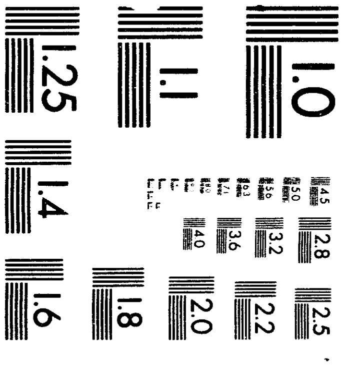
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SUPPORTING DOCUMENT

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6. Author

Name: SS Lowe

SS Lowe
Signature

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7. Abstract

The functions to be performed by subsurface barriers based on their role in retrieving waste from the SSTs are described, and the requirements which constrain their application are identified. These functions and requirements together define the functional baseline for subsurface barriers.

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FUNCTIONS AND REQUIREMENTS FOR SUBSURFACE BARRIERS USED IN SUPPORT OF SINGLE-SHELL TANK WASTE RETRIEVAL

Issued by

Westinghouse Hanford Company

for the

U.S. DEPARTMENT OF ENERGY - RICHLAND FIELD OFFICE
RICHLAND, WASHINGTON

October 1993

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ABBREVIATIONS AND ACRONYMS

ACV	administrative control value
ALARA	as low as reasonably achievable
BARCT	best available radionuclide control technology
CFR	*Code of Federal Regulations*
CX	categorical exclusion
DBA	design basis accident
DCG	derived concentration guide
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
HPS	Hanford Plant Standards
NEPA	*National Environmental Policy Act of 1969*
NOC	notice of construction
PNL	Battelle Pacific Northwest Laboratories
PP/EP	Plio-Pleistocene/early Palouse
PSE	preliminary safety evaluation
QAPP	quality assurance program plan
RCRA	*Resource Conservation and Recovery Act of 1976*
RL	U.S. Department of Energy - Richland Field Office
RWP	radiation work permit
SDC	standard design criteria
SI	*Systeme International*
SST	single-shell tank
TBD	to be determined
TWRS	Tank Waste Remediation System
WAC	*Washington Administrative Code*
WHC	Westinghouse Hanford Company
WPPSS	Washington Public Power Supply System

CONVERSIONS TO SI UNITS

English Unit SI Unit

1 ft = 0.3048 m

1 gal = 0.003785 m^3

1 Ci = 3.7E+10 Bq

(°F - 32)/1.8 = °C

PREFACE

Changes to the Tri-Party Agreement were recently negotiated and are now undergoing public review and comment. Included in the changes was identification of a number of Safety Initiatives which establish goals for achieving improved operational safety. Safety Initiative #5g directs Westinghouse Hanford Company to "Accelerate evaluation and demonstration of barrier technologies beginning demonstrations by October 1995." This initiative was championed by the Tank Farms Operations organization.

The effect of this change is to increase the scope of the subsurface barrier program. Use of barriers was previously limited to confining leaks from single-shell tanks during waste retrieval. Other applications of barriers will now be considered, such as confining leaks from single-shell tanks used for interim waste storage. Planning for the subsurface barrier program is being revisited at this time. The functions and requirements in this document were developed based on using barriers to support single-shell tank waste retrieval; no other applications were considered. As the program scope is further defined, the need for additional functions and requirements will become apparent and this document will be updated.

1.0 INTRODUCTION

The mission of the Tank Waste Remediation System (TWRS) Program is "to store, treat, and immobilize highly radioactive Hanford waste in an environmentally sound, safe, and cost-effective manner" (RL 1993a). The scope of the TWRS Program includes project and program activities for receiving, storing, maintaining, treating, and disposing onsite, or packaging for offsite disposal, all Hanford tank waste. Hanford tank waste includes the contents of 149 single-shell tanks (SSTs) and 28 double-shell tanks (DSTs), plus any new waste added to these facilities, and all encapsulated cesium and strontium stored onsite and returned from offsite users. A key element of the TWRS Program is retrieval of the waste in the SSTs. The waste stored in these underground tanks must be removed in order to minimize environmental, safety, and health risks associated with continuing waste storage.

