant HLW (waste fractionization); and supernatant containing fission product waste, PUREX sludge supernatant, organic wash waste, and DSSF from the 241-A and 241-AX Tank Farms (Henderson 1991). This tank currently contains 320,000 gallons (1.2 million liters) of drainable interstitial liquid, no supernatant liquid, and 748,000 gallons (2.8 million liters) of solids (Hanlon 1994).

This tank is surrounded by eight active radiation monitoring wells and is equipped with automatic temperature sensors, airlift circulators, and an automatic liquid-level gage. This tank has a potential for hydrogen or

flammable gas accumulation above its flammability limit. Tank 241-AX-101 is considered 'sound' and is partially interim isolated. This tank is included in the watchlist tanks program and is on the 'hydrogen flammable gas' list.

2B.1.1.2.2 241-AX-102 Single-Shell Tank. Tank 241-AX-102 is classified as an inactive waste management unit. It operated from 1966 until September 8, 1980. The tank received PUREX HLW and LLW; PUREX organic wash waste; B Plant HLW (waste fractionization); and supernatant containing PUREX HLW, complexant concentrate, B Plant HLW, and complexed waste from the 241-A, 241-AX, and 241-C Tank Farms, the 244-AR Vault, and tank 417 (Henderson 1991). This tank currently contains 14,000 gallons (53,000 liters) of drainable interstitial liquid, 3,000 gallons (11,400 liters) of supernatant liquid, and 39,000 gallons (145,900 liters) of solids (Hanlon 1994).

The tank is surrounded by 10 active radiation monitoring wells and 1 inactive monitoring well, and is equipped with automatic temperature sensors, airlift circulators, and an automatic liquid-level gage. The tank is considered an 'assumed leaker' and is interim isolated.

2B.1.1.2.3 241-AX-103 Single-Shell Tank. Tank 241-AX-103 is classified as an inactive waste management unit. It operated from 1965 until September 8, 1980. The tank received PUREX HLW and LLW; PUREX organic and inorganic wash waste; B Plant HLW and LLW (waste fractionization); and supernatant containing PUREX HLW and sludge supernatant from 241-A, 241-AX, 241-AZ, and 241-C Tank Farms, the 244-AR Vault, and the 241-AX-152 tank (Henderson 1991). This tank currently contains 36,000 gallons (136,000 liters) of drainable interstitial liquid, no supernatant liquid, and 112,000 gallons (424,000 liters) of solids (Hanlon 1994).

This tank is surrounded by six active radiation monitoring wells and is equipped with automatic temperature sensors, airlift circulators, and an automatic liquid-level gage. This tank has a potential for hydrogen or flammable gas accumulation above its flammability limit. This tank is considered 'sound' and is interim isolated. The tank is included in the watchlist tanks program and is on the 'hydrogen flammable gas' list.

2B.1.1.2.4 241-AX-104 Single-Shell Tank. Tank 241-AX-104 is classified as an inactive waste management unit. It operated from 1966 until 1976. The tank received PUREX HLW and LLW; PUREX organic and inorganic wash waste; B Plant HLW (waste fractionization); and supernatant containing PUREX HLW and sludge supernatant from the 241-A and 241-AX Tank Farms, and 244-AR-002 tank (Henderson 1991). This tank currently contains no drainable interstitial liquid, no supernatant liquid, and 7,000 gallons (26,500 liters) of solids (Hanlon 1994).

This tank has a potential for hydrogen or flammable gas accumulation above its flammability limit. This tank is surrounded by seven active radiation monitoring wells and is equipped with automatic temperature sensors and airlift circulators. The tank is considered 'sound' and is interim isolated.

2B.1.1.3 241-C Tank Farm

Sixteen buried SSTs make up the 241-C Tank Farm. It is located approximately 3,000 feet (915 meters) north of the 202-A Building, and 500 feet (152.5 meters) northwest of the 241-AN Tank Farm.

The tanks were placed in service during the mid-1940's and were retired in the late 1970's to mid-1980's. They are numbered 241-C-101 through 241-C-112, and 241-C-201 through 241-C-204. All of the tanks are currently inactive and each has undergone initial stabilization and has a status of either partial interim isolation or interim isolation (Henderson 1991).

2B.1.1.3.1 241-C-101 Single-Shell Tank. Tank 241-C-101 is classified as an inactive waste management unit. It operated from 1946 until 1970. The tank received $BiPO_4$ metal waste; TBP waste; and PUREX coating waste (Henderson 1991). This tank currently contains 3,000 gallons (11,400 liters) of drainable interstitial liquid, no supernatant liquid, and 88,000 gallons (333,000 liters) of solids (Hanlon 1994).

This tank is surrounded by four active radiation monitoring wells and is equipped with manual temperature sensors and an automatic liquid-level gage. This tank has a potential for hydrogen or flammable gas accumulation above its flammability limit. The tank is considered 'sound' and is interim isolated.

2B.1.1.3.2 241-C-102 Single-Shell Tank. Tank 241-C-102 is classified as an inactive waste management unit. It operated from May 1946 until 1976. The tank received $BiPO_4$ metal waste; TBP waste; and PUREX coating waste; thoria HLW; PUREX organic wash waste; and supernatant containing organic wash waste and coating waste from 241-A, 241-AX, and 241-C Tank Farms (Henderson 1991). This tank currently contains 37,000 gallons (140,000 liters) of drainable interstitial liquid, no supernatant liquid, and 423,000 gallons (1.6 million liters) of solids (Hanlon 1994).

This tank has no active radiation monitoring wells, but is equipped with manual temperature sensors and an automatic liquid-level gage. The tank is considered 'sound' and is partially interim isolated.

2B.1.1.3.3 241-C-103 Single-Shell Tank. Tank 241-C-103 is classified as an inactive waste management unit. This tank started operating in August 1946; operation of the tank ceased in 1979. The tank received PUREX coating waste; TBP waste, and supernatant containing TBP waste; coating waste, PUREX HLW, B Plant HLW, B Plant waste fractionization LLW; PUREX sludge supernatant, PUREX LLW, waste fractionization PUREX sludge, and PUREX organic wash waste; laboratory waste, decontamination waste, REDOX ion exchange waste, REDOX HLW, noncomplexed waste, waste fractionization ion exchange waste, N Reactor waste, Pacific Northwest Laboratory (PNL) waste, and evaporator bottoms from 241-A, 241-B, 241-BX, and 241-C Tank Farms. This unit was used as the receiver for operating pH 10 salt water systems within the 241-C Tank Farm (Henderson 1991). This tank currently contains no interstitial drainable liquid, 133,000 gallons (503,400 liters) of supernatant liquid, and

62,000 gallons (235,000 liters) of solids (Hanlon 1994). This tank is included in the watchlist tanks program and is on the 'organic salts' list. This tank is currently planned for priority treatment.

This tank is surrounded by five active radiation monitoring wells and is equipped with manual temperature sensors and an automatic liquid-level gage. This tank is considered 'sound' and is partially interim isolated.

2B.1.1.3.4 241-C-104 Single-Shell Tank. Tank 241-C-104 is classified as an inactive waste management unit. It operated from October 1946 until 1980. The tank received PUREX coating waste; $BiPO_4$ metal waste; PUREX LLW and HLW; thoria LLW and HLW; PUREX organic wash waste; and supernatant containing metal waste, PUREX organic wash waste, PUREX LLW and HLW, coating waste, complexed waste, PNL waste, N Reactor complexed waste, waste fractionization ion exchange waste, decontamination waste, B Plant LLW and HLW, and evaporator bottoms; REDOX HLW, and TBP waste from 241-A, 241-AX, 241-C, 241-BY, 241-TY, and 241-U Tank Farms (Henderson 1991). This tank currently contains 11,000 gallons (41,600 liters) of drainable interstitial liquid, no supernatant liquid, and 295,000 gallons (1.1 million liters) of solids (Hanlon 1994).

This tank is surrounded by seven active radiation monitoring wells and is equipped with manual temperature sensors and an automatic liquid-level gage. This tank is considered 'sound' and is partially interim isolated.

2B.1.1.3.5 241-C-105 Single-Shell Tank. Tank 241-C-105 is classified as an inactive waste management unit. It is uncertain whether this tank started filling February 1947 as second in cascade. Operation of the tank ceased in 1979. The tank received PUREX coating waste; TBP waste; PUREX sludge supernatant; REDOX supernatant; and supernatant containing TBP waste, coating waste, PUREX sludge supernatant, REDOX supernatant, PUREX HLW, REDOX HLW, noncomplexed waste, B Plant waste fractionization low-level and metal waste from 241-A, 241-AX, 241-AY, 241-B, 241-C, and 241-TX Tank Farms; and solids containing PUREX sludge supernatant, coating waste, and cesium feed from 241-AX and 241-A Tank Farms (Henderson 1991). This tank currently contains 11,000 gallons (41,600 liters) of drainable interstitial liquid, no supernatant liquid, and 150,000 gallons (567,800 liters) of solids (Hanlon 1994). This tank is included in the watchlist tanks program and is on the 'high-heat' list.

This tank is surrounded by eight active radiation monitoring wells and is equipped with manual temperature sensors and an automatic liquid-level gage. The tank is considered 'sound' and is partially interim isolated.

2B.1.1.3.6 241-C-106 Single-Shell Tank. Tank 241-C-106 is classified as an inactive waste management unit. This tank started filling in June 1947 as third in cascade. Operation of the tank ceased in 1979. The tank received PUREX coating waste; B Plant LLW (waste fractionization); supernatant containing PUREX HLW and TBP waste from the 241-A and 241-C Tank Farms; and solids containing PUREX sludge supernatant from the 241-A Tank Farms (Henderson 1991). This tank currently contains 16,000 gallons (60,600 liters) of drainable interstitial liquid, 32,000 gallons (121,000 liters) of

supernatant liquid, and 197,000 gallons (745,600 liters) of solids (Hanlon 1994). This tank is included in the watchlist tanks program and is on the 'high-heat' list.

This tank is surrounded by six active radiation monitoring wells and is equipped with manual temperature sensors and an automatic liquid-level gage. This tank has a high-heat load of 150,000 British thermal units (44 kilowatts) per hour. The tank is considered 'sound' and is partially interim isolated.

2B.1.1.3.7 241-C-107 Single-Shell Tank. Tank 241-C-107 is classified as an inactive waste management unit. It operated from April 1946 until 1978. The tank received $BiPO_4$ first-cycle waste; hot 201-C Building (semiworks) waste; TBP; PUREX coating waste; Hanford Laboratory Operations waste; and supernatant containing PUREX coating waste, PNL waste, N Reactor waste, laboratory waste, decontamination waste, waste fractionization ion exchange waste, and evaporator bottoms waste from the 241-C and 241-BX Tank Farms (Henderson 1991). This tank currently contains 26,000 gallons (97,240 liters) of drainable interstitial liquid, no supernatant liquid, and 275,000 gallons (1.04 million liters) of solids (Hanlon 1994).

This tank is surrounded by seven active radiation monitoring wells and is equipped with manual temperature sensors and an automatic liquid-level gage. The tank is considered 'sound' and is partially interim isolated.

2B.1.1.3.8 241-C-108 Single-Shell Tank. Tank 241-C-108 is classified as an inactive waste management unit. It operated from September 1947 until 1976. This tank received $BiPO_4$ first-cycle waste; PUREX coating waste; TBP waste; hot 201-C Building (semiworks) waste; and supernatant containing TBP waste, coating waste, PUREX organic wash waste, fractionization ion exchange waste, and PNL waste; and N Reactor waste, laboratory waste, decontamination waste, and REDOX HLW from the 241-C Tank Farms (Henderson 1991). This tank currently contains no drainable interstitial liquid, no supernatant liquid, and 66,000 gallons (249,800 liters) of solids (Hanlon 1994). The tank is included in the watchlist tanks program and is on the 'ferrocyanide' list.

This tank is surrounded by three active radiation monitoring wells and is equipped with manual temperature sensors and an automatic liquid-level gage. This tank contains ferrocyanide. The tank is considered 'sound' and is interim isolated.

2B.1.1.3.9 241-C-109 Single-Shell Tank. Tank 241-C-109 is classified as an inactive waste management unit. This tank is the third in cascade and started filling in April 1948; operation of the tank ceased in 1976. The tank received $BiPO_4$ first-cycle waste; TBP waste; hot 201-C Building (semiworks) waste; PUREX coating waste; and supernatant containing PUREX coating waste, hot semiworks waste, evaporator bottoms, and ion exchange waste from the 241-C Tank Farms (Henderson 1991). This tank currently contains no drainable interstitial liquid, 4,000 gallons (15,100 liters) of supernatant liquid, and 62,000 gallons (234,700 liters) of solids (Hanlon 1994). The tank is included in the watchlist tanks program and is on the 'ferrocyanide' list.

This tank is surrounded by six active radiation monitoring wells and is equipped with manual temperature sensors and an automatic liquid-level gage. This tank contains ferrocyanide. The tank is considered 'sound' and is interim isolated.

2B.1.1.3.10 241-C-110 Single-Shell Tank. Tank 241-C-110 is classified as an inactive waste management unit. It operated from May 1946 until 1976. The tank received TBP waste; $BiPO_4$ first-cycle waste; and supernatant containing PUREX organic wash waste, ion exchange waste, coating waste, evaporator bottoms, and REDOX ion exchange waste (Henderson 1991). This tank currently contains 7,000 gallons (26,180 liters) of drainable interstitial liquid, no supernatant liquid, and 187,000 gallons (699,400 liters) of solids (Hanlon 1994).

This tank is surrounded by six active radiation monitoring wells and is equipped with manual temperature sensors and an automatic liquid-level gage. The tank is considered an 'assumed leaker' and is partially interim isolated.

2B.1.1.3.11 241-C-111 Single-Shell Tank. Tank 241-C-111 is classified as an inactive waste management unit. It operated from August 1946 until 1976. The tank received $BiPO_4$ first-cycle waste; PUREX organic wash waste; TBP waste; PUREX coating waste; evaporator bottoms; hot 201-C Building (semiworks) waste; and supernatant containing evaporator bottoms, coating waste, and TBP waste from the 241-B and 241-C Tank Farms (Henderson 1991). This tank currently contains no drainable interstitial liquid, no supernatant liquid, and 57,000 gallons (215,700 liters) of solids (Hanlon 1994).

This tank is surrounded by six active radiation monitoring wells and is equipped with manual temperature sensors and an automatic liquid-level gage. This tank also contains ferrocyanide. The tank is considered an 'assumed leaker' and is interim isolated. This tank is included in the watchlist tanks program and is on the 'ferrocyanide' list.

2B.1.1.3.12 241-C-112 Single-Shell Tank. Tank 241-C-112 is classified as an inactive waste management unit. It is uncertain whether this tank started operating in November 1946 or in 1952. Operations ceased in 1976. The tank received TBP waste; PUREX coating waste; hot 201-C Building (semiworks) waste; and supernatant containing coating waste, TBP waste, and ion exchange waste from the 241-C Tank (Henderson 1991). This tank currently contains 32,000 gallons (121,100 liters) of drainable interstitial liquid, no supernatant liquid, and 104,000 gallons (393,600 liters) of solids (Hanlon 1994).

This tank is surrounded by six active radiation monitoring wells and is equipped with manual temperature sensors and an automatic liquid-level gage. This tank also contains ferrocyanide. This tank is considered 'sound' and is partially interim isolated. The tank is included in the watchlist tanks program and is on the 'ferrocyanide' list.

2B.1.1.3.13 241-C-201 Single-Shell Tank. Tank 241-C-201 is classified as an inactive waste management unit. It operated from 1947 until 1977. The tank received $BiPO_4$ metal waste and strontium 201-C Building (semiworks) waste (Henderson 1991). This tank currently contains no drainable interstitial, no supernatant liquids, and 2,000 gallons (7,600 liters) of solids (Hanlon 1994).

This tank has no active radiation monitoring wells but is equipped with manual temperature sensors and an automatic liquid-level gage. The tank is considered an 'assumed leaker' and is interim isolated.

2B.1.1.3.14 241-C-202 Single-Shell Tank. Tank 241-C-202 is classified as an inactive waste management unit. It operated from 1947 until 1977. The tank received $BiPO_4$ metal waste, strontium 201-C Building (semiworks) waste, and supernatant containing $BiPO_4$ metal waste from the 241-C-201 SST (Henderson 1991). This tank currently contains no drainable interstitial, no supernatant liquids, and 1,000 gallons (3,800 liters) of solids (Hanlon 1994).

This tank has no active radiation monitoring wells but is equipped with manual temperature sensors and an automatic liquid-level gage. The tank is considered an 'assumed leaker' and is interim isolated.

2B.1.1.3.15 241-C-203 Single-Shell Tank. Tank 241-C-203 is classified as an inactive waste management unit. It operated from 1947 until 1976. The tank received PUREX HLW (Henderson 1991). The tank currently contains no drainable interstitial nor supernatant liquids, and 5,000 gallons (18,900 liters) of solids (Hanlon 1994).

This tank has no active radiation monitoring wells but is equipped with manual temperature sensors and an automatic liquid-level gage. The tank is considered an 'assumed leaker' and is interim isolated.

2B.1.1.3.16 241-C-204 Single-Shell Tank. Tank 241-C-204 is classified as an inactive waste management unit. It operated from 1948 until 1977. The tank received PUREX HLW (Henderson 1991). This tank currently contains no drainable interstitial nor supernatant liquids, and 3,000 gallons (11,400 liters) of solids (Hanlon 1994).

This tank has two active radiation monitoring wells and is equipped with manual temperature sensors and an automatic liquid-level gage. The tank is considered an 'assumed leaker' and is interim isolated.

2B.1.1.4 241-B Tank Farm

The 241-B Tank Farm consists of a series of 16 buried SSTs containing mixed waste. It is located about 2,600 feet (792 meters) north-northeast of the 221-B Building and covers approximately 120,000 square feet (11,150 square meters).

The 12 large tanks [533,000 gallons (2.02 million liters)] began service between 1945 and 1947 and were used until the mid-1970's (1975-1978). The four small tanks [55,000 gallons (208,000 liters)] began service between 1951 and 1952 and most were used until 1977.

2B.1.1.4.1 241-B-101 Single-Shell Tank. Tank 241-B-101 has undergone initial stabilization and interim isolation (Hanlon 1994). This tank contains $BiPO_4$ metal waste, PUREX coating waste, 221-B Building concentrated waste from cell 23, and supernatant containing evaporator bottoms from the 241-B Tank Farms. Until February 1973, the unit provided storage for the 221-B Building, cell 23 evaporator bottoms and waste enroute to ITS. This tank currently contains 6,000 gallons (22,700 liters) of drainable interstitial liquid, no supernatant liquid, and 113,000 gallons (427,700 liters) of solids (Hanlon 1994). The tank is an 'assumed leaker.'

2B.1.1.4.2 241-B-102 Single-Shell Tank. Tank 241-B-102 has undergone initial stabilization and interim isolation and is considered sound (Hanlon 1994). This tank contains $BiPO_4$ metal waste; PUREX coating waste; supernatant containing 221-B Building LLW; ion exchange waste; and evaporator bottoms from the 241-B, 241-BX, and 241-C Tank Farms). This tank currently contains no drainable interstitial liquid, 4,000 gallons (15,100 liters) of supernatant liquid, and 28,000 gallons (106,000 liters) of solids (Hanlon 1994).

While pumping supernatant from tank 241-B-102 to tank 241-B-101, tank farm personnel noticed soil discoloration around the tank 241-B-102 heel pit, indicating a leak in the tank transfer line. Surface soil contamination with readings of 10 Roentgen per hour were recorded. The contaminated ground area was immediately covered with asphalt to reduce radionuclide migration. This unplanned release (UPR) is reported as UPR-200-E-108.

2B.1.1.4.3 241-B-103 Single-Shell Tank. Tank 241-B-103 has undergone initial stabilization and interim isolation and is an assumed leaker (Hanlon 1994). This tank contains $BiPO_4$ metal waste; PUREX coating waste; supernatant containing ion exchange waste, N Reactor waste, organic wash waste; PNL waste, REDOX HLW, coating waste, evaporator bottoms, and 221-B Building LLW; and decontamination waste, TBP waste, and laboratory waste from the 241-B, 241-BX, and 241-C Tank Farms). This tank currently contains no drainable interstitial nor supernatant liquids, and 59,000 gallons (223,300 liters) of sludge (Hanlon 1994). The tank is planned for priority treatment.

Tank 241-B-103 is included in the watchlist tanks program because of concentrations of organic salts and its waste contains greater than 10 weight percent total organic carbon (TOC). The organic chemicals contained in this tank are potentially flammable and, when mixed with nitrate or nitrate salts, can deflagrate. The temperature in tanks on this list are monitored weekly (Hanlon 1994). The tank is planned for priority treatment.

2B.1.1.4.4 241-B-104 Single-Shell Tank. Tank 241-B-104 has undergone initial stabilization and interim isolation and is sound (Hanlon 1994). This tank contains $BiPO_4$ second-cycle waste; evaporator bottoms and $BiPO_4$ first-cycle waste; and supernatant containing evaporator bottoms from the 241-B Tank Farm. An inadvertent discharge of sludge from this tank partially obstructed the

216-B-8TF Crib (Brown and Ruppert 1950). The tank contains 46,000 gallons (174,100 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 370,000 gallons (1.4 million liters) of solids (Hanlon 1994).

2B.1.1.4.5 241-B-105 Single-Shell Tank. Tank 241-B-105 has undergone initial stabilization and interim isolation (Hanlon 1994). It is an assumed leaker. This tank contains $BiPO_4$ first- and second-cycle waste and flush water containing evaporator bottoms from the 241-B Tank Farm. This tank currently contains 23,000 gallons (87,000 liters) of drainable interstitial liquid, no supernatant liquid, and 306,000 gallons (1.16 million liters) of solids (Hanlon 1994).

2B.1.1.4.6 241-B-106 Single-Shell Tank. Tank 241-B-106 has undergone initial stabilization and interim isolation and is sound (Hanlon 1994). This tank contains $BiPO_4$ second-cycle waste; Hanford Laboratory operations waste; $BiPO_4$ first-cycle waste; and supernatant containing TBP waste, 224-U waste, PNL waste, ion exchange waste, evaporator bottoms, 221-B Building LLW, and $BiPO_4$ first-cycle waste from 241-B, 241-BX, 241-BY, and 241-C Tank Farms. The tank currently contains 6,000 gallons (22,700 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 116,000 gallons (439,000 liters) of solids (Hanlon 1994).

2B.1.1.4.7 241-B-107 Single-Shell Tank. Tank 241-B-107 has undergone initial stabilization and interim isolation and is an assumed leaker (Hanlon 1994). This tank contains PUREX coating waste; $BiPO_4$ first-cycle waste; and supernatant containing $BiPO_4$ first- and second-cycle waste, and evaporator bottoms from the 241-B Tank Farms. In January 1980 the tank was reclassified as a confirmed leaker (Henderson 1991). This tank currently contains 12,000 gallons (45,400 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 164,000 gallons (620,000 liters) of solids (Hanlon 1994).

Soil surrounding 241-B-107 tank became contaminated when approximately 30,000 liters (8,000 gallons) of waste containing 2,000 curies of ^{137}Cs leaked from 241-B-107 tank in 1968. This UPR is recorded as UPR-200-E-127.

2B.1.1.4.8 241-B-108 Single-Shell Tank. Tank 241-B-108 has undergone initial stabilization and interim isolation and is sound (Hanlon 1994). This tank contains PUREX coating waste; $BiPO_4$ first-cycle waste; and supernatant containing evaporator bottoms and ion exchange waste from the 241-B and 241-BY Tank Farms (Henderson 1991). The tank currently contains 4,000 gallons (15,100 liters) of drainable interstitial liquid, no supernatant liquid, and 94,000 gallons (356,000 liters) of solids (Hanlon 1994).

2B.1.1.4.9 241-B-109 Single-Shell Tank. Tank 241-B-109 has undergone initial stabilization and interim isolation and is sound (Hanlon 1994). This tank contains PUREX coating waste; $BiPO_4$ first-cycle waste; and supernatant containing evaporator bottoms and ion exchange waste, 224-U Building waste, and coating waste from the 241-B, 241-BY, and 241-S Tank Farms. The tank

currently contains 8,000 gallons (30,300 liters) of drainable interstitial liquid, no supernatant liquid, and 127,000 gallons (480,700 liters) of solids (Hanlon 1994).

2B.1.1.4.10 241-B-110 Single-Shell Tank. Tank 241-B-110 has undergone initial stabilization and interim isolation and is an assumed leaker (Hanlon 1994). This tank contains $BiPO_4$ first- and second-cycle waste; fission product waste; 221-B Building HLW (waste fractionization); 221-B Building waste from cells 5 and 6; 221-B Building flushes; and ion exchange waste. The tank was reclassified as a confirmed leaker in June 1981 (Henderson 1991). This tank contains 22,000 gallons (83,300 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 245,000 gallons (927,400 liters) of solids (Hanlon 1994).

UPR-200-E-128 occurred in 1969 when approximately 8,300 gallons (31,400 liters) of waste containing about 4,300 curies of ^{137}Cs leaked from 241-B-110 tank, contaminating the surrounding soil tank (Henderson 1991).

2B.1.1.4.11 241-B-111 Single-Shell Tank. Tank 241-B-111 has undergone initial stabilization and interim isolation and is an assumed leaker (Hanlon 1994). This tank contains $BiPO_4$ second-cycle waste; ion exchange waste (waste fractionization); fission product waste; and 221-B Building waste from cells 5 and 6. The tank contains 21,000 gallons (79,500 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 236,000 gallons (893,000 liters) of solids (Hanlon 1994).

2B.1.1.4.12 241-B-112 Single-Shell Tank. Tank 241-B-112 has undergone initial stabilization and interim isolation and is an assumed leaker (Hanlon 1994). This tank contains $BiPO_4$ second-cycle waste; 221-B Building waste from cells 5 and 6; and supernatant containing 221-B Building waste from cells 5 and 6, ion exchange waste, fission product waste, and evaporator bottoms from the 241-B and 241-BX Tank Farms. The tank currently contains no drainable interstitial liquid, 3,000 gallons (11,400 liters) of supernatant liquid, and 30,000 gallons (113,600 liters) of solids (Hanlon 1994).

2B.1.1.4.13 241-B-201 Single-Shell Tank. Tank 241-B-201 has been interim stabilized and interim isolated, and was reclassified as an assumed leaker in January 1980 (Henderson 1991). This tank contains 224-U Building waste. The tank currently contains 3,000 gallons (11,400 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 28,000 gallons (106,000 liters) of solids (Hanlon 1994).

In 1968 a UPR (UPR-200-E-129) occurred when about 1,200 gallons (4,500 liters) of waste containing approximately 420 curies of ^{137}Cs leaked from 241-B-201 tank, contaminating the soil surrounding and beneath the tank (Henderson 1991).

2B.1.1.4.14 241-B-202 Single-Shell Tank. Tank 241-B-202 has been interim stabilized and interim isolated, and is sound (Hanlon 1994). This tank contains 224-U Building waste and 221-B Building HLW. The tank currently

contains 3,000 gallons (11,400 liters) of drainable interstitial liquid, no supernatant liquid, and 27,000 gallons (102,200 liters) of solids (Hanlon 1994).

2B.1.1.4.15 241-B-203 Single-Shell Tank. Tank 241-B-203 has been interim stabilized and interim isolated, and is an assumed leaker (Hanlon 1994). This tank contains 224-U Building waste. The tank currently contains 5,000 gallons (18,900 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 50,000 gallons (189,000 liters) of solids (Hanlon 1994).

UPR-200-E-130 occurred between 1951 and 1977, consisting of about 300 gallons (1,100 liters) of lanthanum fluoride that leaked from 241-B-203 tank and contaminated the soil surrounding and beneath the tank (Henderson 1991).

Tanks 241-B-203 and 241-B-204 are listed as assumed leakers because of decreasing liquid levels. Operating Limit Deviation Report 82-08 (Ellis 1992) was issued in May 1982 because of evidence of liquid-level change, which exceeded the decrease criterion (Henderson 1991).

2B.1.1.4.16 241-B-204 Single-Shell Tank. Tank 241-B-204 has been interim stabilized and interim isolated, and is an assumed leaker (Hanlon 1994). This tank contains 224-U Building waste and 221-B Building flushes. The Environmental Deviation Report 83-02 (Ellis 1992) was issued in November 1983 because of evidence of liquid-level decrease, settling of the solids around the tank perimeter, liner corrosion, and intrusion (Henderson 1991). The tank currently contains 5,000 gallons (18,900 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 49,000 gallons (185,500 liters) of solids (Hanlon 1994).

2B.1.1.5 241-BX Tank Farm

The 241-BX Tank Farm is located immediately west of the 241-B Tank Farm, on the west side of Baltimore Avenue. It consists of a series of 12 buried SSTs containing mixed waste. The 241-BX Tank Farm is located about 2,600 feet (792.5 meters) north of the 221-B Building, adjacent to the southern boundary of the 241-BY Tank Farm and immediately west of the 241-BX Tank Farm, and covers approximately 120,000 square feet (11,150 square meters).

The tanks began service between 1948 to 1950 and continued until the late 1970's. The tanks are inactive and have undergone initial stabilization and interim isolation (Hanlon 1994).

2B.1.1.5.1 241-BX-101 Single-Shell Tank. Tank 241-BX-101 is inactive, has undergone initial stabilization and interim isolation, and is an assumed leaker (Hanlon 1994). A pH 10 salt well pump was installed in this tank to remove residual interstitial fluids when it was taken out of service. This tank contains $BiPO_4$ metal waste; evaporator bottoms; 221-B Building low-level mixed waste; ion exchange waste (waste fractionization); organic wash waste; REDOX ion exchange waste; and supernatant containing 221-B Building LLW, TBP

waste, inorganic wash waste, coating waste, and REDOX ion exchange waste from the 241-B, 241-BX, 241-BY, and 241-C Tank Farms. The unit received an inadvertent transfer of approximately 1,800 gallons (6,800 liters) of ARC-359 organic ion exchange resin in early 1972 (Henderson 1991). This tank currently contains no drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 42,000 gallons (159,000 liters) of solids (Hanlon 1994).

2B.1.1.5.2 241-BX-102 Single-Shell Tank. Tank 241-BX-102 is inactive and has undergone initial stabilization and interim isolation (Hanlon 1994). It was classified as a confirmed leaker in 1971 and an attempt was made to stabilize the unit by addition of diatomaceous soil. This tank contains $BiPO_4$ metal waste; diatomaceous earth; and supernatant containing TBP waste, metal waste, coating waste, 221-B Building LLW, and evaporator bottoms from the 241-B, 241-BX, 241-BY, and 241-C Tank Farms. The tank currently contains 4,000 gallons (15,100 liters) of drainable interstitial liquid, no supernatant liquid, and 96,000 gallons (363,400 liters) of solids (Hanlon 1994).

The tank is included in the watchlist tanks, because it contains more than 1,000 gram-moles of ferrocyanide. These tanks have been declared an USQ because their explosion potential exceeds previously reported safety analysis consequences. The tank is believed to contain between 1,000 and 3,000 gram-moles of ferrocyanide (Hanlon 1994).

A plugged cascade outlet allowed about 22.5 tons (20.4 metric tons) of soil to be contaminated by depleted uranium near 241-BX-102 tank. This incident occurred on March 20, 1951 and has been designated as UPR-200-E-5.

UPR-200-E-131 occurred at the 241-BX-102 tank from 1948 until 1971 resulting from a leak that allowed about 51,000 curies of ^{137}Cs contained in high-level, nonboiling liquid waste to seep into the underlying soil. An estimated 31,000 cubic feet (117,000 liters) of soil has been affected, extending to a depth of 120 feet (36.6 meters). Some of the contaminants may have spread to groundwater during drilling of a monitoring well with a single string of 6-inch (15-centimeter) casing that went through the plume to the groundwater. This was reported by Womack and Larkin (1971). The event occurred in July 1970 when well 299E-33-27 was drilled to a depth of 255 feet (77.7 meters).

In 1974 UPR-200-E-132 occurred when 2,500 gallons (9,500 liters) of waste leaked from 241-BX-102 tank, contaminating the ground around the unit. The area was excavated and, after a radiation survey, backfilled with clean soil.

2B.1.1.5.3 241-BX-103 Single-Shell Tank. Tank 241-BX-103 is inactive, has undergone initial stabilization and interim isolation, and is considered sound (Hanlon 1994). This tank contains $BiPO_4$ metal waste and supernatant containing TBP waste; metal waste; coating waste; organic wash waste; decontamination waste; ion exchange waste; PUREX low-level, high-level, and sludge supernatant waste; PNL waste and N Reactor waste; laboratory waste; evaporator bottoms; REDOX ion exchange waste; and 221-B Building LLW from the

241-B, 241-BX, 241-BY, and 241-C Tank Farms. The tank currently contains no drainable interstitial liquid, 4,000 gallons (15,100 liters) of supernatant liquid, and 62,000 gallons (234,700 liters) of solids (Hanlon 1994).

Tank 241-BX-103 was documented as having contaminated soil in the vicinity of dry wells 21-03-03, 21-03-05, and 21-03-12, which is believed to be from tank overflow and spillage some years ago. It is estimated that 30,000 to 90,000 gallons (113,600 to 340,700 liters) of waste were spilled to the ground between the 241-BX-102 and 241-BX-103 tanks in 1951. It is uncertain why a UPR number was not assigned to this unit.

2B.1.1.5.4 241-BX-104 Single-Shell Tank. Tank 241-BX-104 is inactive, has undergone initial stabilization and interim isolation, and is considered sound (Hanlon 1994). This tank contains $BiPO_4$ metal waste; PUREX coating waste; ion exchange waste (waste fractionization); evaporator bottoms; and supernatant containing REDOX HLW, complexed and noncomplexed waste; and DSSF, TBP waste, 221-B Building LLW, and ion exchange waste from the 241-B, 241-BX, 241-BY, and 241-C Tank Farms. The tank currently contains 30,000 gallons (113,600 liters) of drainable interstitial liquid, 3,000 gallons (11,400 liters) of supernatant liquid, and 96,000 gallons (363,400 liters) of solids (Hanlon 1994).

2B.1.1.5.5 241-BX-105 Single-Shell Tank. Tank 241-BX-105 is inactive, has undergone initial stabilization and interim isolation, and is sound (Hanlon 1994). This tank contains $BiPO_4$ metal waste and supernatant containing metal waste; TBP waste; coating waste; ion exchange waste; evaporator bottoms; complexed and noncomplexed waste; and DSSF from the 241-BX, 241-BY, 241-C, 241-S, and 241-SX Tank Farms (Henderson 1991). The tank currently contains 6,000 gallons (22,700 liters) of drainable interstitial liquid, 5,000 gallons (18,900 liters) of supernatant liquid, and 46,000 gallons (174,100 liters) of solids (Hanlon 1994).

2B.1.1.5.6 241-BX-106 Single-Shell Tank. Tank 241-BX-106 is inactive, has undergone partial isolation, and is sound (Hanlon 1994). This tank contains $BiPO_4$ metal waste and supernatant containing metal waste; TBP waste; coating waste; ion exchange waste; evaporator bottoms; 221-B Building LLW; organic wash waste; and REDOX ion exchange waste from the 241-B, 241-BX, and 241-BY Tank Farms. This tank currently contains no drainable interstitial liquid, 15,000 gallons (56,800 liters) of supernatant liquid, and 31,000 gallons (117,300 liters) of solids (Hanlon 1994).

Tank 241-BX-106 is included in the watchlist tanks program, because it contains up to 1,000 gram-moles of ferrocyanide. Tanks containing more than 1,000 gram-moles of ferrocyanide have been declared a USQ because their explosion potential exceeds previously reported safety analysis consequences. These tanks are monitored weekly; in September 1991, 241-BX-106 tank had a maximum temperature of 69 °F (20 °C) (Hanlon 1994).

2B.1.1.5.7 241-BX-107 Single-Shell Tank. Tank 241-BX-107 is inactive, has undergone initial stabilization and partial isolation, and is sound (Hanlon 1994). This tank contains $BiPO_4$ first-cycle waste; TBP waste; and supernatant containing ion exchange waste from the 241-BX Tank Farm. The tank

currently contains 29,000 gallons (109,800 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 344,000 gallons (1.3 million liters) of solids (Hanlon 1994).

2B.1.1.5.8 241-BX-108 Single-Shell Tank. Tank 241-BX-108 is inactive, has undergone initial stabilization and interim isolation, and is an assumed leaker (Hanlon 1994). This tank contains $BiPO_4$ first-cycle waste and supernatant containing TBP waste, coating waste, and ion exchange waste from the 241-BX and 241-C Tank Farms. The tank currently contains 1,000 gallons (3,800 liters) of drainable interstitial liquid, no supernatant liquid, and 26,000 gallons (98,400 liters) of solids (Hanlon 1994).

UPR-200-E-133 resulted when about 2,500 gallons (9,500 liters) of waste containing 500 curies of ^{137}Cs leaked from 241-BX-108 tank. This incident occurred between 1949 and 1974 and contaminated soil around and beneath the tank. Information concerning cleanup action was not available (Henderson 1991).

2B.1.1.5.9 241-BX-109 Single-Shell Tank. Tank 241-BX-109 is inactive, has undergone initial stabilization and partial isolation, and is sound (Hanlon 1994). This tank contains $BiPO_4$ first-cycle waste, TBP waste, and ion exchange waste (waste fractionization) and supernatant containing TBP waste from the 241-BY and 241-C Tank Farms. The tank currently contains 13,000 gallons (49,200 liters) of drainable interstitial liquid, no supernatant liquid, and 193,000 gallons (730,500 liters) of solids (Hanlon 1994).

2B.1.1.5.10 241-BX-110 Single-Shell Tank. Tank 241-BX-110 is inactive, has undergone initial stabilization and partial isolation, and is an assumed leaker (Hanlon 1994). This tank contains $BiPO_4$ first-cycle waste; ion exchange waste (waste fractionization); evaporator bottoms; and supernatant containing coating waste, evaporator bottoms, and 221-B Building first-cycle waste from the 241-B and 241-C Tank Farms. The tank currently contains 15,000 gallons (56,800 liters) of drainable interstitial liquid and 198,000 gallons (749,300 liters) of solids (Hanlon 1994).

Tank 241-BX-110 is included in the watchlist tanks program because it contains up to 1,000 gram-moles of ferrocyanide. Tanks containing more than 1,000 gram-moles of ferrocyanide have been declared a USQ because their explosion potential exceeds previously reported safety analysis consequences. These tanks are monitored weekly; in September 1991, 241-BX-110 tank had a maximum temperature of 68 °F (20 °C) (Hanlon 1994).

2B.1.1.5.11 241-BX-111 Single-Shell Tank. Tank 241-BX-111 is inactive, has undergone partial isolation, and is an assumed leaker (Hanlon 1994). This tank contains $BiPO_4$ first-cycle waste; evaporator bottoms; in-tank solidification (ITS-2) bottoms and recycle system; and supernatant containing ion exchange waste, coating waste, and first-cycle waste from the 241-BX Tank Farm. The tank currently contains 29,000 gallons (108,460 liters) of drainable interstitial liquid and 211,000 gallons (800,000 liters) of solids (Hanlon 1994).

Tank 241-BX-111 is included in the watchlist tanks program because it contains up to 1,000 gram-moles of ferrocyanide. Tanks containing more than 1,000 gram-moles of ferrocyanide have been declared a USQ because their explosion potential exceeds previously reported safety analysis consequences. The 241-BX-111 tank had a maximum temperature of 70 °F (21.1 °C) in July 1994 (Hanlon 1994).

2B.1.1.5.12 241-BX-112 Single-Shell Tank. Tank 241-BX-112 is inactive, has undergone initial stabilization and partial interim isolation, and is sound (Hanlon 1994). This tank contains ion exchange waste (waste fractionization); supernatant containing evaporator bottoms waste; coating waste; and first-cycle waste from the 241-C Tank Farm). The tank currently contains 7,000 gallons (26,500 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 164,000 gallons (620,000 liters) of solids (Hanlon 1994).

2B.1.1.6 241-BY Tank Farm

The 241-BY Tank Farm is located about 3,000 feet (915 meters) north of the 221-B Building and is adjacent to the northern boundary of the 241-BX Tank Farm; the tank farm covers approximately 120,000 square feet (11,500 square meters). There are twelve 758,000-gallon (2.87-million liter) tanks in the farm numbered 241-BY-101 through 241-BY-112. They were put into service between 1950 and 1953 and continued until the late 1970's.

2B.1.1.6.1 241-BY-101 Single-Shell Tank. Tank 241-BY-101 is inactive, has undergone initial stabilization and interim isolation, and is sound (Hanlon 1994). This tank contains $BiPO_4$ metal waste and supernatant containing TBP and evaporator bottoms waste from the 241-BY and 241-C Tank Farms. The tank currently contains 5,000 gallons (18,900 liters) of drainable interstitial liquid, no supernatant liquid, and 387,000 gallons (1.5 million liters) of solids (Hanlon 1994).

2B.1.1.6.2 241-BY-102 Single-Shell Tank. Tank 241-BY-102 is inactive, has undergone partial isolation, and is considered sound (Hanlon 1994). This tank contains $BiPO_4$ metal waste; and supernatant containing TBP, coating, and evaporator bottoms waste from the 241-BX, 241-BY, and 241-C Tank Farms. This is an ITS-2 unit. The tank currently contains 25,000 gallons (93,500 liters) of drainable interstitial liquid, no supernatant liquid, and 341,000 gallons (1.3 million liters) of solids (Hanlon 1994).

2B.1.1.6.3 241-BY-103 Single-Shell Tank. Tank 241-BY-103 is inactive, has undergone partial isolation, and is an assumed leaker (Hanlon 1994). This tank contains $BiPO_4$ metal waste; PUREX coating waste; and supernatant containing coating waste, TBP waste, and PUREX high-level and organic wash waste from the 241-BX, 241-BY, and 241-C Tank Farms. The tank currently contains 160,000 gallons (605,000 liters) of drainable interstitial liquid, no supernatant liquid, and 400,000 gallons (1.5 million liters) of solids (Hanlon 1994).

Tank 241-BY-103 is included in the watchlist tanks program because it contains up to 1,000 gram-moles of ferrocyanide. Tanks containing more than 1,000 gram-moles of ferrocyanide have been declared a USQ because their explosion potential exceeds previously reported safety analysis consequences. During 1994, 241-BY-103 tank had a maximum temperature of 80 °F (26.7 °C) (Hanlon 1994).

2B.1.1.6.4 241-BY-104 Single-Shell Tank. Tank 241-BY-104 is inactive, has undergone initial stabilization and interim isolation, and is sound (Hanlon 1994). This tank contains $BiPO_4$ metal waste; TBP waste; and supernatant containing coating waste, TBP waste, ion exchange waste, and evaporator bottoms waste from the 241-BX, 241-BY, and 241-C Tank Farms. The tank currently contains 18,000 gallons (68,000 liters) of drainable interstitial liquid, no supernatant liquid, and 406,000 gallons (1.5 million liters) of solids (Hanlon 1994).

Tank 241-BY-104 is included in the watchlist tanks program because it contains between 100,000 and 200,000 gram-moles of ferrocyanide. Tanks containing more than 1,000 gram-moles of ferrocyanide have been declared a USQ because their explosion potential exceeds previously reported safety analysis consequences. During 1994, 241-BY-104 tank had a maximum temperature of 126 °F (52.2 °C) (Hanlon 1994).

2B.1.1.6.5 241-BY-105 Single-Shell Tank. Tank 241-BY-105 is inactive, has undergone partial isolation, and is an assumed leaker (Hanlon 1994). This tank contains TBP waste; $BiPO_4$ metal waste; and supernatant containing TBP waste, coating waste, and evaporator bottoms waste from the 241-BX, 241-BY, and 241-C Tank Farms. The tank currently contains 192,000 gallons (727,000 liters) of drainable interstitial liquid, no supernatant liquid, and 503,000 gallons (1.9 million liters) of solids (Hanlon 1994).

Tank 241-BY-105 is included in the watchlist tanks program because it contains between 70,000 and 100,000 gram-moles of ferrocyanide. Tanks containing more than 1,000 gram-moles of ferrocyanide have been declared a USQ because their explosion potential exceeds previously reported safety analysis consequences. During July 1994, 241-BY-105 tank had a maximum temperature of 119 °F (48.3 °C) (Hanlon 1994).

In November 1966, 63 tons (57,000 kilograms) of Portland cement were added to 241-BY-105 tank (assumed leaker) to determine the immobilization properties of the cement. The tank was then connected to an exhaust system for temperature control. A maximum temperature of 146 °F (63.3 °C) was recorded 4 inches (10 centimeters) above the bottom liner (Hanlon 1994).

2B.1.1.6.6 241-BY-106 Single-Shell Tank. Tank 241-BY-106 is inactive, has undergone partial isolation, and is an assumed leaker (Hanlon 1994). This tank contains first-cycle waste; TBP waste; supernatant containing coating waste, TBP waste, $BiPO_4$ first-cycle waste; and evaporator bottoms waste from the 241-BY and 241-C Tank Farms. The tank currently contains 235,000 gallons (890,000 liters) of drainable interstitial liquid, no supernatant liquid, and 642,000 gallons (2.43 million liters) of solids (Hanlon 1994).