Waste retrieval is also required to support tank closure. Some components of the waste in the SSTs are hazardous waste as defined in the *Resource Conservation and Recovery Act of 1976* (RCRA) and/or the Washington State "Dangerous Waste Regulations," in the *Washington Administrative Code* (WAC) 173-303. The SSTs are classified as treatment, storage, and disposal units that must meet certain operating and closure requirements. Because the SSTs do not meet current interim status standards, an agreement has been reached with the Washington State Department of Ecology (Ecology) to proceed directly to closure rather than to upgrade and permit the SSTs for operation. The closure regulations require the owner or operator of a tank system to remove or decontaminate all waste residues, contaminated containment system components, and contaminated soils. The regulations also provide for closure of a tank system under the landfill requirements if complete removal or decontamination is not practicable. Closure of the SST sites is not included in the TWRS Program. Tank closure will be addressed in the Environmental Restoration (ER) Program. Closure interface responsibilities for the TWRS Program will be negotiated with the ER Program on a case-by-case basis.

Subsurface barriers are being considered as a means to mitigate the effects of tank leaks including those occurring during SST waste retrieval. Some options for waste retrieval, such as past-practice sluicing, have the potential for increasing tank leakage (Squires et al. 1991).

1.1 PURPOSE

Functions are specific actions or processes that achieve or support the achievement of objectives (i.e., what must be done). Requirements are criteria that set acceptable limits on functions and their products (i.e., how well a function must be performed).

A mission analysis defines the function that a system as a whole must perform. This top-level function can be decomposed into subfunctions that are both necessary and sufficient to accomplish the mission. Requirements may be general in nature and apply to an entire system, or they may themselves be decomposed and allocated to subfunctions at a lower level.

The purpose of the *Functions and Requirements for Subsurface Barriers Used in Support of Single-Shell Tank Waste Retrieval* is to describe the functions to be performed by subsurface barriers based on their role in retrieving waste from the SSTs, and to identify the requirements which constrain their application. These functions and requirements together define the functional baseline for subsurface barriers.

The functions and requirements for the TWRS Program are provided in the *Tank Waste Remediation System Functions and Requirements*, DOE/RL-92-60 (RL 1993a). The functions and requirements for SST waste retrieval are provided in the "Single-Shell Tank Waste Retrieval System Functions and Requirements," Appendix D, *Review of Prior Single-Shell Tank Waste Retrieval Process Studies*, WHC-SD-WM-ES-252 (Sabin et al. 1993). Barriers are included in SST waste retrieval, which is in turn part of the TWRS Program. General requirements allocated to upper-level functions of SST waste retrieval and the TWRS Program also apply to barriers.

1.2 BACKGROUND INFORMATION

The official inventory for the waste stored in underground tanks on the Hanford Site is provided in *Tank Farm Surveillance and Waste Status Summary Report for May 1993*, WHC-EP-0182-62 (WHC 1993a). This report is issued monthly and provides data on each of the underground waste storage tanks, and supplemental information regarding tank surveillance anomalies and ongoing investigations.

The geology of the Hanford Site is complex. Significant variations exist both locally and across the site as a whole. The most current description and interpretation of the Hanford site geology is provided in Delaney et al. (1991), Lindsey et al. (1992a), Lindsey et al. (1992b), and Reidel et al. (1992).

1.2.1 Single-Shell Tank Physical Description

There are 149 SSTs and 28 DSTs on the Hanford Site which contain radioactive and hazardous waste from the reprocessing of irradiated fuel elements beginning in 1944. These underground storage tanks are grouped in tank farms located in the 200 East and West Areas.