Tank 241-BY-106 is included in the watchlist tanks program because it contains approximately 30,000 gram-moles of ferrocyanide. Tanks containing more than 1,000 gram-moles of ferrocyanide have been declared a USQ because their explosion potential exceeds previously reported safety analysis consequences. In July 1994, 241-BY-106 tank had a maximum temperature of 128 °F (53.3 °C) (Hanlon 1994).

2B.1.1.6.7 241-BY-107 Single-Shell Tank. Tank 241-BY-107 is inactive, has undergone initial stabilization and interim isolation, and is an assumed leaker (Hanlon 1994). This tank contains TBP waste; $BiPO_4$ first-cycle waste; and supernatant containing TBP waste, coating waste, and evaporator bottoms waste from the 241-BY and 241-C Tank Farms. The tank currently contains 25,000 gallons (95,000 liters) of drainable interstitial liquid, no supernatant liquid, and 266,000 gallons (1.0 million liters) of solids (Hanlon 1994).

Tank 241-BY-107 is included in the watchlist tanks program because it contains between 30,000 and 80,000 gram-moles of ferrocyanide. Tanks containing more than 1,000 gram-moles of ferrocyanide have been declared a USQ because their explosion potential exceeds previously reported safety analysis consequences. In July 1994, 241-BY-107 tank had a maximum temperature of 98 °F (36.7 °C) (Hanlon 1994).

2B.1.1.6.8 241-BY-108 Single-Shell Tank. Tank 241-BY-108 is inactive, has undergone initial stabilization and interim isolation, and is an assumed leaker (Hanlon 1994). This tank contains $BiPO_4$ first-cycle waste; TBP waste; and supernatant containing TBP waste and evaporator bottoms waste from the 241-BY and 241-C Tank Farms. The tank currently contains 9,000 gallons (34,000 liters) of drainable interstitial liquid, no supernatant liquid, and 228,000 gallons (863,000 liters) of solids (Hanlon 1994).

Between 1955 and 1972, approximately 5,000 gallons (18,900 liters) of TBP waste leaked from the tank, contaminating the soil surrounding and underneath the tank. This leak was documented as UPR-200-E-135.

Tank 241-BY-108 is included in the watchlist tanks program because it contains between 30,000 and 70,000 gram-moles of ferrocyanide. Tanks containing more than 1,000 gram-moles of ferrocyanide have been declared a USQ because their explosion potential exceeds previously reported safety analysis consequences. In July 1994, 241-BY-108 tank had a maximum temperature of 108 °F (42.2 °C) (Hanlon 1994).

2B.1.1.6.9 241-BY-109 Single-Shell Tank. Tank 241-BY-109 is inactive, has undergone partial isolation, and is sound (Hanlon 1994). This tank contains supernatant containing TBP waste and PUREX coating waste; $BiPO_4$ metal wastes; evaporator bottoms waste; and PUREX organic wash waste from the 241-B, 241-BX, 241-BY, and 241-C Tank Farms. The tank currently contains 64,000 gallons (239,360 liters) of drainable interstitial liquid, no supernatant liquid, and 423,000 gallons (1.6 million liters) of solids (Hanlon 1994).

2B.1.1.6.10 241-BY-110 Single-Shell Tank. Tank 241-BY-110 is inactive, has undergone initial stabilization and interim isolation, and is sound (Hanlon 1994). This tank contains $BiPO_4$ first-cycle waste; TBP waste; and supernatant containing evaporator bottoms waste, TBP waste, and coating waste from the 241-BY and 241-C Tank Farms and the WR-241 tank. The tank currently contains 9,000 gallons (34,000 liters) of drainable interstitial liquid, no supernatant liquid, and 398,000 gallons (1.5 million liters) of solids (Hanlon 1994).

Tank 241-BY-110 is included in the watchlist tanks program because it contains between 50,000 and 90,000 gram-moles of ferrocyanide. Tanks containing more than 1,000 gram-moles of ferrocyanide have been declared a USQ because their explosion potential exceeds previously reported safety analysis consequences. In July 1994, 241-BY-110 tank had a maximum temperature of 118 °F (47.7 °C) (Hanlon 1994).

2B.1.1.6.11 241-BY-111 Single-Shell Tank. Tank 241-BY-111 is inactive, has undergone initial stabilization and interim isolation, and is considered sound (Hanlon 1994). This tank contains $BiPO_4$ metal waste; TBP waste; PUREX coating waste; organic wash waste; and supernatant containing evaporator bottoms waste, TBP waste, coating waste, and organic wash waste from the 241-BY and 241-C Tank Farms. The tank currently contains no drainable interstitial nor supernatant liquids, and 459,000 gallons (1.74 million liters) of solids (Hanlon 1994).

Tank 241-BY-111 is included in the watchlist tanks program because it contains up to 3,000 gram-moles of ferrocyanide. Tanks containing more than 1,000 gram-moles of ferrocyanide have been declared a USQ because their explosion potential exceeds previously reported safety analysis consequences. During July 1994, 241-BY-111 tank had a maximum temperature of 87 °F (30.6 °C) (Hanlon 1994).

2B.1.1.6.12 241-BY-112 Single-Shell Tank. Tank 241-BY-112 is inactive, has undergone initial stabilization and interim isolation, and is considered sound (Hanlon 1994). This tank contains $BiPO_4$ metal waste; TBP waste; and supernatant containing TBP waste, coating waste, and evaporator bottoms waste from the 241-B, 241-BX, 241-BY, and 241-C Tank Farms. The tank currently contains 8,000 gallons (30,000 liters) of drainable interstitial liquid, no supernatant liquid, and 291,000 gallons (1.1 million liters) of solids (Hanlon 1994).

Tank 241-BY-112 is included in the watchlist tanks program because it contains between 2,000 and 3,000 gram-moles of ferrocyanide. Tanks containing more than 1,000 gram-moles of ferrocyanide have been declared a USQ because their explosion potential exceeds previously reported safety analysis consequences. During July 1994, 241-BY-112 tank had a maximum temperature of 82 °F (27.8 °C) (Hanlon 1994).

UPR-200-E-116 occurred on November 20, 1972 when an unknown volume of caustic flush water containing ^{137}Cs, ^{90}Y, ^{89}Sr, and ^{90}Sr sprayed from the 241-BY-112 pump associated with 241-BY-112 tank. Radiation levels up to 3 Roentgens per hour were measured 6 inches (15 centimeters) above the waste.

2B.1.1.7 241-S Tank Farm

The 241-S Tank Farm, an active unit, is located less than 1 mile (1.6 kilometer) northwest of the 202-S Building. The 241-S Tank Farm was constructed between 1950 and 1951 and contains twelve 750,000-gallon (2.8-million liter) underground tanks.

2B.1.1.7.1 241-S-101 Single-Shell Tank. Tank 241-S-101 actively received waste from 1953 through 1980. Types of waste include REDOX process HLWs; REDOX process coating waste; and supernatant containing waste from PNL coating waste, PUREX LLW, laboratory waste, B Plant HLW, terminal liquor and condensate evaporator bottoms, partial neutralization feed, N Reactor waste, ion exchange waste, and waste from the 241-U, 241-S, and 241-SX Tank Farms. The tank currently contains 84,000 gallons (318,000 liters) of drainable interstitial liquid, 12,000 gallons (45,400 liters) of supernatant liquid, and 415,000 gallons (1.6 million liters) of solids (Hanlon 1994). There are five active monitoring wells associated with this tank (Henderson 1991).

2B.1.1.7.2 241-S-102 Single-Shell Tank. Tank 241-S-102 actively received waste from 1953 through 1980. Types of waste include REDOX process HLWs; nitric acid/potassium permanganate ($HNO_3/KMnO_4$) solution and supernatant containing REDOX process HLW; condensate evaporator bottoms; noncomplexed waste; DSSF; and partial neutralization feed from 241-S, 241-SX, 241-SY, and 241-U Tank Farms. The tank currently contains 230,000 gallons (870,000 liters) of drainable interstitial liquid, no supernatant liquid, and 549,000 gallons (2.08 million liters) of solids (Hanlon 1994).

Tank 241-S-102 is included in the watchlist tanks program because it contains greater than 3 weight percent TOC and has the potential to generate hydrogen or other flammable gas above the flammability limit. This tank is capable of retaining the generated gas in settled sludges or trapped under a layer of waste. This tank is planned for priority treatment.

2B.1.1.7.3 241-S-103 Single-Shell Tank. Tank 241-S-103 actively received waste from 1953 through 1980. Types of waste include REDOX process HLW; REDOX process coating waste; $HNO_3/KMnO_4$ solution; and a supernatant containing REDOX process HLW, condensate evaporator bottoms, noncomplexed waste, and partial neutralization feed from 241-S, 241-SX, 241-SY, and 241-U Tank Farms. The tank currently contains 85,000 gallons (322,000 liters) of drainable interstitial liquid, 17,000 gallons (64,300 liters) of supernatant liquid, and 231,000 gallons (875,000 liters) of solids (Hanlon 1994). There are seven active monitoring wells associated with this tank.

2B.1.1.7.4 241-S-104 Single-Shell Tank. Tank 241-S-104 actively received waste from February 1953 to 1968. Types of waste include REDOX process coating waste, REDOX process HLW, and supernatant containing REDOX process HLW overflow from other tanks in the 241-S Tank Farm. The tank currently contains 28,000 gallons (106,000 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 293,000 gallons (1.1 million liters) of solids (Hanlon 1994).

This tank was removed from service and categorized 'questionable integrity' because of a liquid-level decrease; this tank is now assumed to be a leaker (Henderson 1991). There are four active monitoring wells associated with this tank.

2B.1.1.7.5 241-S-105 Single-Shell Tank. Tank 241-S-105 actively received waste from 1953 to 1974. Types of waste include REDOX process coating waste and REDOX process HLW. The tank currently contains 35,000 gallons (132,500 liters) of drainable interstitial liquid, no supernatant liquid, 456,000 gallons (1.7 million liters) of solids (Hanlon 1994), and has five active monitoring wells associated with it (Henderson 1991).

2B.1.1.7.6 241-S-106 Single-Shell Tank. Tank 241-S-106 actively received waste from 1953 to 1979. Types of waste include REDOX process HLW, supernatant containing REDOX process HLW, and condensate evaporator bottoms waste. The tank currently contains 186,000 gallons (705,000 liters) of drainable interstitial liquid, no supernatant liquid, and 575,000 gallons (2.18 million liters) of solids (Hanlon 1994).

The 1.8-inch (4.6-centimeter) increase to slumping of exposed solids and displacement of liquid and a jet pump salt well was placed in August 1978. The tank has six active monitoring wells associated with it.

2B.1.1.7.7 241-S-107 Single-Shell Tank. Tank 241-S-107 actively received waste from August 1953 until 1980. Types of waste include REDOX process HLW; REDOX process coating waste; and supernatant containing REDOX process HLW, decontamination waste, B Plant HLW and LLW, PNL waste, laboratory waste, N Reactor waste, PUREX LLW, ion exchange waste, fractionization waste, condensate evaporator bottoms, DSSF, partial neutralization feed, and complexed concentrate from 241-BX, 241-C, 241-S, 241-SX, 241-SY, and 241-U Tank Farms. The tank currently contains 45,000 gallons (170,000 liters) of drainable interstitial liquid, 14,000 gallons (53,000 liters) of supernatant liquid, and 362,000 gallons (1.37 million liters) of solids (Hanlon 1994).

Intermittent liquid-level increases since July 1981 have been attributed to decontamination work or precipitation (accumulating in a valve pit). Although the unit was partially isolated in December 1982, liquid-level measurements continue to show a slow increase (Henderson 1991). A slow increase in the surface level has been observed since May 1987, but it has not exceeded 2 inches (5.1 centimeters). The surface-level measurement increased 1.1 inches (2.8 centimeters) in September 1991 during the installation of a salt well screen. The reference baseline was adjusted to reflect this planned water addition. This tank remains on the watchlist. The tank has six active monitoring wells associated with it.

2B.1.1.7.8 241-S-108 Single-Shell Tank. Tank 241-S-108 actively received waste from 1953 to 1979. Types of waste include REDOX process HLW, supernatant containing REDOX process HLW, and condensate evaporator bottoms waste. The tank currently contains 127,000 gallons (480,000 liters) of drainable interstitial liquid, no supernatant liquid, and 604,000 gallons (2.3 million liters) of solids (Hanlon 1994).

Past liquid-level increases are attributed to dry buoyant surface crust. Dry well readings have remained stable during the review period and are the only means of leak detection because the Food Instrument Corporation (FIC) liquid-level measurement device and the manual tape plummet are contacting solids (Henderson 1991). The tank has five active monitoring wells associated with it.

2B.1.1.7.9 241-S-109 Single-Shell Tank. Tank 241-S-109 actively received waste from 1953 until 1979. Types of waste include REDOX process high-level supernatant containing condensate evaporator bottoms waste from the 241-S-102 tank. The tank currently contains 141,000 gallons (534,000 liters) of drainable interstitial liquid, no supernatant liquid, 568,000 gallons (2.15 million liters) of solids (Hanlon 1994), and has six active monitoring wells associated with it.

2B.1.1.7.10 241-S-110 Single-Shell Tank. Tank 241-S-110 actively received waste from 1953 until 1979. Types of waste include REDOX process HLW; REDOX process coating waste; supernatant containing REDOX process ion exchange waste; 224-U Building waste; coating waste; decontamination waste; B Plant LLW; and organic wash waste from 241-B, 241-S, 241-SX, 241-T, 241-TX, and 241-U Tank Farms. The tank currently contains 110,000 gallons (416,400 liters) of drainable interstitial liquid, no supernatant liquid, and 390,000 gallons (1.478 million liters) of solids (Hanlon 1994).

Past increases of surface level had caused considerable operational problems, and special pumping was necessary in October 1975 to lower levels below maximum operating limits. The increase was attributed to drying of the buoyant crust layer. Dry well readings have remained stable during the review period and are the only means of leak detection because the unit predominantly contains solids (Henderson 1991).

Installation of a jet pump salt well system in August 1978 is the only cleanup action taken to date. The tank has eight active monitoring wells associated with it.

2B.1.1.7.11 241-S-111 Single-Shell Tank. Tank 241-S-111 actively received waste from 1953 to 1975. The tank received REDOX process HLW and supernatant containing condensate evaporator bottoms waste. The tank currently contains 195,000 gallons (738,000 liters) of drainable interstitial liquid, 10,000 gallons (38,000 liters) of supernatant liquid, and 586,000 gallons (2.2 million liters) of solids (Hanlon 1994).

The causes of past liquid-level increases are not completely known. Dry well readings have remained stable during the review period and are the primary means of leak detection because the unit contains solids. This tank has the potential to generate hydrogen or other flammable gas. Its maximum temperature reading was 95 °F (35 °C) in February 1991 (Henderson 1991). The unit has six active monitoring wells associated with it, including the dry wells.

Tank 241-S-111 is included in the watchlist tanks program because it contains greater than 3 weight percent TOC and has the potential to generate hydrogen or other flammable gas above the flammability limit. This tank is capable of retaining the generated gas in settled sludges or trapped under a layer of waste. This tank is planned for priority treatment.

2B.1.1.7.12 241-S-112 Single-Shell Tank. Tank 241-S-112 actively received waste from 1953 until 1974. Types of waste include REDOX process HLW and supernatant containing REDOX process HLWs and condensate evaporator bottoms waste. The tank currently contains 110,000 gallons (416,900 liters) of drainable interstitial liquid, no supernatant liquid, and 523,000 gallons (1.98 million liters) of solids (Hanlon 1994).

Its maximum temperature reading was 93 °F (33.9 °C) in February 1988. Past liquid-level increases are attributed to drying of buoyant surface crust. Dry wells have remained stable during the review period and are the only means of leak detection because the unit contains predominantly solids (Henderson 1991). This unit has five active monitoring wells associated with it, including the dry wells (Henderson 1991).

Tank 241-S-112 is included in the watchlist tanks program because it contains greater than 3 weight percent TOC and has the potential to generate hydrogen or other flammable gas above the flammability limit. This tank is capable of retaining the generated gas in settled sludges or trapped under a layer of waste. This tank is planned for priority treatment.

2B.1.1.8 241-SX Tank Farm

The 241-SX Tank Farm is an active site located directly south of the 241-S Tank Farm. The tank farm was constructed between 1953 and 1954 and contains fifteen 1,000,000-gallon (3.8-million liter) SSTs, as well as two aboveground water tanks.

2B.1.1.8.1 241-SX-101 Single-Shell Tank. Tank 241-SX-101 actively received waste from May 1954 until 1980. Types of waste include REDOX process HLW; supernatant containing REDOX process ion exchange waste, evaporator bottoms waste, and partial neutralization feed; and complexed waste from 241-S, 241-BX, 241-SX, and 241-U Tank Farms. The tank currently contains 145,000 gallons (549,000 liters) of drainable interstitial liquids, 1,000 gallons (3,800 liters) of supernatant liquid, and 455,000 gallons (1.72 million liters) of solids (Hanlon 1994).

The unit was connected to the 241-SX sludge cooler in April 1976. Temperatures in the tank range from 190 °F (87.8 °C) in the sludge to 145 °F (62.8 °C) in the bulk solution. Measurement anomalies were attributed to the FIC plummet contacting surface solids exposed during evaporation. This was confirmed by photographs taken in February 1982.

Tank 241-SX-101 is included in the watchlist tanks program because it contains greater than 3 weight percent TOC and has the potential to generate hydrogen or other flammable gas above the flammability limit. This tank is capable of retaining the generated gas in settled sludges or trapped under a layer of waste. This tank is planned for priority treatment.

The unit has eight active monitoring wells associated with it. Monitoring results from dry wells (vadose zone boreholes), the primary means of leak detection, have remained stable during the review period (Henderson 1991).

2B.1.1.8.2 241-SX-102 Single-Shell Tank. Tank 241-SX-102 actively received waste from May 1954 until 1980. Types of waste include REDOX process HLW; carbonate waste; concrete; supernatant containing REDOX process HLW; REDOX process ion exchange waste; evaporator bottoms; and partial neutralization feed from the 241-BX, 241-SX, 241-TX, and 241-U Tank Farms. The tank currently contains 183,000 gallons (693,000 liters) of drainable interstitial liquid, no supernatant liquid, and 543,000 gallons (2.06 million liters) of solids (Hanlon 1994).

Future plans include installation of a jet pump salt well system to remove as much of the remaining interstitial liquid as possible with current technology. The unit is connected to the 241-SX sludge cooler facility because temperatures in the bulk waste rise to above 200 °F (93.3 °C). An apparent liquid-level decrease in the tank was attributed to movement of surface solids. The unit has the potential to generate hydrogen or other flammable gas (Henderson 1991).

Tank 241-SX-102 is included in the watchlist tanks program because it contains greater than 3 weight percent TOC and has the potential to generate hydrogen or other flammable gas above the flammability limit. This tank is capable of retaining the generated gas in settled sludges or trapped under a layer of waste. This tank is planned for priority treatment.

This unit has five active monitoring wells associated with it. Monitoring results from dry wells (vadose zone boreholes) have remained stable during the review period. The only cleanup action taken to date is pumping the waste to a minimum supernatant (Henderson 1991).

2B.1.1.8.3 241-SX-103 Single-Shell Tank. Tank 241-SX-103 actively received waste from May 1954 until 1980. Types of waste include REDOX process HLW; concrete; and supernatant containing REDOX process HLW, coating waste, evaporator bottoms, organic wash waste, and partial neutralization feed from 241-BX, 241-SX, and 241-S Tank Farms. The tank currently contains 232,000 gallons (878,000 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 651,000 gallons (2.46 million liters) of solids (Hanlon 1994).

Future plans include installing a jet pump salt well system to remove as much of the remaining interstitial liquid as possible with current technology. The unit is connected to the 241-SX sludge cooler facility because

temperatures in the bulk waste rise above 200 °F (93.3 °C). A liquid-level decrease following a transfer into the unit was attributed to the FIC plummet measuring an irregular material surface.

Tank 241-SX-103 is included in the watchlist tanks program because it contains greater than 3 weight percent TOC and has the potential to generate hydrogen or other flammable gas above the flammability limit. This tank is capable of retaining the generated gas in settled sludges or trapped under a layer of waste. This tank is planned for priority treatment.

This tank has six active monitoring wells associated with it. Dry well (vadose zone boreholes) radionuclide monitoring results have remained stable during the review period. The only cleanup action initiated at this site is pumping the waste to a minimum supernatant (Henderson 1991).

2B.1.1.8.4 241-SX-104 Single-Shell Tank. Tank 241-SX-104 actively received waste from 1955 until 1980. Types of waste include REDOX process HLW and supernatant containing REDOX process ion exchange waste, and condensate evaporator bottoms waste. The tank currently contains 201,000 gallons (760,000 liters) of drainable interstitial liquid, no supernatant liquid, and 614,000 gallons (2.3 million liters) of solids (Hanlon 1994).

An apparent liquid-level decrease was attributed to a defective liquid-level tape and localized slumping of the solids in the vicinity of the FIC plummet.

Tank 241-SX-104 is included in the watchlist tanks program because it contains greater than 3 weight percent TOC and has the potential to generate hydrogen or other flammable gas above the flammability limit. This tank is capable of retaining the generated gas in settled sludges or trapped under a layer of waste. This tank is planned for priority treatment.

The tank has seven active monitoring wells associated with it. Dry well (vadose zone borehole) radionuclide monitoring results have remained stable during the review periods. Because of the surface solids, the dry wells are the primary means of leak detection. Tank 241-SX-104 was declared an assumed leaker in 1989 after 110,000 gallons (416,000 liters) of liquid had leaked.

2B.1.1.8.5 241-SX-105 Single-Shell Tank. Tank 241-SX-105 actively received waste from February 1955 until 1980. Types of waste include REDOX process HLW and supernatant containing REDOX process HLW; REDOX process ion exchange waste; evaporator bottoms; and partial neutralization feed from 241-BX, 241-S, 241-TX, and 241-U Tank Farms. The tank currently contains 261,000 gallons (988,000 liters) of drainable interstitial liquid, no supernatant liquid, and 683,000 gallons (2.6 million liters) of solids (Hanlon 1994).

Future plans include installing a jet pump salt well system to remove as much of the remaining interstitial liquid as the current technology allows. The unit is connected to the 241-SX sludge cooler facility and temperatures in the bulk waste rise above 200 °F (93.3 °C). A liquid-level decrease was attributed to the FIC plummet contacting surface solids.

Tank 241-SX-105 is included in the watchlist tanks program because it contains greater than 3 weight percent TOC and has the potential to generate hydrogen or other flammable gas above the flammability limit. This tank is capable of retaining the generated gas in settled sludges or trapped under a layer of waste. This tank is planned for priority treatment.

The unit has seven active monitoring wells associated with it. Monitoring results from dry wells (vadose zone boreholes) and laterals have remained stable during the review period. Because of surface solids, dry wells and laterals are the primary means of leak detection. The only cleanup action taken to date at this unit is pumping the waste to a minimum supernatant (Henderson 1991).

2B.1.1.8.6 241-SX-106 Single-Shell Tank. Tank 241-SX-106 actively received waste from 1954 until 1980. Types of waste include Hanford Site laboratory waste; PNL waste; $HNO_3/KMnO_4$ solution; supernatant containing REDOX process waste and fractionization ion exchange waste; evaporator bottoms; B Plant LLW; coating waste; REDOX process HLW; complexed and noncomplexed waste; and partial neutralization feed from 241-B, 241-BX, 241-C, 241-S, 241-SX, 241-SY, 241-TX, and 241-U Tank Farms. The tank currently contains 194,000 gallons (734,000 liters) of drainable interstitial liquid, 61,000 gallons (231,000 liters) of supernatant liquid, and 477,000 gallons (1.8 million liters) of solids (Hanlon 1994).

The unit is connected to the 241-SX sludge cooler because temperatures rise to 140 °F (60 °C) in the bottom solids and 120 °F (49 °C) in the bulk solution. Test augerings in 1974 at locations adjacent to the earlier suspect well (41-06-09) were inconclusive, and no further studies are planned. A liquid-level increase in the tank was attributed to a leaking 241-SX sludge cooler steam coil and failure of a steam coil valve. In addition, a surface-level increase in the tank was attributed to water vapor condensing in the 241-SX sludge cooler ducting and draining to this unit. This unit has the potential to generate hydrogen or other flammable gases. This unit also contains potentially high concentrations of organic salts (Henderson 1991). This tank is included in the watchlist tanks program. The tank is planned for priority treatment.

This tank has six active monitoring wells associated with it. Dry well (vadose zone boreholes) radionuclide monitoring results have remained stable during the review period and are the primary means of leak detection because of surface solids (Henderson 1991).

2B.1.1.8.7 241-SX-107 Single-Shell Tank. Tank 241-SX-107 actively received waste from April 1956 until 1964. Types of waste include REDOX process HLW, REDOX process coating waste, concrete, and supernatant containing REDOX process HLW. The unit contains the contents of 41 bottles of neutralized waste from the 100-F Reactor, each containing less than 1 gram (2×10^{-3} pound) ^{239}Pu. The tank currently contains 5,000 gallons (18,900 liters) of drainable interstitial liquid, no supernatant liquid, and 104,000 gallons (394,000 liters) of sludge (Hanlon 1994).

The only known release is UPR-200-W-140 where approximately 5,000 gallons (18,900 liters) of waste was spilled (Henderson 1991). Contamination spread laterally in a stratum 55 to 60 feet (16.75 to 18.29 meters) below grade.

The unit is connected to the 241-SX sludge cooler. The solid waste is estimated to generate 16,000 joule per second (53,000 British thermal units per hour), and the current average temperature of the bulk solids is 150 °F (71.1 °C). The maximum temperature recorded by any of the sludge thermocouples is 208 °F (97.8 °C). The unit is considered to have high-heat load of 12,000 joules per second (Henderson 1991). This tank is included in the watchlist tanks program. The tank is on the 'high-heat', greater than 12,000 joules per second list.

The unit was removed from service as a 'confirmed leaker.' Because of a caked surface, dry wells and laterals are the only means of leak detection. All wells, except well 41-07-08, have remained stable during the review period. The level of nearby well 41-07-08 continues to increase slowly, and past directional probe data indicate that the activity is coming from the northeast, which is the direction of this unit.

2B.1.1.8.8 241-SX-108 Single-Shell Tank. Tank 241-SX-108 actively received waste from November 1955 until 1962. Types of waste include REDOX process HLW, concrete, and supernatant containing REDOX process HLW from other tanks in the 241-SX Tank Farm. The tank currently contains 5,000 gallons (18,900 liters) of drainable interstitial liquid, no supernatant liquid, and 87,000 gallons (329,700 liters) of sludge (Hanlon 1994).

The tank has a known release, UPR-200-W-141, where approximately 9,100 liters (2,400 gallons) of waste leaked (Henderson 1991). This tank is included in the watchlist tanks program. The tank is on the 'high-heat,' greater than 12,000 joules per second list.

This unit is considered to have a high-heat load of 13,000 joules per second. Photographs have indicated no surface liquid. The dry well and lateral radiation radioisotope monitoring results have remained stable during the past review period and are the only means of leak detection because the unit contains primarily solids. Radiation levels in dry well 41-08-04 were substantially reduced in November 1981 when a caisson located between this unit and dry well 41-08-04 was filled with dirt (Henderson 1991).

The tank has six active monitoring wells associated with it (Henderson 1991).

2B.1.1.8.9 241-SX-109 Single-Shell Tank. Tank 241-SX-109 actively received waste from September 1955 through 1965. Types of waste include REDOX process HLW and supernatant containing REDOX process HLW from other tanks in the 241-SX Tank Farm. The tank currently contains 10,000 gallons (38,000 liters) of drainable interstitial liquid, no supernatant liquid, and 250,000 gallons (946,000 liters) of sludge (Hanlon 1994).

This unit has a known release associated with it, UPR-200-W-142, where approximately 5,000 gallons (18,900 liters) of waste leaked (Henderson 1991).

The unit is connected to the 241-SX sludge cooler and was interim stabilized in May 1981. The estimated heat generation of the solids is 10,300 joules per second (35,000 British thermal unit per hour), and the average temperature of the sludge is 163 °F (72.8 °C). The unit is considered to have a high-heat potential and flammable gas accumulation because other 241-SX tanks vent through it (Henderson 1991). This tank is included in the watchlist tanks program and is on the high-heat and flammable gas list.

The unit was removed from service as a 'confirmed leaker.' Dry wells and laterals are monitored to track the migration of existing radionuclides in the soil. During the review period, radiation levels in dry wells and laterals remained stable, with the exception of dry well 41-09-09, which continues to show a steady increase at the 74-foot (22.6-meter) level. The unit has eight active monitoring wells associated with it (Henderson 1991).

2B.1.1.8.10 241-SX-110 Single-Shell Tank. Tank 241-SX-110 actively received waste from November 1960 until 1976. Types of waste include REDOX process HLW; concrete; supernatant containing REDOX process HLW; PNL waste; B Plant LLW; ion exchange waste; evaporator bottoms; and 244-U Building waste from 241-B, 241-BX, and 241-SX Tank Farms. The contents of 16 plastic bottles containing the following were added to this unit: natural uranium, depleted uranium, enriched uranium, and ^{239}Pu. The tank currently contains no drainable interstitial or supernatant liquids; however, it does contain 62,000 gallons (235,000 liters) of sludge (Hanlon 1994).

The unit was classified 'questionable integrity' in 1976 because of an unexplained liquid-level decrease. The unit was connected to the 241-SX sludge cooler in July 1972. The solids have an estimated heat generation rate of 16,000 joules per second (56,000 British thermal units per hour), and an average bulk temperature of 150 °F (71.1 °C) (Henderson 1991).

This unit has nine active monitoring wells associated with it. The dry well and lateral radiation readings remained stable during the review period and are the only means of leak detection because the unit contains solids (Henderson 1991).

2B.1.1.8.11 241-SX-111 Single-Shell Tank. Tank 241-SX-111 actively received waste from 1956 until May 1974. Types of waste include REDOX process HLW and supernatant containing REDOX process HLW and REDOX process ion exchange waste. The tank currently contains 7,000 gallons (26,500 liters) of drainable interstitial liquid, no supernatant liquid, and 125,000 gallons (473,000 liters) of sludge (Hanlon 1994).

2B.1.1.8.12 241-SX-112 Single-Shell Tank. Tank 241-SX-112 actively received waste from 1959 until 1969. Types of waste include REDOX process HLW and supernatant containing REDOX process HLW from other tanks in the 241-SX Tank Farm. The tank currently contains 3,000 gallons (11,400 liters) of drainable interstitial liquid, no supernatant liquid, and 92,000 gallons (348,000 liters) of sludge (Hanlon 1994).

There is a known release associated with this unit, UPR-200-W-144, when approximately 30,000 gallons (114,000 liters) of waste were released (Henderson 1991).

The unit is connected to the 241-SX sludge cooler. The estimated heat generation rate of the sludge is 18,000 joule per second (61,000 British thermal units per hour), and the average temperature of the material is 140 °F (60 °C) (Henderson 1991). This tank is included in the watchlist tanks program and is on the high-heat list.

The tank was removed from service as a 'confirmed leaker.' The dry well and lateral leak detection radiation readings appeared to be stable during the review period. The tank has seven active monitoring wells associated with it (Henderson 1991).

2B.1.1.8.13 241-SX-113 Single-Shell Tank. Tank 241-SX-113 actively received waste from February 1958 until June 1958. Types of waste include REDOX process HLW with diatomaceous earth added. The tank currently contains no drainable interstitial nor supernatant liquid; however, it does contain 26,000 gallons (98,400 liters) of sludge (Hanlon 1994).

This unit had a known release, UPR-200-W-145, when approximately 15,000 gallons (56,800 liters) of waste were released (Henderson 1991).

This unit was removed from service as a 'confirmed leaker' in 1962. The dry well readings remained stable during the review period. The unit was equipped with five prototype laterals; they have been dissembled and are not serviceable. The unit was stabilized with diatomaceous earth, and photographs indicate that no liquid is present. The tank has three active monitoring wells associated with it (Henderson 1991).

2B.1.1.8.14 241-SX-114 Single-Shell Tank. Tank 241-SX-114 actively received waste from November 1956 until 1972. Types of waste include REDOX process HLW and supernatant containing REDOX process HLW, REDOX process ion exchange waste, and condensate evaporator bottoms from 241-SX Tank Farm. The tank currently contains 14,000 gallons (53,000 liters) of drainable interstitial liquid, no supernatant liquid, and 181,000 gallons (685,000 liters) of solids (Hanlon 1994).

The unit is now attached to the sludge cooler. The estimated rate of heat generated by the remaining solids is 25,479 joules per second (86,999 British thermal units per hour), and the average temperature of this material is 190 °F (87.8 °C). This tank is included in the watchlist tanks program and is on the 'high-heat' list. The unit was categorized 'questionable integrity' because of dry well activity. The dry well and lateral radiation readings have remained stable during the review period (Henderson 1991). The tank has seven active monitoring wells associated with it (Henderson 1991).

2B.1.1.8.15 241-SX-115 Single-Shell Tank. Tank 241-SX-115 actively received waste from September 1958 until 1965. Types of waste include REDOX process HLW and supernatant containing REDOX process HLW. The tank currently contains no drainable interstitial nor supernatant liquids; however, it does contain 12,000 gallons (45,400 liters) of sludge (Hanlon 1994).

There was a known release at this unit, UPR-200-W-146, when approximately 200,000 liters (50,000 gallons) of waste were released (Henderson 1991). The unit was removed from service as a 'confirmed leaker.' Photographs taken in 1974 indicate that no liquid is present. The dry wells and laterals data indicate no changes during the review period. The tank has seven active monitoring wells associated with it (Henderson 1991).

2B.1.1.9 241-T Tank Farm

The 241-T Tank Farm consists of twelve 533,000-gallon (2.0-million liter) and four 55,000-gallon (208,000-liter) buried SSTs containing high-level mixed waste. The 241-T Tank Farm is approximately 2,000 feet (610 meters) west of the 221-T Building and directly north of the 241-TY Tank Farm and 23rd Street.

2B.1.1.9.1 241-T-101 Single-Shell Tank. This inactive unit operated from December 1944 until 1979 and received the following waste: $BiPO_4$ metal waste; TBP waste; REDOX coating waste; and supernatant containing coating waste, REDOX ion exchange waste, REDOX HLW, PNL waste, B Plant LLW, decontamination waste, evaporator bottoms, and 224-U waste from 241-BX, 241-SX, and 241-T Tank Farms (Henderson 1991). This tank currently contains 16,000 gallons (60,600 liters) of drainable interstitial liquid, 1,000 gallons (3,790 liters) of supernatant liquid, and 101,000 gallons (382,800 liters) of solids (Hanlon 1994).

Structures associated with the tank include six active radiation monitoring wells, temperature sensors, and an automatic liquid-level gages (Henderson 1991). The tank is currently partially interim isolated and of sound integrity.

A review of the shift logs, internal memos, and drilling and gamma logs for dry wells around the unit suggests that a spill of an estimated volume of 400,000 gallons (1.5 million liters) occurred some time before 1973. The duration and quantity of the release is unknown. Based on one vadose monitoring well, high-level liquid waste penetrated up to 122 feet (37.2 meters) beneath the surface (Henderson 1991).

As of December 1991, this unit contained less than 1 kilogram-moles of ferrocyanide at a maximum temperature of 73 °F (22.8 °C). This tank is included in the watchlist tank program and is on the 'ferrocyanide' list.

2B.1.1.9.2 241-T-102 Single-Shell Tank. This inactive waste management unit operated from September 1945 until 1974 or 1976. During this time, the tank received $BiPO_4$ metal waste; REDOX coating waste; and supernatant containing REDOX HLW, evaporator bottoms, coating waste, B Plant ion exchange waste, and B Plant LLW from the 241-C and 241-T Tank Farms (Henderson 1991). This tank

currently contains no drainable interstitial liquid, 13,000 gallons (49,200 liters) of supernatant liquid, and 19,000 gallons (79,000 liters) of solids (Hanlon 1994).

Structures associated with the tank include seven active radiation monitoring wells, a temperature sensor, and an automatic liquid-level gage (Henderson 1991). The tank is interim isolated and of sound integrity.

2B.1.1.9.3 241-T-103 Single-Shell Tank. Active from March 1946 to 1974, this tank received $BiPO_4$ metal waste; coating waste; and supernatant containing B Plant LLW, REDOX ion exchange waste, and evaporator bottoms from the 241-C and 241-T Tank Farms (Henderson 1991). The 241-T-103 tank was taken out of service because of a liquid-level decrease of 0.30 inch (0.76 centimeter). Radiation readings in accompanying dry wells are attributed to the 241-T-106 tank leak. The tank is thought to have questionable integrity and is an assumed leaker (Hanlon 1994). This tank currently contains no drainable interstitial liquid, 4,000 gallons (15,100 liters) of supernatant liquid, and 23,000 gallons (87,100 liters) of solids (Hanlon 1994).

Associated structures include six active radiation monitoring wells, a temperature sensor, and an automatic liquid-level gage (Henderson 1991). This tank is interim isolated.

One UPR (UPR-200-W-147) is associated with 241-T-103 tank. While monitoring wells were being drilled to track the extent of the 241-T-106 tank leak, contamination was encountered near the 241-T-103 tank. Subsequent investigations revealed that a leak resulted from a failed grout seal in a spare entry line. The volume of the leak has been determined to be about 1,320 gallons (5,000 liters). The data show that radioactivity has preferentially moved toward the southeast. The greatest depth to which the liquid waste penetrated is about 82 feet (25 meters) below the ground surface and is about 121.4 feet (37 meters) above the water table.

2B.1.1.9.4 241-T-104 Single-Shell Tank. Active from March 1946 to 1974, this tank received $BiPO_4$ first-cycle waste. This tank was removed from service when it became filled with solids (Henderson 1991). The tank currently contains 47,000 gallons (178,000 liters) of drainable interstitial liquid, 3,000 gallons (11,400 liters) of supernatant liquid, and 442,000 gallons (1.67 million liters) of solids (Hanlon 1994).

Structures associated with the tank include five active radiation monitoring wells, a temperature sensor, and an automatic liquid-level gage (Henderson 1991). The tank is partially interim isolated and of sound integrity.

2B.1.1.9.5 241-T-105 Single-Shell Tank. From 1945 until 1974, this tank received $BiPO_4$ first-cycle and second-cycle waste; REDOX coating waste; decontamination waste; Hanford Laboratory operation waste; and supernatant containing B Plant LLW, $BiPO_4$ first-cycle waste, decontamination waste, and ion exchange waste from the 241-BX, 241-S, and 241-T Tank Farms

(Henderson 1991). This tank currently contains 23,000 gallons (87,000 liters) of drainable interstitial liquid, no supernatant liquid, and 98,000 gallons (371,000 liters) of solids (Hanlon 1994).

Associated structures include three active radiation monitoring wells, a temperature sensor, a salt well screen, a plummet, and an automatic liquid-level gage (Henderson 1991). The tank is interim isolated and of sound integrity.

2B.1.1.9.6 241-T-106 Single-Shell Tank. Active from June 1947 until 1973, this tank received $BiPO_4$ first-cycle waste and supernatant containing coating waste, B Plant LLW, and ion exchange waste from the 241-S, 241-T, and 241-U Tank Farms (Henderson 1991). This tank currently contains no drainable interstitial liquid, 2,000 gallons (7,700 liters) of supernatant liquid, and 19,000 gallons (71,900 liters) of solids (Hanlon 1994).

Structures associated with the tank include nine active radiation monitoring wells, a temperature sensor, a plummet, and an automatic liquid-level gage (Henderson 1991). The tank is interim isolated and an assumed leaker.

Tank 241-T-106 was removed from service because of UPR-200-W-148, which is believed to have started on April 20, 1973 during a routine filling operation. The leak was not detected until June 8, 1973. Upon investigation of the leak, it was determined that the total loss of fluid to the ground had been 115,000 gallons (435,000 liters), containing approximately 40,000 curies of ^{137}Cs, 14,000 curies of ^{90}Sr, 4 curies of plutonium, and various fission products. It is estimated the leak contaminated over 25,000 cubic meters of soil. The unit was pumped to a minimum heel in June 1973 and was further pumped down to a residual layer of less than 6 inches (15.24 centimeters) in July 1974.

2B.1.1.9.7 241-T-107 Single-Shell Tank. Active from 1944 or 1945 until April 1976, this tank received the following waste: $BiPO_4$ first-cycle waste; TBP; and supernatant containing $BiPO_4$ first-cycle waste, TBP waste, ion exchange waste, and coating waste from the 241-C, 241-BX, and 241-T Tank Farms (Henderson 1991). This tank currently contains 13,000 gallons (49,200 liters) of drainable interstitial liquid, 9,000 gallons (34,100 liters) of supernatant liquid, and 171,000 gallons (647,000 liters) of solids (Hanlon 1994). In December 1991, 241-T-107 tank contained 5 kilogram-moles of ferrocyanide at a maximum temperature of 70 °F (21.1 °C) (Hanlon 1994). This tank is included in the watchlist tanks program and is on the 'ferrocyanide' list.

Associated structures include three active radiation monitoring wells, a temperature sensor, a salt well screen, a plummet, and an automatic liquid-level gage (Henderson 1991). This tank is partially interim isolated and an assumed leaker.

2B.1.1.9.8 241-T-108 Single-Shell Tank. Active from September 1945 until 1974, this tank received TBP waste; $BiPO_4$ first-cycle waste; Hanford Laboratory operations waste; and supernatant containing TBP waste, B Plant LLW, $BiPO_4$ first-cycle waste, ion exchange waste, and evaporator bottoms from

the 241-T and 241-TX Tank Farms (Henderson 1991). This tank currently contains no drainable interstitial nor supernatant liquids, and 44,000 gallons (166,500 liters) of solids (Hanlon 1994).

Structures associated with the tank include six active radiation monitoring wells, a temperature sensor, and an automatic liquid-level gage. A center riser was installed to permit installation of a salt well pump that extended to the low point of the dished bottom (Henderson 1991). The tank is interim isolated and an assumed leaker.

This unit was removed from service because of questionable integrity when the liquid level decreased by 0.30 inch (0.76 centimeter). In 1978 studies were made with the conclusion that all dry well activity is associated with the 241-T-106 tank leak. In 1979 additional wells were drilled because activity in one of the established dry wells continued to increase. The source of the increase was evaluated with the conclusion that 241-T-106 tank release was a questionable source of the activity increase (Henderson 1991).

2B.1.1.9.9 241-T-109 Single-Shell Tank. Active from December 1945 until 1974, this tank received the following waste: $BiPO_4$ first-cycle waste; TBP waste; evaporator bottoms; and supernatant containing TBP waste, B Plant LLW, $BiPO_4$ first-cycle waste, ion exchange waste, and PNL waste from the 241-T and 241-TX Tank Farms (Henderson 1991). This tank currently contained no drainable interstitial nor supernatant liquids, and 58,000 gallons (219,500 liters) of solids (Hanlon 1994).

Associated structures include six active radiation monitoring wells, a temperature sensor, a salt well screen, a plummet, and an automatic liquid-level gage (Henderson 1991). This tank is interim isolated and an assumed leaker.

The integrity of this unit was questioned when increasing activity was found in dry wells. Since 1976, activity in all dry wells has steadily decreased.

2B.1.1.9.10 241-T-110 Single-Shell Tank. From December 1944 until 1976, this tank received $BiPO_4$ second-cycle waste and 224-U Building waste. This unit has the potential for hydrogen or other flammable gas generation (Henderson 1991). This tank is included in the watchlist tanks program and is on the 'flammable gas' list. The highest temperature in this tank in December 1991 was 65 °F (18.3 °C), which does not exceed the applicable maximum temperature criteria or surveillance frequency limits (Hanlon 1994). This tank currently contains 39,000 gallons (147,600 liters) of drainable interstitial liquid, 3,000 gallons (11,400 liters) of supernatant liquid, and 376,000 gallons (1.4 million liters) of solids (Hanlon 1994).

Structures associated with the tank include five active radiation monitoring wells, a temperature sensor, a salt well screen, and an automatic liquid-level gage (Henderson 1991). The tank is partially interim isolated and of sound integrity.

2B.1.1.9.11 241-T-111 Single-Shell Tank. Active from October 1945 until March 1974, this tank has received $BiPO_4$ second-cycle waste and 224-U Building waste (Henderson 1991). This tank currently contains 53,000 gallons (200,870 liters) of drainable interstitial liquid and 453,000 gallons (1.7 million liters) of solids (Hanlon 1994).

Associated structures include six active radiation monitoring wells, a temperature sensor, a salt well screen, and an automatic liquid-level gage (Henderson 1991). This tank is partially interim isolated and an assumed leaker.

Tank 241-T-111 was categorized as having questionable integrity after an unexplained liquid-level decrease of 0.30 inch (0.76 centimeter) in 1974 (Henderson 1991).

2B.1.1.9.12 241-T-112 Single-Shell Tank. Active from January 1946 until 1977, this tank received $BiPO_4$ second-cycle waste; PNL waste; decontamination waste; and supernatant containing B Plant LLW and ion exchange waste from the 241-T Tank Farm (Henderson 1991). This tank currently contains no drainable interstitial liquid, 7,000 gallons (26,500 liters) of supernatant liquid, and 60,000 gallons (227,000 liters) of solids (Hanlon 1994).

Structures associated with the tank include three active radiation monitoring wells, a temperature sensor, and an automatic liquid-level gage (Henderson 1991). The tank is interim isolated and of sound integrity.

2B.1.1.9.13 241-T-201 Single-Shell Tank. From 1952 to 1976, the tank received 224-U Building waste; the tank is currently inactive (Henderson 1991). This tank currently contains 3,000 gallons (11,400 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 28,000 gallons (106,000 liters) of solids (Hanlon 1994).

Associated structures include one active radiation monitoring well, a temperature sensor, a salt well screen, and an automatic liquid-level gage (Henderson 1991). The tank is interim isolated and of sound integrity.

2B.1.1.9.14 241-T-202 Single-Shell Tank. From 1952 until April 1976, this inactive tank received 224-U Building waste (Henderson 1991). This tank currently contains 2,000 gallons (7,600 liters) of drainable interstitial liquid, no supernatant liquid, and 21,000 gallons (79,500 liters) of solids (Hanlon 1994).

Associated structures include a temperature sensor, a salt well screen, and an automatic liquid-level gage. No active radiation monitoring wells are associated with the 241-T-202 tank (Henderson 1991). The tank is interim isolated and of sound integrity.

2B.1.1.9.15 241-T-203 Single-Shell Tank. In operation from 1952 to April 1976, this tank received waste from the 224-U Building (Henderson 1991). This tank currently contains 4,000 gallons (15,100 liters) of drainable interstitial liquid, no supernatant liquid, and 35,000 gallons (132,000 liters) of solids (Hanlon 1994).

Associated structures include one active radiation monitoring well, a temperature sensor, a salt well screen, and an automatic liquid-level gage (Henderson 1991). This tank is interim isolated and of sound integrity.

2B.1.1.9.16 241-T-204 Single-Shell Tank. In 1976, this tank received waste from the 224-U Building; it is currently inactive (Henderson 1991). This tank currently contains 4,000 gallons (15,100 liters) of drainable interstitial liquid, no supernatant liquid, and 38,000 gallons (144,000 liters) of solids (Hanlon 1994).

Associated structures include a temperature sensor, a salt well screen, and an automatic liquid-level gage. No active radiation monitoring wells are associated with this tank (Henderson 1991). The tank is interim isolated and of sound integrity.

2B.1.1.10 241-TX Tank Farm

The 241-TX Tank Farm includes eighteen 758,000-gallon (2.87-million liter) buried SSTs containing high-level mixed waste. The 241-TX Tank Farm is approximately 2,500 feet (762 meters) southwest of the 221-T Building and is directly south of the 241-TY Tank Farm.

2B.1.1.10.1 241-TX-101 Single-Shell Tank. Active from July 1949 until 1980, this tank received $BiPO_4$ metal waste and supernatant waste. The supernatant waste contained REDOX HLW and coating waste, TBP waste, $BiPO_4$ first-cycle waste, REDOX and waste fractionization ion exchange waste, B Plant HLW and LLW, noncomplexed waste, PUREX LLW, organic wash waste, partial neutralization feed, and evaporator bottoms and decontamination waste from the 241-C, 241-BX, 241-SX, and 241-TX Tank Farms (Henderson 1991). This tank currently contains 2,000 gallons (7,600 liters) of drainable interstitial liquid, 3,000 gallons (11,400 liters) of supernatant, and 84,000 gallons (318,000 liters) of solids (Hanlon 1994).

Associated structures include four active radiation monitoring wells, a temperature sensor, a salt well screen, and an automatic liquid-level gage (Henderson 1991). Tank 241-TX-101 is interim isolated and of sound integrity.

Although the cover blocks for this tank were sealed in January 1982, intrusions of precipitation, via the 241-TXR-152 diversion box, became evident in October 1982 (Henderson 1991).

2B.1.1.10.2 241-TX-102 Single-Shell Tank. From January 1950 until 1977, this tank received the following waste: $BiPO_4$ metal waste, 242-T Evaporator waste, and supernatant containing REDOX HLW and evaporator bottoms from the 241-TX Tank Farm (Henderson 1991). This tank currently contains 22,000 gallons (83,300 liters) of drainable interstitial liquid, no supernatant liquid, and 217,000 gallons (822,430 liters) of solids (Hanlon 1994).

Associated structures include six active radiation monitoring wells, airlift circulators, a temperature sensor, a salt well screen, a salt receiver, and an automatic liquid-level gage (Henderson 1991). Tank 241-TX-102 is interim isolated and of sound integrity.

2B.1.1.10.3 241-TX-103 Single-Shell Tank. Tank 241-TX-103 was active from July 1959 until 1980. During this time, the tank received $BiPO_4$ metal waste, 242-T Evaporator waste, and supernatant. The supernatant contained $BiPO_4$ metal waste, noncomplexed waste, TBP waste, and partial neutralization feed from the 241-TX Tank Farm (Henderson 1991). This tank currently contains 15,000 gallons (57,000 liters) of drainable interstitial liquid, no supernatant liquid, and 157,000 gallons (594,000 liters) of solids (Hanlon 1994).

Associated structures include six active radiation monitoring wells, a temperature sensor, a salt well screen, a salt receiver, a plummet, and an automatic liquid-level gage (Henderson 1991). Tank 241-TX-102 is interim isolated and of sound integrity.

In 1977, two exploratory dry wells, 51-03-01 and 51-03-11, were drilled to acquire additional data to evaluate high scintillometer measurements in well 51-03-12 at the 51-foot (17.5-meter) level (see tank 241-TX-107). Activity in dry wells associated with the 241-TX-107 tank leak plume appears to have stabilized (1981) with the exception of well 51-03-09, which has low-level activity, approximately 100 counts per second, at the 60- and 69-foot (18.29- and 21.03-meter) levels.

2B.1.1.10.4 241-TX-104 Single-Shell Tank. Tank 241-TX-104 remained active from November 1950 until 1977. During this time, the tank received $BiPO_4$ metal waste, 242-T Evaporator waste, and supernatant waste containing REDOX ion exchange and HLW, PUREX organic wash waste, $BiPO_4$ metal waste, B Plant LLW, and TBP from the 241-TY and 241-TX Tank Farms (Henderson 1991). This tank currently contains 14,000 gallons (53,000 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant, and 64,000 gallons (242,000 liters) of solids (Hanlon 1994).

Associated structures include seven active radiation monitoring wells, a temperature sensor, a salt receiver, and an automatic liquid-level gage (Henderson 1991). Tank 241-TX-104 is interim isolated and of sound integrity.

2B.1.1.10.5 241-TX-105 Single-Shell Tank. Tank 241-TX-105 was active from March 1951 until 1977, during which it received the following waste: $BiPO_4$ metal waste, 242-T Evaporator waste, and supernatant containing REDOX ion exchange and HLW and PUREX organic waste from the 241-BX and 241-SX Tank Farms (Henderson 1991). This tank currently contains 20,000 gallons (75,700 liters) of drainable interstitial liquid, no supernatant liquid, and 609,000 gallons (2.3 million liters) of solids (Hanlon 1994).

Associated structures include six active radiation monitoring wells, a temperature sensor, airlift circulators, a salt receiver, a salt well screen, and an automatic liquid-level gage (Henderson 1991). Tank 241-TX-105 is interim isolated and an assumed leaker.

The unit was classified as questionable integrity in 1977 because of activity in five of the six dry wells associated with the tank (Henderson 1991).

Tank 241-TX-105 contains concentrations of organic salts greater than 3 percent by weight TOC. This tank is included in the watchlist tanks program and is on the 'organic salts' list. This tank is planned for priority treatment. The temperature in this tank is monitored weekly because of its potential for release of HLW from uncontrolled increases in temperature or pressure.

2B.1.1.10.6 241-TX-106 Single-Shell Tank. Tank 241-TX-106 was active from June 1951 to 1977. During this time, the tank received $BiPO_4$ metal waste, TBP waste, 242-T Evaporator waste, and supernatant. The supernatant contained REDOX ion exchange and HLW, PUREX organic wash waste, $BiPO_4$ metal waste, evaporator bottoms, and coating waste from the 241-TX Tank Farm (Henderson 1991). This tank currently contains 10,000 gallons (38,000 liters) of drainable interstitial liquid, no supernatant liquid, and 453,000 gallons (1.71 million liters) of solids (Hanlon 1994).

Associated structures include five active radiation monitoring wells, a temperature sensor, airlift circulators, a salt receiver, a salt well screen, and an automatic liquid-level gage (Henderson 1991). Tank 241-TX-106 is interim isolated and of sound integrity.

2B.1.1.10.7 241-TX-107 Single-Shell Tank. Active from 1950 to 1977, 241-TX-107 tank received $BiPO_4$ metal waste, 242-T Evaporator waste, and supernatant that contained $BiPO_4$ metal waste and REDOX HLW from the 241-TX Tank Farm (Henderson 1991). This tank currently contains 1,000 gallons (3,800 liters) of drainable interstitial liquid, 1,000 gallons (3,800 liters) of supernatant liquid, and 35,000 gallons (132,500 liters) of solids (Hanlon 1994).

Associated structures include seven active radiation monitoring wells, a temperature sensor, an open hole pump, a salt receiver, and an automatic liquid-level gage (Henderson 1991). Tank 241-TX-107 is interim isolated and an assumed leaker.

UPR-200-W-149 is associated with this tank. It is estimated that 2,500 gallons (9,500 liters) of water leaked from the tank (Hanlon 1994). During July 1977, after the tank was first classified as possibly leaking, the tank was pumped to a minimum level to remove as much of the supernatant material as possible (Henderson 1991).

2B.1.1.10.8 241-TX-108 Single-Shell Tank. This tank operated from 1950 to 1977, receiving $BiPO_4$ metal waste, REDOX HLW, 242-T Evaporator waste, and supernatant. The supernatant contained decontamination waste, TBP waste, and evaporator bottoms from the 241-TX and 241-TY Tank Farms (Henderson 1991). This tank currently contains no drainable interstitial or supernatant liquids, and 134,000 gallons (507,000 liters) of solids (Hanlon 1994).

Associated structures include three active radiation monitoring wells, a temperature sensor, a salt receiver, a salt well screen, a plummet, and an automatic liquid-level gage (Henderson 1991). Tank 241-TX-108 is interim isolated and of sound integrity.

2B.1.1.10.9 241-TX-109 Single-Shell Tank. Tank 241-TX-109 was active from 1949 to 1977. During this time, it received $BiPO_4$ first-cycle waste; 242-T Evaporator waste; and supernatant, containing $BiPO_4$ first-cycle waste and evaporator bottoms from the 241-T, 241-TX, and 241-TY Tank Farms (Henderson 1991). This tank currently contains 10,000 gallons (38,000 liters) of drainable interstitial liquid, no supernatant liquid, and 384,000 gallons (1.5 million liters) of solids (Hanlon 1994).

Associated structures include six active radiation monitoring wells, a temperature sensor, a salt receiver, a salt well screen, a plummet, and an automatic liquid-level gage (Henderson 1991). Tank 241-TX-109 is interim isolated and of sound integrity.

2B.1.1.10.10 241-TX-110 Single-Shell Tank. Operating from September 1949 to 1977, this tank received $BiPO_4$ first-cycle waste and 242-T Evaporator waste (Henderson 1991). This tank currently contains 15,000 gallons (56,800 liters) of drainable interstitial liquid, no supernatant liquid, and 462,000 gallons (1.75 million liters) of solids (Hanlon 1994).

Associated structures include six active radiation monitoring wells, airlift circulators, a temperature sensor, a salt receiver, a salt well screen, and an automatic liquid-level gage (Henderson 1991). Tank 241-TX-110 is interim isolated and an assumed leaker.

In March 1974, the liquid level in 241-TX-110 tank was reportedly 0.5 inch (1.3 centimeters) lower than expected. The tank was removed from service for observation. During the observation period no further declines in fluid level were observed, and dry wells showed no readings above normal background.

2B.1.1.10.11 241-TX-111 Single-Shell Tank. Active from March 1950 to 1977, this tank received $BiPO_4$ first-cycle waste, 242-T Evaporator waste, and supernatant containing TBP waste from the 241-TX Tank Farm (Henderson 1991). This tank currently contains 9,000 gallons (34,000 liters) of drainable interstitial liquid, no supernatant liquid, and 370,000 gallons (1.4 million liters) of solids (Hanlon 1994).

Associated structures include five active radiation monitoring wells, airlift circulators, a temperature sensor, a salt receiver, a salt well screen, and an automatic liquid-level gage (Henderson 1991). Tank 241-TX-111 is interim isolated and of sound integrity.

2B.1.1.10.12 241-TX-112 Single-Shell Tank. Active from August 1950 until 1974, 241-TX-112 tank received 242-T Evaporator waste, $BiPO_4$ first-cycle waste, and supernatant containing evaporator bottoms from the 241-TX Tank Farm

(Henderson 1991). This tank currently contains 24,000 gallons (90,800 liters) of drainable interstitial liquid, no supernatant liquid, and 649,000 gallons (2.46 million liters) of solids (Hanlon 1994).

Associated structures include six active radiation monitoring wells, airlift circulators, a temperature sensor, a salt receiver, a salt well screen, and automatic liquid-level gages (Henderson 1991). Tank 241-TX-112 is interim isolated and of sound integrity.

2B.1.1.10.13 241-TX-113 Single-Shell Tank. Active from December 1950 until 1971, this tank received 242-T Evaporator waste and supernatant, containing evaporator bottoms from the 241-TX Tank Farm (Henderson 1991). This tank currently contains 16,000 gallons (60,600 liters) of drainable interstitial liquid, no supernatant liquid, and 607,000 gallons (2.3 million liters) of solids (Hanlon 1994).

Associated structures include three active radiation monitoring wells, airlift circulators, a temperature sensor, a salt well screen, and automatic liquid-level gages (Henderson 1991). Tank 241-TX-113 is interim isolated and an assumed leaker.

In January 1971, while leak testing a new jumper assembly, an employee closed a valve in a pump pit, thereby causing a caustic radioactive solution to spray up through the pit cover. The employee was decontaminated, the area was surveyed, and the pump pit was hosed down. An occurrence report was prepared on January 11, 1971, that addressed this incident.

2B.1.1.10.14 241-TX-114 Single-Shell Tank. From April 1951 to 1971, the tank received 242-T Evaporator waste and supernatant, containing $BiPO_4$ first-cycle waste and evaporator bottoms from the 241-TX Tank Farm. As this tank was filled with salt, it was removed from service. A prototype electrical immersion heater was installed in 1964, and no plans exist for its removal (Henderson 1991). This tank currently contains 15,000 gallons (56,800 liters) of drainable interstitial liquid, no supernatant liquid, and 535,000 gallons (2.0 million liters) of solids (Hanlon 1994).

Associated structures include three active radiation monitoring wells, airlift circulators, a temperature sensor, a salt receiver, a salt well screen, and automatic liquid-level gages (Henderson 1991). Tank 241-TX-114 is interim isolated and an assumed leaker.

All the dry wells surrounding this tank have activity at 43 feet (13.1 meters). Well 51-14-04 displayed an extensive profile change below the 48-foot (14.6-meter) level in 1977 and 1978 (Henderson 1991).

2B.1.1.10.15 214-TX-115 Single-Shell Tank. Active from 1951 to 1977, this tank received 242-T Evaporator waste; TBP waste; coating waste; decontamination waste; and supernatant containing $BiPO_4$ metal waste, decontamination waste, coating waste, and evaporator bottoms from the 241-U, 241-S, 241-T, and 241-TX Tank Farms (Henderson 1991). This tank currently

contains 19,000 gallons (71,900 liters) of drainable interstitial liquid, no supernatant liquid, and 640,000 gallons (2.4 million liters) of solids (Hanlon 1994).

Associated structures include four active radiation monitoring wells, a temperature sensor, a salt receiver, a salt well screen, and automatic liquid-level gages (Henderson 1991). Tank 241-TX-114 is interim isolated and an assumed leaker.

Tank 214-TX-115 was designated a 'dormant' leaker in February 1975 because of increasing radiation peaks observed in nearby dry wells. The tank is filled with salt cake to a depth of 20 feet (6.1 meters), containing the second greatest quantity of waste in the tank farm (241-TX-112 tank contains more waste) (Henderson 1991).

Liquid observation well scans revealed an interstitial liquid-level increase in excess of the established 4.8-inch (12.2-centimeter) increase criteria in both May 1987 and March 1991. As of October 1994, the estimated volume leaked is less than 2,500 gallons (9,500 liters) (Hanlon 1994).

2B.1.1.10.16 241-TX-116 Single-Shell Tank. Tank 241-TX-116 was active from 1951 to 1969. During this time, it received supernatant, containing evaporator bottoms from the 241-TX Tank Farm (Henderson 1991). In October 1970, 256,000 pounds (116,000 kilograms) of diatomaceous earth were added to this tank, and approximately 100,000 gallons (380,000 liters) of supernatant fluid was removed in an unsuccessful stabilization attempt. Radiation monitoring of dry well 51-16-11 in 1975 suggested that the tank was still leaking. An additional attempt to remove the remaining fluid was unsuccessful (Hanlon 1994; Henderson 1991). This tank currently contains 23,000 gallons (87,000 liters) of drainable interstitial liquid, no supernatant liquid, and 631,000 gallons (2.4 million liters) of solids (Hanlon 1994).

Associated structures include three active radiation monitoring wells, a temperature sensor, a salt receiver, a salt well screen, and automatic liquid-level gages (Henderson 1991). Tank 241-TX-116 is interim isolated and an assumed leaker.

2B.1.1.10.17 241-TX-117 Single-Shell Tank. Operation of 241-TX-117 tank began in April 1951 and ceased in 1969. During this time, the tank received supernatant, containing first-cycle waste and evaporator bottoms from the 241-TX Tank Farm (Henderson 1991). This tank currently contains 8,000 gallons (30,300 liters) of drainable interstitial liquid, no supernatant liquid, and 626,000 gallons (2.37 million liters) of solids (Hanlon 1994).

Associated structures include four active radiation monitoring wells, a temperature sensor, a salt receiver, a salt well screen, and automatic liquid-level gages (Henderson 1991). Tank 241-TX-117 is interim isolated and an assumed leaker.

Photographs taken of the inside of the 241-TX-117 tank in November 1969 show a radial crack in the concrete dome of the tank. In October 1970, 86,000 pounds (39,000 kilograms) of diatomaceous earth were added to this tank in an unsuccessful stabilization attempt (Henderson 1991).

2B.1.1.10.18 241-TX-118 Single-Shell Tank. This tank operated from April 1951 to November 1980. During this time, it received 242-T Evaporator feed tank waste; 234-Z and 235-Z Buildings waste; caustic solution; and TBP waste, decontamination waste, and supernatant. The supernatant contained TBP waste; $BiPO_4$ first-cycle waste; evaporator bottoms; decontamination waste; partial neutralization feed; and coating waste from the 241-T, 241-TX, 241-TY, and 241-U Tank Farms (Henderson 1991). This tank currently contains 27,000 gallons (102,000 liters) of drainable interstitial liquid, no supernatant liquid, and 347,000 gallons (1.31 million liters) of solids (Hanlon 1994).

Associated structures include seven active radiation monitoring wells, a temperature sensor, a salt receiver, a salt well screen, a plummet, and automatic liquid-level gages (Henderson 1991). Tank 241-TX-118 is interim isolated and of sound integrity.

This tank contains greater than 10 percent by weight of total organic compounds of organic salts. The temperature of the tank is monitored because of its potential for release of HLW from an uncontrolled increase in temperature or pressure. The tank also contained less than 1 kilogram-mole of ferrocyanide at a maximum temperature of 75 °F (23.9 °C) during July 1994 (Hanlon 1994).

2B.1.1.11 241-TY Tank Farm

The 241-TY Tank Farm consists of six 758,000-gallon (2.87-million liter) buried SSTs containing high-level mixed waste. The 241-TY Tank Farm is approximately 2,400 feet (732 meters) southwest of the 221-T Building and is directly north of the 241-TX Tank Farm. This Tank Farm is included in the watchlist tank program and is on the 'ferrocyanide and organic salts' list. This tank is planned for priority treatment.

2B.1.1.11.1 241-TY-101 Single-Shell Tank. Operations began in 1953 at this unit and ceased in 1973. During this time, the tank received $BiPO_4$ first-cycle waste and supernatant, containing $BiPO_4$ first-cycle waste, TBP waste, and evaporator bottoms from the 241-TY, 241-TX, and 241-S Tank Farms (Henderson 1991). The integrity of this unit was questioned when a liquid-level increase exceeded 0.30 inch (0.76 centimeter) (Henderson 1991). This tank currently contains no drainable interstitial or supernatant liquids, and 118,000 gallons (447,000 liters) of solids (Hanlon 1994).

Associated structures include three active radiation monitoring wells, a temperature sensor, a jet pump with screen, an automatic liquid-level gage, and a plummet (Henderson 1991). Tank 241-TY-101 is interim isolated and an assumed leaker.

In July 1994, the tank contained 23 kilogram-moles of ferrocyanide, at a maximum temperature of 68 °F (20 °C) (Hanlon 1994). This tank is included in the watchlist tank program and is on the 'ferrocyanide' list.

2B.1.1.11.2 241-TY-102 Single-Shell Tank. Active from 1953 to 1979, this tank received supernatant, containing B Plant LLW, REDOX HLW, PUREX organic wash waste, REDOX ion exchange waste, and evaporator bottoms from the 241-TX and 241-TY Tank Farms (Henderson 1991). This tank currently contains 14,000 gallons (53,000 liters) of drainable interstitial liquid, no supernatant liquid, and 64,000 gallons (242,000 liters) of solids (Hanlon 1994).

Associated structures include five active radiation monitoring wells, a temperature sensor, an open hole pump, and an automatic liquid-level gage (Henderson 1991). Tank 241-TY-102 is interim isolated and of sound integrity.

Tank 241-TY-102 is the only tank in the 241-TY Tank Farm that contains salt cake. Dry well 52-02-11 was drilled in May 1975 to test the validity of using resistivity measurements as a method of leak detection by injecting a salt solution ($NaNO_3$) and monitoring formation response (Henderson 1991). In January 1989 the activity in the well increased from approximately 70 counts per second at a depth of 40 feet (12.2 meters) to about 160 counts per second, and then stabilized (Henderson 1991).

2B.1.1.11.3 241-TY-103 Single-Shell Tank. Operations began at 241-TY-103 tank in July 1953 and ceased in 1973. During this time, the tank received $BiPO_4$ first-cycle waste, TBP waste, and supernatant. The supernatant contained $BiPO_4$ first-cycle waste; TBP waste; PUREX organic wash waste; REDOX ion exchange waste; coating waste; evaporator bottoms; and decontamination waste from the 241-BX, 241-T, 241-TX, 241-TY, and 241-AX Tank Farms (Henderson 1991). Tank 241-TY-103 currently contains 5,000 gallons (18,900 liters) of drainable interstitial liquid, no supernatant liquid, and 162,000 gallons (613,000 liters) of solids (Hanlon 1994).

Associated structures include three active radiation monitoring wells, a temperature sensor, a salt well screen with jet pump, a plummet, and an automatic liquid-level gage (Henderson 1991). Tank 241-TY-103 is interim isolated and an assumed leaker.

In February 1976, overflow of the 241-TX-155 diversion box catch tank flowed back into 241-TY-103 tank, depositing 1.3 inches (3.3 centimeters) of sludge waste. Based on the liquid-level decrease, approximately 3,000 gallons (11,400 liters) were estimated to have leaked from the tank, with an activity of 700 curies ^{137}Cs (Hanlon 1994). Dry wells showed a significant increase that was attributable to this flooding event (UPR-200-W-150). The unit was removed from service in October 1973 because two dry wells, 52-03-06 and 52-03-03, had shown radiation increases, suggesting leakage from this unit or 241-TY-105 tank (Henderson 1991).

In July 1994, 241-TY-103 tank contained 28 kilogram-moles of ferrocyanide, at a maximum temperature of 70 °F (21.1 °C) (Hanlon 1994). This tank is included in the watchlist tank program and is on the 'ferrocyanide' list.

2B.1.1.11.4 241-TY-104 Single-Shell Tank. Operations began at this tank in August 1953 and were terminated in March 1974. During this time, the tank received TBP waste and supernatant. The supernatant contained REDOX ion exchange waste, PUREX organic wash waste, $BiPO_4$ first-cycle waste, TBP waste, and decontamination waste from the 241-TX and 241-TY Tank Farms (Henderson 1991). This tank currently contains 12,000 gallons (45,400 liters) of drainable interstitial liquid, 3,000 gallons (11,400 liters) of supernatant, and 43,000 gallons (162,800 liters) of solids (Hanlon 1994).

Associated structures include five active radiation monitoring wells, a temperature sensor, a salt well screen, and an automatic liquid-level gage (Henderson 1991). Tank 241-TY-104 is interim isolated and an assumed leaker.

This unit was removed from service when the liquid level decreased in excess of the 0.30-inch (0.76-centimeter) limit. In 1974, approximately 1,400 gallons (5,300 liters) of supernatant leaked from the tank (UPR-200-W-151). The leak consisted of REDOX ion exchange waste, PUREX organic wash waste, $BiPO_4$ first-cycle waste, TBP waste, and decontamination waste from the 241-TX and 241-TY Tank Farms. The leak was noticed when the liquid level dropped more than the 0.3-inch (0.76-centimeter) limit. The P-10 salt well was pumped as a cleanup effort for this UPR.

In December 1991, 241-TY-104 tank contained 12 kilogram-moles of ferrocyanide at a maximum temperature of 68 °F (20 °C) (Hanlon 1994). This tank is included in the watchlist tank program and is on the 'ferrocyanide' list.

2B.1.1.11.5 241-TY-105 Single-Shell Tank. Active from January 1953 until September 1960, this tank received TBP waste (Henderson 1991). This tank currently contains no drainable interstitial nor supernatant liquids, and 231,000 gallons (874,000 liters) of solids (Hanlon 1994).

Associated structures include one active radiation monitoring well, a temperature sensor, a jet pump with screen, and an automatic liquid-level gage (Henderson 1991). Tank 241-TY-105 is interim isolated and an assumed leaker.

UPR-200-W-152 is associated with this tank. In 1960 TBP was released. Based on the liquid-level decrease in the tank, the leak is estimated at 35,000 gallons (132,500 liters) with an activity of 4,000 curies of ^{137}Cs (Hanlon 1994). Two dry wells are associated with this unit. The radioactivity in both dry wells may be the result of interstitial liquid leakage (Henderson 1991).

2B.1.1.11.6 241-TY-106 Single-Shell Tank. Operations began at this unit in June 1953 and ceased in 1959. During this time, the tank received TBP waste (Henderson 1991). This tank currently contains no drainable interstitial nor supernatant liquids, and 17,000 gallons (64,300 liters) of solids (Hanlon 1994).

Associated structures include five active radiation monitoring wells, a temperature sensor, and an automatic liquid-level gage (Henderson 1991). Tank 241-TY-106 is interim isolated and an assumed leaker.

Because of UPR-200-W-153, 241-TY-106 tank was removed from service. The release was discovered when routine surveillance of radiation dry wells indicated a change of profile in dry well 52-06-05 (which now appears to have stabilized). The waste involved was identified as TBP containing 2,000 curies of ^{137}Cs. The leak volume is estimated at 20,000 gallons (75,700 liters) based on the liquid-level decrease in the tank (Hanlon 1994). The tank was stabilized with diatomaceous earth in 1969 (Hanlon 1994).

2B.1.1.12 241-U Tank Farm

The 241-U Tank Farm consists of 16 SSTs; 12 are 533,000-gallon (2.02-million liter) capacity and 4 are 55,000-gallon (208,000-liter) capacity. The tanks were constructed in 1943 to 1944. The 241-U Tank Farm is located immediately west of Camden Avenue and north of 16th Street in the 200 West Area.

2B.1.1.12.1 241-U-101 Single-Shell Tank. Tank 241-U-101 is classified as an inactive, mixed waste management unit. It operated from 1946 until 1959, receiving high-level liquid waste from T Plant, 221-U Building, and the REDOX Plant. From 1969 to 1972, 241-U-101 tank also received a variety of solid waste including enriched uranium, plutonium, ^{60}Co, and mixed fission products. Liquid contents of 241-U-101 tank are $BiPO_4$ metal waste and supernatant, containing $BiPO_4$ metal waste and REDOX HLW from the 241-U and 241-SX Tank Farms (Henderson 1991). This tank currently contains no drainable interstitial liquid, 3,000 gallons (11,400 liters) of supernatant liquid, and 22,000 gallons (83,300 liters) of solids (Hanlon 1994).

This tank is equipped with radiation monitoring wells, temperature sensors, and automatic liquid-level gages. A 60-horsepower (45-kilowatt) pump may be raised and lowered in the tank. A heel jet, two sluicing nozzles, and two recirculating lines also reside in the tank. The tank is currently interim isolated and interim stabilized.

There are approximately 29,000 gallons (110,000 liters) of $BiPO_4$ metal waste and supernatant, containing HLW known to have leaked from the tank in 1959. The tank was removed from service at that time and later was used to store the solid waste mentioned previously. The tank was pumped out and liquid-level measurements were discontinued until 1974 when in-tank photos revealed residual liquid in the tank. Two additional dry wells were drilled at the perimeter of the tank in 1974 and 1975 for monitoring purposes.

2B.1.1.12.2 241-U-102 Single-Shell Tank. Tank 241-U-102 is classified as an inactive, mixed waste management unit that operated from 1946 until 1979, receiving high-level liquid waste from T Plant, U Plant, and REDOX. Liquid contents of 241-U-102 tank are $BiPO_4$ metal waste; 242-T Evaporator waste; $HNO_4/KMnO_4$ solution; and supernatant, containing REDOX HLW, evaporator bottoms, $BiPO_4$ metal waste, and uncomplexed waste from the 241-C, 241-SX, 241-SY, 241-TX, and 241-U Tank Farms (Henderson 1991). This tank currently contains 126,000 gallons (477,000 liters) of drainable interstitial liquid, 18,000 gallons (68,100 liters) of supernatant liquid, and 356,000 gallons (1.35 million liters) of solids (Hanlon 1994).

This tank is equipped with radiation monitoring wells, temperature sensors, and automatic liquid-level gages. A 60-horsepower (45-kilowatt) pump may be raised and lowered within the tank. A heel jet, two sluicing nozzles, and two recirculating lines also reside in the tank. Currently, the tank is partially interim isolated.

2B.1.1.12.3 241-U-103 Single-Shell Tank. Tank 241-U-103 is classified as an inactive, mixed waste management unit that operated from 1947 until 1978, receiving high-level liquid waste from T Plant, U Plant, and REDOX. Liquid contents of 241-U-103 tank are $BiPO_4$ metal waste; 242-T Evaporator waste; $HNO_4/KMnO_4$ solution; and supernatant, containing REDOX HLW, evaporator bottoms, and PNL waste from the 241-SX, 241-SY, 241-TX, and 241-U Tank Farms (Henderson 1991). This tank currently contains 176,000 gallons (666,000 liters) of drainable interstitial liquid, 13,000 gallons (49,200 liters) of supernatant liquid, and 455,000 gallons (1.72 million liters) of solids (Hanlon 1994).

Tank 241-U-103 is included in watchlist tanks because it contains greater than 3 weight percent of total organic compound and has the potential to generate hydrogen or other flammable gas beyond the flammability limit. This tank is capable of retaining the generated gas in settled sludges or trapped under a layer of waste. This tank is planned for priority treatment.

Tank 241-U-103 is equipped with radiation monitoring wells, temperature sensors, and automatic liquid-level gages. A 60-horsepower (45-kilowatt) pump may be raised and lowered within the tank. A heel jet, two sluicing nozzles, and two recirculating lines also reside in the tank. Currently, the tank is partially interim isolated.

A UPR occurred at this site in 1971 when a waste line was inadvertently cut, and contaminated liquid waste was spilled onto the surface (Section 2.3.10; UPR-200-W-128).

2B.1.1.12.4 241-U-104 Single-Shell Tank. Tank 241-U-104 is classified as an inactive, mixed waste management unit that operated from 1947 until 1956 to receive high-level liquid waste from T Plant, U Plant, and REDOX and is a confirmed leaker (Henderson 1991). Approximately 55,000 gallons (208,000 liters) are believed to have leaked from the tank. The unit was removed from service in 1956 when a rupture in the tank bottom was detected (Section 2.3.10; UPR-200-W-155). This tank currently contains 7,000 gallons (26,500 liters) of drainable interstitial liquid, no supernatant liquid, and

122,000 gallons (462,000 liters) of solids (Hanlon 1994). The sludge in the tank contains some diatomaceous earth, which was added to the tank contents in 1969 (Hanlon 1994).

Tank 241-U-104 is equipped with radiation monitoring wells, temperature sensors, and automatic liquid-level gages. A 60-horsepower (45-kilowatt) pump may be raised and lowered in the tank. A heel jet, two sluicing nozzles, and two recirculating lines also reside in the tank. Currently, the tank is partially interim isolated.

2B.1.1.12.5 241-U-105 Single-Shell Tank. Tank 241-U-105 is classified as an inactive, mixed waste management unit that operated from 1947 until 1978 to receive high-level liquid waste from T Plant, U Plant, and REDOX. Liquid contents of 241-U-105 tank are $BiPO_4$ metal waste, 242-T Evaporator waste, and supernatant, containing coating waste from the 241-U Tank Farm (Henderson 1991). This tank currently contains 142,000 gallons (537,000 liters) of drainable interstitial liquid, 37,000 gallons (140,000 liters) of supernatant liquid, and 381,000 gallons (1.44 million liters) of solids (Hanlon 1994).

Tank 241-U-105 is included in the watchlist tanks program because it contains greater than 3 weight percent of total organic compounds and has the potential to generate hydrogen or other flammable gas above the flammability limit. This tank is capable of retaining the generated gas in settled sludges or trapped under a layer of waste. The tank is planned for priority treatment.

This tank is equipped with radiation monitoring wells, temperature sensors, and automatic liquid-level gages. A 60-horsepower (45-kilowatt) pump may be raised and lowered in the tank. A heel jet, two sluicing nozzles, and two recirculating lines also reside in the tank. Currently, the tank is partially interim isolated.

2B.1.1.12.6 241-U-106 Single-Shell Tank. Tank 241-U-106 is classified as an inactive, mixed waste management unit that operated from 1948 until 1977, receiving high-level liquid waste from the T Plant, 221-U Building, and REDOX. Liquid contents of 241-U-106 tank are $BiPO_4$ metal waste, REDOX HLW, PUREX LLW, B Plant LLW, and evaporator bottoms from the 241-C and 241-U Tank Farms (Henderson 1991). This tank currently contains 68,000 gallons (257,000 liters) of drainable interstitial liquid, 15,000 gallons (56,800 liters) of supernatant liquid, and 211,000 gallons (800,000 liters) of solids (Hanlon 1994). This tank is included in the watchlist tank program and is on the 'organic salts' list. The tank is planned for priority treatment.

Tank 241-U-106 is equipped with radiation monitoring wells, temperature sensors, and automatic liquid-level gages. A 60-horsepower (45-kilowatt) pump may be raised and lowered in the tank. A heel jet, two sluicing nozzles, and two recirculating lines also reside in the tank. Currently, the tank is partially interim isolated.

A sudden reduction in fluid level in 1977 caused alarm that this tank may have begun to leak. Subsequent studies determined that no leaking had occurred.

2B.1.1.12.7 241-U-107 Single-Shell Tank. Tank 241-U-107 is classified as an inactive, mixed waste management unit that operated from 1948 until 1980, receiving high-level liquid waste from T Plant, U Plant, and REDOX. Liquid contents of 241-U-107 tank are $BiPO_4$ metal waste and $HNO_4/KMnO_4$ solution; N Reactor waste and PNL waste; decontamination waste; laboratory waste; and supernatant, containing decontamination waste, PNL waste, coating waste, DSSF, REDOX HLW, N Reactor waste, evaporator bottoms, and complexed and noncomplexed waste from the 241-S, 241-SX, 241-T, 241-U, and 241-SY Tank Farms (Henderson 1991). Three of four dry wells associated with this tank have had low-level activity at approximately the 50-foot (15.2-meter) depth level. This tank contains 147,000 gallons (556,000 liters) of drainable interstitial liquid, 31,000 gallons (117,400 liters) of supernatant liquid, and 375,000 gallons (1.42 million liters) of solids (Hanlon 1994). This tank is included in the watchlist tank program and is on the 'organic salts' list. The tank is planned for priority treatment.

Tank 241-U-107 is equipped with radiation monitoring wells, temperature sensors, and automatic liquid-level gages. A 60-horsepower (45-kilowatt) pump may be raised and lowered in the tank. A heel jet, two sluicing nozzles, and two recirculating lines also reside in the tank. The tank is currently partially interim isolated.

2B.1.1.12.8 241-U-108 Single-Shell Tank. Tank 241-U-108 is classified as an inactive, mixed waste management unit that operated from 1949 until 1979, receiving high-level liquid waste from T Plant, U Plant, and REDOX. Liquid contents of 241-U-108 tank are $BiPO_4$ metal waste, REDOX coating waste; and supernatant, containing coating waste, N Reactor waste, lab waste, PNL waste, and evaporator bottoms from the 241-S and 241-U Tank Farms (Henderson 1991). This tank currently contains 172,000 gallons (651,000 liters) of drainable interstitial liquid, 24,000 gallons (90,800 liters) of supernatant liquid, and 444,000 gallons (1.68 million liters) of solids (Hanlon 1994).

Tank 241-U-108 is included in watchlist tanks because it contains greater than 3 weight percent of total organic compound and has the potential to generate hydrogen or other flammable gas above the flammability limit. The tank is capable of retaining the generated gas in settled sludges or trapped under a layer of waste. This tank is planned for priority treatment.

Tank 241-U-108 is equipped with radiation monitoring wells, temperature sensors, and automatic liquid-level gages. A 60-horsepower (45-kilowatt) pump may be raised and lowered in the tank. A heel jet, two sluicing nozzles, and two recirculating lines also reside in the tank. The tank is currently partially interim isolated.

2B.1.1.12.9 241-U-109 Single-Shell Tank. Tank 241-U-109 is classified as an inactive, mixed waste management unit that operated from 1949 until 1978, receiving high-level liquid waste from T Plant, U Plant, and REDOX. Liquid contents of 241-U-109 tank are $BiPO_4$ metal waste and supernatant containing

REDOX HLW, coating waste, and evaporator bottoms from the 241-TX and 241-U Tank Farms (Henderson 1991). This tank currently contains 163,000 gallons (617,000 liters) of drainable interstitial liquid, 19,000 gallons (72,000 liters) of supernatant liquid, and 444,000 gallons (1.7 million liters) of solids (Hanlon 1994).

Tank 241-U-109 is included in the watchlist tanks program because it contains greater than 3 weight percent of total organic compound and has the potential to generate hydrogen or other flammable gas above the flammability limit. This tank is capable of retaining the generated gas in settled sludges or trapped under a layer of waste. The tank is planned for priority treatment.

Tank 241-U-109 is equipped with radiation monitoring wells, temperature sensors, and automatic liquid-level gages. A 60-horsepower (45-kilowatt) pump may be raised and lowered in the tank. A heel jet, two sluicing nozzles, and two recirculating lines also reside in the tank. Currently, the tank is partially interim isolated.

2B.1.1.12.10 241-U-110 Single-Shell Tank. Tank 241-U-110 is classified as an inactive, mixed waste management unit that operated from 1946 until 1975, receiving high-level liquid waste from T Plant, U Plant, and REDOX. Tank 241-U-110 is a confirmed leaker (Henderson 1991), and its liquid contents are $BiPO_4$ metal waste, REDOX coating, and HLW; lab waste; and PNL waste (Henderson 1991). This tank currently contains 15,000 gallons (56,800 liters) of drainable interstitial liquid, no supernatant liquid, and 186,000 gallons (704,000 liters) of solids (Hanlon 1994).

Tank 241-U-110 is equipped with radiation monitoring wells, temperature sensors, and automatic liquid-level gages. A 60-horsepower (45-kilowatt) pump may be raised and lowered in the tank. A heel jet, two sluicing nozzles, and two recirculating lines also reside in the tank. The tank is currently interim stabilized and partially interim isolated.

High-level waste, 8,100 gallons (30,700 liters) of $BiPO_4$ first-cycle waste, and REDOX coating are thought to have leaked to soil in 1975. The tank was removed from service and pumped to a heel. A salt well was installed to remove the residual heel and interstitial liquid after a rapid snow melt in a pump pit intruded into the tank (Section 2.3.10; UPR-200-W-156).

2B.1.1.12.11 241-U-111 Single-Shell Tank. Tank 241-U-111 is classified as an inactive, mixed waste management unit that operated from 1947 until 1980, receiving high-level liquid waste from T Plant, U Plant, and REDOX. Liquid contents of 241-U-111 tank are $BiPO_4$ first cycle waste; $NHO_4/KMnO_4$; and supernatant, containing REDOX HLW, N Reactor waste, PNL waste, decontamination waste, evaporator concentrate, partial neutralization feed, and complexed waste from the 241-SY, 241-TY, and 241-U Tank Farms (Henderson 1991). This tank currently contains 122,000 gallons (462,000 liters) of drainable interstitial liquid, no supernatant liquid, and 329,000 gallons (1.25 million liters) of solids (Hanlon 1994).

Tank 241-U-111 is equipped with radiation monitoring wells, temperature sensors, and automatic liquid-level gages. A 60-horsepower (45-kilowatt) pump may be raised and lowered in the tank. A heel jet, two sluicing nozzles, and two recirculating lines also reside in the tank. Currently, the tank is partially interim stabilized.

2B.1.1.12.12 241-U-112 Single-Shell Tank. Tank 241-U-112 is classified as an inactive, mixed waste management unit that operated from 1949 until 1978, receiving high-level liquid waste from T Plant, U Plant, and REDOX. Tank 241-U-112 is a confirmed leaker (Henderson 1991), and its liquid contents are $BiPO_4$ first-cycle waste and supernatant, containing $BiPO_4$ first-cycle waste and REDOX HLW from the 241-U Tank Farm (Henderson 1991). Tank 241-U-112 currently contains no drainable interstitial liquid, 4,000 gallons (15,100 liters) of supernatant liquid, and 45,000 gallons (170,000 liters) of solids (Hanlon 1994).

Tank 241-U-112 is equipped with radiation monitoring wells, temperature sensors, and automatic liquid-level gages. A 60-horsepower (45-kilowatt) pump may be raised and lowered in the tank. A heel jet, two sluicing nozzles, and two recirculating lines also reside in the tank. The tank is currently interim stabilized and interim isolated.

In 1969, 500 gallons (1,900 liters) of supernatant containing $BiPO_4$ first-cycle and recycled waste were lost to the soil through a tank leak. A total volume of 8,500 gallons (32,200 liters) is believed to have leaked from the tank by 1980. The tank was removed from service in 1970, and a salt well system was installed to remove tank contents (UPR-200-W-157; Henderson 1991).

2B.1.1.12.13 241-U-201 Single-Shell Tank. Tank 241-U-201 is classified as an inactive, mixed waste management unit that operated from 1956 to 1977. It was constructed to receive supernatant, containing REDOX HLW from the existing 241-U Tank Farm (Henderson 1991). In 1977, when inactivated, the tank was pumped out. This tank currently contains 1,000 gallons (3,800 liters) of supernatant liquid and 4,000 gallons (15,100 liters) of solids (Hanlon 1994).

Tank 241-U-201 is currently interim isolated and interim stabilized. The condenser towers have been removed, and all surface-level tank fixtures have been weather sealed with plasticized foam (Henderson 1991).

2B.1.1.12.14 241-U-202 Single-Shell Tank. Tank 241-U-202 is classified as an inactive, mixed waste management unit that operated from 1956 to 1977. It was constructed to receive supernatant, containing REDOX HLW from the existing 241-U Tank Farm (Henderson 1991). In 1977, when inactivated, the tank was pumped out. This tank currently contains 1,000 gallons (3,800 liters) of supernatant liquid and 4,000 gallons (15,100 liters) of solids (Hanlon 1994).

Tank 241-U-202 is currently interim isolated and interim stabilized. The condenser towers have been removed, and all surface-level tank fixtures have been weather sealed with plasticized foam (Henderson 1991).

2B.1.1.12.15 241-U-203 Single-Shell Tank. Tank 241-U-203 is classified as an inactive, mixed waste management unit that operated from 1956 to 1977. It was constructed to receive supernatant, containing REDOX HLW from the existing 241-U Tank Farm (Henderson 1991). In 1977, when inactivated, the tank was pumped out. This tank currently contains 1,000 gallons (3,800 liters) of supernatant liquid and 2,000 gallons (7,600 liters) of solids (Hanlon 1994).