There are 133 SSTs classified as 100 series tanks. Tanks in this series are 75 ft in diameter with dome tops. Tank volumes are either 500,000 gal, 750,000 gal, or 1 million gal. These tanks have a minimum of 6 ft of soil cover on the dome and a below grade invert elevation of 37 ft to 51 ft. The 500,000 gal and 750,000 gal tanks were originally arranged in cascades of three, four, or six tanks such that when the first tank in a cascade filled it overflowed to the next tank, and so on. Tank farms with this arrangement include 241-B, 241-BX, 241-BY, 241-C, 241-S, 241-T, 241-TX, 241-TY, and 241-U. The 1 million gal tanks are located in the 241-A, 241-AX, and 241-SX tank farms.

The other 16 SSTs are classified as 200 series tanks. These tanks are 20 ft in diameter with flat tops. Tank capacities are all 55,000 gal. The tanks all have a minimum of 12 ft of soil cover and a below grade invert elevation of 32 ft. The tanks are arranged in groups of four and located in the 241-B, 241-C, 241-T, and 241-U tank farms.

Many of the SSTs have leaked or are assumed to have leaked in the past for various reasons. An interim stabilization program to reduce the waste volumes and remove all SSTs from liquid storage service is ongoing. Free liquid is pumped out to the extent possible to minimize the potential environmental impact in the event of a tank leak. Status of each of the SSTs and estimates of the leaked volumes are provided in WHC (1993b).

1.2.2 Single-Shell Tank Waste Description

A total of 37 million gal of waste is stored in the SSTs. About 600,000 gal is supernatant, 23 million gal is salt cake, and 12 million gal is sludge (WHC 1993a). The salt cake consists of the various salts formed from the evaporation of alkaline waste and is approximately 93 wt% sodium nitrate ($NaNO_3$) and sodium nitrite ($NaNO_2$). The sludge consists of the solids (hydrous metal oxides) precipitated from the neutralization of acid waste before being transferred to the SSTs. On transfer of the evaporator slurry into the SSTs, some of the salt precipitated with the sludge. As a result, roughly 50% of the reported sludge volume is salt cake. The liquid solution exists as supernatant and interstitial liquid in the tanks. An estimated 6 million gal of drainable interstitial liquid is present in the SST salt cake and sludge.

The SSTs contain primarily inorganic waste, although relatively small amounts of plant solvents were entrained during fuel reprocessing. Also, water-soluble complexing agents and carboxylic acids added in the 221-B Plant fractionation process are in some SST wastes. A listing of all nonradioactive chemicals known to have been used at production plants and support facilities that transferred waste to the SSTs is documented in *Inventory of Chemicals Used at Hanford Production Plants and Support Operations (1944-1980)*, WHC-EP-0172 (Klem 1990). Specific chemicals that may have been transferred to the SSTs and that appear on the "Dangerous Waste Sources List," WAC 173-303-9904, include carbon tetrachloride, methylene chloride, hexone, acetone, and ethyl ether. Chemical reactions (e.g., oxidation-reduction, neutralization, precipitation) and radiolysis may have converted many of these chemicals into other compounds with different physical and chemical properties.

Core samples have been taken from relatively few of the 149 SSTs to date. Additional information is needed about the waste properties and composition to evaluate the applicability of the different barrier concepts being considered. The transport of contaminants in the soil column to the ground water is also dependent on the soil chemistry. The mobility of key waste components varies greatly under different conditions (e.g., alkaline, acidic, or organic). Tri-Party Agreement milestones have been established for characterizing the contents of the SSTs. Future funding plans give priority to waste characterization efforts.

1.2.3 Hanford Site Geology

The geology of the vadose zone beneath the tank farms is highly variable. In the 200 East Area the most important suprabasalt stratigraphic unit underlying the tank farms is the Hanford formation. Hanford formation strata also form an important part of the vadose zone beneath the tank farms in the 200 West Area. However, a significant part of the vadose zone in the 200 West Area also consists of units underlying the Hanford formation, the Plio-Pleistocene/early Palouse interval and the Ringold Formation.