Tank 241-U-203 is currently interim isolated and interim stabilized. The condenser towers have been removed, and all surface-level tank fixtures have been weather sealed with plasticized foam (Henderson 1991).

2B.1.1.12.16 241-U-204 Single-Shell Tank. Tank 241-U-204 is classified as an inactive, mixed waste management unit that operated from 1956 to 1977. It was constructed to receive supernatant, containing REDOX HLW from the existing 241-U Tank Farm (Henderson 1991). In 1977, when inactivated, the tank was pumped out. This tank currently contains 1,000 gallons (3,800 liters) of supernatant liquid and 2,000 gallons (7,600 liters) of solids (Hanlon 1994).

Tank 241-U-204 is currently interim isolated and interim stabilized. The condenser towers have been removed, and all surface-level tank fixtures have been weather sealed with plasticized foam (Henderson 1991).

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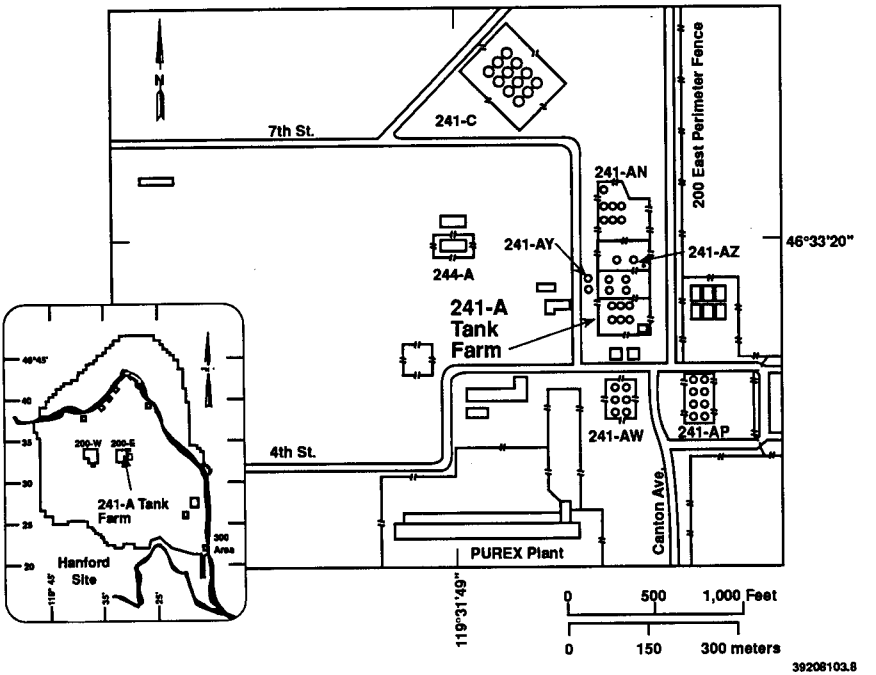

Figure 2B-1. 241-A Single-Shell Tank Farm Site Plan.

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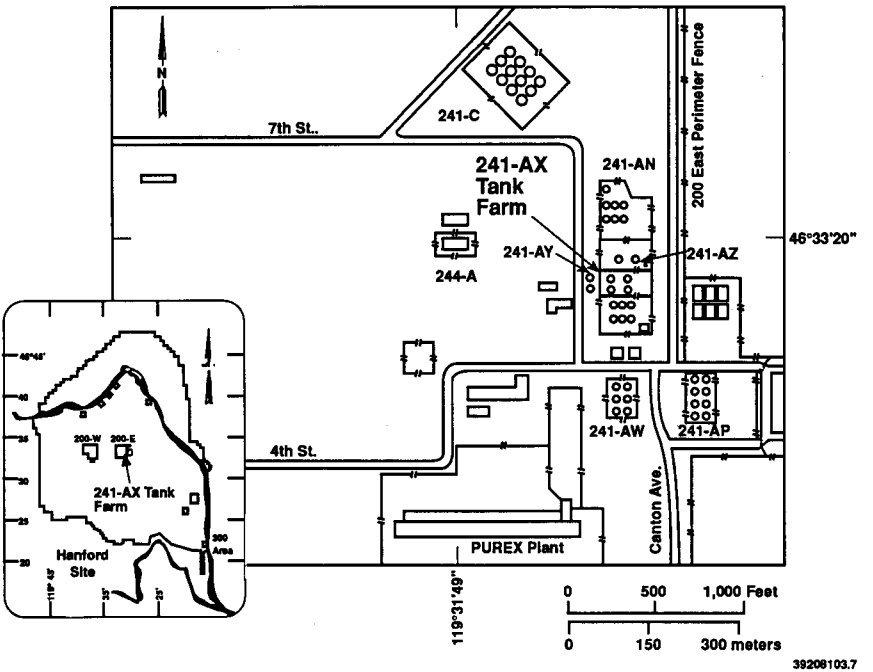

Figure 2B-2. 241-AX Single-Shell Tank Farm Site Plan.

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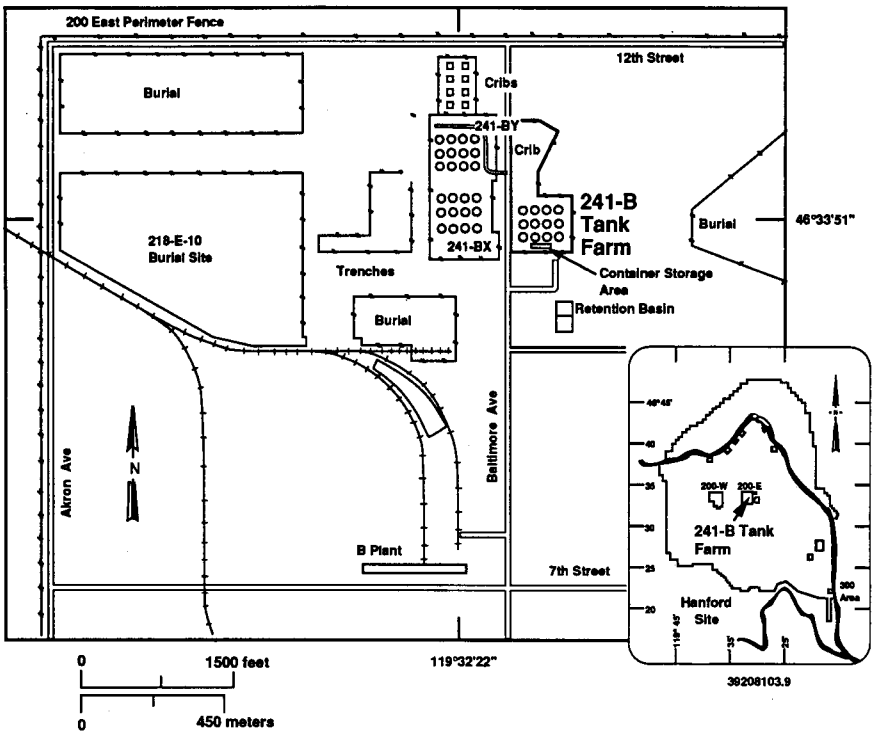

Figure 2B-3. 241-B Single-Shell Tank Farm Site Plan.

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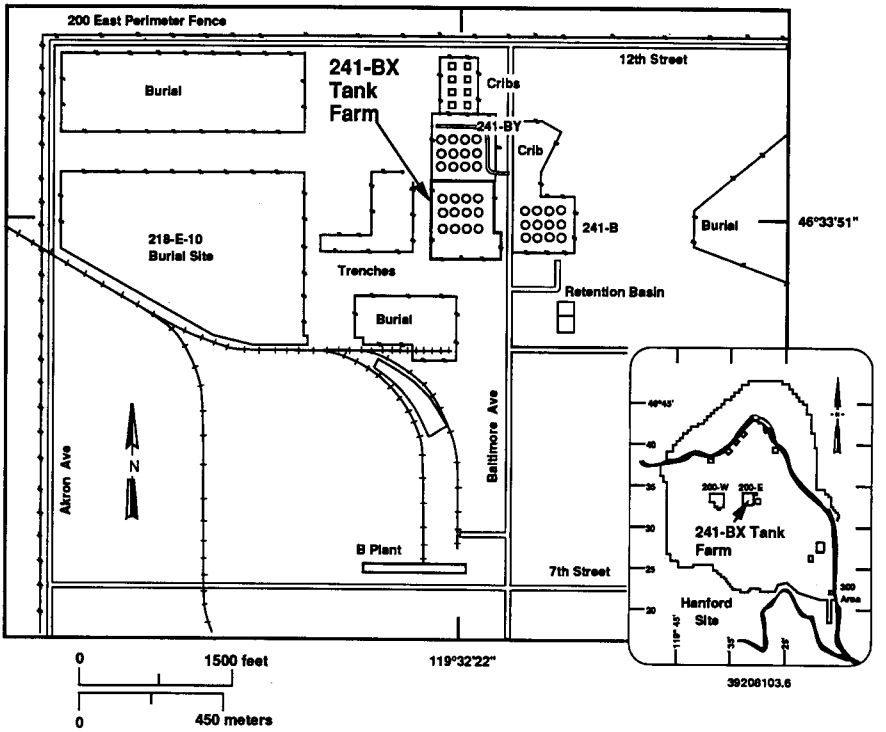

Figure 2B-4. 241-BX Single-Shell Tank Farm Site Plan.

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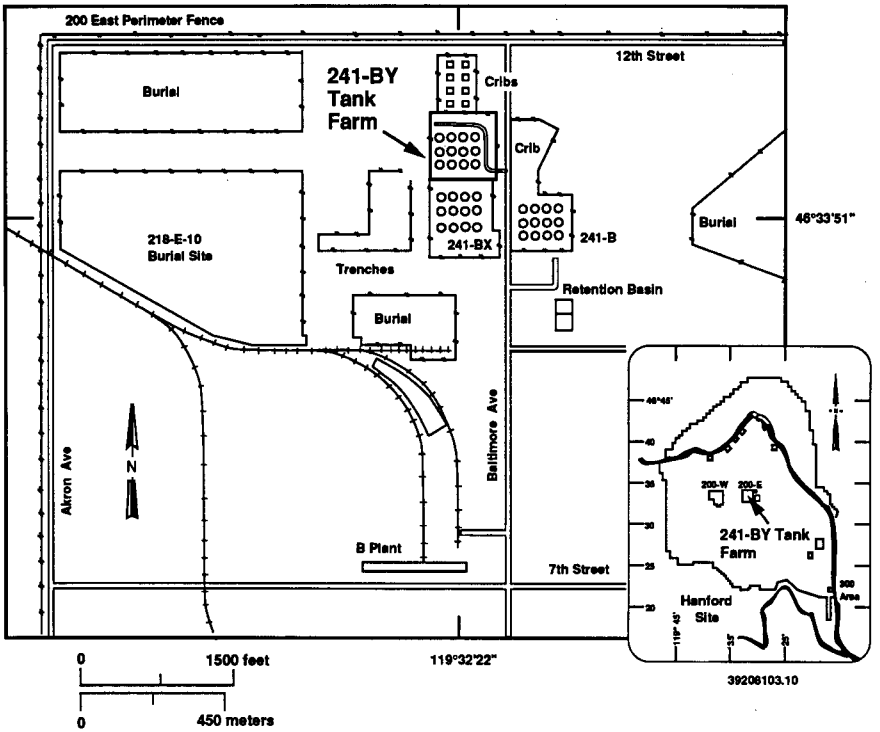

Figure 2B-5. 241-BY Single-Shell Tank Farm Site Plan.

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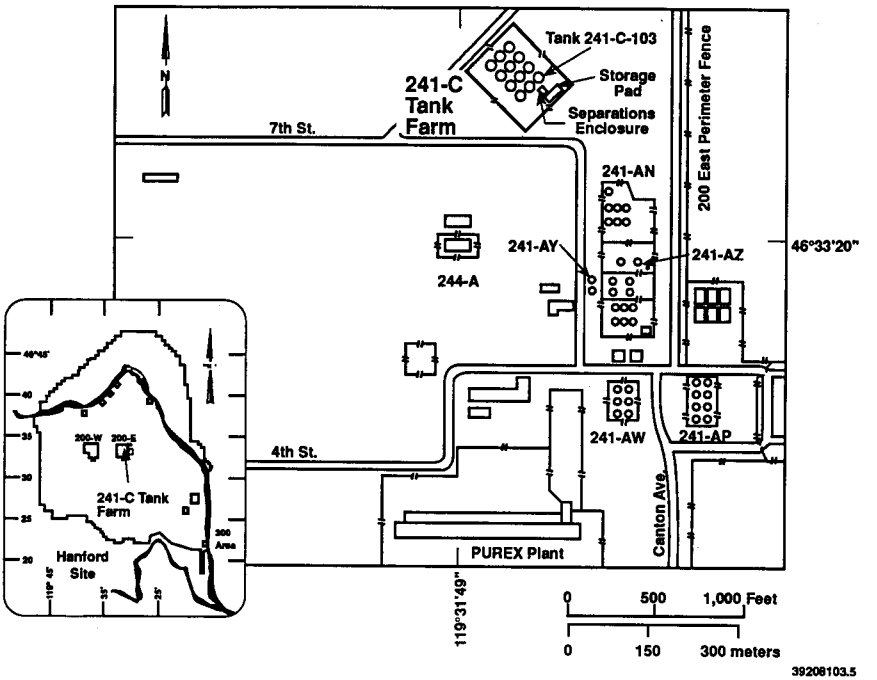

Figure 2B-6. 241-C Single-Shell Tank Farm Site Plan.

960517.0707

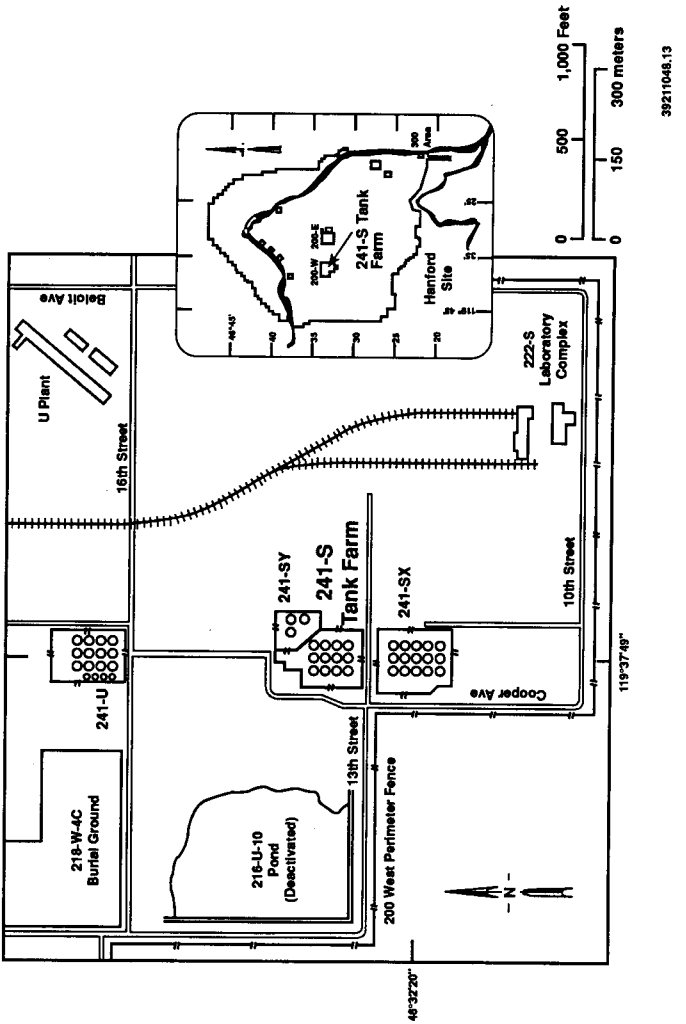

Figure 2B-7. 241-S Single-Shell Tank Farm Site Plan.

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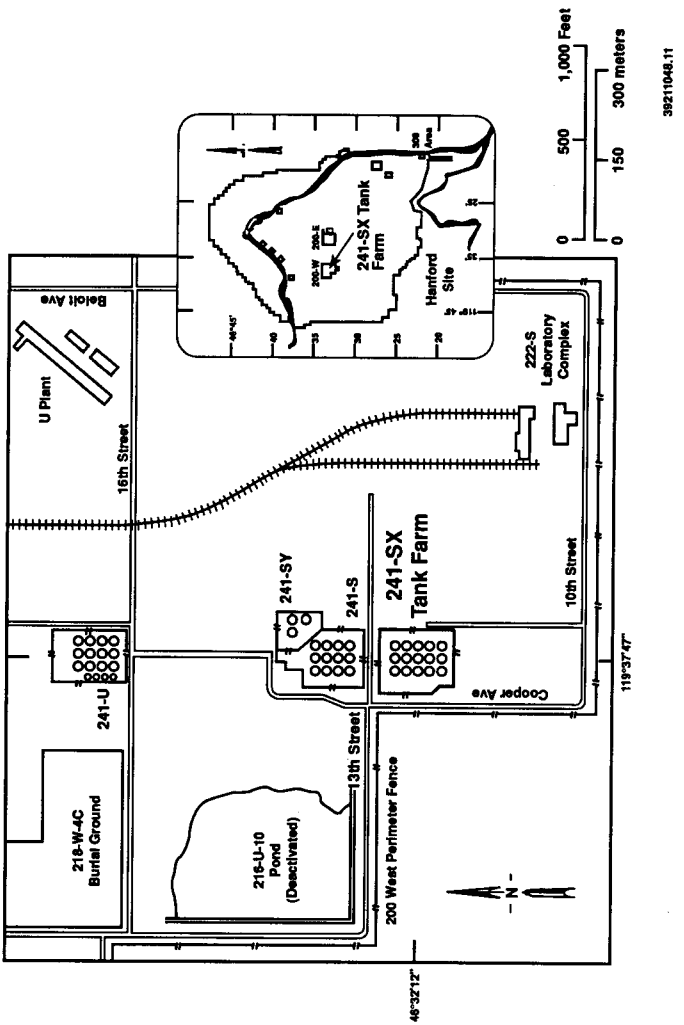

Figure 2B-8. 241-SX Single-Shell Tank Farm Site Plan.

960517.0707

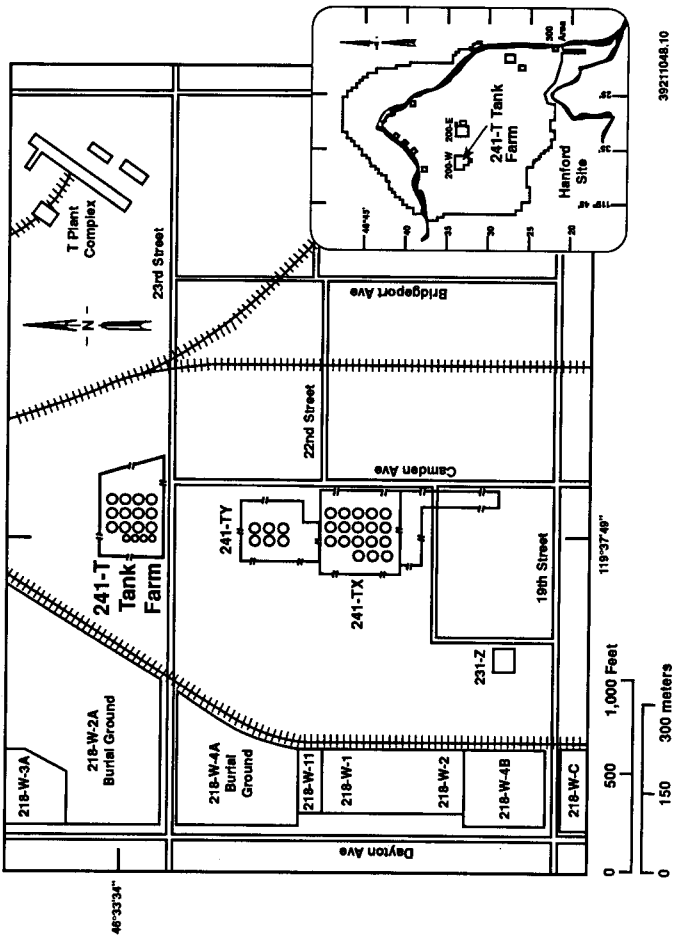

Figure 2B-9. 241-T Single-Shell Tank Farm Site Plan.

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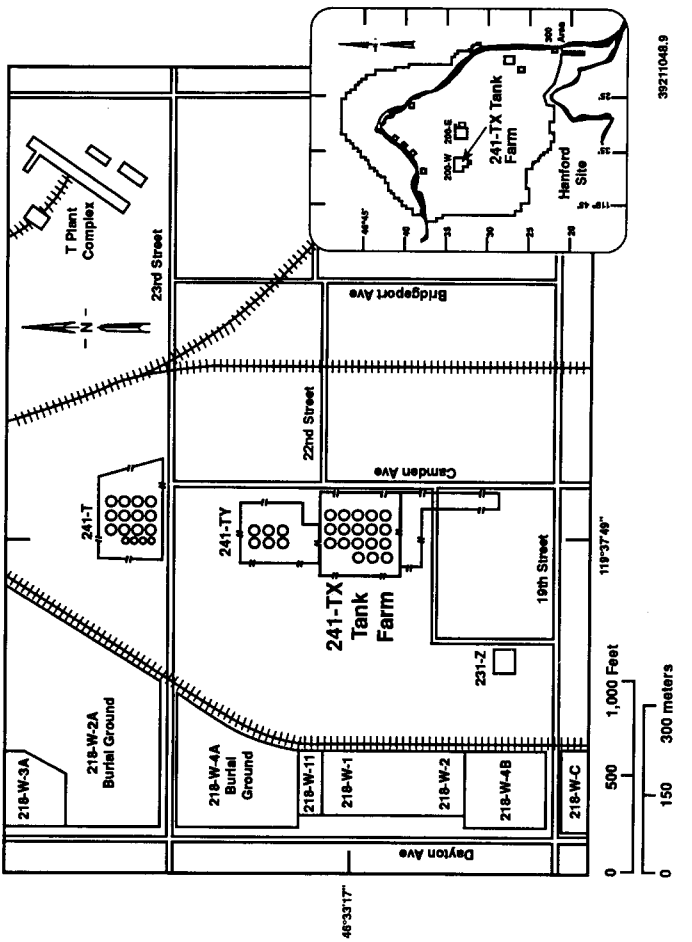

Figure 2B-10. 241-TX Single-Shell Tank Farm Site Plan.

960517.0707

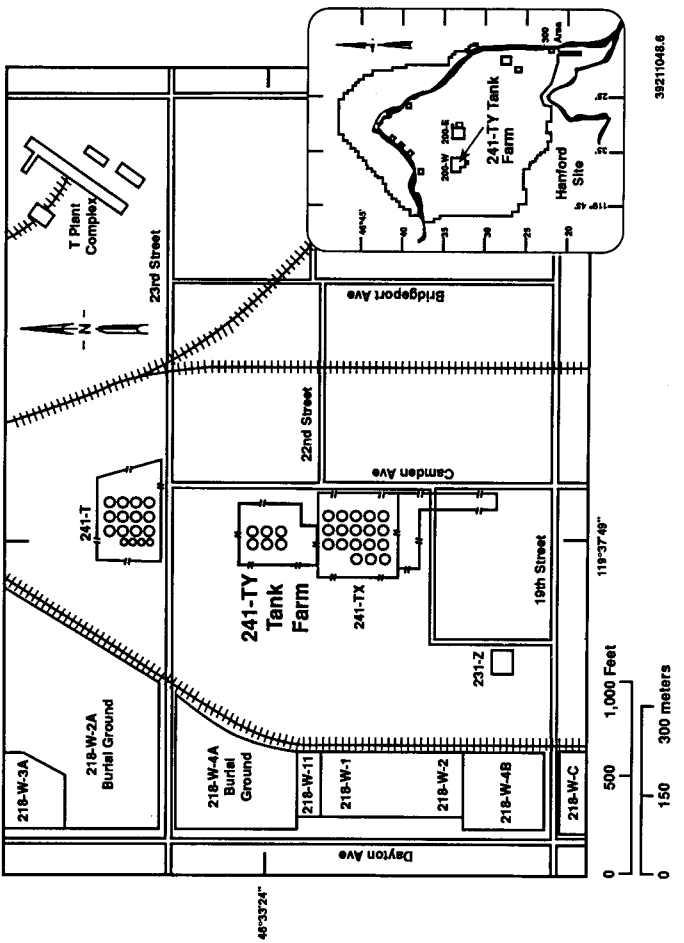

Figure 2B-11. 241-TY Single-Shell Tank Farm Site Plan.

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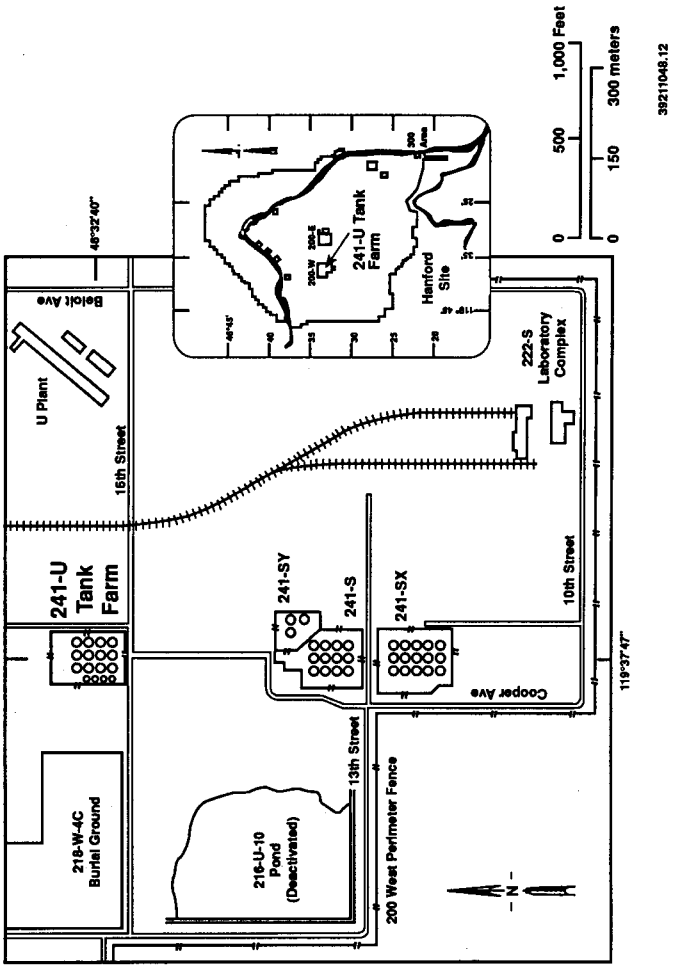

Figure 2B-12. 241-U Single-Shell Tank Farm Site Plan.

960517.0707

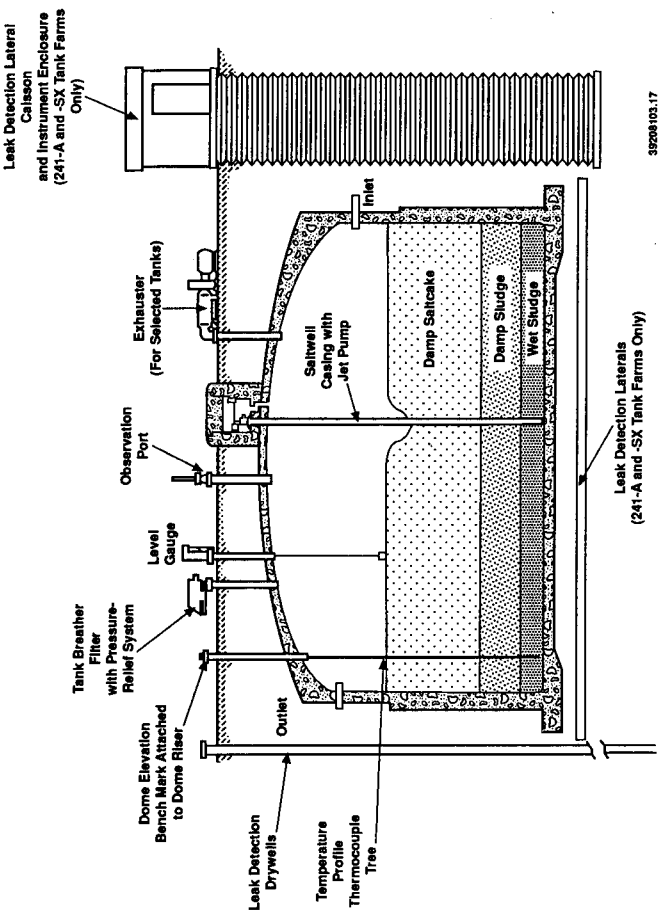

Figure 2B-13. Typical Single-Shell Tank.

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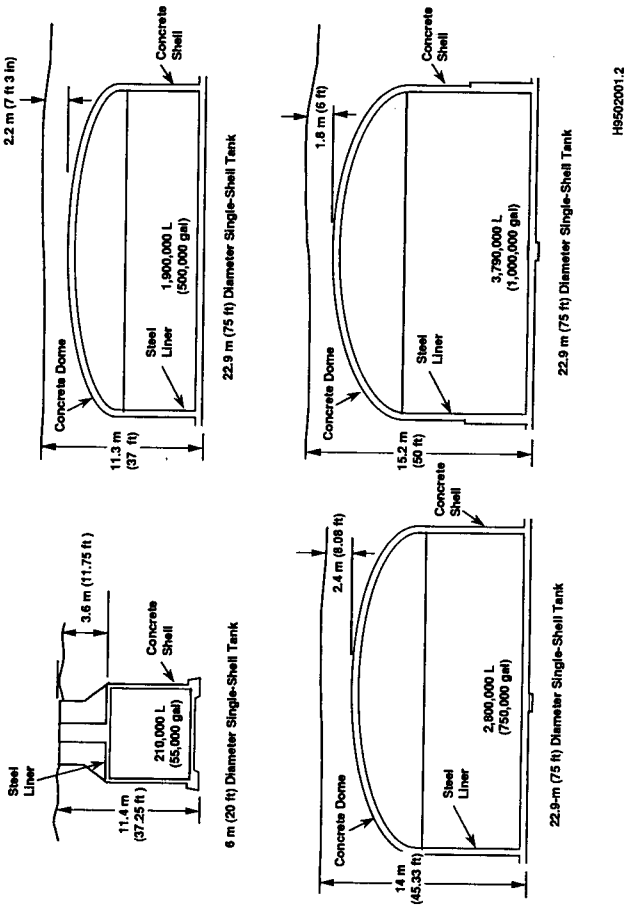

Figure 2B-14. Cross-Sectional Views of Hanford Single-Shell Tanks.

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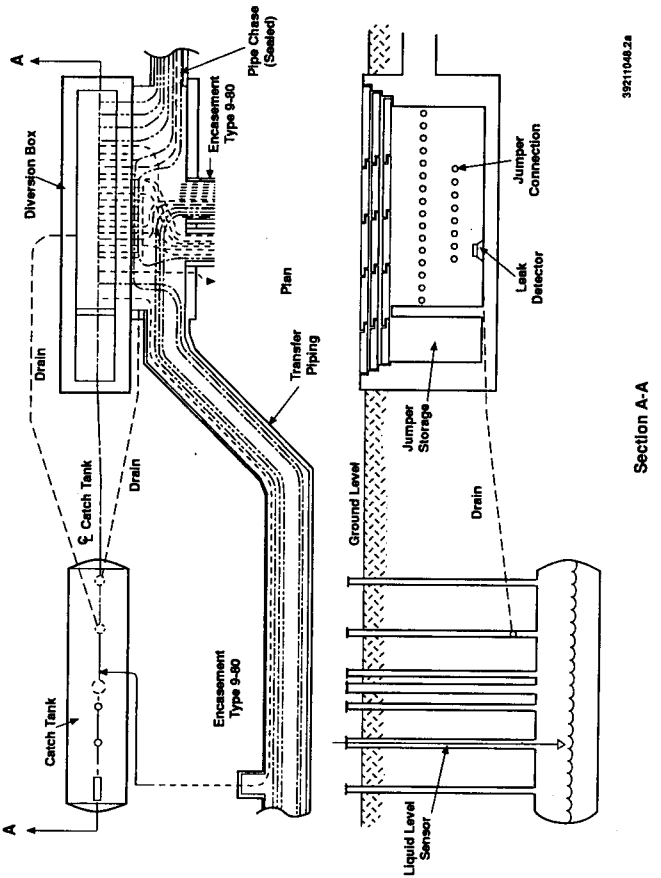

Figure 2B-15. Typical Transfer System.

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46°33'11"
119°31'02"

8800284-1CN
(PHOTO TAKEN 1988)

Figure 2B-16. 241-A Single-Shell Tank Farms.

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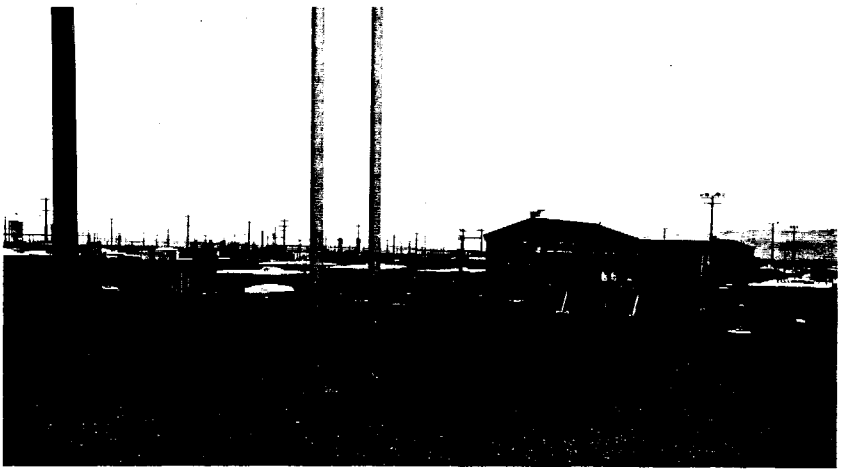

8800284-2CN
(PHOTO TAKEN 1988)

46°33'15"
119°31'02"

8800284-3CN
(PHOTO TAKEN 1988)

Figure 2B-17. 241-AX Single-Shell Tank Farm.

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46°33'52"
119°32'12"

8800284-6CN
(PHOTO TAKEN 1988)

Figure 2B-18. 241-B Single-Shell Tank Farm.

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46°33'51"
119°32'22"

8800284-7CN
(PHOTO TAKEN 1988)

Figure 2B-19. 241-BX Single-Shell Tank Farm.

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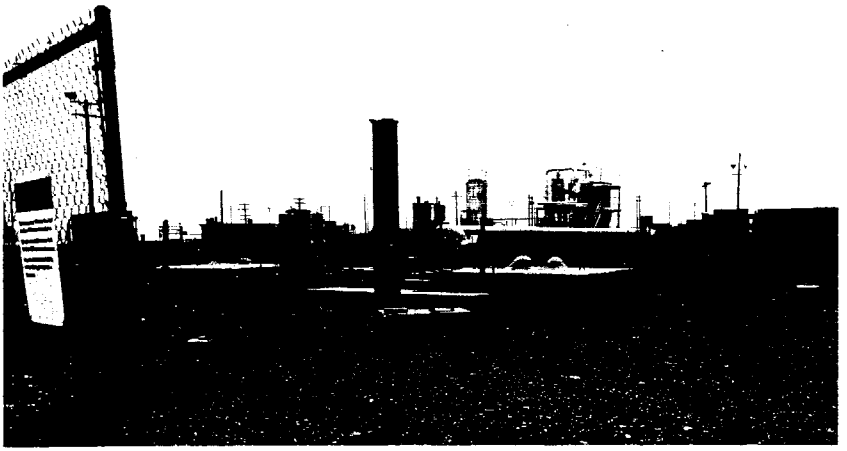

8800284-8CN
(PHOTO TAKEN 1988)

46°33'58"
119°32'22"

8800284-9CN
(PHOTO TAKEN 1988)

Figure 2B-20. 241-BY Single-Shell Tank Farm.

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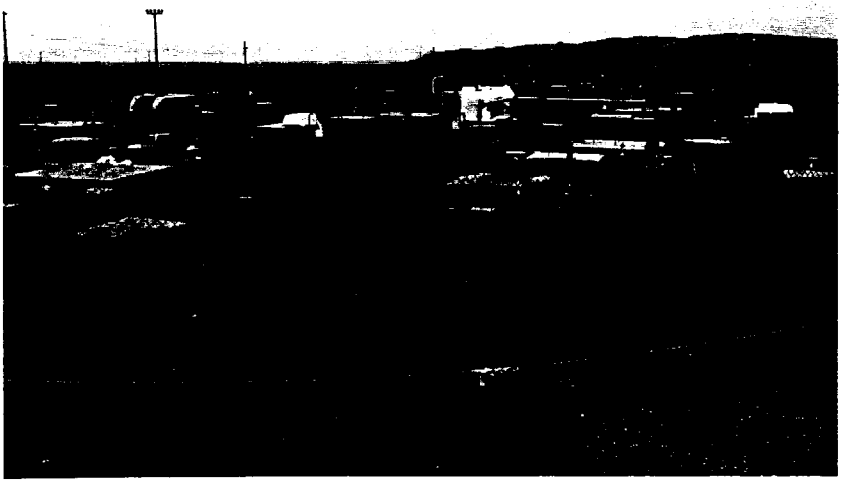

46°33'27"
119°31'13"

8800284-5CN
(PHOTO TAKEN 1988)

Figure 2B-21. 241-C Single-Shell Tank Farm.

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46°32'12"
119°37'47"

8800284-16CN
(PHOTO TAKEN 1988)

Figure 2B-23. 241-SX Single-Shell Tank Farm.

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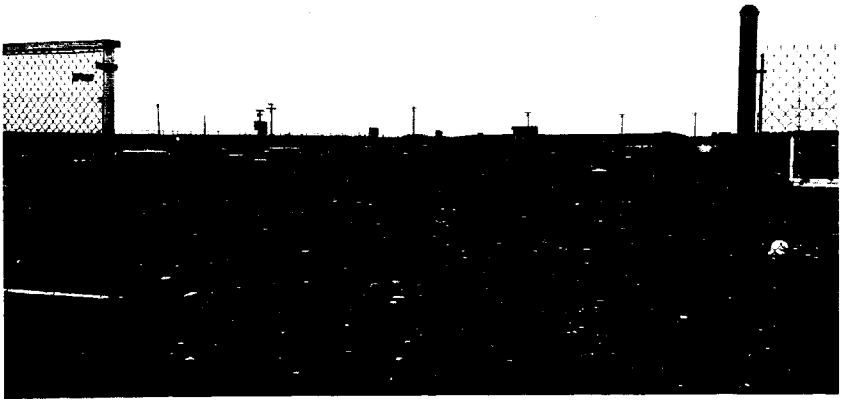
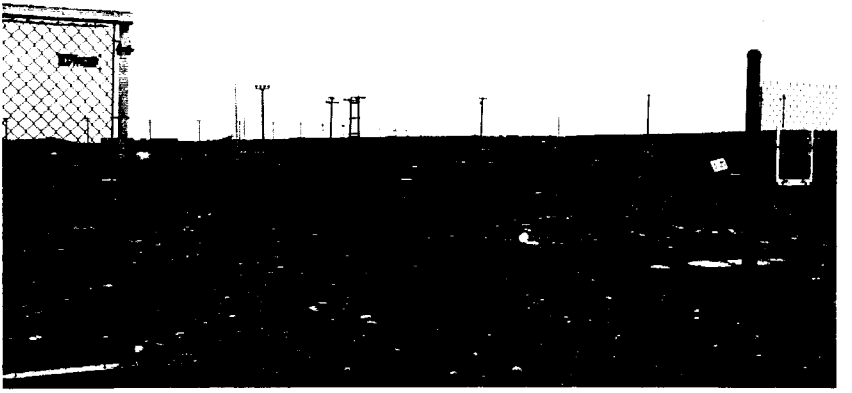


8800284-10CN
(PHOTO TAKEN 1988)



46°33'34"
119°37'47"

8800284-11CN
(PHOTO TAKEN 1988)

Figure 2B-24. 241-T Single-Shell Tank Farm.

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46°33'17"
119°37'49"

8800284-13CN
(PHOTO TAKEN 1988)

Figure 2B-25. 241-TX Single-Shell Tank Farm.

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46°33'24"
119°37'49"

8800284-12CN
(PHOTO TAKEN 1988)

Figure 2B-26. 241-TY Single-Shell Tank Farm.

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46°32'40"
119°37'47"

8800284-14CN
(PHOTO TAKEN 1988)

Figure 2B-27. 241-U Single-Shell Tank Farm.

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APPENDIX 2C

SINGLE-SHELL TANK INTERIM STABILIZATION OPERATIONS AND SURVEILLANCE SYSTEM UPGRADES

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CONTENTS

2C.1.0 SINGLE-SHELL TANK INTERIM STABILIZATION OPERATIONS AND SURVEILLANCE SYSTEM UPGRADES . . . . . APP 2C-1

2C.1.1 INTERIM STABILIZATION . . . . . APP 2C-1
2C.1.1.1 Background, Definition, and Criteria . . . . . APP 2C-1
2C.1.1.2 Planned Interim Stabilization Activities . . . . . APP 2C-2
2C.1.1.3 Safety Concerns Associated with Tank Waste Stabilization Activities . . . . . APP 2C-4

2C.1.2 EMERGENCY PUMPING OPERATION . . . . . APP 2C-5
2C.1.2.1 Emergency Pumping Preparatory Activities . . . . . APP 2C-5
2C.1.2.2 Emergency Pumping Equipment . . . . . APP 2C-7

2C.1.3 SINGLE-SHELL TANK SURVEILLANCE EQUIPMENT AND PROCEDURES . . . . . APP 2C-8
2C.1.3.1 Waste Level Measurement . . . . . APP 2C-8
2C.1.3.2 Interstitial Liquid Level Measurement . . . . . APP 2C-10
2C.1.3.3 Temperature Monitoring . . . . . APP 2C-10
2C.1.3.4 Drywells . . . . . APP 2C-11
2C.1.3.5 Laterals . . . . . APP 2C-11
2C.1.3.6 In-Tank Photography . . . . . APP 2C-11

2C.1.4 PLANNED SURVEILLANCE INSTRUMENTATION UPGRADE . . . . . APP 2C-12
2C.1.4.1 Level Monitoring Upgrade Strategy and Status . . APP 2C-12
2C.1.4.2 Temperature Monitoring Upgrade Status . . . . . APP 2C-13
2C.1.4.3 SST Leak Detection Capability Upgrade . . . . . APP 2C-14
2C.1.4.4 Vapor Space Monitoring Upgrade . . . . . APP 2C-15

FIGURES

2C-1 Tri-Party Agreement Single-Shell Tank Stabilization Schedule . . . . . APP F2C-1
2C-2 Salt Well Jet Pump . . . . . APP F2C-2

TABLES

2C-1 Single-Shell Tanks Interim Stabilization Status (June 30, 1994) . . . . . APP T2C-1
2C-2 Double-Shell Tank Waste Type and Space Allocation (May 1994) . . . . . APP T2C-2
2C-3 Single-Shell Tanks Scheduled to Receive ENRAF ATG Gauges* in Fiscal Year 1994 and First Quarter of Fiscal Year 1995 . . APP T2C-3

2C.1.0 SINGLE-SHELL TANK INTERIM STABILIZATION OPERATIONS AND SURVEILLANCE SYSTEM UPGRADES

Hanford's SSTs have been storing chemical and nuclear waste for a period much longer than their original design lives. Inadequate characterization of tank waste, frequent failure and/or obsolescence of existing surveillance instrumentation, and past occurrence of tank leaks are among the factors that have caused concern over the potential environmental degradation and hazards associated with continued storage of waste in these aging SSTs. A concerted effort is being made through the TWRS program to provide treatment, storage, and/or disposal of tank waste in a safe, cost-effective, and environmentally sound manner. This chapter provides information about two of the most significant elements of the TWRS program; the SST interim stabilization program, and surveillance of SSTs. The current status of the SST interim stabilization program (including activities scheduled to take place in fiscal year 1995), as well as safety concerns associated with waste stabilization operations are addressed in Section 2C.1.1. The discovery of a leak from a noninterim stabilized tank may mandate the emergency pumping of the tank (and consequently lead to its interim stabilization before its Tri-Party Agreement milestone-scheduled stabilization date). The activities required to prepare a SST for emergency pumping, the potential impact of emergency pumping a leaking SST on the scheduled interim stabilization activities for other SSTs, and the equipment and facilities used to pump, transport, and store the SST waste are discussed in Section 2C.1.2. Descriptions of SST surveillance equipment and procedures are provided in Section 2C.1.3, while activities planned to upgrade the surveillance system are discussed in Section 2C.1.4.

2C.1.1 INTERIM STABILIZATION

2C.1.1.1 Background, Definition, and Criteria

The waste contained in SSTs exists in two phases: (1) solid waste mostly in the form of sludge and/or salt cake with interstitial liquids contained within their pores and (2) a freestanding liquid layer called the supernate. Interim stabilization refers to the removal and transfer of pumpable liquids (i.e., the supernate plus the amount of interstitial liquid capable of being pumped) from SSTs to DSTs. A tank is considered interim stabilized if it contains less than 50,000 gallons (189,500 liters) of drainable interstitial liquids and less than 5,000 gallons (18,950 liters) of supernate (Hanlon 1994). Interim stabilization is achieved by (1) jet pumping interstitial liquids until a flow rate of 0.05 gallons (0.1895 liters) per minute is reached, (2) pumping the supernate, or (3) declaring the SST administratively stabilized if the stabilization criteria are met. Because the SSTs have exceeded their original design life, interim stabilization represents a proactive approach to minimize the potential of waste leakage from tanks whose structural integrity have been, or are likely to be, compromised before all waste (i.e., both solids and liquids) has been removed from these tanks.

The interim stabilization program for Hanford Site SSTs began with the pumping of BY-107 tank. Tanks A-104, BX-101, and SX-115 were the first SSTs to be declared interim stabilized (September 1978). Table 2C-1 lists the completion dates and stabilization method for each of the interim stabilized SSTs. As of May 1994, 106 out of 149 SSTs have been classified as being interim stabilized. Among the interim stabilized SSTs, six (B-104, B-110, B-111, T-102, T-112, and U-110 tanks) do not meet the current supernate and interstitial liquid volume criteria to be considered interim stabilized (Hanlon 1994).

2C.1.1.2 Planned Interim Stabilization Activities

Tri-Party Agreement milestones have been established for the attainment of interim stabilization status for the 43 remaining SSTs (Ecology et al. 1994). The scheduled start and completion dates for stabilization of noninterim stabilized SSTs are listed in Figure 2C-1. However, unforeseen events such as a tank leak may mandate emergency pumping of the tanks involved, resulting in the diversion of resources from scheduled stabilization activities and delaying the attainment of certain Tri-Party Agreement interim stabilization milestones. Single-shell tank stabilization activities planned to be pursued in fiscal year 1995 include the following:

- Resolving all review comments on safety assessment pertaining to interim stabilization of nonstabilized watchlist SSTs; the final approved report will be submitted to the regulators (EPA and Ecology) by December 31, 1994

- Completing interim stabilization of BY-102, BY-109, C-102, C-107, and C-110 tanks (Tri-Party Agreement Milestones M-41-01-T1 and M-41-01-T3)

- Completing 'S' farm interim stabilization preparation:

  - Provide DOE-RL with a milestone for the partial completion of field preparations to pump S-101, S-103, S-106, S-108, S-109, and S-110 tanks to support the associated Tri-Party Agreement milestone for these tanks (M-41-09).

  - Complete preparations for stabilizing the aforementioned S farm tanks as dictated by Tri-Party Agreement Milestone M-41-09 by September 30, 1995, and notify DOE-RL.

- Monitoring flammable gas watchlist SSTs:

  - Determine all flammable gas tanks to be monitored.

  - Install the required monitoring equipment.

  - Commence monitoring and continue monitoring through the fiscal year or until sufficient information is available to resolve safety issues associated with flammable gas watchlist SSTs.

- Monitoring organic watchlist SSTs:
  - Determine all organic watchlist tanks to be monitored.
  - Install the required monitoring equipment.
  - Commence monitoring and continue monitoring through the fiscal year or until sufficient information is available to resolve safety issues associated with organic watchlist SSTs.
- Completing 241-U Tank Farm field preparations:
  - Completing all required field preparations and safety assessments to begin pumping U-102, U-106, U-107, and U-111 tanks by July 31, 1995 (Tri-Party Agreement Milestones M-41-08 and M-41-13)
  - Issue resource-loaded schedule for repairs required to begin stabilization of U-103, U-105, U-108, and U-109 tanks (Tri-Party Agreement Milestone M-41-11 requires pumping of these tanks to begin by April 30, 1996).
  - Provide DOE-RL with a milestone for the partial completion of field preparations required to pump these tanks during fiscal year 1995.
  - Complete preparations for stabilizing the aforementioned U Tank Farm tanks (as required by Tri-Party Agreement Milestone M-41-11) by April 30, 1996, and notify DOE-RL.
- Conducting 241-A Tank Farm field preparations:
  - Issue resource-loaded schedule for repairs required to commence the stabilization of A-101 tank (Tri-Party Agreement Milestone M-41-10 requires pumping of this tank to begin by April 30, 1996).
  - Provide DOE-RL with a milestone for the partial completion of field preparations required to pump A-101 tank.
  - Complete preparations for stabilizing A-101 tank (as required by Tri-Party Agreement Milestone M-41-10) by April 30, 1996, and notify DOE-RL.
- Conducting 241-AX Tank Farm field preparations:
  - Issue resource-loaded schedule for repairs required to commence the stabilization of AX-101 tank (Tri-Party Agreement Milestone M-41-10 requires pumping of this tank to begin by April 30, 1996).
  - Provide DOE-RL with a milestone for the partial completion of field preparations required to pump AX-101 tank.

- Complete preparations for stabilizing AX-101 tank (as required by Tri-Party Agreement Milestone M-41-10) by April 30, 1996, and notify DOE-RL.

- Completing pumping of T-111 tank by March 31, 1995, and notify DOE-RL (Tri-Party Agreement Milestone M-41-16A-T01)

- Completing intrusion prevention of two SSTs by September 30, 1995

- Preparing recommendations on pumping methods to be used to stabilize nonstandard tanks (e.g., sludge tanks such as T-111 tank). The recommendations will be used to determine if an alternate style of salt well pumping could be employed to pump these tanks more efficiently

- Preparing appropriate documentation for the EPA and Ecology to reach consensus over the use of repaired existing SST transfer lines for interim stabilization pumping.

2C.1.1.3 Safety Concerns Associated with Tank Waste Stabilization Activities

Before the pumping of SSTs can be authorized, potential hazards associated with the removal of liquid waste from the concerned tanks must be addressed and their resolution documented. An unresolved safety question (USQ) analysis is performed to determine if a USQ exists, or will be created during the installation of pumping equipment and subsequent pumping operations. Because the physiochemical properties of waste varies from tank to tank, the identification of safety issues and their resolution process also varies with each tank. Issues identified for each of the SSTs that have already been interim stabilized, and the processes adopted to resolve these issues, is documented in each tank's stabilization authorization documents. A general description of the safety issues and resolution strategies for watchlist SSTs can be found in the *Status Report on Resolution of Waste Safety Issues at the Hanford Site* (Reep 1993). In general, the following are some of the safety concerns frequently addressed before the beginning stabilization activities for SSTs:

- Reduction in moisture content of waste following liquid removal

- Increase in dome loading, potential for riser damage, and other pump installation risk

- Explosive gas accumulation in tank

- Spray leaks and hydrogen accumulation in double-contained receiver tanks (DCRT)

- Waste stability following a mistransfer

- Leakage or breakage of waste transfer lines
- Equipment fires in SST or DCRT
- Temperature increase and development of hot spots in sludge following liquid removal
- Stability of organics in sludge following liquid removal
- Liquid organic layering in sludge
- Hydrogen accumulation in pumping equipment
- Ignition sources for flammable gases
- Submersible pump overheat
- Spill to ground from overground transfer lines
- Changes in neutron moderation resulting from pumping liquid out of SST.

2C.1.2 EMERGENCY PUMPING OPERATION

Emergency pumping is defined as the pumping of a tank's liquid waste on an accelerated schedule to minimize the loss of liquids to the environment caused by a tank leakage. Supernates are generally removed by submersible pumping, while interstitial liquids are removed by salt well jet pumping. The quickest way to emergency pump a tank is to use a submersible pump followed by a jet pump. The submersible pump [capable of pumping 10 to 30 gallons per minute (38 to 115 liters per minute) of supernate] quickly reduces the driving force behind the leak, thereby minimizing the impact of liquid leaking to the environment. The jet pump is capable of pumping between 0.05 to 4.0 gallons per minute (0.190 and 15 liters per minute) of interstitial liquids. Activities required to be performed to prepare a tank for emergency pumping, as well the equipment used to emergency pump an assumed leaker, are described in subsequent paragraphs. Operational activities associated with submersible pumping and jet pumping are listed in Wiggins (1994).

2C.1.2.1 Emergency Pumping Preparatory Activities

Once an SST is assumed to be leaking, a number of operational and safety issues need to be resolved and pertinent documents prepared before pumping can begin. A kick-off meeting is held to assign responsibilities for specific activities related to emergency pumping. An Operational Readiness Review Board is formed per WHC-CM-1-5 to determine the state of readiness to begin emergency pumping of the concerned tank. Watchlist tanks require special safety documentation and startup approval (possibly including approval of the

Secretary of the DOE) before pumping can proceed. Other activities that must be performed and issues that must be resolved before emergency pumping can begin include the following.

- Selection of a DST as the waste receiver tank: Emergency pumping of an SST requires that the SST waste be transferred to, and stored in, a DST. Appendix 2E lists the DST recommended by the *Single-Shell Tank Leak Emergency Pumping Guide* (Wiggins 1994) to serve as the receiver tank for each noninterim stabilized tank. The choice of a DST to receive liquid waste from a given SST depends on the following factors:

  - Waste compatibility--Waste samples will be collected from the assumed leaker as well as the DST being considered to receive the SST waste. The samples from the two tanks will be analyzed both individually and collectively (as a mixture) to determine if the waste belonging to the two tanks is compatible. Waste compatibility criteria have been established and are listed in Carothers (1991).

  - DST space availability--The DST space allocated for various specific waste types and the current waste inventory for DSTs is shown in Table 2C-2. The available DST space may be at a premium for certain SST waste types, and the impact of transferring waste to a particular DST (in terms of future stabilization activities for other non-interim stabilized SSTs) must be considered before beginning emergency pumping.

- Selection and field testing of a waste transfer route: The availability of pipelines, DCRTs, and other facilities used to transfer waste from the leaking SST to the receiver DST must be verified. Wiggins (1994) recommends a desired transfer route as well as an alternate route for transferring the liquid waste belonging to each of the noninterim stabilized SSTs. These routes are listed in Appendix 2E. Pressure tests and leak detection tests must be performed on the transfer line, and the integrity of the leak detection system for the entire transfer route must be verified. Utility services for the tanks (water, electricity, and air) as well as the condition of surveillance instrumentation must be checked before beginning emergency pumping.

- Impact on future waste retrieval and processing: The diversion of resources (e.g., the use of DST space and waste transfer lines) from other waste retrieval activities to perform emergency pumping on a leaking SST must be considered. Funding for emergency pumping may also need to be obtained by diverting funds from other previously scheduled stabilization activities. The diversion of resources and funding from other waste retrieval efforts to perform emergency pumping could lead to a delay in meeting Tri-Party Agreement milestone deadlines for the interim stabilization of other noninterim stabilized SSTs (Ecology et al. 1994).

- Hazard analysis: To determine if the proposed activities for emergency pumping can be performed within the constraints of the authorization basis documents, an USQ analysis must be performed. This analysis should address potential safety hazards associated with the removal of liquids from the concerned tanks (such as the ones identified in Section 2C.1.1.3).

2C.1.2.2 Emergency Pumping Equipment

Design details and description of emergency pumping equipment can be found in Wiggins (1994). In general, the following basic equipment is required to emergency pump SSTs, although additional special equipment may be required to pump a particular SST.

- Jet pump and jet pump jumper assemblies: The following features are part of the jet pump and jet pump jumper assembly:

  - Jet assembly with a foot valve mounted to the base of two pipes extending from the top of the well to near the bottom of the well casing inside the salt well screen (Figure 2C-2).

  - Centrifugal pump [assembled per drawing H-2-78320 (KEH 1994a)] to supply power fluid to the downhole jet assembly.

  - Jumpers [modified according to drawing H-2-78320 (KEH 1994a)] containing valves, piping, pressure, and limit switches (PS-1, PS-2, LS-1). The switches are connected to the emergency pumping relay and the instrumentation cabinet on the emergency trailer/skid. If activated, the switches will shut down jet pumping operations (Wiggins 1994).

  - Flush line.

  - Flowmeter.

- Submersible pump: The pump is fabricated according to drawing H-2-68521 (KEH 1991b). The pump may be assembled in any of the several forms that appear on the drawing, depending on the head requirements of the pump and whether a rigid pipe or a flexible hose is used (Wiggins 1994).

- Tractor-type emergency pumping trailer: This 45-foot (13.7 meters), tractor-type trailer [described by drawings H-2-82564, H-2-82557, and H-2-99136 (KEH 1991a, 1990, 1994b)] is equipped to service and store emergency pumping equipment, including: two jet pump and jet pump jumper assemblies; two submersible pumps and attached piping; a nonwheeled skid housing; a weight factor instrument enclosure, containing a power control station for pumps; a pump pit leak detection and associated instrumentation; and a rack holding over a

100 feet (30.5 meters) of overground double-contained piping (Wiggins 1994). The trailer possesses a roll-off roof to aid with the removal of equipment by cranes.

- Wheeled utility trailer: This trailer [described in drawings H-2-99136, H-2-99137, H-2-99139, and H-2-99142 (KEH 1994b, 1987b, 1987a, 1994c)] provides support services for both jet pumping and submersible pumping of waste tanks. The trailer houses a weight factor instrument enclosure with associated instrumentation, a 5-horsepower electric air compressor, electrical utility components, pump motor controls, and a reel holding 500 feet (152 meters) of power cord (Wiggins 1994). The trailer also contains instrumentation to monitor jet pumping operations. Instrumentation includes a flow totalizer, a strip chart recorder, and a jet pump shutdown alarm beacon and buzzer (Wiggins 1994). Both this trailer and the skid stored in the tractor-type trailer have undergone the operational readiness testings (on June 30, 1992) as described in the *Emergency Jet Pump Control Operability Test Procedure* document (Wiggins 1993).

2C.1.3 SINGLE-SHELL TANK SURVEILLANCE EQUIPMENT AND PROCEDURES

Surveillance instrumentation is installed in tanks to monitor vital tank parameters (e.g., waste surface levels, temperatures, vapor pressure). The monitoring of such parameters is critical to indicating any potential breach in the structural integrity of the SSTs or any change in the physicochemical properties of the waste. Surveillance instruments are used to determine if the process parameters of concern fall within the operating ranges specified in safety documents such as Operational Safety Requirements (OSR) and Safety Analysis Reports. The following sections discuss SST surveillance instrumentation and monitoring procedures.

2C.1.3.1 Waste Level Measurement

Level monitoring criteria have been have established for each SST by the Tank Farm Surveillance, Analysis, and Support (TFSA&S). These criteria generally relate to both decreases and increases in waste levels (except in the case of interim stabilized SSTs, which only have level increase criteria to detect liquid intrusion). Criteria also exist for the minimum monitoring frequency. The *Waste Storage Tank Status and Leak Detection Criteria* document (Schofield 1993) lists the liquid level increase and decrease criteria and the minimum monitoring frequency requirements for each SST.

One or more of the following devices are used to measure waste surface levels of SSTs:

- Food Instrument Company (FIC) gauge
- Manual tape
- Zip cord
- ENRAF ATG gauge.

All SSTs either have a FIC gauge or a manual tape (with the exception of T-101 and S-108 tanks, which have both). Tank T-101 also has a zip cord (Hanlon 1994).

2C.1.3.1.1 Food Instrument Company Gauges. Level gauges manufactured by FIC are used to measure liquid level surfaces in SSTs. A drawing of a FIC gauge is shown in Figure 2C-3. The FIC gauge uses an electric motor to raise and lower a plummet or probe tip on the end of a tape. When the plummet contacts the liquid surface, an electrical circuit to ground is completed, thus determining the liquid level. The FIC gauge operates in both manual and automatic modes. In the automatic mode, the gauge breaks and reestablishes contact with the liquid surface every 60 seconds, and the output of the gauge is directly transmitted to the Computer Automated Surveillance System (CASS). All SST FIC gauges are connected to CASS, with the exception of BX-106 tank (Hanlon 1994). The BX-106 tank FIC gauge operates in the manual mode. A 0.5-inch (1.27-centimeter) line from an instrument air header provides a continuous purge of the FIC housing in the primary tank. This purging is done to minimize containment vapor condensation on tape take-up components and sprocket wheels. Although the FIC gauges were originally installed to indicate leak detection, the gauges within certain stabilized tanks (the bulk of whose waste is solid) have been modified to detect liquid intrusion.

2C.1.3.1.2 Manual Tape. A manual tape serves as a backup for the FIC to measure waste levels. This assembly is typically mounted on top of a riser using a 3-foot- (0.91-meter-) long spool piece. The manual tape is a steel measuring tape with a plummet or probe tip attached to one end of the tape. The other end is attached to a reel using a screw through the tape. The tape is inserted through the hole in the riser flange. Containment at the tape riser/tape reel interface is provided by a set of neoprene gasket seals among which the tape slides. A manual crank is used to lower or raise the plummet attached at the end of the tape. A portable ammeter connected to the tape and ground (i.e., riser flange) is used to determine the completion of an electrical circuit to ground. The plummet is lowered until an electrical circuit is completed (indicated by an initial positive deflection of the ammeter needle), and the liquid level at the point of contact is read manually from the tape housing. A 0.5-inch (1.27-centimeter) line from an instrument air header provides a continuous purge of the level indicator housing into the primary tank. A zip cord is sometimes used to measure waste surface levels.

2C.1.3.1.3 Zip Cord. A zip cord is used to measure waste levels in SSTs to support the level measurements made by FIC gauges and manual tapes. The zip cord consists of a measured length of electrical cord connected to a metal plummet or a donut-shaped weight, and is manually lowered down a tank observation port riser. The upper end of the zip cord is graduated in inches and is referenced to the tank riser. The waste level is estimated by calculating the length of the zip cord (i.e., the distance between its upper and lower ends) when its lower end makes contact with the tank waste. Contact with the tank's liquid waste is indicated by a rise in an attached ohmmeter's reading (caused by the completion of an electrical circuit between the zip cord and ground). The zip cord is capable of measuring waste level in SSTs with an accuracy of approximately 0.5 inch (1.27 centimeters).

2C.1.3.1.4 ENRAF 854 ATG Gauge. The Enraf-Nonius Model 854 Advanced Technology Gauge (ENRAF) is the latest addition to the SST level measuring system. The ENRAF gauge is a displacer-type automatic device that is part of an integrated hardware/software system designed to manage tank farm inventory. The gauge displacer utilizes a high precision servo motor and cabling system capable of measuring liquid level changes to accuracies exceeding ±0.1 inch. ENRAF gauges are intrinsically safe, and are capable of recalibrating themselves to partially compensate for any solid buildup and precipitation on the displacer element. Due to the heterogenous nature of a tank's waste, the level measurement taken by the gauge depends upon gauge positioning (i.e., the position at which the gauge is lowered into the tank). Although the primary function of the ENRAF gauge is to measure liquid levels, it is also capable of detecting gas/liquid interfaces, and to a limited extent (i.e., for density changes of up to ±0.1 grams/cc) liquid/liquid and liquid/solid interfaces. Fifteen SSTs are scheduled to receive the ENRAF gauges in fiscal year 1994 or the first quarter of fiscal year 1995 (Table 2C-3).

2C.1.3.2 Interstitial Liquid Level Measurement

The interstitial liquid level of SSTs is measured by Liquid Observation Wells (LOW). The LOW measurements can indicate both increases and decreases in interstitial liquid levels, thus making them the primary instrumentation for both leak detection and intrusion detection in SSTs. The LOWs are constructed of fiberglass, steel, or TEFZEL[1]-reinforced epoxy-polyester resin (Hanlon 1994). LOWs have a nominal outer diameter of 3.5 inches (8.9 centimeters) with an inner diameter of 3 inches (7.6 centimeters). The LOWs are sized to extend within 1 inch (2.54 centimeters) of the bottom of the tank's steel liner. Three different types of probes (i.e., gamma, neutron, and acoustic probes) are lowered into the LOWs on a calibrated cabling system. The acoustic probes are no longer in use. The cabling system and associated electronics are mounted on a mobile van that can be driven from one LOW to another. The LOWs are installed in only 58 of the 149 SSTs; two of the LOWs are out of service (Hanlon 1994). Both the interstitial level increase and decrease criteria, as well as the monitoring frequencies for LOWs, are listed in *Waste Storage Tank Status and Leak Detection Criteria* (Schofield 1993).

2C.1.3.3 Temperature Monitoring

In-tank temperatures are monitored by one or more temperature probes [thermocouple (TC) trees] mounted on existing risers or LOWs. Some of the TC trees are connected to Tank Monitoring and Control System (TMACS) to generate automated continuous temperature readings; temperature readings from TC trees not connected to TMACS are read manually. The 105-A tank also has four TC laterals beneath it by which temperature readings are taken by 34 TCs (Hanlon 1994). Specific temperature reading requirements exist for high heat tanks and ferrocyanide watchlist tanks, and these criteria, along with

[1]TEFZEL is a trademark of E. I. duPont de Nemours & Company.

temperature monitoring frequencies and reporting requirements, are listed in *Waste Storage Tank Status and Leak Detection Criteria* (Schofield 1993). The temperature monitoring frequencies for all watchlist tanks are listed in Appendix 2D. All ferrocyanide watchlist SSTs connected to TMACS require continuous monitoring; those ferrocyanide watchlist SSTs not connected to TMACS require weekly manual monitoring (Hanlon 1994). Monitoring requirements for high heat load (greater than 40,000 British thermal units per hour) tanks are documented in the *Single-Shell Tank Isolation Safety Analysis Report* (Smith and Bergmann 1994) and Hanlon (1994). No requirements for temperature measurement have been established for nonwatchlist SSTs (Bigsbee and Bouchey 1993).

2C.1.3.4 Drywells

Drywells are designed to detect leaks and characterize radiological contamination of the subsoil surrounding SSTs. These 'dry' wells (which do not penetrate the water table) are vertical boreholes with 6-inch-internal-diameter carbon steel casings positioned radially around SSTs. The wells range from 50 to 250 feet (15.2 to 76.2 meters) in depth and are monitored between the range of 50 and 150 feet (15.2 to 45.7 meters) by gross gamma and spectral gamma logging systems and neutron sensors (Hanlon 1994). The gamma and neutron sensors scan for radiation or moisture as a function of well depth to detect potential leakage of tank waste into the surrounding soil. The cabling system and electronics associated with the sensors are mounted on mobile vans that can be driven from one drywell to another. At present, both the drywells and the LOWs are served by the same vans, although LOW vans and spectral gamma ray vans are currently being procured to serve LOWs and drywells separately. Drywells are covered when not in use. The drywell monitoring schedules are listed in the *Waste Storage Tank Status and Leak Detection Criteria* document (Schofield 1993).

2C.1.3.5 Laterals

Laterals are horizontal drywells located under SSTs to detect radionuclides in soil that could indicate tank leakage. The laterals are steel pipes with an inner diameter of 4 inches (10.2 centimeters) located 8 to 10 feet (2.4 to 3.05 meters) below the tank's concrete base (Hanlon 1994). These laterals are monitored by radiation detection probes. Only certain tanks within the A and SX Tank Farms (all A Tank Farm SSTs and 107-SX through 112-SX, 114-SX, and 115-SX tanks) have laterals, with three laterals being dedicated to each tank. The lateral monitoring schedules are listed in the *Waste Storage Tank Status and Leak Detection Criteria* (Schofield 1993).

2C.1.3.6 In-Tank Photography

In-tank photographs are taken in SSTs to verify the structural integrity of the tanks and to estimate sludge and liquid waste levels and compositions by visual examination. The still photography system consists of a camera and a flash unit mounted in a metal frame. A flexible hose containing wiring

leading up to the camera and the flash unit suspends the photography system in the tank. A portable generator located on the surface of the ground above the tank supplies power to the flash unit. The camera and riser unit are lowered down a riser. Their levels are controlled by an adjustable safety stop located at the top of the riser. The riser is lined with a disposable plastic sleeve to minimize contamination of the camera system. Only cameras meeting National Electric Code (NEC), Class 1, Division 1, Group B, requirements have been authorized for use in flammable watchlist SSTs.

2C.1.4 PLANNED SURVEILLANCE INSTRUMENTATION UPGRADE

Many of the instruments used to monitor SSTs are currently out of service, have experienced frequent failures, or have exceeded their design life. Frequent repairs of out-of-service instrumentation, the inability of instrumentation to operate in compliance with current regulatory requirements, and a need to automate most instrumentation systems have spurred a major effort to upgrade SST surveillance instrumentation under the auspices of Project W314A. Common operational problems associated with surveillance instrumentation as well as activities currently being undertaken to enhance SST monitoring capabilities are discussed in the following sections.

2C.1.4.1 Level Monitoring Upgrade Strategy and Status

The FIC gauge and manual tapes were only designed to sense conductive liquids, and, like most conductivity-based gauges, these gauges are subject to corrosion. In addition, the constant lowering and raising of the plummet to take level readings results in mechanical wear of the gauges, necessitating frequent repairs. Components of the FIC gauges facing occasional servicing and maintenance problems and/or needing replacement include rotameters, motors, bob switches, and the sight glass. The current strategy for upgrading level monitoring in SSTs was outlined in Scaief (1994) as follows.

For interim stabilized and nonstabilized SSTs with surface liquids, a new level monitoring device will be installed and connected to TMACS.

For interim stabilized and nonstabilized SSTs without surface liquids, a device to detect liquid intrusion will be installed, and LOWs will be installed in those tanks that currently do not have them.

A number of alternate level measuring gauges are currently being tested on site to determine the best candidate to replace and/or supplement the existing level instrumentation. Level measuring technologies that are currently being examined include conductivity, radar, buoyancy/tension wire, and optical/laser. Two radar level gauges (CannonBear gauge manufactured by TN Technologies and the BM-70 gauge manufactured by Krohne) were tested by Pacific Northwest Laboratory (PNL) and Westinghouse Hanford (Scaief 1994). However, test results indicated that neither unit was suitable to measure waste levels in SSTs. Another radar gauge, the ENRAF Series 872 radar gauge was installed in tank SY-101 (a DST) in fiscal year 1991. Discrepancies in level readings taken by the radar gauge and the conductivity gauge (FIC gauge)

have raised concerns regarding the use of radar gauges in the Hanford Site waste storage tanks. Consequently, plans to install additional ENRAF radar gauges in SSTs are on hold (Scaief 1994). Tests have indicated the ENRAF level gauge (a buoyancy/tension wire-type gauge) to be the best candidate currently available to replace the FIC gauges (see Section 2C.1.3.1.4). ENRAF-Nonius Model 854 Advanced Technology Gauge level gauges have been, or are scheduled to be installed in 15 SSTs during fiscal year 1994 and the first quarter of fiscal year 1995 (Table 2C-3).

2C.1.4.2 Temperature Monitoring Upgrade Status

As reported in Hanlon (1994), many of the existing TC trees in SSTs are out of service (i.e., the trees have been cut off or are otherwise unable to function). The temperature monitoring upgrade is based on the following minimum criteria (Scaief 1994).

- For watchlist SSTs:
  - Install one tree with at least two operable TCs in the waste and one operable TC in the vapor space.
  - The previously mentioned TCs will be replaceable (i.e., the entire tree need not be removed/replaced should a certain TC fail and require replacement).
- For nonwatchlist SSTs:
  - Install one tree with at least one operable TC in the waste and one operable TC in the vapor space.

Temperature measuring capability is being improved by reconnecting and repairing existing temperature devices whenever possible, installing new TC trees and multifunctional instrument trees (MIT), and connecting existing and newly installed trees to TMACS. The TCs or MITs were installed or are scheduled to be installed in the following ferrocyanide and organic watchlist tanks during fiscal years 1992, 1993, 1994 and the first quarter of 1995:

- Fiscal year 1992: BY-104, BY-110, C-109, C-112 (ferrocyanide watchlist tanks).
- Fiscal year 1993: BY-101, BY-111, BY-112, BX-106, C-108 (ferrocyanide watchlist SSTs), and TX-118 (present on both the ferrocyanide and organic watchlist).
- Fiscal year 1994 and first quarter of 1995: BY-103, BY-107, BY-108, T-107, C-111, TY-101, TY-103, TY-104 (ferrocyanide watchlist SSTs), and B-103, U-106, U-107, U-111 (organic watchlist SSTs).

In addition, MITs will be installed in hydrogen/flammable gas watchlist SSTs during fiscal year 1995 through fiscal year 1998 (Scaief 1994).

TC trees are being repaired in one of the following ways (Scaief 1994):

- Recovering the abandoned tree when possible, and repairing it
- Reconnecting the wires that have been disconnected from local selector boxes or from the central readout station
- Using the iron pipe of the probe as a replacement for failed positive (iron) TC wires. Iron pipes have been determined by tests to be adequate substitutes for iron TC wires.

Additionally, new TC trees and MITs are being considered for installation in SSTs. The new TC trees are being designed from existing designs with required modifications (e.g., the changing of temperature sensors from type J to type K TCs). The TC tree designs include provisions for an instrument enclosure to be added to the tree head (to terminate the TCs) and contain tank-specific dimensional values and flange adaption (Scaief 1994). Future trees will use resistance temperature detectors (RTD) in place of type K TCs because RTDs have been determined to be more accurate and have a longer sensor lifetime (Scaief 1994).

The MITs are capable of measuring both temperature and vapor pressure. The MITs were designed and constructed by the Los Alamos National Laboratory (LANL) primarily for installation into 4-inch risers (with an ability to be adapted for use in 12-inch risers). The MITs may contain up to 24 TCs spaced vertically along the length of the tree. Gas sampling by MITs can be performed at three locations above the waste to determine the differential pressure (DP) between the tank and the atmosphere (Scaief 1994). A validation probe can also be inserted down the MIT assembly to verify the temperature in the tank at a given elevation. The decision on which type of tree (i.e., TC tree or MIT) to install in a particular tank depends on the pressure and temperature monitoring frequencies and requirements for that tank. In general, only one MIT is required for an SST. Watchlist tanks whose temperature and pressure require continuous monitoring per Public Law 101-510 (also known as the 'Wyden Bill') are good candidates for MITs (Scaief 1994).

Work is underway to upgrade the temperature measuring capabilities of ferrocyanide watchlist tanks and connect their trees to TMACS. Information pertaining to the TC testing procedures and results from these tests for ferrocyanide watchlist tanks can be found in Scaief (1994). The TC trees in the hydrogen/flammable gas watchlist tanks and organic watchlist tanks will be inspected to determine if they need replacement.

2C.1.4.3 SST Leak Detection Capability Upgrade

The following activities were identified by Reep (1993) as undertaken to upgrade the leak detection capability for SSTs:

- Installation of LOWs in SSTs with pumpable liquids--LOWs are scheduled to be installed in 12 SSTs during fiscal year 1995, in 15 SSTs during fiscal year 1996, and in 15 SSTs during fiscal year 1997

- Procurement of four new LOW vans--four new LOW vans have been purchased to support the expanding LOW measurement program. These units are being fabricated and tested. The LOW vans will also support the drywell monitoring program until new spectral gamma drywell vans are procured. Acceptance and operational test procedures for these vans will be conducted in fiscal year 1995 before they are authorized for use on site

- Spectral Gamma-Ray Borehole Logging Project--initiated to implement a system that enhances the detection and characterization abilities of radiological contaminants in the soils surrounding the SSTs. The project consists of three phases, with the first two phases having already been completed. Phase 1 involved the preparation and planning required to procure a prototype surveillance truck and a computer surveillance system (to store and analyze the spectral gamma-ray baseline data gathered by the prototype truck). Phase 2 involved the actual procurement and fabrication of the prototype truck and the surveillance computer system. Phase 3 work (currently in progress, and scheduled to be completed by September 1998) will involve the procurement of surveillance trucks whose designs are going to be based on the prototype truck. Programs designed to employ both the prototype and the surveillance trucks to collect, store, and analyze spectral ray data will also be implemented during this phase. Neutron activation methods will be tested to identify nonradioactive pollutants, moisture flow and content, and those subsoil compositions that may serve as barriers or pathways to pollution migration.

2C.1.4.4 Vapor Space Monitoring Upgrade

The Standard Hydrogen Monitoring System (SHMS) was specifically designed to monitor hydrogen in waste tank atmosphere; the tank atmosphere may also contain nitrous oxide, ammonia, water vapor, carbon monoxide, and carbon dioxide. The SHMS will be installed in hydrogen/flammable gas watchlist SSTs during fiscal years 1995 and 1996 (Scaief 1994). The SHMS consists of hydrogen-specific monitors, a grab sampler to identify other gaseous constituents, and a gas sampling system (comprising tubes, valves, and vacuum pumps) to support instrumentation operation. The SHMS will be located in an environmentally controlled cabinet for installation local to the tank and will be connected to the data acquisition system.

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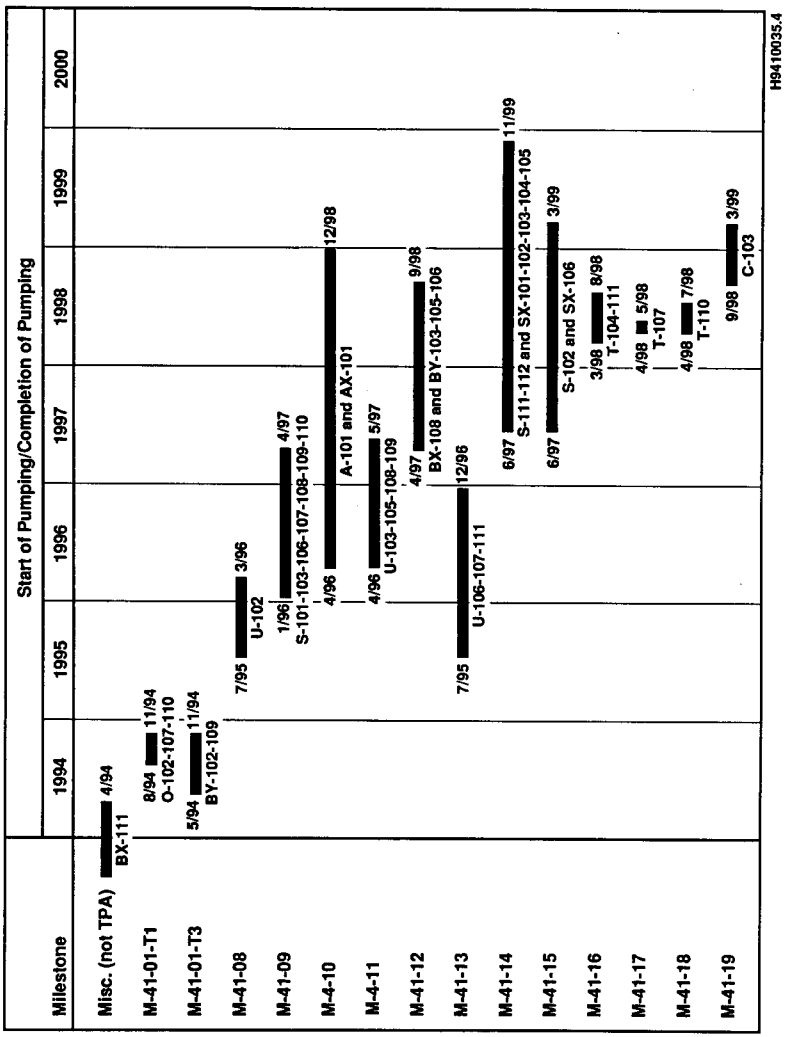

Figure 2C-1. Tri-Party Agreement Single-Shell Tank Stabilization Schedule.

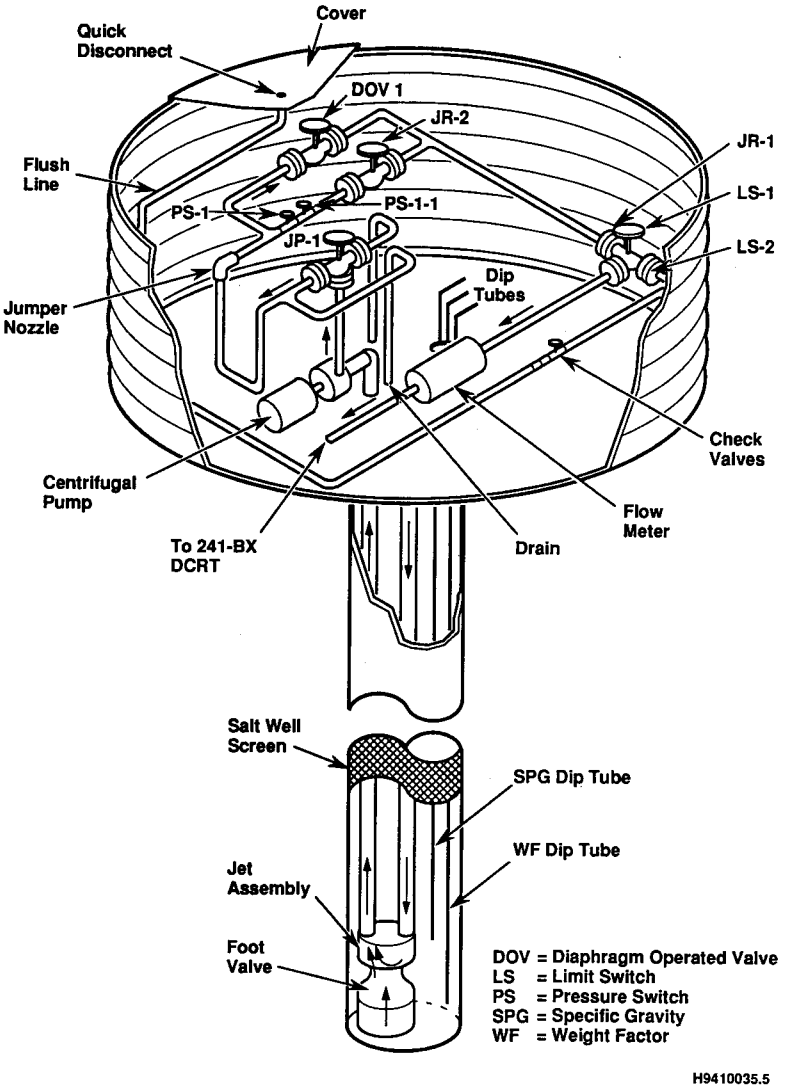

Figure 2C-2. Salt Well Jet Pump.

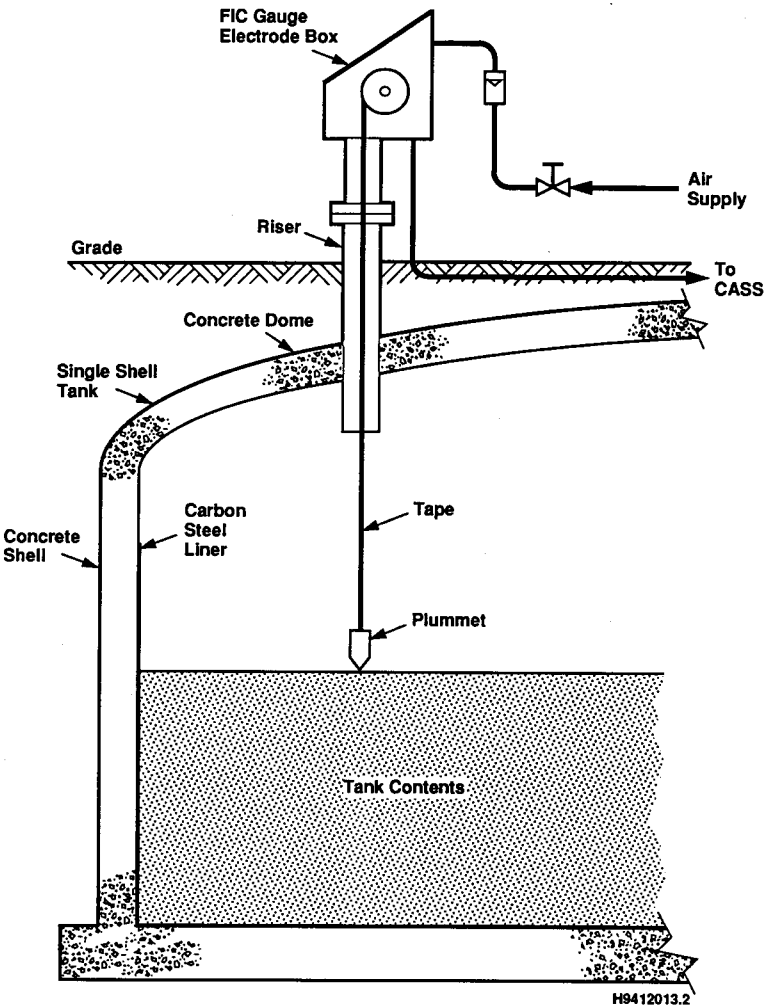

Figure 2C-3. Food Instrument Corporation Gauge.

960517.0800

Table 2C-1. Single-Shell Tanks Interim Stabilization Status (June 30, 1994). (sheet 1 of 3)

Tank number	Tank integrity	Interim stabilized date[1]	Stabilized method	Tank number	Tank integrity	Interim stabilized date[1]	Stabilized method	Tank number	Tank integrity	Interim stabilized date[1]	Stabilized method
A-101	Sound	N/A	--	C-101	ASMD LKR	11/83	AR	T-108	ASMD LKR	11/78	AR
A-102	Sound	08/89	SN	C-102	Sound	N/A	--	T-109	ASMD LKR	12/84	AR
A-103	ASMD LKR	06/88	AR	C-103	Sound	N/A	--	T-110	Sound	N/A	--
A-104	ASMD LKR	09/78	AR	C-104	Sound	09/89	SN	T-111	ASMD LKR	N/A	--
A-105	ASMD LKR	07/79	AR	C-105	Sound	N/A	--	T-112	Sound	03/81	AR[2,3]
A-106	Sound	08/82	AR	C-106	Sound	N/A	--	T-201	Sound	04/81	AR[2]
AX-101	Sound	N/A	--	C-107	Sound	N/A	--	T-202	Sound	08/81	AR
AX-102	ASMD LKR	09/88	SN	C-108	Sound	03/84	AR	T-203	Sound	04/81	AR
AX-103	Sound	08/87	AR	C-109	Sound	11/83	AR	T-204	Sound	08/81	AR
AX-104	ASMD LKR	08/81	AR	C-110	ASMD LKR	N/A	--	TX-101	Sound	02/84	AR
B-101	ASMD LKR	03/81	SN	C-111	ASMD LKR	03/84	SN	TX-102	Sound	04/83	JET
B-102	Sound	08/85	SN	C-112	Sound	09/90	AR	TX-103	Sound	08/83	JET
B-103	ASMD LKR	02/85	SN	C-201	ASMD LKR	03/82	AR	TX-104	Sound	09/79	SN
B-104	Sound	06/85	SN[2]	C-202	ASMD LKR	08/81	AR	TX-105	ASMD LKR	04/83	JET
B-105	ASMD LKR	12/84	AR	C-203	ASMD LKR	03/82	AR	TX-106	Sound	06/83	JET
B-106	Sound	03/85	SN	C-204	ASMD LKR	09/82	AR	TX-107	ASMD LKR	10/79	AR
B-107	ASMD LKR	03/85	SN	S-101	Sound	N/A	--	TX-108	Sound	03/83	JET
B-108	Sound	05/85	SN	S-102	Sound	N/A	--	TX-109	Sound	04/83	JET
B-109	Sound	04/85	SN	S-103	Sound	N/A	--	TX-110	ASMD LKR	04/83	JET
B-110	ASMD LKR	12/84	AR[2]	S-104	ASMD LKR	12/84	AR	TX-111	Sound	04/83	JET
B-111	ASMD LKR	06/85	SN[2]	S-105	Sound	09/88	JET	TX-112	Sound	04/83	JET

Table 2C-1. Single-Shell Tanks Interim Stabilization Status (June 30, 1994). (sheet 2 of 3)

	Tank number	Tank integrity	Interim stabilized date[1]	Stabilized method	Tank number	Tank integrity	Interim stabilized date[1]	Stabilized method	Tank number	Tank integrity	Interim stabilized date[1]	Stabilized method
1	B-112	ASMD LKR	05/85	SN	S-106	Sound	N/A	--	TX-113	ASMD LKR	04/83	JET
2	B-201	ASMD LKR	08/81	AR[3]	S-107	Sound	N/A	--	TX-114	ASMD LKR	04/83	JET
3	B-202	Sound	05/85	AR	S-108	Sound	N/A	--	TX-115	ASMD LKR	09/83	JET
4	B-203	ASMD LKR	06/84	AR	S-109	Sound	N/A	--	TX-116	ASMD LKR	04/83	JET
5	B-204	ASMD LKR	06/84	AR	S-110	Sound	N/A	--	TX-117	ASMD LKR	03/83	JET
6	BX-101	ASMD LKR	09/78	AR	S-111	Sound	N/A	--	TX-118	Sound	04/83	JET
7	BX-102	ASMD LKR	11/78	AR	S-112	Sound	N/A	--	TY-101	ASMD LKR	04/83	JET
8	BX-103	Sound	11/83	AR	SX-101	Sound	N/A	--	TY-102	Sound	09/79	AR
9	BX-104	Sound	09/89	SN	SX-102	Sound	N/A	--	TY-103	ASMD LKR	02/83	JET
10	BX-105	Sound	03/81	SN	SX-103	Sound	N/A	--	TY-104	ASMD LKR	11/83	AR
11	BX-106	Sound	N/A	--	SX-104	ASMD LKR	N/A	--	TY-105	ASMD LKR	02/83	JET
12	BX-107	Sound	09/90	JET	SX-105	Sound	N/A	--	TY-106	ASMD LKR	11/78	AR
13	BX-108	ASMD LKR	07/79	SN	SX-106	Sound	N/A	--	U-101	ASMD LKR	09/79	AR
14	BX-109	Sound	09/90	JET	SX-107	ASMD LKR	10/79	AR	U-102	Sound	N/A	--
15	BX-110	ASMD LKR	08/85	SN	SX-108	ASMD LKR	08/79	AR	U-103	Sound	N/A	--
16	BX-111	ASMD LKR	N/A	--	SX-109	ASMD LKR	05/81	AR	U-104	ASMD LKR	10/78	AR
17	BX-112	Sound	09/90	JET	SX-110	ASMD LKR	08/79	AR	U-105	Sound	N/A	--
18	BY-101	Sound	05/84	JET	SX-111	ASMD LKR	07/79	SN	U-106	Sound	N/A	--
19	BY-102	Sound	N/A	--	SX-112	ASMD LKR	07/79	AR	U-107	Sound	N/A	--
20	BY-103	ASMD LKR	N/A	--	SX-113	ASMD LKR	11/78	AR	U-108	Sound	N/A	--
21	BY-104	Sound	01/85	JET	SX-114	ASMD LKR	07/79	AR	U-109	Sound	N/A	--
22	BY-105	ASMD LKR	N/A	--	SX-115	ASMD LKR	09/78	AR	U-110	ASMD LKR	12/84	AR[2]

Table 2C-1. Single-Shell Tanks Interim Stabilization Status (June 30, 1994). (sheet 3 of 3)

	Tank number	Tank integrity	Interim stabilized date[1]	Stabilized method	Tank number	Tank integrity	Interim stabilized date[1]	Stabilized method	Tank number	Tank integrity	Interim stabilized date[1]	Stabilized method
1	BY-106	ASMD LKR	N/A	--	T-101	ASMD LKR	04/83	SN	U-111	Sound	N/A	--
2	BY-107	ASMD LKR	07/79	JET	T-102	Sound	03/81	AR[2,3]	U-112	ASMD LKR	09/79	AR
3	BY-108	ASMD LKR	02/85	JET	T-103	ASMD LKR	11/83	AR	U-201	Sound	08/79	AR
4	BY-109	Sound	N/A	--	T-104	Sound	N/A	--	U-202	Sound	08/79	SN
5	BY-110	Sound	01/85	JET	T-105	Sound	06/87	AR	U-203	Sound	08/79	AR
6	BY-111	Sound	01/85	JET	T-106	ASMD LKR	08/81	AR	U-204	Sound	08/79	SN
7	BY-112	Sound	06/84	JET	T-107	ASMD LKR	N/A	--				
8									Interim Stabilized Tanks			106
									Not Yet Interim Stabilized			43
									Total Single-Shell Tanks			149

[1]These dates indicate when the tanks were actually interim stabilized. In some cases, the official interim stabilization documents were issued at a later date.