Throughout the 200 East and West Areas the Hanford formation is the uppermost stratigraphic unit underlying the tank farms. Hanford formation strata consist of uncemented gravel, sand, and silt deposited by Pleistocene cataclysmic flood waters. The Hanford formation varies from 200 to 300 ft thick in the 200 East Area to 100 to 150 ft thick in the 200 West Area. Hanford deposits are divided into three facies that are gradational with each other and summarized as follows:

- Gravel-dominated facies: Generally consists of cross stratified, coarse-grained sand and granule to boulder gravel that contain minor intercalated silt-rich horizons. This facies generally is uncemented and matrix-poor, displays an open-framework texture, and has high saturated hydraulic conductivities.

- Sand-dominated facies: Well stratified, fine- to coarse-grained sand and granule to pebble gravel dominate. Silt content is variable, but where it is low an open-framework texture is common. Lenticular pebble gravel and silt interbeds may be present. Hydraulic conductivity values for this facies are dependant on silt content and as such are variable.

- Silt-dominated facies: Interbedded silt and fine- to coarse-grained sand forming well stratified fining upwards beds are characteristic. Perched water is common where this facies occurs because of the abundance of low hydraulic conductivity silt horizons.

In addition to the three facies, clastic dikes are also commonly found in the Hanford formation as well as locally in other sedimentary units in the Pasco Basin. These clastic dikes are structures that generally cross-cut bedding, although they do locally parallel bedding. The dikes usually consist of thin, alternating vertical to subvertical layers of silt, sand, and granules that can combine to form a dike several feet across. Where the dikes intersect the ground surface a feature known as patterned ground may be observed. Clastic dikes may act as both barriers to lateral flow as well as conduits for vertical flow depending on their composition.

Strata comprising the Plio-Pleistocene/early Palouse (PP/EP) interval and the Ringold Formation form the lower half of the vadose zone in the 200 West Area. In addition, Ringold Formation deposits locally comprise the lowermost few tens of feet of the vadose zone in the 200 East Area. The PP/EP interval underlies the Hanford formation beneath most of the 200 West Area. It is up to approximately 40 ft thick and consists of (1) lenticular beds of uncemented silt, sand, and gravel, (2) calcium carbonate lenses and concretions, and

(3) calcium carbonate and silica cemented sands and gravels. Perched water can occur locally on silt-rich and cemented zones within the PP/EP interval.

Ringold Formation strata in the 200 East and West Areas are dominated by partially consolidated to cemented, clast to matrix supported, pebble to cobble gravels with a fine- to coarse-grained sand matrix. Localized sand-rich intervals also occur in the Ringold Formation. Silt content in Ringold gravels and sands generally is low (<5%), although the presence of cementation and local silt-rich zones may produce perched water conditions. About 50 to 90 ft of Ringold strata occur in the vadose zone in the 200 West Area.

1.3 TANK WASTE REMEDIATION SYSTEM RETRIEVAL PROGRAM

The TWRS Retrieval Program is described in the *Integrated Retrieval Program Plan*, WHC-SD-WM-PLN-067 (WHC 1993b). The plan describes the scope of the Retrieval Program and how it integrates with other elements of the TWRS Program. It also describes the approach to meeting the technical, quality, and safety objectives of the program.

1.3.1 Mission and Scope

The mission of the Retrieval Program is to remove the waste from the SSTs and DSTs for subsequent interim storage, treatment, immobilization, and disposal. Key elements of the Retrieval Program are as follows:

- Support resolution of safety issues
- Transfer waste from SSTs to DSTs for safe interim storage
- Transfer waste between DSTs to facilitate tank space management
- Transfer waste to treatment and disposal facilities
- Comply with regulatory requirements and commitments.

1.3.2 Program Planning

To manage the hazardous waste at the Hanford Site, the U.S. Department of Energy (DOE) has entered into the *Hanford Federal Facility Agreement and Consent Order* (referred to as the Tri-Party Agreement) (Ecology et al. 1990). The agreement provides for oversight by the U.S. Environmental Protection Agency (EPA) and Ecology of environmental restoration activities. Specific milestones in the Tri-Party Agreement apply to retrieving waste from the underground tanks. These are the driving force behind the schedule of activities in the Retrieval Program Plan.

- M-06-00: "Develop single-shell tank waste retrieval technology and complete scale-model testing," scheduled for June 1994.
- M-07-00: "Initiate full-scale demonstration of waste retrieval technology," scheduled for October 1997.

- M-08-00: "Initiate full-scale tank farm closure demonstration project," scheduled for June 2004.

In addition, milestone M-09-00, "Complete closure of all 149 single-shell tanks," scheduled for June 2018, will be directly affected by the success of the retrieval technologies and systems employed to satisfy the earlier milestones.

Program planning is based on the identification, development, and deployment of multiple technologies that are required for retrieval of the diverse tank wastes at the Hanford Site. Proven technologies are considered first when evaluating retrieval alternatives. Other potentially-improved and cost-effective retrieval techniques are evaluated as they become available. This approach offers the highest probability of success in meeting program objectives at a reasonable cost and within the schedule constraints. The focus in the near term is to support resolution of tank safety issues, which have the number one priority at the Hanford Site. In the longer term, attention shifts to development and implementation of projects to satisfy the Tri-Party Agreement milestones.

1.4 BARRIER DEVELOPMENT ACTIVITIES

Subsurface barriers have been identified as a possible means to confine tank leaks during the SST waste retrieval process and slow the migration of contamination through the soil column. As such, they are included in the top-level Retrieval Program planning and require more thorough evaluation of their applicability and benefit. Barriers could be deployed under individual tanks or entire tank farms to confine potential leaks. Several workshops have been conducted and engineering studies have been completed for the specific application of barriers to tank 241-C-106 and/or the 241-C tank farm. Various technologies are being evaluated for applications elsewhere on the Hanford Site.

Demonstration tests are planned to be performed on selected barrier technologies under existing Hanford Site soil conditions. Feature tests will establish barrier constructability, with monitoring to verify barrier performance and integrity. A full-scale demonstration is planned to be conducted after testing is completed and a preferred barrier design is selected.

1.4.1 Need for Barriers

There are no regulations which specifically require the use of subsurface barriers. The regulatory drivers for subsurface barriers are more of the form found in the *Code of Federal Regulations* (CFR) Title 40, Part 265.196(c)(1), which states that for tank systems in interim status from which there has been a leak the owner or operator must "Prevent further migration of the leak or spill to soils or surface water." Similarly, the DOE Order 5400.5 [chapter II, paragraph 3c(2)], *Radiation Protection of the Public and the Environment*, states that "Liquid discharges, even though uncontaminated, are prohibited in inactive release areas to prevent the further spread of radionuclides previously deposited." Areas of localized contamination exist in the tank farms as a result of previous leaks and spills; while these do not present an immediate hazard, the contamination could be mobilized by adding liquids to the soil column.

Other drivers for the use of barriers include:

- A TWRS National Technology Workshop convened in 1992 brought together experts in various aspects of the TWRS Program (Anttonen 1992). The Retrieval Technology Working Group developed a program strategy for waste retrieval, and performed an analysis to determine the functions needed to retrieve waste from the underground storage tanks. Retrieval technologies were identified which were considered mature and having low technical, regulatory, and programmatic risk. Enhancements to these "reference" systems were identified; subsurface barriers were specifically included. These enhancements are now subjects for retrieval technology development.

- The extent to which any contamination which leaks out during retrieval must be cleaned up is unclear. Ecology has taken the position that if contamination which leaks during retrieval is cleaned up down to any barrier, then the tank farms may be closed as landfills (Anderson 1993). Closing the tank farms as landfills would offer significant cost savings compared to clean closure.

- The *Engineering Study of Tank Leaks Related to Hydraulic Retrieval of Sludge from Tank 241-C-106*, WHC-SD-WM-ES-218 (Lowe et al. 1993) showed the benefit of subsurface barriers in delaying the migration of leaked contaminants to the groundwater. The bulk of the contaminants would remain in the vicinity of the tank, allowing for follow-up remediation if needed.