[2]Tanks do not meet current established supernatant and interstitial liquid interim stabilization criteria, but did meet the criteria in existence when declared interim stabilized.

[3]Interim stabilization data are missing. Tanks were administratively interim stabilized.

AR = Administratively interim stabilized
ASMD LKR = Assumed leaker
JET = Salt well jet pumped to remove drainable interstitial liquid
N/A = Not yet interim stabilized
SN = Supernate pumped (Non-Jet pumped).

Table 2C-2. Double-Shell Tank Waste Type and Space Allocation (May 1994).

Double-shell tank inventory by waste type		Space designated for specific use	
Complexed waste (102-AN, 107-AN, 101-SY, 103-SY) 101-AY (DC)	4.88 Mgal	Spare tanks[3] (1 aging and 1 non-aging waste tank)	2.28 Mgal
Concentrated phosphate waste (102-AP, 106-AN)	1.12 Mgal	Segregated tank space (102-AP, 105-AP, 101-AY, 102-AN, 107-AN)	0.60 Mgal
Double-shell slurry (DSS) and slurry feed (103-AN, 104-AN, 105-AN, 105-AP, 101-AW)	5.08 Mgal	Watchlist tank space (103-AN, 104-AN, 105-AN, 101-SY, 103-SY, 101-AW)	0.73 Mgal
Aging waste (NCAW) at 5M Na Dilute in Aging tanks (101-AZ, 102-AZ)	1.23 Mgal 0.71 Mgal	Priority/operational tank space[2] (101-AW, 102-SY, 102-AW, 106-AW)	1.87 Mgal
Dilute waste[1] (101-AW, 101-AP, 103-AP, 106-AP, 107-AP, 108-AP, 102-AW, 104-AW, 105-AW, 106-AW, 102-AY, 102-SY, 104-AP)	9.2 Mgal	Miscellaneous head space	0.17 Mgal
NCRW, PFP and settled solids (103-AW, 105-AW, 102-SY, 102-AW, 104-AW, 106-AW, 102-AY)	1.52 Mgal	Total specific use space (06/30/94)	5.65 Mgal
Total Inventory =	23.74 Mgal	Total double-shell tank space	
		24 Tanks at 1,140 Kgal 4 Tanks at 980 Kgal	27.36 Mgal 3.92 Mgal 31.28 Mgal
		Total available space Double-shell tank inventory Space designated for specific use Remaining unallocated space	31.28 Mgal 23.74 Mgal 5.65 Mgal 1.89 Mgal

Note: Net change in total inventory since last month: -1.380 Mgal.

[1]Was reduced in volume by -1.397 Mgal this month (Evaporator Waste Volume Reduction).
[2]Reduced by Salt Well Liquid pumping, and PFP operations.
[3]241-101-AY: A minimum liquid level is set to provide extra protection against any bottom uplifting of the tank's steel liner. Schofield (1993) specifies 64 inches as the minimum surface level measurement when the annulus system is in operation, and 18 inches if the annulus ventilation system is shut down. See also OSD-T-151-0007, Unclassified Operation Specifications for the 241AN, 241AP, 241AW, 241AY and 241SY Tank Farms (OSD 1992). Because of space availability, waste is stored in 102-AY, the aging waste spare tank. In case of a leak, the contents of 102-AY will be distributed to any other double-shell tank(s) having available space. Tank 104-AP has been designated as the non-aging spare tank.

DC = dilute complexed
Kgal = thousand gallons
Mgal = million gallons
NCAW = neutralized current acid waste
NCRW = neutralized cladding removal waste
PFP = Plutonium Finishing Plant.
Mgal = 3.79 Mliters

Table 2C-3. Single-Shell Tanks Scheduled to Receive ENRAF ATG Gauges* in Fiscal Year 1994 and First Quarter of Fiscal Year 1995.

Tank	Status**	Safety concern	Tank	Status**	Safety concern
S-111	X	Hydrogen	SX-106	X	Hydrogen/organic
BX-106	X	FeCN	T-111		None
C-103	X	Organic	U-103	X	Hydrogen
C-106		High heat	U-105	X	Hydrogen
S-103	X	None	U-106	X	Organic
S-106	X	None	U-107	X	Organic
S-107	X	None	U-109	X	Hydrogen
T-107	X	FeCN	--		--

*Enraf-Nonius Model 854 Advanced Technology Gauge.
**If checked, gauge has been installed.

APPENDIX 2D

TEMPERATURE MONITORING SCHEDULES FOR WATCHLIST SINGLE-SHELL TANKS

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APPENDIX 2D

TEMPERATURE MONITORING SCHEDULES FOR WATCHLIST SINGLE-SHELL TANKS

Appendix 2D lists the temperature monitoring frequencies for SSTs on the hydrogen/flammable gas, organic, ferrocyanide, and high heat load watchlists. The temperature probe number and type, baseline temperature, and the maximum temperature criteria for each tank are also given. The source for the information is Schofield (1993).

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Temperature Monitoring Schedule

HIGH HEAT LOAD TANKS

Tank No.	Monitoring Frequency	Probe No.	Baseline Temperature (F.)	Max Temp Criteria (F.)	Instrument Type
104-A	Weekly	R-12	184	300	J
		R-18	185	300	
105-A	Weekly	R-09	109	300	E
		R-15	110	300	
		R-16	115	300	
		R-17	109	300	
		R-19	111	300	
		R-22	109	300	
105-A Laterals (3)	Weekly	34 TCs	217	300	J
105-C	Monthly	TC Tree	100	300	E
106-C (1)	Weekly	TC Tree	161	300	E
107-SX	Monthly	Tree #2	171	300	J
		Tree #8	166	300	
108-SX	Monthly	Tree #2	196	300	J
		Tree #8	198	300	
109-SX (2)	Weekly	Tree #2	148	300	J
		Tree #8	159	300	
110-SX	Monthly	Tree #2	173	300	J
		Tree #8	166	300	
111-SX	Monthly	Tree #2	191	300	J
		Tree #8	161	300	
112-SX	Monthly	Tree #2	153	300	J
		Tree #8	158	300	
114-SX	Monthly	Tree #2	187	300	J
		Tree #8	182	300	

11 Tanks

(1) Standard Operating Procedure requires temperature to be monitored in Riser 8.
(2) Flammable gas accumulation tanks vent through 109-SX.
(3) Active soil temperature laterals underneath the tank. Although lateral temperatures are not regulated by OSD or OSR/SAR, the same limits and reporting requirements are applied.

NOTE:
An OSD violation will be incurred if the above are not monitored at least every 38 days.
An OSR/SAR violation will be incurred if the above are not monitored at least every 45 days.
TC = Thermocouple

Temperature Monitoring Schedule

FERROCYANIDE TANKS

Tank No.	Monitoring Frequency	Baseline Temperature (F.)	Surveillance Alert 10 F. above baseline	Max Temp Criteria 18 F. above baseline	Instrument Type
102-BX	Weekly	64	74	82	J
106-BX	Weekly	64	74	82	J
110-BX	Weekly	65	75	83	J
111-BX	Weekly	69	79	87	J
101-BY	Weekly	74	84	82	J
103-BY	Weekly	80 (LOW) (1)	90	98	K
104-BY	Weekly	130	140	148	J
105-BY	Weekly	114	124	132	J
106-BY	Weekly	131	141	149	J
107-BY	Weekly	77	87	95	J
108-BY	Weekly	89	99	107	J
110-BY	Weekly	122	132	140	E
111-BY	Weekly	84 (LOW)	94	102	K
112-BY	Weekly	75 (LOW)	85	93	K
108-C	Weekly	73	83	91	J
109-C	Weekly	76	86	94	J
111-C	Weekly	71	81	89	J
112-C	Weekly	79	89	97	J
101-T	Weekly	69	79	87	J
107-T	Weekly	62	72	80	J
118-TX (2)	Weekly	74	84	92	J
101-TY	Weekly	65	75	83	J
103-TY	Weekly	63 (LOW)	73	81	K
104-TY	Weekly	63	73	81	J
24 Tanks					

(1) LOW - Temperatures taken in Liquid Observation Wells

(2) 118-TX also contains Organic Salts

NOTE: Any temperatures taken temporarily by Maintenance Engineering Services/Instrument Technicians while repairs are being made to thermocouples, may show some variation from the above (usually approximately +/- 10 degrees F.). Occurrence reporting would not apply.

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Temperature Monitoring Schedule

ORGANIC SALT TANKS

Tank No.	Monitoring Frequency	Baseline Temperature (F.)	Instrument Type
103-B	Weekly	62	J
103-C	Weekly	126	E
102-S (1)	Weekly	109	J
106-SX (1)	Weekly	109	K
105-TX	Weekly	102	J
118-TX (2)	Weekly	74	J
106-U	Weekly	84	J
107-U	Weekly	81	J
8 Tanks			

(1) These tanks also contain Hydrogen
(2) This tank also contains Ferrocyanide

Temperature Monitoring Schedule

HYDROGEN TANKS

Tank #	Monitoring Frequency	Baseline Temperature (F.)	Surveillance Alert 10 F. above baseline	Max Temp Criteria 35 F. above baseline	Instrument Type
101-A	Weekly	158	168	193	J
101-AX	Weekly	142	152	177	J
103-AX	Weekly	117	127	152	J
102-S (1)	Weekly	109	119	144	J
111-S	Weekly	95	105	130	J
112-S	Weekly	87	97	122	J
101-SX	Weekly	143	153	178	J
102-SX	Weekly	159	169	194	J
103-SX	Weekly	181	191	216	J
104-SX	Weekly	175	185	210	J
105-SX	Weekly	188	198	223	J
106-SX (1)	Weekly	109	119	144	K
109-SX (2)	Weekly	148 Tree 2	158	183	J
		159 Tree 8	169	194	J
110-T	Weekly	62	72	97	J
103-U	Weekly	90	100	125	J
105-U	Weekly	92	102	127	J
108-U	Weekly	90	100	125	J
109-U	Weekly	88	98	123	J
18 Tanks					

(1) These tanks also contain Organic Salts

(2) This tank is included because other SX flammable gas accumulation tanks vent through it.

NOTE: Five double-shell tanks also contain Hydrogen - these tanks are monitored by other surveillance procedures.

APPENDIX 2E

PROPOSED TRANSFER ROUTES FOR EMERGENCY PUMPING OF SINGLE-SHELL TANKS

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APPENDIX 2E

PROPOSED TRANSFER ROUTES FOR EMERGENCY PUMPING OF SINGLE-SHELL TANKS

Appendix 2E lists a preferred transfer route, an alternate route, and a receiver DST to be used during the emergency pumping of those SSTs that have not yet been interim stabilized. Jumper and nozzle connections as well the DCRTs to be used during waste transfer are also mentioned. The source for the information is Wiggins (1994).

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241-A TANK FARM

The 241-A Tank Farm consists of six 1,000,000 gallon tanks. Tanks A-102, A-103, A-104, A-105, and A-106 are declared interim stabilized. Tank A-101 has liquid that remains to be pumped.

Heat Trace details for the tank farm are set forth by H-2-69157.
Leak Detection details for the tank farm are set forth by H-2-71825.

A-101 *WATCH LIST TANK*

Route: Distributor pit 01H Riser 4 to Nozzle U-1 (SL-107)
SL-107 to A-A Valve Pit
SL-104 from A-A Valve Pit to A-B Valve Pit
SL-100 from A-B Valve Pit to AX-B Valve Pit
SN-247 from AX-B Valve Pit to AN-101 Pit 01E

Jumpers: Nozzle L-5 to Nozzle L-18 in A-A Pit (H-2-73765)
Nozzle R-18 to Nozzle R-9 in A-B Pit (H-2-73766)
Nozzle R-3 to Nozzle R-11A in AX-B Pit (H-2-73767)
Nozzle R-11A to Nozzle R-11 in AX-B Pit (H-2-73768)

Alt. Route:Pump Pit 01B Riser 21 to Nozzle U-2 (SN-207)
SN-207 to A-A Valve Pit
Flexible Jumper to Nozzle L-18 in A-A
Continue preferred route

Receiver DST:AN-101

Installation:Saltwell Screen in Riser 4
Obstruction: Saltwell Screen and P-10 Pump in Riser 13

Exhauster: Attach portable exhauster at Riser 10
(If Required)

241-AX TANK FARM

The 241-AX Tank Farm consists of four 1,000,000 gallon tanks. Tanks AX-102, AX-103, and AX-104 have been declared interim stabilized. Tank AX-101 has liquid that remains to be pumped.

Heat Trace details for the tank farm are set forth by H-2-69157.
Leak Detection details are set forth by H-2-71825.

AX-101 *WATCH LIST TANK*

Route: Distribution pit 01A Riser 5B to Nozzle A (SL-108)
SL-108 to AX-A Valve Pit
SL-110 from AX-A Valve Pit to AX-B Valve Pit
SN-247 from AX-B Valve Pit to AN-101 Pit 01E

Jumpers: Nozzle L-9 to Nozzle L-18 in AX-A Pit (H-2-73768)
Nozzle R-18 to Nozzle R-11A in AX-B Pit (H-2-73767)
Nozzle R-11A to Nozzle R-11 in AX-B Pit (H-2-73778)

Alt. Route:Pump pit 01B Riser 1B to Nozzle A (SN-208)
SN-208 to AX-A Valve Pit
Flexible jumper to nozzle L-18 in AX-B Pit
Continue with preferred route

Receiver DST:AN-101

Installation:Saltwell screen and P-10 pump in riser 5B
Obstruction: Sluicer in riser 1B

Exhauster: Attach portable exhauster at Riser 9D
(If Required)

241-B TANK FARM

The 241-B Tank Farm consists of twelve 500,000 gallon tanks. All twelve of the B farm tanks have been declared interim stabilized. Several of the tanks (B-104, B-107, B-110, and B-111) do not meet the present interim stabilization criteria and future pumping of these tanks is possible.

Heat Trace details for the tank farm are set forth in H-2-73612.

B-104

Route: Saltwell Pump Pit, Riser 9 to Nozzle A (SN-232)
SN-232 to SN-231
SN-231 to 244-BX DCRT (Connection F)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank B-107 Saltwell Pit
SN-233 to SN-231
Continue with preferred route

Receiver DST:AN-101

Installation:Saltwell Screen Installed
Obstruction: Jet Pump installed

Exhauster: Attach portable exhauster to Riser 2
(If Required)

B-107

Route: Saltwell Pump Pit, Riser 11 to Nozzle A (SN-233)
SN-233 to SN-231
SN-231 to 244-BX DCRT (Connection F)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank B-110 Saltwell Pit
SN-234 to SN-231
Continue with preferred route

Receiver DST:AN-101

Installation:Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 2
If Required)

B-110

Route: Saltwell Pump Pit, Riser 11 to Nozzle A (SN-234)
SN-234 to SN-231
SN-231 to 244-BX DCRT (Connection F)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank B-107 Saltwell Pit
SN-233 to SN-231
Continue with preferred route

Receiver DST:AN-101

Installation:Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 3
(If Required)

B-111

Route: Saltwell Pump Pit, Riser 13 to Nozzle A (SN-228)
SN-228 to SN-227
SN-227 to 244-BX DCRT (Connection G)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank B-108 Saltwell Pit
SN-227 to 244-BX DCRT (Connection G)

Receiver DST:AN-101

Installation:Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 3
(If Required)

241-BX TANK FARM

The 241-BX Tank Farm consists of twelve 500,000 gallon tanks. Tanks BX-101, BX-102, BX-103, BX-104, BX-105, BX-107, BX-108, BX-109, and BX-112, have been declared interim stabilized. Tanks BX-106, and BX-111 have liquid remaining to be pumped. Pumping of BX-111 was initiated in 1993, and will be completed in 1994.

Tank BX-110 did not meet the present interim stabilization requirements, and pumping of this tank was initiated in 1993; completion anticipated in 1994.

Heat Trace details for the tank farm are set forth in H-2-73612.

BX-106 *WATCH LIST TANK*

Route: Overland Transfer from BX-106 Riser 13 to Tank BX-109 Saltwell
Pit Nozzle A
SN-213 to SN-215
SN-215 to 244-BX DCRT (Connection A)

Jumpers: Pump Jumper Only

Alt. Route:Different Overland Transfer

Receiver DST:AN-101

Obstructions:No Saltwell Screen Installed: Heel Jet in Riser 13

Exhauster: Attach portable exhauster to Riser 2
(If Required)

BX-110

Route: Saltwell Pump Pit, Riser 13 to Nozzle A
SN-216 to 244-BX DCRT (Connection E)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank BX-107 Saltwell Pit
SN-217 to SN-216
SN-216 to 244-BX DCRT (Connection E)

Receiver DST:AN-101

Installation:Saltwell Screen and Jet-Pump in Riser 13.

Exhauster: Attach portable exhauster to Riser 3
(If Required)

BX-111

Route: Saltwell Pump Pit, Riser 13 to Nozzle A
SN-215 to 244-BX DCRT (Connection A)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank BX-112 Saltwell Pit
SN-214 to SN-215
SN-215 to 244-BX DCRT (Connection A)

Receiver DST:AN-101

Obstructions:Submersible pump in Riser 13
Installation:Saltwell Screen and Jet-Pump (2 sets of piping) installed in Riser 13

Exhauster: Attach portable exhauster to Riser 3
(If Required)

241-BY TANK FARM

The 241-BY Tank Farm consists of twelve 750,000 gallon tanks. Tanks BY-101, BY-104, BY-107, BY-108, BY-110, BY-111, and BY-112 have been declared interim stabilized. Tanks BY-103, BY-105, and BY-106 have liquid remaining to be pumped. BY-102, and BY-109 were partially jet pumped in FY 92; completion is planned during FY 1994.

Heat Trace details for the tank farm are set forth in H-2-73612.

BY-102

Route: Pump Pit 02A, Riser 7 to Nozzle A
SN-200 to 244-BX DCRT (Connection C)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank BY-105 Pump Pit 05A
SN-202 to SN-200
SN-200 to 244-BX DCRT (Connection C)

Receiver DST:AN-101

Obstructions:Jet Pump In Saltwell Screen
Installation:Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 4
(If Required)

BY-103 *WATCH LIST TANK*

Route: Pump Pit 03A, Riser 7 to Nozzle U-2
SN-201 to SN-200
SN-200 to 244-BX DCRT

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank BY-102 Pit 02A
SN-200 to 244-BX DCRT

Receiver DST:AN-101

Obstructions:Jet Pump In Saltwell Screen

BY-103 (continued)

Installation:Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 10B

(If Required)

BY-105 *WATCH LIST TANK*

Route: Pump Pit 05A, Riser 7 to Nozzle A
SN-202 to SN-200
SN-200 to 244-BX DCRT (Connection C)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank BY-106 Pit 06A
SN-203 to SN-200
SN-200 to 244-BX DCRT (Connection C)

Receiver DST:AN-101

Installation:Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 4
(If Required)

BY-106 *WATCH LIST TANK*

Route: Pump Pit 06A, Riser 7 to Nozzle A
SN-203 to SN-200
SN-200 to 244-BX DCRT (Connection C)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank BY-105 Pit 05A
SN-202 to SN-200
SN-200 to 244-BX DCRT (Connection C)

Receiver DST:AN-101

Installation:Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 4
(If Required)

BY-109

Route: Pump Pit 09A, Riser 6 to Nozzle A
SN-205 to SN-207
SN-207 to 244-BX DCRT (Connection D)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank BY-108 Pit 08A
SN-204 to SN-207
SN-207 to 244-BX DCRT (Connection D)

Receiver DST:AN-101

Installation:Saltwell Screen Installed, Jet Pump Installed

Exhauster: Attach portable exhauster to Riser 10B
(If Required)

241-C TANK FARM

The 241-C Tank Farm consists of twelve 500,000 gallon tanks. Tanks C-101, C-104, C-108, C-109, C-111, and C-112 have been declared interim stabilized. Tanks C-102, C-107, and C-110 have been partially jet-pumped in FY 1992; completion is planned for FY 1994. Tanks C-103, C-105, and C-106 have liquid remaining to be pumped.

C-102

Route: Pump Pit 02B, Riser 13 to Nozzle U3
SN-255 to C Valve Pit
SN-275 from C Valve Pit to Tank 244-CR-003

Jumpers: Nozzle L-1 to Nozzle U-1 in C Pit (H-2-73881)

Alt. Route:Overland Transfer to C Valve Pit (SN-275)
Continue preferred route

Receiver DST:AY-101

Installation:Saltwell Screen Installed, Jet Pump installed

Exhauster: Attach portable exhauster to Riser 8
(If Required)

C-103 *WATCH LIST TANK*

Route: Pump Pit 03B, Riser 13 to Nozzle U-6 (SN-250)
SN-250 to C Valve Pit
SN-275 from C Valve Pit to Tank 244-CR-003

Jumpers: Nozzle L-6 to Nozzle U-6 in C Pit (H-2-73881)

Alt. Route:Overland Transfer to C Valve Pit
Continue preferred route

Receiver DST:AY-101

Installation:Saltwell Screen Installed in Pump Pit

Exhauster: Attach portable exhauster to Riser 7
(If Required)

C-105 *HIGH HEAT (NOT IN WATCH LIST)*

Route: Pump Pit 05B, Riser 13 Overland Transfer to
C Valve Pit Nozzle L-3
SN-275 from C Valve Pit to Tank 244-CR-003

Jumpers: Nozzle L-1 to Nozzle U-1 in C Pit (H-2-73881)

Alt. Route:Overland Transfer to C-102 Pump Pit 02B Nozzle U-1
SN-255 to C Valve Pit
Continue preferred route

Receiver DST:AN-106

Installation:No Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 11
(If Required)

C-106 *WATCH LIST TANK*

Route: Pump Pit 06B, Riser 13 Overland Transfer to
C Valve Pit Nozzle L-3
SN-275 from C Valve Pit to Tank 244-CR-003

Jumpers: Nozzle L-1 to Nozzle U-1 in C Pit (H-2-73881)

Alt. Route:Overland Transfer to C-102 Pump Pit 02B Nozzle U-1
SN-255 to C Valve Pit
Continue preferred route
C-106 (continued)

Receiver DST:AN-106

Installation:No Saltwell Screen Installed

Exhauster: Permanently installed on this tank for routine ventilation

WHC is preparing a special leak response plan for this tank. Contact Process Engineering prior to any pumping plan preparation.

C-107

Route: Saltwell Pump Pit,Riser 13 to Nozzle U1
SN-253 to C Valve Pit
SN-275 from C Valve Pit to Tank 244-CR-003

Jumpers: Nozzle L-3 to Nozzle U-3 in C Pit (H-2-73881)

Alt. Route:Overland Transfer to C Valve Pit
Continue preferred route

Receiver DST:AY-101

Installation:Saltwell Screen Installed, Jet Pump installed

Exhauster: Attach portable exhauster to Riser 3
(If Required)

C-110

Route: Saltwell Pump Pit,Riser 13 to Nozzle U-1
SN-252 to C Valve Pit
SN-275 from C Valve Pit to Tank 244-CR-003

Jumpers: Nozzle L-4 to Nozzle U-4 in C Pit (H-2-73881)

Alt. Route:Overland Transfer to C Valve Pit
Continue preferred route

Receiver DST:AY-101 (Core Sampled in April, 1992)

Installation:Saltwell Screen Installed, Jet Pump installed

Exhauster: Attach portable exhauster to Riser 2
(If Required)

241-S TANK FARM

The 241-S Tank Farm consists of twelve 750,000 gallon tanks. Tanks S-104 and S-105 have been declared interim stabilized. All of the remaining tanks in S Farm have liquid that is to be pumped. For important information on transfer piping S-Farm, see WHC-SD-WM-ES-259, Single-Shell Tank Saltwell Transfer Piping Evaluation."

Heat Trace details for the tank farm are set forth in H-2-46159.

S-101

Route: Pump Pit 01A, Riser 5 to Nozzle B (SL-121)
SL-121 to S-B Valve Pit

Note:SN-216 from S-B Valve Pit to S-D Valve Pit failed Leak/
Pressure testing in 1992: overland transfer will be
necessary to reach S-D Valve-Pit

SN-246 from S-D Valve Pit to 244-S DCRT

Jumpers: Nozzle R-5 will connect to new line (To Be Determined TBD)
Nozzle (TBD) to Nozzle R-2 in S-D Pit (H-2-70606/1-A)

Alt. Route:Pump Pit 01A, Riser 5 to Nozzle A (SN-221)
SN-221 to S-B Valve Pit
Flexible Jumper to Nozzle TBD
Continue with new or overland route as above

Receiver DST:SY-102 (liquid sample data available)

Installation:Saltwell Screen in Riser 5

Exhauster: Attach portable exhauster to Riser 4 (if required)

S-102 *WATCH LIST TANK*

Route: Distribution Pit 02B, Riser 13 to Nozzle (SL-140)
SL-140 to S-A Valve Pit
SL-134 from S-A Valve Pit to S-B Valve Pit

Note:SN-216 from S-B Valve Pit to S-D Valve Pit failed Leak/
Pressure testing in 1992:overland transfer will be
necessary to reach S-D Valve-Pit

SN-246 from S-D Valve Pit to 244-S DCRT

S-102 (continued)

Jumpers: Nozzle L-5 to Nozzle L-18 in S-A Pit (H-2-73770)
Nozzle R-18 to Nozzle TBD in S-B Pit (H-2-73771/73774)
Nozzle TBD to Nozzle R-2 in S-D Pit (H-2-70606/1-A)

Alt. Route:Pump Pit 02A Riser R-8 to Nozzle G
SN-242 to S-A Valve Pit
Flexible jumper to Nozzle L-18 in S-A Pit
Continue with new or overland route above

Receiver DST:SY-102

Obstructions:Jet Pump in Riser 13
Installation:Saltwell Screen in Riser 13
No Saltwell Screen in Riser 8 (pump pit)

Exhauster: Attach portable exhauster to Riser 6
(If Required)

S-103
Route: Pump Pit 03A, Riser 5 to Nozzle B (SN-219)
SN-219 to S-A Valve Pit
SL-134 from S-A Valve Pit to S-B Valve Pit

Note:SN-216 from S-B Valve Pit to S-D Valve Pit failed Leak/ Pressure testing in 1992: overland transfer will be necessary to reach S-D Valve-Pit

SN-246 from S-D Valve Pit to 244-S DCRT

Jumpers: Nozzle L-7 to Nozzle L-18 in S-A Pit (H-2-73770)
Nozzle R-18 to Nozzle TBD in S-B Pit (H-2-73771/774)
Nozzle TBD to Nozzle R-2 in S-D Pit (H-2-70606/1-A)

Alt. Route:Overland from Pump Pit 03A, Riser 5 to S-A Valve Pit
(SL-119 failed a Leak/ Pressure test in 1992)
Flexible jumper to Nozzle L-18 in S-A Pit
Continue with new or overland route as above

Receiver DST:SY-102 (Liquid sample data available)

Installation:Saltwell Screen in Riser 5

Exhauster: Attach portable exhauster to Riser 7 (if required)

S-106

Route: Pump Pit 06A Riser 5 to Nozzle B (SL-120)
SL-120 to S-A Valve Pit
SL-134 from S-A Valve Pit to S-B Valve Pit

Note:SN-216 from S-B Valve Pit to S-D Valve Pit failed Leak/
Pressure testing in 1992: overland transfer will be
necessary to reach S-D Valve-Pit

SN-246 from S-D Valve Pit to 244-S DCRT

Jumpers: Nozzle L-9 to Nozzle L-18 in S-A Pit (Flexible)
Nozzle R-18 to Nozzle TBD in S-B Pit (H-2-73771/774)
Nozzle TBD to Nozzle R-2 in S-D Pit (H-2-70606/1-A)

Alt. Route:Pump Pit 06A Riser 5 to Nozzle A (SN-220)
SN-220 to S-A Valve Pit
Flexible jumper to Nozzle L-18 in S-A Pit
Continue with new or overland route as above

Receiver DST:SY-102 (Liquid sample data available)

Obstructions:Pump in Riser 5
Installation:Saltwell Screen in Riser 5

Exhauster: Attach portable exhauster to Riser 7
(If Required)

S-107

Route: Pump Pit 07A, Riser 5 to Nozzle B (2" Encasement)
1" SN-246 to (# 17) 244-S DCRT

Alternate
Route: Pump Pit 07A, Riser 5 to Nozzle A (3" SN-226)
SN-226 to S-D Valve Pit
SN-247 from S-D Valve Pit to 244-S DCRT
Jumpers: Nozzle R-14 to Nozzle R-2 in S-D Valve Pit (Flexible)
(for alternate route only)

Receiver DST:SY-102 (Liquid sample data available)

Installation:Saltwell Screen in Riser 5

Exhauster: Attach portable exhauster to Riser 7
(If Required)

S-108

Route: Pump Pit 08A, Riser 5 to Nozzle B (SL-124)
SL-124 to S-C Valve Pit
SL-135 from S-C Valve Pit to S-D Valve Pit
SN-245 from S-D Valve Pit to 244-S DCRT

Jumpers: Nozzle L-5 to Nozzle L-18 in S-C Pit (Flexible)
Nozzle R-18 to Nozzle R-2 in S-D Pit (H-2-70606/2-D)

Alt. Route:Pump Pit 08A, Riser 5 to Nozzle A (SN-224)
SN-224 to S-C Valve Pit
Flexible jumper to Nozzle L-18 in S-C Pit
Continue preferred route

Receiver DST:SY-102 (Liquid sample data available)

Installation:Saltwell Screen in Riser 5
Obstruction: Jet Pump in Riser 5

Exhauster: Attach portable exhauster to Riser 7
(If Required)

S-109

Route: Pump Pit 09A, Riser 5 to Nozzle B (SL-123)
SL-123 to S-C Valve Pit
SL-135 from S-C Valve Pit to S-D Valve Pit
SN-245 from S-D Valve Pit to 244-S DCRT

Jumpers: Nozzle L-7 to Nozzle L-18 in S-C Pit (Flexible)
Nozzle R-18 to Nozzle R-2 in S-D Pit (H-2-70606/2-D)

Alt. Route:Pump Pit 09A, Riser 5 to Nozzle A (SN-223)
SN-223 to S-C Valve Pit
Flexible jumper to Nozzle L-18 in S-C Pit
Continue preferred route

Receiver DST:SY-102 (Liquid sample data available)

Installation:Saltwell Screen in Riser 5
Obstruction: Jet Pump in Riser 5

Exhauster: Attach portable exhauster to Riser 7
(If Required)

S-110

Route: Pump Pit 10A, Riser 5 to Nozzle B (St-127)
SL-127 to S-D Valve Pit
SN-248 from S-D Valve Pit to 244-S DCRT

Jumpers: Nozzle R-7 to Nozzle R-2 in S-D Pit (H-2-70606/3-E)

Alt. Route:Pump Pit 10A, Riser 5 to Nozzle A (SN-227)
SN-227 to S-D Valve Pit
Flexible jumper to Nozzle R-2 in S-D Pit
Continue preferred route

Receiver DST:SY-102

Installation:Saltwell Screen in Riser 5
Obstruction: Jet Pump in Riser 5

Exhauster: Attach portable exhauster to Riser 7

S-111 *WATCH LIST TANK*

Route: Pump Pit 11A, Riser 5 to Nozzle A (SN-228)
SN-228 to S-D Valve Pit
SN-247 from S-D Valve Pit to 244-S DCRT

Jumpers: Nozzle R-16 to Nozzle R-2 in S-D Pit (H-2-70606/6-D)

Alt. Route:Pump Pit 11A, Riser 5 to Nozzle B (SL-128)
SL-128 to S-D Valve Pit
Flexible jumper to Nozzle R-2 in S-D Pit
Continue preferred route

Receiver DST:SY-102

Installation:Saltwell Screen in Riser 5
Obstruction: Jet Pump in Riser 5

Exhauster: Attach portable exhauster to Riser 8
(If Required)

S-112 *WATCH LIST TANK*

Route: Pump Pit 12A, Riser 5 to Nozzle B (SL-124)
SL-125 to S-C Valve Pit
SL-135 from S-C Valve Pit to S-D Valve Pit
SN-245 from S-D Valve Pit to 244-S DCRT

Jumpers: Nozzle L-9 to Nozzle L-18 in S-C Pit (Flexible)

Nozzle R-18 to Nozzle R-2 in S-D Pit (H-2-70606/2-D)

Alt. Route:Pump Pit 12A, Riser 5 to Nozzle A (SN-225)
SN-225 to S-C Valve Pit
Flexible jumper to Nozzle L-18 in S-C Pit
Continue preferred route

Receiver DST:SY-102

Installation:Saltwell Screen in Riser 5
Obstruction: Jet Pump in Riser 5

Exhauster: Attach portable exhauster to Riser 7
(If Required)

241-SX TANK FARM

The 241-SX Tank Farm consists of fifteen 1,000,000 gallon tanks.Tanks SX-107 through SX-115 have been declared interim stabilized.Tanks SX-101 through SX-106 have liquid remaining to be pumped.

Heat Trace details for the tank farm are set forth in H-2-46159.
Leak Detection details are set forth in H-2-34965 and H-2-46477.

SX-101 *WATCH LIST TANK*

Route: Pump Pit 01A, Riser 9 to Nozzle B (SL-137)
SL-137 to SX-B Valve Pit
SL-118 from SX-B Valve Pit to S-D Valve Pit
SN-249 from S-D Valve Pit to 244-S DCRT

Jumpers: Nozzle R-7 to Nozzle R-3 in SX-B Pit (H-2-70606)
Nozzle R-10 to Nozzle R-2 in S-D Pit (H-2-93653/2-D)

Alt. Route:Pump Pit 01A, Riser 9 to Nozzle A (SN-241)
SN-241 to SX-B Valve Pit
Flexible Jumper to Nozzle R-3 in SX-B Pit
Continue preferred route

Receiver DST:SY-102

Installation:No Saltwell Screen in tank (one available in storage)

SX-102 *WATCH LIST TANK*

Route: Pump Pit 02B, Riser 9 to Nozzle B (SL-130)
SL-130 to SX-A Valve Pit
SL-117 from SX-A Valve Pit to S-C Valve Pit
SL-135 from S-C Valve Pit to S-D Valve Pit
SN-245 from S-D Valve Pit to 244-S DCRT

Jumpers: Nozzle L-5 to Nozzle L-3 in SX-A Pit (H-2-70606)
Nozzle L-10 to Nozzle L-18 in S-C Pit (H-2-93653/5-E)
Nozzle R-18 to Nozzle R-2 in S-D Pit (H-2-93653/2-B)

Alt. Route:Pump Pit 02B, Riser 9 to Nozzle A (SN-230)
SN-230 to SX-A Valve Pit
Flexible Jumper to Nozzle L-3 in SX-A Pit
Continue preferred route

Receiver DST:SY-102

Obstructions:P-10 Pump in Riser 9
Installation:Saltwell Screen in Riser 9

SX-103 *WATCH LIST TANK*

Route: Pump Pit 03B, Riser 9 to Nozzle B (SL-129)
SL-129 to SX-A Valve Pit
SL-117 from SX-A Valve Pit to S-C Valve Pit
SL-135 from S-C Valve Pit to S-D Valve Pit
SN-245 from S-D Valve Pit to 244-S DCRT

Jumpers: Nozzle L-7 to Nozzle L-3 in SX-A Pit (H-2-70606)
Nozzle L-10 to Nozzle L-18 in S-C Pit (H-2-93653/5-E)
Nozzle R-18 to Nozzle R-2 in S-D Pit (H-2-93653/2-B)

Alt. Route:Pump Pit 03B, Riser 9 to Nozzle A (SN-229)
SN-229 to SX-A Valve Pit
Flexible Jumper to Nozzle L-3 in SX-A Pit
Continue preferred route

Receiver DST:SY-102

Installation:Saltwell Screen in Riser 9

SX-104 *WATCH LIST TANK*

Route: Pump Pit 04A, Riser 5 to Nozzle A
SN-233 to 241-SX-B Valve Pit
SL-118 from 241-SX-B Valve Pit to 241-S-D Valve Pit
6" Encased Pipe from 241-S-D Valve Pit to TK 241-S-107 Valve Pit
SN-249 from TK 241-S-107 Valve Pit to 244-S DCRT

Jumpers: Nozzle R-15 to Nozzle R-3
Nozzle R-10 to Nozzle R-2

Alt. Route:Overground transfer to 241-SX-B Valve Pit
SL-118 from 241-SX-B Valve Pit to 241-S-D Valve Pit
6" Encased Pipe from 241-S-D Valve Pit to TK 241-S-107 Valve Pit
SN-249 from TK 241-S-107 Valve Pit to 244-S DCRT

Receiver DST:SY-102

Obstructions:Submersible pump on hose in Riser 5
Installation:Saltwell Screen in Riser 5

Exhauster: Attach a portable exhauster to Riser 7
(If Required)

SX-105 *WATCH LIST TANK*

Route: Pump Pit 05A, Riser 5 to Nozzle A (SN-232)
SN-232 to SX-B Valve Pit
SL-118 from SX-8 Valve Pit to S-D Valve Pit
SN-249 from S-D Valve Pit to 244-S DCRT

Jumpers: Nozzle R-16 to Nozzle R-3 in SX-B Pit (H-2-70606)
Nozzle R-10 to Nozzle R-2 in S-D Pit (H-2-93653/2-D)

Alt. Route:Pump Pit 05B, Riser 13 to Nozzle B (SL-132)
SL-132 to SX-B Valve Pit
Flexible Jumper to Nozzle R-3 in SX-B Pit
Continue preferred route

Receiver DST:SY-102

Obstructions:Submersible pump in Riser 5
Installation:Saltwell Screen in Riser 5

SX-106 *WATCH LIST TANK*

Route: Pump Pit 06A, Riser 5 to Nozzle B (SL-131)
SL-131 to SX-A Valve Pit
SL-117 from SX-A Valve Pit to S-C Valve Pit
SL-135 from S-C Valve Pit to S-D Valve Pit
SN-245 from S-D Valve Pit to 244-S DCRT

Jumpers: Nozzle L-9 to Nozzle L-3 in SX-A Pit (H-2-70606)
Nozzle L-10 to Nozzle L-18 in S-C Pit (H-2-93653/5-E)
Nozzle R-18 to Nozzle R-2 in S-D Pit (H-2-93653/2-B)

Alt. Route:Pump Pit 06A, Riser 5 to Nozzle A (SN-231)
SN-231 to SX-A Valve Pit
Flexible jumper to Nozzle L-3 in SX-A Pit
Continue preferred route

Receiver DST:SY-102

Obstructions:Submersible pump in Riser 5
Installation:Saltwell Screen in Riser 5

241-T TANK FARM

The 241-T Tank Farm consists of twelve 500,000 gallons tanks. Tanks T-101, T-102, T-103, T-105, T-106, T-108, T-109, and T-112 have been declared interim stabilized (T-101 in 1993). Tanks T-102 and T-112 do not meet the current interim stabilization criteria, however, and future pumping of these tanks is possible. Tanks T-104, T-107, T-110, and T-111 have liquid remaining to be pumped.

T-102 *WATCH LIST TANK*

Route: Overland Transfer from T-102 Riser 10 to Tank T-101 Saltwell
Pit Nozzle U-3
2" Line from Tank T-101 to SN-6012
SN-6012 to 244-TX DCRT (Connection H)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank T-104 Saltwell Pit
SN-252 to SN-6012
SN-6012 to 244-TX DCRT (Connection H)

Receiver DST:SY-102

Installation:No Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 2 (If Required)

T-104

Route: Saltwell Pit, Riser 13 to Nozzle U-3
SN-252 to SN-6012
SN-6012 to 244-TX DCRT (Connection H)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank T-101 Saltwell Pit
2" Line from Tank T-101 to SN-6012
SN-6012 to 244-TX DCRT (Connection H)

Receiver DST:SY-102

Installation:Saltwell Screen Installed in Riser 13

Exhauster: Attach portable exhauster to Riser 3
(If Required)

T-107 *WATCH LIST TANK*

Route: Saltwell Pit, Riser 13 to Nozzle U-3
2" Line from Tank T-107 to SN-7624
SN-7624 to 244-TX DCRT (Connection I)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank T-110 Saltwell Pit
2" Line from Tank T-110 to SN-7624
SN-7624 to 244-TX DCRT (Connection I)

Receiver DST:SY-102 (Core sampled in Sept. 1992)

Obstructions:Submersible Pump in Riser 13
Installation:Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 2
(If Required)

T-110 *WATCH LIST TANK*

Route: Saltwell Pit, Riser 13 to Nozzle U-3
2" Line from Tank T-110 to SN-7624
SN-7624 to 244-TX DCRT (Connection I)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank T-107 Saltwell Pit
2" Line From Tank T-107 to SN-7624
SN-7624 to 244-TX DCRT (Connection I)

Receiver DST:SY-102

Installation:Saltwell Screen Installed in Riser 13

Exhauster: Attach portable exhauster to Riser 2

T-111

Route: Saltwell Fit, Riser 13 to Nozzle U-3
2" Line from Tank T-111 to SN-7624
SN-7624 ta 244-TX DCRT (Connection I)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank T-110 Saltwell Pit
2" Line from Tank T-110 to SN-7624

SN-7624 to 244-TX DCRT (Connection I)

Receiver DST:SY-102 (Core Sampled in Nov. 1991)

Installation:Saltwell Screen Installed in Riser 13

Exhauster: Attach portable exhauster to Riser 2
(If Required)

T-112

Route: Overland Transfer from T-112 Riser 13 to T-111 Saltwell Pit
Nozzle U-3
2" Line from Tank T-111 to SN-7624
SN-7624 to 244-TX DCRT (Connection I)

Jumpers: Pump Jumper Only

Alt. Route:Overland Transfer to Tank T-109 Saltwell Pit
2" Line From Tank T-109 to SN-7624
SN-7624 to 244-TX DCRT (Connection I)

Receiver DST:SY-102

Installation:No Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 2
(If Required)

244-U TANK FARM

The 241-U Tank Farm consists of twelve 500,000 gallon tanks. Tanks U-101, U-104, U-110 and U-112 have been declared interim stabilized. Tanks U-102, U-103, U-105, U-106 through U-109, and U-111 have liquid remaining to be pumped.