- The TWRS Program Leadership Council included in their guidance for selecting a new technical strategy the direction to "Develop and implement barriers to reduce soil contamination" in managing the SST waste. This recommendation is documented in the meeting minutes for the February 4-5, 1993 meeting (DOE et al. 1993).

- The DOE-HQ Office of Technology Development issued the following need statement to solicit proposals to demonstrate subsurface barrier technologies: "Subsurface barrier technologies are being sought to provide secondary means of confinement for underground storage tanks. The proposed technologies should be sufficiently mature to be capable of being demonstrated as a total system within a two year time frame (independent of regulatory issues). The total system should include barrier technology (e.g., thermal or polymer), deployment technology (e.g., horizontal drilling), testing technologies (i.e., barrier integrity) and performance monitoring. Individual technologies may be proposed, but will be required to be integrated into a total system demonstration. Conditions at the host site include arid soils with minimal water content, cobble, severe soil contamination (not in the demonstration site), and restricted access to proximity to the tanks" (Gibson 1993).

1.4.2 Barrier Test Site

An area has been tentatively identified on the Hanford Site for conducting future subsurface barrier tests. The test area is located north of the WNP-1 site on DOE property leased to the Washington Public Power Supply System (WPPSS). The site was selected because its geology is similar to that around the 241-C Tank Farm (primarily sands and gravels), and for its accessibility. Other sites are continuing to be investigated with the assistance of WHC Site Planning should the WNP-1 site be unavailable. Barriers for single tanks and entire tank farms will be tested. Bore holes will be drilled throughout the test site for instruments to monitor barrier performance and integrity. A separate barrier test site description document is planned that will describe the local geology, model scale factor, installed instruments and monitoring capability, and site services and utilities available at the test site.

A categorical exclusion (CX) is being pursued for barrier testing in accordance with the *National Environmental Policy Act of 1969* (NEPA). An existing CX already covers intrusive site characterization and environmental monitoring activities on the Hanford Site including the installation and monitoring of groundwater and vadose zone wells (Wagoner 1992). No adverse environmental effects are anticipated as a result of testing. The site is not presently contaminated with radioactive or hazardous materials, and none will be introduced. When testing is completed, the bore holes are planned to be sealed in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," so as to not provide a pathway to the groundwater.

1.4.3 Barrier Test Plans

Constructability of several barrier technologies will be demonstrated at the test site. The effects of subsurface barriers on surrounding soils and structures will be determined. Instruments in the bore holes will measure the horizontal and vertical displacement, and local acceleration forces caused by the barrier (e.g., due to driving sheet pilings). Barrier integrity and physical continuity will be investigated by excavating in and around a barrier after it is installed. Performance of the barrier technologies will also be measured. A test strategy document is being prepared that will more fully describe the different testing that is planned. A separate test specification document will establish the criteria to be used to evaluate barrier performance.

Laboratory testing of barrier materials is planned as a parallel activity to support barrier development. Degradation of barrier materials due to high temperature, freeze cycling, chemical attack, and radiation exposure will be investigated. The physical strength of barrier materials, their permeability and hydraulic conductivity, and parameters that affect their application (e.g., shrinkage or swelling on curing, injectability, plasticity) will be evaluated. Testing will also verify that barrier materials (and products of their decomposition) are environmentally acceptable.

1.5 ISSUES AND UNCERTAINTIES

Use of barriers to support retrieval of waste from the SSTs is a new concept in remediation. As with many new concepts, there are a number of issues associated with the use of subsurface barriers. There are also uncertainties in the requirements for closure of the SSTs (in general), and the role of barriers in tank closure. Closure of the SSTs is to be in accordance with an approved closure plan. The TPA milestone M-09-02, "Submit closure plan to Ecology for approval," is scheduled for December 2003. This date is too late to support retrieval planning. Until these issues and uncertainties are resolved, certain assumptions are needed in order to proceed:

- The regulators' (i.e., Ecology, EPA, DOE) position on subsurface barriers is not defined. There are no regulations which specifically apply to barriers.