Tank U-110 does not meet present interim stabilization criteria and future pumping of this tank is possible.

Heat Trace details for the farm are set forth in H-2-37326.

U-102

Route: Pump pit 02B, Riser 13 to Nozzle B (SL-111)
SL-111 to U-B Valve Pit
SL-103 from U-B Valve Pit to U-D Valve Pit
SN-264 from U-D Valve Pit to 244-U DCRT

Jumpers: Nozzle R-7 to Nozzle R-3 in U-B Pit (H-2-73718)
Nozzle R-10 to Nozzle R-5 in U-D Pit (H-2-73707)

Alt. Route:Overland Transfer to U-B Valve Pit

Receiver DST:SY-102

Obstructions:Distributor Jet in Riser 13
Installation:No Saltwell Screen

Exhauster: Attach portable exhauster to Riser 7
(If Required)

U-103 *WATCH LIST TANK*

Route: Pump pit 03B, Riser 13 to Nozzle B (SL-109)
SL-109 to U-B Valve Pit
SL-103 from U-B Valve Pit to U-D Valve Pit
SN-264 from U-D Valve Pit to 244-U DCRT

Jumpers: Nozzle R-9 to Nozzle R-3 in U-B Pit (H-2-73718)
Nozzle R-10 to Nozzle R-5 in U-D Pit (H-2-73707)

Alt. Route:Overland transfer to U-B Valve Pit

Receiver DST:SY-102

U-103 (continued)

Installation:No Saltwell Screen

Exhauster: Attach portable exhauster to Riser 2
(If Required)

U-105 *WATCH LIST TANK*

Route: Pump Pit 05B, Riser 13 to Nozzle B (SL-112)
SL-112 to U-A Valve Pit
SL-102 from U-A Valve Pit to U-C Valve Pit
SL-113 from U-C Valve Pit to U-D Valve Pit
SN-265 from U-D Valve Pit to 244-U DCRT

Jumpers: Nozzle L-7 to Nozzle L-3 in U-A Pit (H-2-73719)
Nozzle L-10 to Nozzle L-18 in U-C Pit (H-2-73714)
Nozzle R-18 to Nozzle R-4 in U-D Pit (H-2-73715)

Alt. Route:Overland Transfer to U-A Valve Pit

Receiver DST:SY-102

Installation:No Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 7
(If Required)

U-106 *WATCH LIST TANK*

Route: Pump Pit 06B, Riser 13 to Nozzle B (SL-110)
SL-110 to U-A Valve Pit
SL-102 from U-A Valve Pit to U-C Valve Pit
SL-113 from U-C Valve Pit to U-D Valve Pit
SN-265 from U-D Valve Pit to 244-U DCRT

Jumpers: Nozzle L-9 to Nozzle L-3 in U-A Pit (H-2-73719)
Nozzle L-10 to Nozzle A in U-C Pit (H-2-73713)
Nozzle A to Nozzle L-18 in U-C Pit (H-2-73714)
Nozzle R-18 to Nozzle R-4 in U-D Pit (H-2-73715)

Alt. Route:Overland Transfer to U-A Valve Pit

Receiver DST:SY-102

Installation:No Saltwell Screen Installed
Exhauster: Attach portable exhauster to Riser 7

U-107 *WATCH LIST TANK*

Route: Pump Pit 07B, Riser 13 to Nozzle B (SL-106)
SL-106 to U-D Valve Pit
SN-266 from U-D Valve Pit to 244-U DCRT

Jumpers: Nozzle R-3 to Nozzle B in U-D Pit (H-2-73708)
Nozzle B to Nozzle R-22 in U-D Pit (H-2-73716)

Alt. Route:Overland Transfer to U-D Valve Pit

Receiver DST:SY-102

Obstructions:Distributor Jet in Riser 13
Installation:No Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 7
(If Required)

U-108 *WATCH LIST TANK*

Route: Pump Pit 08B, Riser 13 to Nozzle B (SL-105)
SL-105 to U-C Valve Pit
SL-113 from U-C Valve Pit to U-D Valve Pit
SN-265 from U-D Valve Pit to 244-U DCRT

Jumpers: Nozzle L-9 to Nozzle A in U-C Pit (H-2-73713) Nozzle A to Nozzle L-18 in U-C Pit (H-2-73714)
Nozzle R-18 to Nozzle R-4 in U-D Pit (H-2-73715)

Alt. Route:Overland Transfer to U-C Valve Pit

Receiver DST:SY-102

Obstructions:Distributor Jet in Riser 13
Installation:No Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 7
(If Required)

U-109 *WATCH LIST TANK*

Route: Pump Pit 09B, Riser 13 to Nozzle B (SL-104)
SL-104 to U-C Valve Pit
SL-113 from U-C Valve Pit to U-D Valve Pit
SN-265 from U-D Valve Pit to 244-U DCRT

Jumpers: Nozzle L-7 to Nozzle A in U-C Pit (H-2-73713)
Nozzle A to Nozzle L-18 in U-C Pit (H-2-73714)
Nozzle R-18 to Nozzle R-4 in U-D Pit (H-2-73715)

Alt. Route:Overland Transfer to U-C Valve Pit

Receiver DST:SY-102

Obstructions:Distributor Jet in Riser 13
Installation:No Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 7
(If Required)

U-110

Route: Pump Pit 10B, Riser 13 to Nozzle A
SL-108 to 241-U-D Valve Pit
SN-264 to 244-U DCRT

Jumpers: Nozzle R-7 to Nozzle R-5 in 241-U-D Valve Pit

Alt. Route:Overground transfer to 241-U-D Valve Pit

Receiver DST:SY-102

Installation:Saltwell Screen in Riser 13

Exhauster: Attach a portable exhauster to Riser 2
(If Required)

U-111 *WATCH LIST TANK*

Route: Pump Pit 11B, Riser 13 to Nozzle B (SL-107)
SL-107 to U-C Valve Pit
SL-217 from U-C Valve Pit to U-D Valve Pit
SN-266 from U-D Valve Pit to 244-U DCRT

Jumpers: Nozzle L-5 to Nozzle L-19 in U-C Pit (H-2-73712)
Nozzle R-19 to Nozzle R-22 in U-D Pit (H-2-73716)

Alt. Route:Overland Transfer to U-C Valve Pit

Receiver DST:SY-102

Installation:No Saltwell Screen Installed

Exhauster: Attach portable exhauster to Riser 7
(If Required)

Additional Information on Transfer Line Status:

Pressure/leak tests completed on the following transfer lines are as described below:

Tank Farm Transfer Lines Status

241-BY	SN-200, SN-205 PASSED, Aug. 1991 SN-207 PASSED, Aug. 1991
241-C	SN-255, SN-275 PASSED, Aug. 1991 SN-253, SN-252 PASSED, Aug. 1991
241-S	SL-119, SL-115 FAILED, JAN. 1992 SL-116, SN-215, FAILED, FEB. 1992 SN-216 FAILED, FEB. 1992 SN-219 PASSED, JAN. 1992

See WHC-SD-WM-ES-259, Single-Shell Tank Saltwell Transfer Piping Evaluation, for additional important information.

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APPENDIX 3A

SINGLE-SHELL TANK WASTE CLASSIFICATION: REFERENCED LETTERS

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Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

MAR 06 1989

Mr. Robert M. Bernero, Director
Office of Nuclear Materials Safety
and Safeguards
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Bernero:

Members of our staffs have been meeting to discuss the classification and disposal of the Hanford double-shell tank wastes. The central issue is the definition of high-level waste (HLW), and the application of the HLW definition in the Hanford Defense Waste Environmental Impact Statement. Over forty-five years of Hanford operations have resulted in numerous waste streams, involving several treatment activities. This makes classification of wastes somewhat complex. Various approaches have been discussed in detail to resolve the classification issue. The alternate approach suggested in the November 29, 1988, letter from Mr. Michael J. Bell of the Nuclear Regulatory Commission (NRC) to Mr. Ronald E. Gerton of my staff, on classifying the fraction of Hanford's double-shell tank waste planned for disposal by grouting in near-surface vaults, appears to us to be the appropriate way to proceed. This approach utilizes an overall material balance of tank waste at the Hanford site to demonstrate that the largest practical amount of the total site activity attributable to "first-cycle solvent extraction" wastes has been segregated so that only the residuals will be grouted.

An overall radionuclide material balance for all Hanford tank wastes has been prepared and is enclosed. In addition to the HLW, we have included other liquid wastes (low-level waste (LLW) and transuranic waste) which have entered the waste tanks, however, their radionuclide contribution (in curies) is small as compared to the HLW streams. This material balance shows 3-5% of the key radionuclides which entered the tanks will be disposed as LLW in near-surface vaults when the double-shell tank wastes are grouted. The concentration of radionuclides will be comparable to Class C for cesium and transuranic, and to Class A or B for the remainder. The total amount of such waste will be greater than the amount of Class C waste that might be contained in a typical commercial burial ground. It is our understanding that the NRC's concern over the amount of Class C waste is related to the possibility of intrusion and the degree of institutional control to be maintained. Hanford's grout disposal system will provide excellent protection against intrusion since the grout vaults are a solid concrete mass that will have a multilayer engineered barrier on top. In addition, Hanford, as a dedicated government facility, should have a greater likelihood of maintaining institutional controls for relatively long times.

Mr. Robert M. Bernero -2-

Based on consideration of alternative separation processes, and to meet the suggested criteria of segregating the largest practical amount of activity, the Department of Energy, Richland Operations Office, proposes to remove additional radionuclides from the double-shell tank waste for disposal as HLW. Specifically, we will remove at least 95% of the Cs-137 from the complexant concentrate waste. This will reduce the 3-5% material balance values to 2-3%.

We believe that the data in the enclosure and discussed in this letter demonstrate that the double-shell tank waste planned for disposal by grouting in near-surface vaults is not HLW, and that NRC licensing is not required. We await your concurrence so that we can proceed with this vital waste disposal program.

If you should have any questions or comments, please feel free to contact me or Mr. Ronald E. Gerton of my staff on (509) 376-1366.

Sincerely,

A. J. Rizzo, Assistant Manager
for Operations

WMD:PKC

Enclosure:
Radionuclide Material Balance

Enclosure I

HANFORD TANK WASTE RADIONUCLIDE MATERIAL BALANCE

INTRODUCTION

At the Hanford Site, reprocessing of irradiated nuclear fuel started in 1944. Three uranium and plutonium recovery processes have been used: bismuth phosphate, reduction-oxidation (REDOX), and plutonium-uranium extraction (PUREX).

Each of these facilities generated a source-based high-level waste stream (first-cycle waste from recovery process) and several low-level waste streams including sump wastes, miscellaneous wastes, organic treatment wastes, and decladding wastes.

Supporting operations such as plutonium purification (Plutonium Finishing Plant), equipment decontamination (T Plant), and on-site laboratories generate transuranic (TRU) and low-level waste. Decontamination operations in the Department of Energy's nuclear reactor (N Reactor) also produce low-level waste. These low-level wastes and the treated liquids from the processes described below have routinely been concentrated in evaporators to reduce the waste volume to be stored. The process condensates were discharged to ground (typically after ion exchange to remove entrained Cs-137) while the concentrate is stored for later grout disposal.

The wastes are currently stored in underground single-shell (SST) and double-shell (DST) tanks. The SSTs have been removed from active liquid waste service (some residual liquid is still being removed). The DST waste inventory will be feed to the grout and vitrification disposal processes.

WASTE PARTITIONING

First-cycle waste generated prior to 1983 has gone through a combination of treatments such that the supernate of the treated waste is considered low-level waste. The treatments include neutralization/decantation, cesium removal, and strontium removal (see Figure 1).

Neutralization/Decantation

All facility wastes stored in underground tanks have always been neutralized with sodium hydroxide to a caustic endpoint. The neutralization precipitates the actinides and the bulk of the fission products including strontium-90 (Sr-90). The solids settle in the 75-foot diameter tanks and form a sludge layer. Important radionuclides that are primarily soluble and remain in the alkaline supernate are carbon-14 (C-14), technetium-99 (Tc-99), iodine-129 (I-129), and cesium-137 (Cs-137).

The settled solids remain in the tanks when the supernate is decanted and transferred for further processing. Special efforts such as sluicing or agitation with mixing pumps are required to transfer the settled solids.

Cesium Removal

Cs-137 has been removed from HLW supernate via several processes. The first-cycle wastes from the bismuth phosphate process were treated with nickel ferrocyanide in the mid-1950s to precipitate the cesium in some single-shell tanks.

The alkaline supernates generated by the REDOX and PUREX plants prior to 1968 were processed in B Plant for cesium removal by ion exchange. This process will also be used to remove cesium from PUREX Plant alkaline supernates generated since 1983. During the period from 1968 until the PUREX Plant shutdown in late 1971, the acidic PUREX Plant HLW was routed to B Plant without neutralization. A phosphotungstic acid (PTA) precipitation process was then used in B Plant to remove the cesium.

The cesium recovered in B Plant was purified and doubly encapsulated for long-term storage. This cesium will be disposed in a geologic repository.

Strontium Removal

As discussed previously, the routine neutralization/decantation of first-cycle extraction waste provides a Sr-90 and actinide separation. However, some first-cycle extraction waste had further strontium removal performed. The Sr-90 in acid PUREX Plant HLW was removed in B Plant via a solvent extraction process concurrently with the cesium PTA precipitation. The B Plant residual wastes were then neutralized and routed to the underground storage tanks.

The settled sludge produced from the neutralized PUREX Plant first-cycle extraction waste prior to 1968 was sluiced, acidified, and processed for Sr-90 removal via the B Plant solvent extraction process.

The strontium recovered in B Plant was doubly encapsulated for long-term storage. This strontium will also be disposed in a geologic repository.

The PUREX Plant HLW sludge (containing the Sr-90 and transuranic nuclides) generated since the 1983 restart will be separated from the supernate. The sludge, along with Cs-137 removed from the supernate, will be incorporated into glass in the Hanford Waste Vitrification Plant (HWVP) for disposal in a geologic repository.

Transuranic Removal

The organic complexants used in the B Plant solvent extraction process to recover strontium tend to solubilize the strontium and actinides and inhibit their precipitation. The complexant concentrate (CC) waste contains the bulk of the waste from B Plant strontium recovery and will be treated in B Plant with the transuranic-extraction (TRUEX) process to remove transuranics (TRU) which will be routed to HWVP for disposal in a geologic repository.

The sludge from the PUREX Plant neutralized cladding removal waste (NCRW) and the solids from the Plutonium Finishing Plant (PFP) wastes contain greater than 100 nCi/g TRU nuclides. These sludges will also be treated in B Plant with the TRUEX process to remove TRU which will be routed to HWVP for disposal in a geologic repository.

HANFORD WASTE PARTITIONING

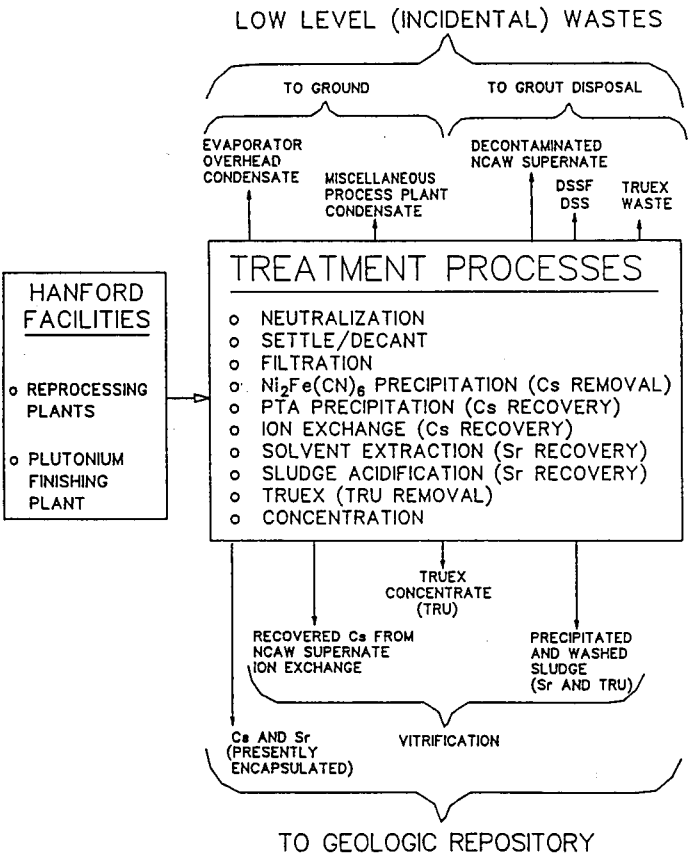

FIGURE 1

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RADIONUCLIDE MATERIAL BALANCE

The estimated percentage disposition of the Sr-90, Cs-137, TRU nuclides and total activity from Hanford reprocessing wastes is shown in Figure 2.

The bases for the radionuclide inventories used to calculate the percentages are estimates of the radionuclide inventory that entered the SST and DST wastes prior to 1983, the measured inventory in strontium and cesium capsules, and estimates of the radionuclides in wastes produced after the PUREX Plant restarted in 1983.

The pre-1983 SST/DST estimates are from the Hanford Defense Waste Environmental Impact Statement (DOE/EIS-0113) and the Hanford input to the Integrated Data Base (IDB) document for 1988 (DOE/WM-0006, Rev. 4). The IDB document was the source for the strontium/cesium capsule inventory. Both documents used the Track Radioactive Components (TRAC) System as the primary source for the radionuclide inventory in the Hanford tanked waste. Input data for the TRAC System were historical records of reactor, reprocessing, and waste management operations. The computer programs RIBD-2 and DCODE were used to calculate the radionuclides in the irradiated reactor fuel. The TRAC model then used these inputs to calculate the waste generated by the reprocessing plants as a function of time and follow the waste through the various waste management processes and transactions to arrive at the final waste tank inventories.

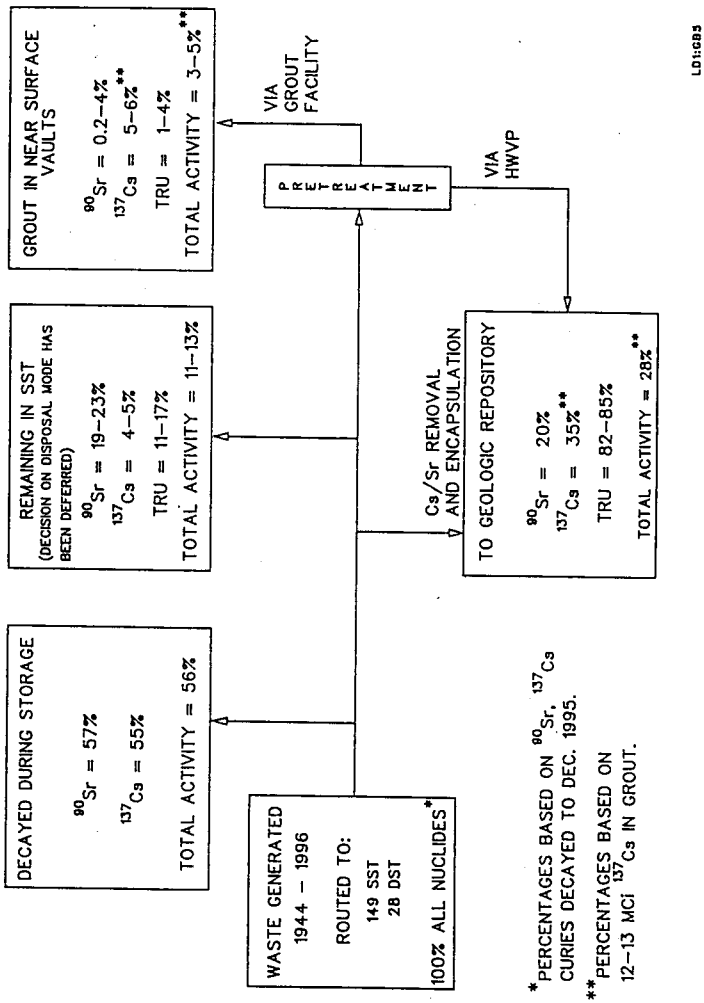
The radionuclide inventories for post-1983 wastes were estimated using the ORIGEN-2 computer program to calculate the radionuclides in all irradiated N Reactor fuel to be reprocessed following the 1983 restart of the PUREX Plant. The PUREX Plant, waste management and planned B Plant pretreatment flowsheets were used to estimate the partitioning of the radionuclides between HLW (HWVP feed) and LLW (grout feed).

The radionuclide inventories as shown in the EIS and IDB documents are best estimates but are subject to uncertainties because of factors such as:

- o incomplete/inaccurate records dating back to 1944;
- o the use of bounding fuel impurity limits to calculate maximum activation products, i.e. C-14, since actual analyses are no longer available; and
- o incomplete understanding of the chemistry and resulting pathways of some elements in the reprocessing and waste treatment processes.

Ideally, actual analytical data for all Hanford tanked waste would be available. All grout and vitrification feeds will have such analyses before they are processed. However, only limited analytical results are currently available. These analyses indicate that the total Cs-137 that may exist in grout feed could be as much as 20 million curies (Ci) vice the 12-13 million Ci which is the basis for the 5-6% range shown in Figure 2. (Both of these inventories are corrected for decay to the end of CY 1995.)

RADIONUCLIDE MATERIAL BALANCE HANFORD TANK WASTE



*PERCENTAGES BASED ON ^{90}Sr, ^{137}Cs CURIES DECAYED TO DEC. 1995.

**PERCENTAGES BASED ON 12–13 MCi ^{137}Cs IN GROUT.

FIGURE 2

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PLANNED PRETREATMENT OF GROUT FEEDS

Pretreatment in B Plant is planned for four of the stored Hanford waste types before they are considered to be suitable grout feeds. These waste types are the neutralized current acid waste (NCAW-PUREX Plant first-cycle extraction waste), the neutralized cladding removal waste (NCRW) solids, the Plutonium Finishing Plant (PFP) waste solids and complexant concentrate (CC).

The NCAW will be transferred to B Plant where the solids containing the Sr-90 and actinides will be removed and the clarified supernate ion exchanged for Cs-137 removal. The washed NCAW solids and the recovered Cs-137 will be routed to HWVP and the decontaminated supernate stored for grout feed.

The NCRW and PFP solids are TRU wastes. These solids will be transferred to B Plant, dissolved in acid and then treated using the TRUEX extraction process. The TRU concentrate from the TRUEX process and any undissolved solids will be routed to HWVP.

Some stored complexant concentrate is TRU waste. Present plans are to treat all the CC in B Plant for complexant destruction and then TRU removal by the TRUEX process. The TRU concentrate and any undissolved solids will be routed to HWVP. These plans may be modified if further characterization determines some of the wastes are non-TRU or that complexant destruction is not required.

The non-TRU wastes from the above pretreatment processes are considered to be suitable LLW grout feeds. Waste solids would be routed directly to a grout feed tank while the supernates may be further concentrated.

No additional treatment is planned for double-shell slurry feeds (DSSF). The DSSF is produced by evaporation of the dilute Hanford LLW; e.g. NCRW supernate, PFP supernate, PUREX and B Plant miscellaneous wastes, pretreatment wastes and SST residual liquids.

Additional treatment of double-shell slurry (DSS) is not planned. The DSS is produced by further concentration of DSSF past the sodium aluminate phase boundary. This stored waste contains solids and dilution/dissolution will be required for retrieval.

POTENTIAL ADDITIONAL RADIONUCLIDE REMOVAL

Estimated curies disposed to grout for key radionuclides are shown in Table 1. The incorporation of these nuclides into grout would result in radionuclide concentrations comparable to or below Class C (10 CFR 61) LLW.

The estimated concentrations of C-14 and I-129 in the grout would be comparable to Class A (10 CFR 61) limits. There is no viable technology available to further remove these nuclides from the large volume of grout feed. As previously indicated, the inventory of C-14 is probably overstated. The estimated maximum concentration of Tc-99 in grout feed (in the pretreated NCAW supernate) would be near or slightly above the Class A limit. Additional removal of Tc-99 via an ion exchange process is theoretically possible. However, further removal does not appear practical or cost effective. Accordingly, no pretreatment for removal of these nuclides is planned.

Transuranic wastes will be pretreated for TRU removal. The treated grout feed would be comparable to NRC Class C LLW.

The inventories of Sr-90 and Cs-137 dominate the estimated total activity to be disposed to grout. The inventories of these nuclides estimated for grout disposal are not significant in the Performance Assessment for grout due to their relatively short half-lives (Sr-90 = 28.5 years, Cs-137 = 30.0 years). The estimated maximum concentration of Sr-90 plus Cs-137 in grout would be a factor of approximately 30 below the Class C LLW limit. However, possible additional removal processes were examined to assess the practicality of further removal of these nuclides from grout feed.

The Sr-90 inventory estimates are uncertain, but the bulk of this nuclide is in the complexant concentrate (CC) which contains a large fraction of precipitated solids. The CC is treated with the TRUEX process to reduce the quantity of solids routed to HWVP for incorporation into glass. After acidification of the CC in B Plant to dissolve solids, complexant destruction, and TRU removal by the TRUEX process, the Sr-90 would remain in solution. It then would be routed to grout with the TRUEX waste. If it is necessary to remove the Sr-90, the TRUEX process would not be used but rather the Sr-90 and TRU solids would be routed to HWVP by neutralization/precipitation after complexant destruction. However, the total volume of vitrified waste would be increased (approximately 20%) and additional costs of about $150 million would be incurred. It is likely that alternative processes could be developed to reduce these additional volumes and costs.

Smaller quantities of Sr-90 are contained in the DSSF. The presence of low concentrations of complexant in the DSSF precludes further Sr-90 removal by precipitation processes. Destruction of the dilute complexant in DSSF in B Plant for Sr-90 removal would delay the grout program by about 5 years while process equipment was designed, fabricated and installed and the initial grout feed batch was processed. The complexant destruction would require approximately four years of B Plant operation and increase B Plant and HWVP operating costs 100 to 200 million dollars.

The cesium nickel ferrocyanide precipitation process used previously in Hanford SSTs could effectively remove Cs-137 from tanked waste. However, the ferrocyanide precipitate, if routed to HWVP, could result in potential explosion hazards and metal phase production in the glass melter which would not be tolerated.

The presence of potassium in some Hanford DSSF precludes the use of the SRP process of cesium tetraphenyl boron precipitation since the potassium would be co-precipitated with the cesium. At least two orders of magnitude more tetraphenyl boron (i.e., thousands of tons) would be required for treatment of the Hanford waste as compared to the SRP waste, with the attendant problems involved in handling this benzene compound.

Ion exchange remains as the only technically viable process for removing the Cs-137. Use of this process is already planned for the NCAW supernate, with startup scheduled for 1992 in B Plant. The process could be used on other grout feeds, but there are timing and logistics problems. If ion exchange removal of Cs-137 were fully utilized for all grout feeds, the volume of ion exchange feed would increase from about seven million gallons to approximately

TABLE 1

ESTIMATED RADIONUCLIDES DISPOSED TO GROUT

Nuclide	MCi
C-14	0.0027
Tc-99	0.016 - 0.028
I-129	33×10^{-6}
Sr-90*	1 - 8
Cs-137*	12 - 13
TRU	0.002 - 0.01
Total Activity**	13 - 21

*The Sr-90 and Cs-137 curies are decayed to the end of CY 1995

**Total activity taken as sum of Sr-90 plus Cs-137 since these two nuclides (and their daughter products) dominate the total inventory.

35 million gallons. This increased volume represents approximately 15 years additional operation with the present ion exchange system design or 10 years additional operation with an upgraded system. The grout volume would be increased about 10%.

If the tanks that are now available for grout feed are held for ion exchange processing (which cannot start before 1992), the grout program would have to shut down. These tanks then would not be emptied and made available to store waste currently being generated. A waste storage space shortfall would result. New waste storage tanks could not be provided in time to support Hanford programs, including removal of residual liquids from SSTs and production operations.

Full ion exchange treatment of all grout feeds would route approximately 12.8 MCi of Cs-137 to glass rather than grout. This would reduce the total radioactivity disposed to grout by about 61%. However, Cs-137 is not the radionuclide of primary concern for the grout long-term performance assessment, and the Cs-137 removal would not significantly enhance the safety of the grout disposal system.

The cost for Cs-137 removal from NCAW supernate in B Plant will be approximately $3/Ci (allocated operating cost). The estimated ROM costs (incremental capital plus allocated operating) for Cs-137, Sr-90 removal from the remaining grout feeds are as follows:

Cs-137 Removal	MCi Removed	$/Ci
DSSF/DSS	6-7	25-30
CC	~6	~8
Sr-90 Removal		
DSSF/DSS	0.25	~800
CC	1-8	20-150

The above costs would increase if detailed analysis of facility operating schedules (e.g., PUREX, B Plant, HWVP) determined that unproductive standby time for a facility was unavoidable.

CONCLUSION

As discussed previously, delaying the grout processing of currently available feeds, i.e., DSSF/DSS, will severely impact Hanford site programs. However, pretreatment of the CC in B Plant is not scheduled to begin until CY 2000. Thus, time is available for flowsheet development and design/installation of additional equipment as necessary to remove Cs-137 from the CC. The removal and vitrification of the Cs-137 from CC is expected to result in less than 10 additional canisters for repository disposal, a minimal impact. Figure 3 shows that if the approximately 6 MCi Cs-137 contained in the CC is removed, the percentage of Cs-137 and total activity in the grout would drop to approximately 3% and 2-3% respectively. This additional pretreatment is now being proposed.

It is concluded that with the addition of Cs-137 removal from CC, the planned grout feed pretreatment represents a "good faith" effort to maximize isolation of HLW from Hanford site LLW.

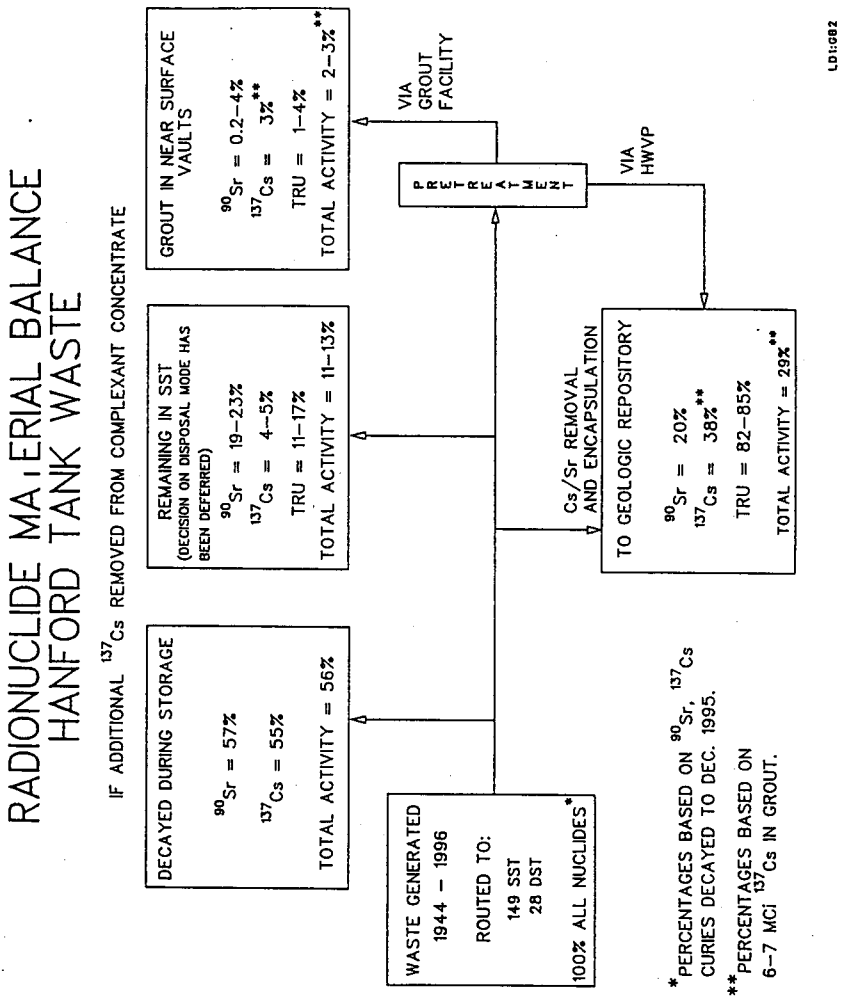

FIGURE 3

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

XC. Staff

SEP 26 1989

9-25-89

Copy to LEACH

Mr. A. J. Rizzo
Assistant Manager for Operations
U.S. Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

Dear Mr. Rizzo:

We have reviewed your letter dated March 6, 1989 concerning the classification and disposal of the Hanford double-shell tank waste. Your letter and supporting information assert that the double-shell tank waste planned for disposal by grouting in near-surface vaults is not high-level waste (HLW), and that U.S. Nuclear Regulatory Commission (NRC) licensing is not required. Your letter requests NRC concurrence in this position.

As you know, our staffs have met on several occasions over the past year in an effort to determine which of the Hanford tank wastes are properly classified as HLW. We consider that the applicable definition of HLW, for purposes of classifying the Hanford tank wastes, is that set forth in 10 CFR Part 50, Appendix F. Specifically, HLW is defined as "those aqueous wastes resulting from the operation of the first cycle solvent extraction system or equivalent, and the concentrated waste from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuels."

The rulemaking record for Appendix F specifically recognizes a number of "incidental," non-HLW waste streams associated with reprocessing plant operations. These include cladding hulls, ion exchange media, sludges, and miscellaneous trash generated during reprocessing operations. Not mentioned, however, are wastes resulting from further processing of HLW (e.g., volume reduction) or removing non-radioactive materials that were added to the HLW for improved processing and/or storage (e.g., the addition of alkaline material to neutralize acidic HLW). At West Valley and the Savannah River Plant, NRC has agreed that such wastes are not HLW. At Hanford, the question of waste classification (and NRC licensing authority) has been complicated by the mixing of waste from various sources over the past 45 years. This mixing has changed the original characteristics of the wastes and has resulted, in some cases, in the mixing of HLW and low-level waste (LLW). Consequently, it is now difficult to directly differentiate between HLW and LLW, using the source-based definition of Appendix F.

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In earlier meetings of our staffs, criteria were suggested for determining when such wastes should be classified as "incidental" wastes rather than as HLW, and these criteria were documented in our letter of November 29, 1988. Your March 6, 1989 letter records U.S. Department of Energy's (DOE's) application of these criteria. Specifically, your letter proposes that the bulk of the key radionuclides (i.e., strontium, cesium and transuranics) would be separated for disposal in a geologic repository, so that only three to five percent of the original inventories of those radionuclides would be disposed by grouting in near-surface vaults. Your letter also states that the concentration of radionuclides in the grout will be comparable to Class C LLW as defined by 10 CFR Part 61 for cesium and transuranics, and to Class A or B for the remainder. Finally, your letter evaluates the practicability and cost-effectiveness of additional radionuclide removal. An additional separation process, beyond those originally contemplated, was found to be cost-effective for removal of an additional six million curies of cesium. This step would further reduce the total activity disposed in the grout facility to two to three percent of the inventory of HLW that originally entered the tanks. DOE is now proposing to perform this additional radionuclide removal to improve the isolation of HLW. The NRC agrees that the criteria used by DOE for classification of the grout feed as LLW are appropriate. Therefore, the grout facility for the disposal of the double-shell tank waste would not be subject to our licensing authority.

Note →

Your letter indicates that the radionuclide inventory is an estimate based on existing computer models, rather than actual analyses of tank waste. Given the uncertainty in the actual radionuclide inventory, we endorse your plans to sample and analyze the grout feeds before disposal in an effort to control the final composition of the grout feed. If in the course of conducting this sampling program, you find that the inventories of key radionuclides entering the grout facility are significantly higher than you now estimate, you should notify us so that the classification of the waste can be reconsidered. The NRC requests that DOE periodically submit summaries of the analytical results of all the samples to NRC and other affected parties in a timely manner.

Note →

Our position on the double-shell tank waste should not be interpreted to reflect a decision on disposal of single-shell tank waste or to establish a precedent in any other context. We intend to defer judgment on the classification of single-shell tank waste until after DOE has completed its program of characterizing this waste. We anticipate that final documentation will be issued for public comment before a decision is made on the disposal of single-shell tank waste.

Mr. A. J. Rizzo - 3 -

If you should have any questions or comments about this letter, please contact me or Dr. Michael J. Bell, Chief, Regulatory Branch, of my staff at (301) 492-0560.

Sincerely,

Robert M. Bernero, Director
Office of Nuclear Material Safety
and Safeguards

cc: Terry Husseman
WA Department of Ecology
William Don Tahkeal
Yakima Indian Nation
Jeff Breckel
Oregon/Washington Liaison

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APPENDIX 7A

DATA AND INFORMATION REQUIREMENTS FOR RISK ASSESSMENTS

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CONTENTS

7A.1.0 DATA AND INFORMATION REQUIREMENTS FOR RISK ASSESSMENTS . . . . . APP 7A-1

7A.1.1 ACCIDENT SEQUENCE ANALYSIS DATA . . . . . APP 7A-1

7A.1.2 CONTAMINANT WASTE INVENTORY DATA . . . . . APP 7A-2

7A.1.3 CONTAMINANT TRANSPORT MODELING DATA . . . . . APP 7A-2

7A.1.4 EXPOSURE AND TOXICITY INFORMATION . . . . . APP 7A-4

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7A.1.0 DATA AND INFORMATION REQUIREMENTS FOR RISK ASSESSMENTS

7A.1.1 ACCIDENT SEQUENCE ANALYSIS DATA

A significant part of accident sequence analysis involves determining presence of hazards, frequencies of initiators, and probability of failures required for the initiators to cause undesirable consequences. In general, initiators are characterized by data that is time related; per hour, per day, or per year. Equipment or human failure data can be either time or demand related.

The raw information needed for estimating the event-model parameters include the following:

- The number of workers involved in the activity and those in proximity to the activity or process that can be affected by accidents that occur
- The number of hours during which the activity or process occurs
- The physical layout of the area in which the activity or process takes place
- The type of ambient conditions in which the activity or process takes place
- The design requirements established by orders, codes, or directives
- Critical design features such as configuration of confinement barriers and remediation equipment
- The degree and types of automatic features that are incorporated in the design of the process or activity
- The expected level of procedures that will be present.

The data may also be used to test the applicability of the event model; in this case, it is necessary to know the time of each failure.

The sources of data may include other operating facility records (Coats and Murray 1985), existing data reports (Kennedy et al. 1990, Tallman 1989, CCPS 1989, Chandler et al. 1991, IEEE 1984), and previous analysis of similar operations (Blanton and Eide 1993). It is necessary that representative existing data sources be closely examined to clearly establish the type of data needed before beginning the collection of design specific data.

7A.1.2 CONTAMINANT WASTE INVENTORY DATA

The radionuclide and hazardous nonradioactive chemical inventory of the 149 SSTs is not fully characterized. The SSTs currently contain approximately 36.1 million gallons (136,640 cubic meters) of solid and liquid mixed waste. The TRAC System estimates the amount of some radionuclides and stable chemicals in the entire system (RHO 1985).

Characterization of waste that has leaked from the 40-year-old tanks is included in the TRAC System; however, the amount leaked is not certain. It is estimated that 67 of the SSTs have leaked approximately 600,000 to 900,000 gallons (2,270 to 3,400 cubic meters) respectively (Cruse et al. 1994a). Constituents that have been identified are technetium-99, carbon-14, iodine-129, uranium-238, nitrate (NO_3), nitrite (NO_2), tributyl phosphate, and EDTA (Brodeur 1993, Hanlon 1994, Van Vleet 1993, Boomer et al. 1993). An evaluation of current and planned disposal facilities with their associated waste streams is needed to assess release rates to the vadose zone and to study contaminant plume interference.

Knowledge of background levels of contamination will be needed to narrow the list of constituents in the risk assessment process. The natural composition of radioactive and nonradioactive constituents in soil and groundwater at the Hanford Site is described in a series of background documents (DOE-RL 1993d, DOE-RL 1994h).

7A.1.3 CONTAMINANT TRANSPORT MODELING DATA

Data are needed for exposure to air, soil, groundwater, surface water, and river sediment media. Data should be provided for release, transport, transfer, contaminant loss, and retardation processes that will be considered. The variability as functions of time and location should be considered for all data needs. Related data considerations are presented in Appendix 2A, Hydrogeology.

Release conditions for the atmosphere include concentrations, volume, and velocity. For transport and transfer processes, information is needed on wind direction, wind speed, temperature, and atmospheric stability.

Release data for soil include concentrations, volume, velocity, moisture content (or pressure), and chemical properties, such as leachability and solubility.

For transport, transfer, contaminant loss, and retardation processes, a large variety of data are required to describe the physicochemical surface and subterranean conditions. Key components of this data set include the following items:

- Topography, Stratigraphy, and Lithology
- Moisture characteristic information for vadose zone: unsaturated hydraulic conductivity, moisture content as functions of pressure (limited information available)
- Dry bulk density
- Total, diffusional, and effective porosities (limited information available)
- In situ volumetric moisture content (site-specific information)
- In situ matric potential (site-specific information)
- Longitudinal and transverse dispersivities (textbook)
- Molecular diffusion coefficients (textbook)
- Sorption distribution coefficients (much information available, but not necessarily appropriate)
- Recharge estimates
- Decay rates and products (DOE 1981).

The majority of this data needs to be identified for each soil layer.

Contamination in the soil media will often be considered for a nonleaching scenario (e.g., for ingestion). In that case, most of the data items listed will not be required for the risk assessment of the soil medium.

The release data to be determined for groundwater are identical to those for soil. The data should be converted to concentrations in the liquid, rather than concentrations in the soil matrix. A distribution coefficient is used to relate the concentration in the liquid to the concentration in the soil matrix.

For transport, transfer, contaminant loss, and retardation processes, all data from the soil are required. Additional data requirements include the following aquifer data:

- Spatial description of aquifers
- Effective porosity of aquifer soils
- Saturated hydraulic conductivity (site-specific information)

- Dry bulk density
- Specific storativity (limited information available).

If a surface water computer program is used, a sample of the data that will be required is as follows:

- Geometric description of surface water boundaries
- Initial conditions, such as velocities for surface water
- Boundary conditions (site-specific information)
- Contamination entering the surface water from all sources including groundwater
- Conservation considerations that include:
  - Conditions affecting gaining and losing water from natural causes: evaporation, rainfall, leakage, inflow from other surface waters and groundwater
  - Conditions affecting gaining and losing water from manmade causes: inflow from dammed waters, sewer plant discharges, storm sewer discharges, outflow from irrigation systems and municipal water supplies
- Dispersivities (textbook information).

The dilution capacity of the Columbia River is large. A gross mixing factor based on conservative assumptions may be used. An appropriate mixing factor will be selected based on the extent of the river for which risk will be assessed.

A sorption distribution coefficient is needed for the river sediments, so that the contaminant concentration in the surface water can be converted to a contaminant concentration in the river sediments.

7A.1.4 EXPOSURE AND TOXICITY INFORMATION

Whether something is a risk to the environment, health and safety is largely determined by the length of exposure and level of toxicity. Exposure assessment includes the determination of exposure scenarios, pathways, parameters, concentrations, and quantification of the exposure. Exposure parameters commonly used in CERCLA and RCRA programs at the Hanford Site are presented in the HSBRAM (DOE-RL 1993e), RERA (DOE-RL 1994h), other sources for exposure parameters include regulatory guidance [Risk Assessment Guidance for Superfund (RAGS), *Model Toxics Control Act* (MTCA)], and other Hanford Site reports (e.g., performance assessments, safety analysis reports, environmental impact statements).

Toxicity assessments provide information on the potential effects of noncarcinogenic and carcinogenic substances. General profiles of human toxicity can be obtained from the *Integrated Risk Information System* (IRIS), Agency for Toxic Substances and Disease Registry (ATSDR), and other sources. A Hanford Site-specific summary of toxicity profiles is in development. The evaluation of ecotoxicity for aquatic receptors requires the use of Ambient Water Quality Criteria (EPA 1986, WAC 173-201). Toxicity to terrestrial receptors is not well understood and site-specific data are often necessary. The HSBRAM provides some guidance on Hanford Site-specific ecotoxicity.

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APPENDIX 8A

BARRIER AND MARKER SYSTEM DESIGN CONSIDERATIONS

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CONTENTS

8A.1.0 BARRIER AND MARKER SYSTEM DESIGN CONSIDERATIONS . . . . . APP 8A-1

8A.1.1 WATER INFILTRATION CONTROL . . . . . APP 8A-4
8A.1.1.1 Run-off . . . . . APP 8A-4
8A.1.1.2 Capillary Barrier . . . . . APP 8A-4
8A.1.1.3 Low-Permeability Layers . . . . . APP 8A-5
8A.1.1.4 Edge Effects . . . . . APP 8A-5
8A.1.1.5 Physical Stability . . . . . APP 8A-7

8A.1.2 BIOINTRUSION CONTROL . . . . . APP 8A-7
8A.1.2.1 Plant Root Intrusion Control . . . . . APP 8A-7
8A.1.2.2 Burrowing Animal Intrusion Control . . . . . APP 8A-8

8A.1.3 WIND AND WATER EROSION CONTROL . . . . . APP 8A-8
8A.1.3.1 Barrier Surface . . . . . APP 8A-8
8A.1.3.2 Barrier Side Slopes and Toe . . . . . APP 8A-9
8A.1.3.3 Surface Soils Surrounding the Barrier . . . . . APP 8A-10

8A.1.4 HUMAN INTERFERENCE CONTROL . . . . . APP 8A-11
8A.1.4.1 Offsite Records . . . . . APP 8A-11
8A.1.4.2 Surface Markers . . . . . APP 8A-12
8A.1.4.3 Subsurface Markers . . . . . APP 8A-12
8A.1.4.4 Barrier Design . . . . . APP 8A-13

8A.1.5 GASEOUS RELEASE CONTROL . . . . . APP 8A-14

8A.1.6 CONCLUSIONS . . . . . APP 8A-15

FIGURES

8A-1 Transport Processes Affecting Surface Barrier Performance . . . . . APP F8A-1
8A-2 Conceptual Design of Proposed Hanford Engineered Barrier . . . . . APP F8A-2
8A-3 Design of the Layering Sequence for the Proposed Hanford Engineered Barrier . . . . . APP F8A-3
8A-4 Hanford Engineered Barrier Overhang Feature . . . . . APP F8A-4
8A-5 Use of Curtains to Minimize Return Flow from the Edges . . . . . APP F8A-5
8A-6 Side Slope Treatment: Clean Fill . . . . . APP F8A-6
8A-7 Side Slope Treatment: Basalt . . . . . APP F8A-7

8A.1.0 BARRIER AND MARKER SYSTEM DESIGN CONSIDERATIONS

Disposal of SST waste at the Hanford Site may include the use of in-place stabilization techniques. In-place stabilization provides isolation protection of the contaminant from the following transport pathways:

- Water infiltration--the infiltration and percolation of water through the waste zone resulting in the leaching and subsequent transport of radionuclides and other contaminants to the water table

- Biointrusion--the penetration of deep-rooting plants and burrowing animals into the waste zone. The deep-rooting plants could uptake radionuclides and other contaminants into their root systems and subsequently translocate the contaminants to the abovegrade portion of the plant. The contaminants in the abovegrade portion of the plant could then be dispersed by animals that eat the plants or by wind dispersing dried portions. Animals burrowing directly into the waste zone could contact contaminants and subsequently bring them to the earth's surface as part of the soil castings. In addition, the presence of animal burrows may provide a preferential pathway for infiltrating water to gain access to the waste zone

- Wind and water erosion--the gradual deterioration and saltation of the surface soils at the waste site. Erosion could provide a direct pathway for contaminant transport if the erosive forces are strong enough to remove the surface soils and expose the buried waste to the accessible environment. A more probable scenario is for wind and water erosion to reduce the thickness of soils overlying a waste zone such that another transport pathway (i.e., water infiltration) has easier access to the waste zone

- Human interference--the inadvertent intrusion of humans into the waste site (assuming institutional control is lost) and subsequent dispersal of contaminants

- Gaseous release--the diffusion of noxious gases from the waste zone to the accessible environment.

Figure 8A-1 provides a schematic representation of the transport pathways.

Appropriately designed engineered barrier and marker systems have been proposed for use in protecting human health and the environment from either processed and disposed treated and in-place stabilized waste (Figure 8A-2). The design of all protective surface barriers is similar in concept and employs the use of a variety of different materials (e.g., fine soil, sand, gravel, riprap, clay, asphalt, and human-generated synthetics). These barriers are placed in layers to form an abovegrade mound directly over the waste zone to prevent these pathways from forming.

Typically, the protective surface barriers include three to five layers depending on the risk. Surface barriers usually include a surface or cover layer, a protective or filter layer, a drainage layer, and a low-permeability layer. The EPA recommended that cover designs consist of five layers and include the use of a flexible membrane liner (FML), which is placed above the low-permeability layer. All layers will be constructed using the materials previously specified. The specific design of each layer will vary and will depend on the functions and requirements specified for each layer. Application of this approach results in a 'graded approach' in the use of protective surface barriers and covers. Chapter 8.0, Section 8.2.3, provides additional information on the use of a graded approach.

Depending on the hazard, surface markers may be placed on the periphery of the waste site to alert future generations of the nature and hazards of the buried waste. In addition, subsurface markers could be placed in the barrier to warn human intruders of the dangers of the buried waste. In contrast to the consistency associated with surface barrier design, there is no single approach to both the need for and use of surface marker systems. Wing (1993) addresses functional performance criteria that include the use of surface and subsurface markers for the Hanford Engineered Barrier.

Preparation of the waste site for the construction of protective surface barriers is critical to the long-term performance of the barrier. It is important that an appropriate bearing surface is provided before the construction of the surface barrier to prevent differential settlement and/or subsidence that could compromise the performance of the barrier. Surface barriers and covers are large and heavy structures and this design load must be taken into consideration. It is important to note that differential settlement and subsidence has been a major cause of barrier failure (Daniel and Koerner 1993).

As part of the site preparation work, activities such as the filling of SST (void filling) with suitable materials to prevent dome collapse must be completed if the tanks are partially or totally stabilized in place. Dome collapse could result in the subsidence of overlying backfill and barrier construction materials which, in turn, could seriously impair the performance of the barrier.

In addition to dome filling, other SST site preparation activities that need to be performed include the capping or removal of risers and other influent and effluent piping to facilitate the unobstructed construction of protective barriers. Once the initial site preparation activities have been completed and the SSTs have been stabilized, protective barriers can be constructed directly over the SST sites. Section 8.2.2 contains additional information on stabilization activities that are designed to minimize and prevent subsidence.

The surface, filter, and drainage layers of the protective barrier consist of a fine soil layer overlying other layers of coarser materials such as sands, gravels, or basalt riprap. Each of these layers serves a distinct purpose. The fine soil layer acts as a medium in which moisture is stored until the processes of evaporation and transpiration can recycle any excess

water back to the atmosphere. The fine soil layer also provides the medium for establishing plants necessary for transpiration. The coarser materials that are placed directly below the fine soil layer create a capillary break that inhibits the downward percolation of water through the barrier.

The coarser materials also act as deterrents for burrowing animals, deep-rooting plants, and human intruders. Low-permeability layers, placed in the barrier profile below the capillary break, are also being considered for use in the protective barriers. The low-permeability layers would be used to divert any percolating water that penetrates the capillary break away from the waste zone, and to inhibit the upward movement of noxious gases from the waste zone. Solution grouts also are being evaluated for use as a construction aid and as a means of providing additional structural stability to the barrier.

Preliminary performance objectives have been established for the Hanford Engineered Barrier and warning marker systems. These preliminary performance objectives have been established based on the HDW-EIS (DOE 1987a) and the EPA's standard for disposal systems for spent fuel, high-level, and transuranic radioactive waste (40 CFR 191). The preliminary performance objectives for the Hanford Engineered Barrier have recently been documented (Wing 1994).

One of the requirements in 40 CFR 191 is that there be a reasonable expectation, based on performance assessments, that waste will be protected from the accessible environment for 10,000 years. An additional requirement of 40 CFR 191 is that institutional control by the federal government is assumed to be lost 100 years after the disposal of the waste.

Existing barrier designs, such as covers to facilitate compliance with RCRA regulations, are currently available (EPA 1989b). However, these designs are for a short period of time (a few tens to hundred years), such as the 30-year postclosure period specified by RCRA. The performance of barriers during this short period can be monitored and maintenance activities can be performed to correct any problems that may be encountered. However, if institutional control is assumed to be lost 100 years after waste disposal, these short-term designs may not be satisfactory for disposing of waste that requires isolation for periods up to 1,000 years or longer.

A Hanford Site barrier development team, which includes members from all DOE-RL contractors, has been organized to develop and demonstrate the performance of protective barrier and warning marker systems for periods that extend well beyond the institutional control period. The current focus of development efforts is to design protective barrier and warning marker systems that will function in an arid to semiarid climate (such as at the Hanford Site), limit the infiltration and percolation of water through the waste zone to near-zero amounts, last up to 1,000 years, and be maintenance free.

Because of the need for the barrier to perform for 1,000 years without maintenance, natural construction materials (e.g., fine soil, sand, gravel, cobble, crushed basalt riprap, clay, asphalt), as opposed to human-generated materials (e.g., FML), have been selected to maximize the potential for long-term barrier performance. These natural construction materials, most of which

exist in large quantities on the Hanford Site, are known to have existed for thousands of years. In contrast to the natural construction materials, the ability of human-generated construction materials to survive and function properly for 1,000 years is not known. Because of this uncertainty, human-generated construction materials cannot be relied on to perform satisfactorily (or even exist) over the design life.

Conceptual protective barrier and warning marker designs are being prepared to satisfy the preliminary performance objectives for the environmental conditions and hazards that exist at the Hanford Site. These designs use a number of components integrated into a simple and constructable structure. The bases for these designs are presented by evaluating how the various components of the barrier and marker systems are used to isolate waste from the accessible environment by controlling water infiltration, biointrusion, wind and water erosion, human intrusion, and the release of noxious gases. A prototype Hanford Engineered Barrier has been constructed on the Hanford Site and is scheduled to be tested and monitored beginning in fiscal year 1995 (Wing 1994; Gee et al. 1993).

8A.1.1 WATER INFILTRATION CONTROL

The infiltration and percolation of water through a protective barrier can be controlled by: (1) engineering the barrier surface to maximize run-off while minimizing erosion, (2) incorporating a capillary barrier (or capillary break) within the integrated barrier system, and (3) incorporating a low-permeability, umbrella-like layer within the barrier profile to shed any infiltrating or percolating water away from the waste zone.

8A.1.1.1 Run-off

The surface of the protective barrier can be engineered with a slight slope or crown to maximize the run-off of meteoric water and, in turn, minimize the amount of precipitation available for infiltration and percolation. The amount of water available for infiltration and percolation is a function of the amount of precipitation that falls on the barrier surface minus the amount of water that runs off of the barrier surface and away from the barrier. The engineering of the barrier surface can be optimized such that the run-off of water from the barrier surface is maximized and the erosion of the fine soil is minimized. The recommended surface slope to promote run-off while minimizing the potential for erosion is 3 to 5 percent (EPA 1988).

8A.1.1.2 Capillary Barrier

The Hanford Engineered Barrier is designed and constructed with a fine soil layer overlying a layer of coarser materials (e.g., sands and/or gravels). The differences in textures between the barrier materials at this interface provide a capillary barrier for percolating water (Figure 8A-3).

The capillary barrier concept is based on the principles and physics that govern water retention in unsaturated soils (Richards 1950). In an unsaturated system, the capillary forces of the fine-textured materials are at less than atmospheric pressure. For soil water to percolate from the fine-textured soils into the coarse-textured materials below, the fine-textured soils at the interface must approach saturation. As the fine-textured soils approach saturation, the soil water at the interface and the capillary head approach atmospheric pressure. If the water retention capacity of the fine soil layer is exceeded, water will penetrate into the capillary barrier and drain through the coarser layers of the protective barrier (Wing 1993).

The critical component of the capillary barrier is the fine soil layer. The fine soil layer must be able to retain precipitating water until the processes of evaporation and transpiration recycle the water back to the atmosphere. A large deposit of fine soils that possesses suitable moisture-retention characteristics has been located on the Hanford Site. The fine soil site, known as the McGee Ranch, was characterized during the spring of 1986. The results of the characterization indicate that a quantity of suitable fine soils, far in excess of the projected volume requirements, exists at the McGee Ranch site (Last et al. 1987).

8A.1.1.3 Low-Permeability Layers

The premise of the capillary barrier concept is that most of the meteoric water that is absorbed in the fine soil surface layer can be evapotranspired back to the atmosphere. However, for periods of unusually heavy or intense precipitation, the capillary barrier may not be capable of completely recycling all of the water back to the atmosphere. Unless checked, the water would be free to migrate down through the barrier and into the waste zone below. As a means of restricting the percolating water from gaining access to the waste zone and ensuring compliance with existing regulatory requirements, a low-permeability component has been placed within the barrier profile below the capillary barrier to divert percolating water away from the buried waste. This diversion barrier is constructed of material with low permeability (e.g., clay or asphalt). In the design and construction of the prototype barrier, a low-permeability layer consisting of 6 inches of asphaltic concrete overlain by a coating of liquid-applied asphalt has been used. The low-permeability layer is expected to be designed in such a way that near-zero drainage rates through the barrier can be achieved.

8A.1.1.4 Edge Effects

A protective barrier designed with a sloped, fine soil surface layer and low-permeability subsurface layers will channel water to the side slopes and eventually to the toe of the barrier. As a result of this channeling, a significant amount of water could accumulate at the toe. Because the run-off water is being concentrated in a relatively localized area, the amount of water available for recharge at the toe may be significantly higher than at another location that receives only ambient precipitation. Several design features are being considered for the Hanford Engineered Barrier to control

this accumulation of water at the toe so that it does not flow or diffuse laterally back into the waste zone or spread via overland flow into adjacent waste sites.

8A.1.1.4.1 Barrier Overhang. Barrier overhang is the terminology used to describe the distance from the outer edge of the waste zone to the outer edge of the barrier. The overhang feature can be used to prevent the backflow of water from the toe to the waste zone. If the barrier overhang is sized properly, the amount of diffusing water that gains access to the waste zone can be minimized. Figure 8A-4 depicts the barrier overhang feature and its function in preventing the backflow of water from the toe to the waste zone.

Computer simulation models have been used to determine the optimal amount of barrier overhang needed for the Hanford Engineered Barrier (Fayer 1987). Although overhang is required to control the diffusive flow of water into the waste zone, from an economic perspective it is important to minimize the sizing of the overhang because this will reduce the overall size of the barrier. The computer simulation models will help designers optimize the amount of overhang needed while minimizing the cost of the surface barrier. The amount of barrier overhang is site specific and is an important design consideration to both minimize cost and prevent backflow.

8A.1.1.4.2 Curtains. Curtains constructed from grout, steel, or asphalt can also be used to restrict the flow of accumulated water from the toe to the waste zone (Figure 8A-5). The curtains would consist of a ring or band of low-permeability materials that completely encircles a waste site. The curtain would be constructed such that run-off water from the barrier would be diverted onto the side of the curtain opposite the waste zone. In this manner, the curtain would serve as a barrier between the water and the waste.

The incorporation of low-permeability curtains into barrier design could be used to offset the need for overhang. An engineering evaluation could be performed to determine the cost effectiveness of this concept.

8A.1.1.4.3 Barrier Toe Design. The barrier must be designed in such a manner that the accumulation of water at the toe is not allowed to travel indiscriminately via overland or subsurface flow into adjacent waste sites. Design features such as the ones illustrated in Figures 8A-6 and 8A-7 will be tested on the prototype barrier. The low-permeability asphalt is extended beneath the side slopes to the toe of the barrier. The accumulation of water at the toe is expected to enhance the establishment of plants in this region. Plants are known to be very effective in extracting or mining and transpiring water from soils.

The distance of the toe from the waste zone will need to be designed with consideration of barrier overhang. Enough barrier overhang will be needed to minimize the lateral migration of the accumulated waste back to the waste zone. In addition, enough barrier overhang will be needed to ensure that plant roots are far enough away from the waste zone to prevent biointrusion.

The effectiveness of the two side slope/toe design concepts shown in Figures 8A-6 and 8A-7 will be evaluated as part of the testing and monitoring of the prototype barrier. Based on the results of these tests, the side slope/toe design will be adopted or modified for future application.

8A.1.1.5 Physical Stability

Protective barriers must be designed to maintain their functional integrity following potentially disruptive natural events (e.g., earthquakes, the deposition of volcanic ash and/or blown sand, tornados, probable maximum precipitation events, and subsidence). The occurrence of these potentially disruptive natural events could seriously affect the ability of the protective barrier to limit the infiltration and percolation of water through the barrier. Studies to ensure that current protective barrier designs will provide the level of physical stability needed are ongoing but have not been completed for the Hanford Engineered Barrier.

8A.1.2 BIOINTRUSION CONTROL

Protective barriers must be designed to protect waste from the intrusion of deep-rooting plants and burrowing animals. The protective barrier design configurations being considered to control these potential problem areas are presented in the following sections. The basic EPA cover design (EPA 1989b) requires a top layer soil component with a minimum thickness of 60 centimeters.

8A.1.2.1 Plant Root Intrusion Control

Barrier designs are intended to control the penetration of plant roots into the waste zone beneath the protective barrier by using a combination of techniques. The materials used to construct protective barriers (e.g., fine soil, sand, gravel, cobble, crushed basalt riprap, asphalt, and clay) may provide an effective deterrent to plant root intrusion. For example, the use of crushed basalt riprap may discourage plant root intrusion by limiting plant-available water and by providing a formidable obstacle for plant roots to penetrate.

In addition to barrier construction materials, the sheer thickness of the protective barrier may exceed the maximum rooting depths of most plants expected to grow on the barrier. The top layer thickness of the current Hanford Engineered Barrier design is 2 meters. The total thickness of the Hanford Engineered Barrier is approximately 5 meters. The thickness of the barrier in addition to the thickness of the preparatory overburden material that may be placed over the waste zone before barrier construction will also provide a substantial barrier-to-root intrusion. The textural break at the capillary interface between the fine soil and sand layers is expected to substantially limit root penetration into the lower portion of the barrier profile (Wing 1993).

8A.1.2.2 Burrowing Animal Intrusion Control

The methods used to control plant root intrusion into the waste zone will also be effective in controlling animal intrusion into the waste zone. The types of barrier construction materials used (especially the coarser materials) and the thickness of the barrier will provide effective deterrents to burrowing animals (both vertebrates and invertebrates).

Most of the animals that currently inhabit or are expected to inhabit the Hanford Site during the design life of the protective barriers do not have a need to burrow deeper than 1 meter (Landeen 1991). Food and shelter for most of the animals can be obtained within the top 1 meter of the Earth's surface. Because there is no need or incentive for animals to burrow deeper than 1 meter, the animals very likely will not expend the additional energy required to dig deeper into the barrier profile. The coarser barrier construction materials, such as the crushed basalt riprap and the pitrun gravels, will further discourage animals from burrowing deeper into the barrier profile.

Tests to assess the impact of burrowing animals on the infiltration and percolation of water through the Hanford Engineered Barrier have been completed. The burrowing of small animals is not expected to significantly impact the performance of the Hanford Engineered Barrier by creating pathways for deep percolation or penetration of water (Landeen 1991). A final report, which provides a summary of the work performed on controlling animal intrusion, recently has been issued (Landeen 1994).

8A.1.3 WIND AND WATER EROSION CONTROL

Protective barriers are being designed to minimize the effects of wind and water erosion of the surface cover, side slopes, and toe of a protective barrier. In addition, designs for stabilizing the areas surrounding the protective barriers are being considered to minimize the deposition of windblown materials from these areas onto the surface of the barrier.

8A.1.3.1 Barrier Surface

Throughout the majority of a barrier and marker system's design life, vegetation is expected to grow on the surface of the protective barrier. The presence of vegetation on the barrier surface will significantly reduce the amount of fine soil lost from the barrier by wind and water erosion. However, to protect the barrier surface during periods of time when the vegetative cover is disturbed by range fires, drought, disease, or some other phenomenon, surface gravels will be either mixed into or spread onto the surface of the protective barrier.

The amount of gravel used to stabilize the surface of the protective barrier is a critical design consideration. If too much gravel is ad?mixed into or spread onto the fine soil surface, plant transpiration and surface evaporation could be significantly reduced, thereby increasing the potential

for water drainage through the barrier. Conversely, if too little gravel is used, the ability of the gravel mulch to reduce wind and water erosion may be severely limited. The range of surface-gravel concentrations and sizes over which protective barriers perform best is being determined in the barrier development program by using computer simulation models as well as laboratory and field tests. The results of these studies have been incorporated into the present design. As a result of studies performed by PNL, 15 percent by weight of pea gravel has been added to the topmost layer of the Hanford Engineered Barrier prototype design (Ligotke 1993).

Another concern being evaluated in the barrier development program is the potential for enhanced erodibility of soils excavated from and brought to the surface of a protective barrier by burrowing animals. The soils excavated by burrowing animals are thought to be more susceptible to accelerated erosion than the surrounding soils that have not been disturbed by animal activity. As stated previously, the activities of small burrowing animals are not expected to exceed a depth of 1 meter. Because this depth is consistent with the thickness of the armored mix, the effect of burrowing animals is not anticipated to have any detrimental effects on the performance of the Hanford Engineered Barrier. The prototype barrier will be monitored to quantify the extent of colonization and to determine the characteristics of the burrowing behavior.

8A.1.3.2 Barrier Side Slopes and Toe

Crushed basalt riprap is being considered to armor the side slopes and toe of the protective barrier from wind and water erosion. Because of its angularity, the crushed basalt riprap serves as an excellent material to place on sloped surfaces. The angularity of the riprap provides many interlocking surfaces between adjacent rocks. The interlocking surfaces provide a much more stable configuration than rocks with relatively smooth surfaces. A description of how riprap is used to control wind and water erosion is provided in the following sections.

8A.1.3.2.1 Riprap as a Deterrent to Wind Erosion. As wind passes over protective barriers, turbulent eddies could be created on the upwind and downwind side slopes and toe of the protective barriers. Unless protected with a material such as riprap, these turbulent eddies could possess enough energy to scour away relatively finer materials adjacent to the toe of the barrier. Over time, this scouring effect could render the toe and, subsequently, the side slopes of the barrier unstable. The riprap is large enough that its displacement because of the effects of wind erosion is improbable. As a result, the riprap provides an effective deterrent to wind erosion.

Studies on the prototype barrier will analyze the effects of wind erosion on the long-term stability and performance of the edges of protective barriers (Gee et al. 1993). Various techniques are being considered for use in the analysis. For example, physical models, used in conjunction with wind tunnels, could be employed to analyze wind streamlines (boundary layers) over abovegrade barrier surfaces. Areas on the edges of the barrier that are

susceptible to wind erosion could be detected, and proposed solutions to erosion-related problems could be tested and evaluated. The use of analytical models is another technique or tool that could be used to better understand the effects of wind erosion on protective barrier edges. The insights gained from conducting these studies will be integrated into future protective barrier designs.

8A.1.3.2.2 Riprap as a Deterrent to Water Erosion. As presented in Section 8A.1.1.4.3, the accumulation of water at the toe of the barrier must be considered during the design of protective barrier and warning marker systems. With the accumulation of water at the toe of the barrier, the potential for structural stability and erosion-related problems of the barrier toe and side slopes is increased. Designs that use crushed basalt riprap are being engineered to accommodate the run-off water without compromising the structural stability of the barrier toe and side slopes.

Studies are currently planned in the barrier development program to assess the stability of the barrier toe and side slopes under various conditions. These studies will provide useful data and insight into the design of protective barriers. The results of these studies will be integrated into future protective barrier designs.

8A.1.3.3 Surface Soils Surrounding the Barrier

The existence of various geologic features in the surface soils at the Hanford Site (e.g., blowouts, dunes) suggests that the eolian processes of wind erosion and deposition have been active for thousands of years. The influence of these eolian processes on the soils immediately surrounding protective barriers could have an adverse effect on the performance of the barrier.

Turbulent eddies created by the wind could erode soils surrounding a protective barrier and subsequently deposit the wind-suspended soil particles onto the barrier surface. If the windblown materials deposited on the barrier surface are coarser in texture than the fine soils used in constructing the protective barrier, the moisture-retention capability of the barrier could be adversely affected. The potential for having more coarse-grained, windblown soils (which possess poorer moisture-retention characteristics than the original fine soils) on the surface of the barrier could affect the establishment of desired species of vegetation on the barrier, promote deeper drainage, and reduce evaporation.

Another potential adverse impact on barrier performance could be caused by the deposition of windblown soil particles on the surface of a barrier. One of the key functions of the upper layer of the barrier (normally comprised of fine soil) is to store meteoric precipitation until the processes of evaporation and transpiration recycle any excess moisture back to the atmosphere. If the upper moisture-retaining layer of the barrier is too thick, moisture may be able to percolate below the root zone of the plants growing on the barrier surface, thereby becoming difficult or impossible to

evapotranspire back to the atmosphere. The deposition of windblown soil particles on the barrier surface could be a contributing factor to an upper moisture-retaining layer that is too thick.

Stabilizing the soils immediately surrounding a protective barrier may be necessary to reduce the amount of wind-suspended soil particles available for deposition on the barrier surface. This stabilization could be accomplished by applying a gravel mulch to the surface of the surrounding soils. Because the potential increase in water drainage caused by the gravel mulch is not as much of a concern for soils surrounding the barrier as for soils on the barrier, heavier applications of gravel may be acceptable and beneficial in reducing the wind erosion of soils surrounding the barrier.

The prototype barrier includes the use of both an 'earthen fill side slope' and a riprap side slope. The earthen fill sides are located along the west, northwest, and southwest sides of the prototype structure. All of these faces are blended into the local topography using a 10:1 gradient. The riprap side slope treatment is located along the east, northeast, and southeast sides of the prototype. The gradient along the riprap faces will be a 2:1 gradient. The two treatments (i.e., earthen, riprap) will be observed and evaluated during the testing and monitoring period.

8A.1.4 HUMAN INTERFERENCE CONTROL

During the institutional control period, the inadvertent intrusion of humans into waste sites is unlikely because the DOE-RL still will be managing and patrolling the Hanford Site. However, the loss of institutional control 100 years after the waste has been disposed is an assumption that must be considered (40 CFR 191). Because barrier and marker systems are intended to function for up to 10,000 years, a method for reducing the likelihood of inadvertent human intrusion into the waste sites for the thousands of years following institutional control is needed. The EPA standard 40 CFR 191.14e states, "Disposal systems shall be identified by the most permanent markers and records practicable to indicate the dangers of the waste and their location." The following sections describe the plans for accomplishing the objectives of this standard.

An approach with built-in redundancies is being taken to warn future generations of the hazards of the waste disposed at the Hanford Site. The approach consists of using: (1) offsite records, (2) surface markers, (3) subsurface markers, and (4) barrier designs. The role that each of these components plays in controlling human interference is described in the following sections.

8A.1.4.1 Offsite Records

Records and other information pertaining to the type, location, and quantity of waste disposed at the Hanford Site will be provided to applicable offsite organizations such as municipal, county, state, and federal governments. The possession of these records by offsite organizations will

provide redundant archives of records and information regarding the disposal of waste at the Hanford Site. The multiple archives will enable waste disposal records and information to be readily accessible to future generations. The offsite archives of waste disposal records at multiple locations are particularly significant given that regulations require the assumption be made that institutional control of the Hanford Site is lost 100 years after disposal of the waste.

8A.1.4.2 Surface Markers

Surface markers are large monolithic stone obelisks on which have been inscribed a message to warn potential intruders of the nature and hazards of the waste buried at a disposal site. Preliminary designs for modern surface markers have been patterned after the characteristics of ancient surface markers (e.g., the Pyramids of Egypt, the Great Wall of China, Stonehenge, the Acropolis, and Serpent Mound). These ancient archaeological analogs of surface markers have existed for thousands of years and provide valuable insights into the design of modern surface markers that are expected to last for thousands of years into the future.

The surface markers will be placed around the periphery of the waste sites in a manner in which they can be easily seen and recognized. For example, the surface markers will be placed at the corners of each barrier mound (disposal block) and at any other locations necessary to clearly delineate areas where waste has been disposed. In addition, the surface markers will be used to delineate a marker perimeter around a group of disposal sites such as the 200 Areas at the Hanford Site.

The placement of markers will involve a determination of surface marker placement locations and intervals based on actual Hanford Site topography and vegetative cover considerations. Field surveys will be conducted to locate marker placement points that offer the best visibility while optimizing placement intervals and costs. Maps will be prepared to guide marker placement. Preliminary sketches and specifications for surface markers have been drafted (Wing 1993).

8A.1.4.3 Subsurface Markers

A network of subsurface markers will be placed at strategic locations throughout the barrier to provide a redundant warning system to the surface markers. Should inadvertent human intruders get past the surface markers without seeing the warning message, the intruders could conceivably start digging into the protective barrier without knowledge of the inherent dangers of the waste buried below. The subsurface markers will provide a backup mechanism to increase the probability that a warning message is seen and understood.

The design of subsurface markers has benefitted greatly from the examination of analogous archaeological artifacts. For example, the placement schemes, size, and materials used in the design of the subsurface markers have been patterned after the insights gained from studying buried archaeological artifacts (e.g., pottery) that have existed for thousands of years.

Current designs of subsurface warning markers use circular ceramic discs that are approximately 5 inches in diameter and 1/2-inch (1.27 centimeters) thick. The disks are yellow and use magenta letters and pictograms to create the warning message.

The first layer of subsurface markers is placed 2 feet (61 centimeters) below the surface of the barrier; the second layer is placed 4 feet (1.22 meters) below the surface of the barrier; and the third layer is placed at the original grade.

To achieve the maximum probability that at least one marker will be exposed should an intruder dig into the barrier, the subsurface markers have been strategically spaced throughout each layer. In addition to being spaced within a layer, the subsurface markers in the three different layers have been staggered. The concept of staggering subsurface markers is based on the natural angle of repose of the soils used to construct the protective barriers. Unless shored in some way, the side slopes of unconsolidated soils will remain unstable during excavation activities and will tend to slough until the natural angle of repose of the soils is reached. As a result of this sloughing, the area opened up at the original grade of an excavation will be much larger than the area at the bottom (or working face) of the excavation. Consequently, the deeper an excavation is dug into a protective barrier, the wider the opening will become at the surface of the barrier. The subsurface markers have been spaced and staggered such that if a subsurface marker were not directly in the path of the excavation, an intruder would not have to dig too deeply before a subsurface marker would be uncovered due to the sloughing of soils trying to reach their stable, natural angle of repose.

8A.1.4.4 Barrier Design

Should the messages in the archives and on surface and subsurface markers be misunderstood, not seen, or ignored, the protective barrier itself will provide two additional lines of defense against human intruders. These two additional lines of defense are the types of materials used to construct the protective barrier and the thickness of the protective barrier.

The types and thickness of the materials used to construct barriers will protect waste sites from the most probable human intrusion activities. Some of the barrier construction materials used to discourage the intrusion of burrowing animals and deep-rooting plants will provide a formidable obstacle to human intruders as well. For example, the lower levels of the protective barrier consist of relatively thick layers of coarse materials such as crushed basalt riprap or pitrun gravels. These coarse materials by themselves likely will provide a substantial obstacle for human intrusion. In addition, the combined layers of barrier construction materials provide a relatively thick

obstacle (likely no less than 3 meters and possibly as much as 5 meters or more) for a human intruder. The types and thickness of barrier construction materials should provide an effective deterrent to all but the most determined human intrusion activities that reasonably could be expected to occur on the protective barrier.

8A.1.5 GASEOUS RELEASE CONTROL

Depending on the types of tank waste selected for in-place disposal, noxious gases from the waste could be generated and subsequently diffuse from the waste zone to the accessible environment. Unless checked in some way, the noxious gases could pose a potential threat to human health and the environment. An assessment of the noxious gases that may impact the performance of surface barriers designed and constructed to support SST closure activities has not been performed. For the design of the prototype barrier constructed over the 216-B-57 crib, radon was the only gas of any consequence that was identified.

The potential for problems associated with the release of radon gas is not unique to the Hanford Site. For example, uranium mill tailings sites are often challenged by the emanation of elevated concentrations of radon gas. One such site is located in Grand Junction, Colorado.

A number of years ago, scientists and engineers, several of whom are currently serving on the Hanford Site Protective Barrier Development Team, were requested to participate in finding a solution to the elevated radon gas concentrations at the Grand Junction uranium mill tailings sites. Various barrier designs that used several different barrier construction materials were developed and tested. In general, the designs consisted of a multilayer barrier of compacted soils and gravels with a low-permeability component (asphalt or clay) incorporated into the barrier profile. Full-scale protective barriers have been constructed over uranium mill-tailing sites.

Nearly 8 years after the protective barriers had been constructed, the opportunity arose to perform a postmortem examination of the performance of the Grand Junction protective barriers. The results of the postmortem showed that the protective barriers that were constructed with low-permeability, asphaltic layers performed the best in inhibiting the diffusion of radon gas to the surface of the barrier. The results also suggested that asphaltic layers constructed in the field with conventional equipment can perform as designed for an extended period of time (Gee et al. 1989a).

The Hanford Protective Barrier Development Program will use the experience and expertise gained at Grand Junction, Colorado and elsewhere to address and resolve any noxious gas-related problems at the Hanford Site. In addition to controlling the upward diffusion of noxious gases from the waste zone, the low-permeability layer will also limit the downward percolation of water into the waste zone. Designs of low-permeability layers will consider both these purposes as appropriate.

8A.1.6 CONCLUSIONS

Progress is being made in the development, design, and performance assessment of protective barrier and warning marker systems. A functioning barrier development team, organized to resolve the technical issues regarding protective barrier and warning marker systems, is directing the development effort. The design of the prototype Hanford Engineered Barrier being constructed over the 216-B-57 crib in the 200 East Area has incorporated the data and knowledge collected to date. An external peer review of the Barrier Development Program was conducted from March 9 to 11, 1992 to evaluate the scope of, need for, results, and planned work; and the design of the proposed prototype barrier. After this information was gathered, a Value Engineering workshop was held February 8 to 12, 1993 to review the program plan with the regulators and stakeholders. This workshop's sole purpose was to come to an agreement on the work that remained to bring the Hanford Engineered Barrier to fruition. A program plan that captures the guidance and recommendations resulting from these reviews was issued (Wing 1994). Most of the research and development tasks have been completed and final documentation is ongoing. The construction of the prototype barrier has been completed and performance monitoring of the prototype is scheduled to begin in fiscal year 1995. Testing of the prototype is scheduled to be completed in fiscal year 1998.

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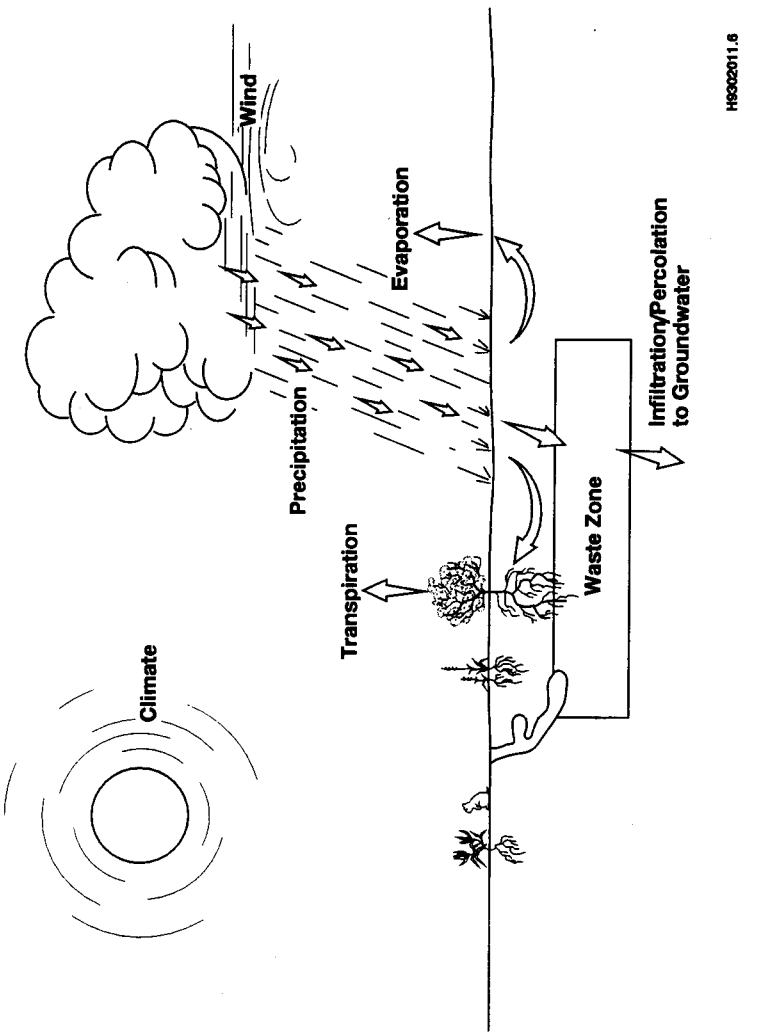

Figure 8A-1. Transport Processes Affecting Surface Barrier Performance.

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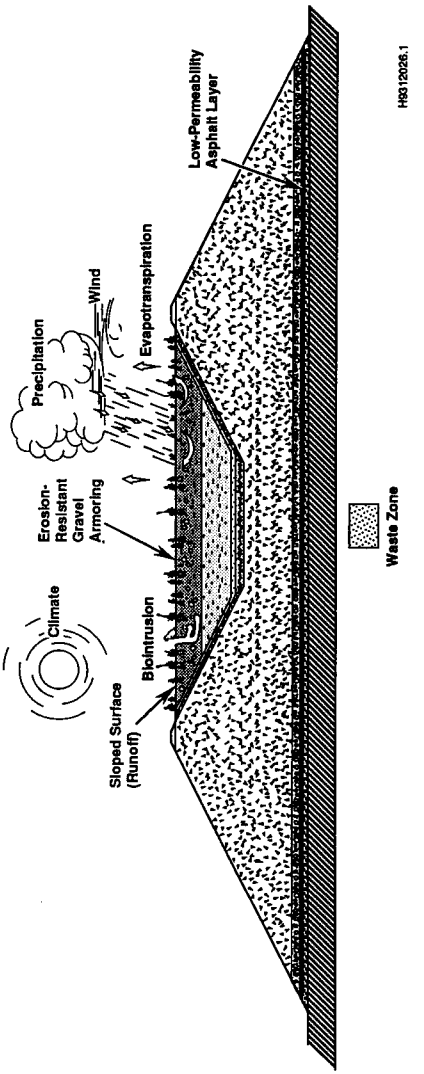

Figure 8A-2. Conceptual Design of Proposed Hanford Engineered Barrier.

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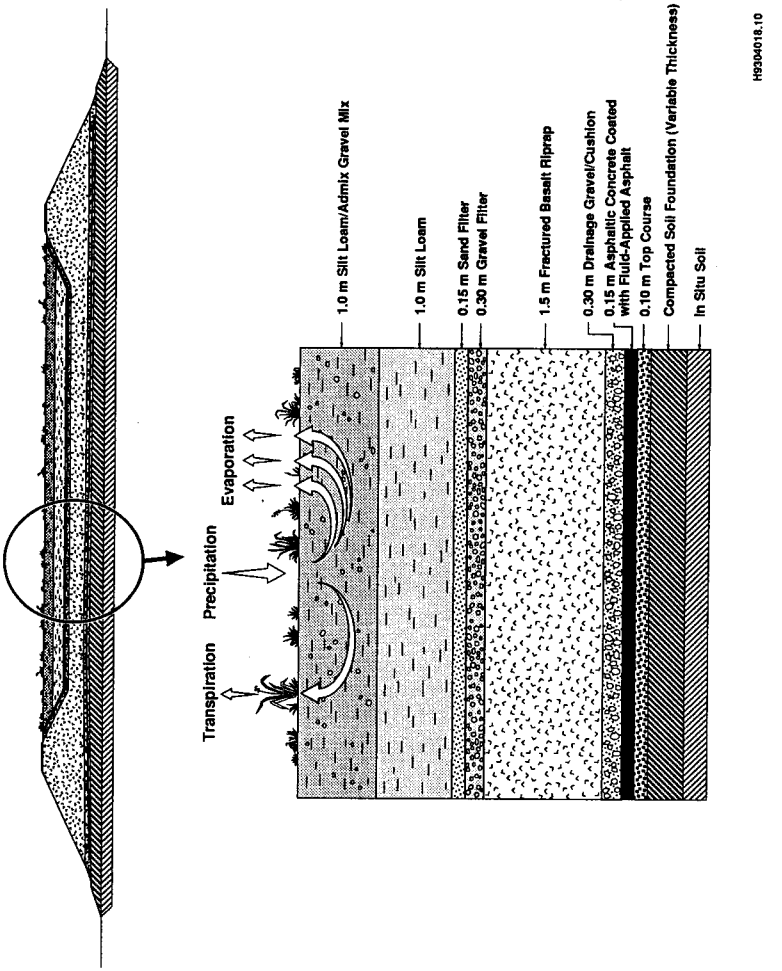

Figure 8A-3. Design of the Layering Sequence for the Proposed Hanford Engineered Barrier.

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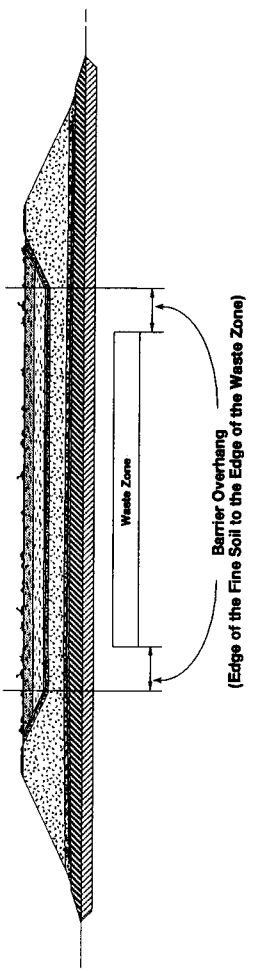

Figure 8A-4. Hanford Engineered Barrier Overhang Feature.

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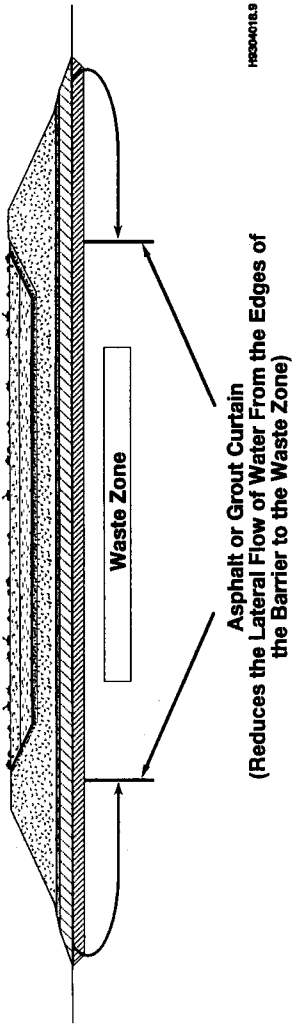

Figure 8A-5. Use of Curtains to Minimize Return Flow from the Edges.

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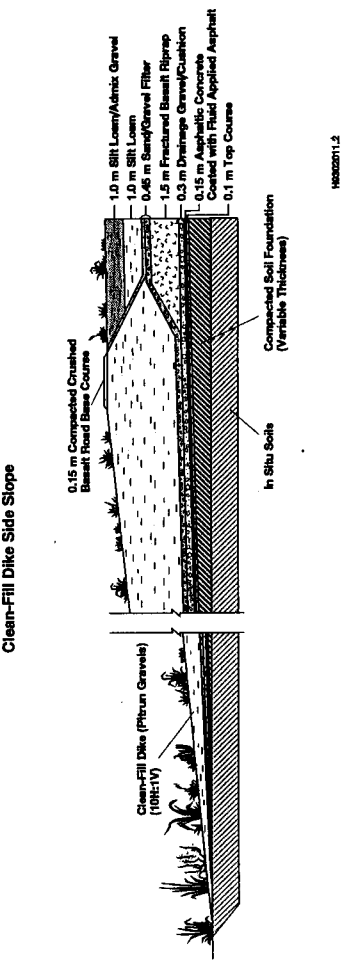

Figure 8A-6. Side Slope Treatment: Clean Fill.

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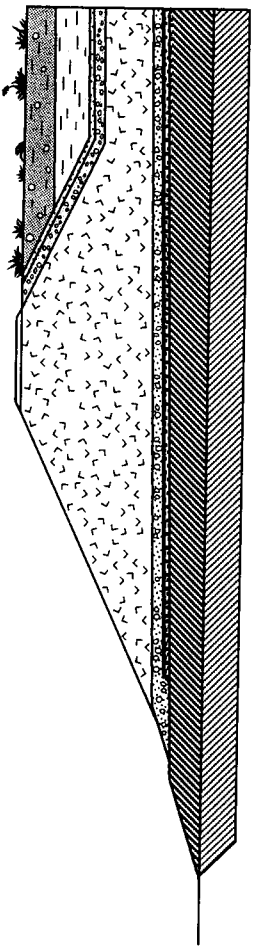

Figure 8A-7. Side Slope Treatment: Basalt.

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