  Enabling Assumption: The overall performance of the entire waste-tank-soil-barrier system will be measured against established standards and criteria. The requirements in Section 3 are those which apply to the entire system and have direct implications for barriers.

- The soil column around many SSTs is contaminated by radioactive and hazardous waste as a result of previous leaks and spills. Whether subsurface barriers must confine both existing contamination and leaks which may occur during retrieval is unclear.

  Enabling Assumption: The primary purpose of subsurface barriers is to confine leaks which may occur during retrieval. The extent to which existing contamination is confined depends on the particular barrier technology employed.

- The WAC 173-303-640(8)(a,b) requires the removal or decontamination of all waste residues and contaminated containment system components, soils, structures, and equipment at closure of a tank system. If this is not practicable, then the tank system may be closed in accordance with requirements that apply to landfills. What is practicable in terms of removing the waste and cleaning up the single-shell tank farms is unknown.

  Enabling Assumption: Waste will be removed from the SSTs and the tank farms cleaned up to the extent that it can be shown there is no threat to human health or the environment. Use of barriers shall not preclude this.

- Contamination between a tank and any subsurface barrier may need to be recovered prior to closure. This could prove difficult and may entail removal of the SSTs themselves; the added cost would be significant. Ecology, in a preliminary response to a proposal to close the single-shell tank farms as landfills, requires that "A tank farm can be closed as a landfill provided that it is cleaned up down to the waste barrier." Some cleanup will likely be needed, but to what extent is unknown.

Enabling Assumption: Contamination between the tank and barrier will be cleaned up to the extent required to support closure of the SSTs.

2.0 BARRIER FUNCTIONS

The mission of subsurface barriers is to:

> ***Confine tank leaks during waste retrieval to protect the environment and ensure the safety of workers and general public.***

This is represented by the function "Confine Tank Leaks." Functional analysis was used to decompose this top-level function into subfunctions and identify the functional dependencies. The functional analysis produced the following:

- Function Hierarchy: A diagram showing the breakdown of functions into subfunctions as developed in the functional analysis.
- Function Flow Diagrams: Diagrams showing dependencies among functions (i.e., enabling inputs, required outputs), and constraints that act on the functions.
- Function Descriptions: A list of all the function titles, descriptions, dependencies, and upper-level functions and subfunctions.
- Input and Output Descriptions: A list of the inputs and outputs, source functions (for inputs), and enabled functions (for outputs).

The function hierarchy, function flow diagrams, function descriptions, and input and output descriptions are contained in the appendix. The functions were integrated vertically to ensure all the functions and the inputs and outputs were decomposed properly and are traceable. The functions were horizontally integrated at each level to ensure all the inputs and outputs flow between functions and all functional relationships were described.

2.1 FUNCTION HIERARCHY

The overall function hierarchy is shown in Figure 1. The Level 0 to Level 3 functions and function numbers are from the *Tank Waste Remediation System Functions and Requirements*, DOE/RL-92-60 (RL 1993a). The retrieval functions at Level 4 and Level 5 are from the "Single-Shell Tank Waste Retrieval System Functions and Requirements," Appendix D, *Review of Prior Single-Shell Tank Waste Retrieval Process Studies*, WHC-SD-WM-ES-252 (Sabin et al. 1993). Only those TWRS Program and retrieval functions which pertain to subsurface barriers are shown. The functions for subsurface barriers begin at Level 6. The barrier functions are numbered beginning with "X" until the upper-level retrieval functions are further developed.

2.2 FUNCTION DESCRIPTIONS

The barrier function names and their descriptions are listed in Table 1. More complete descriptions of the barrier functions are provided in the appendix.

Figure 1. Function Hierarchy for Barriers.

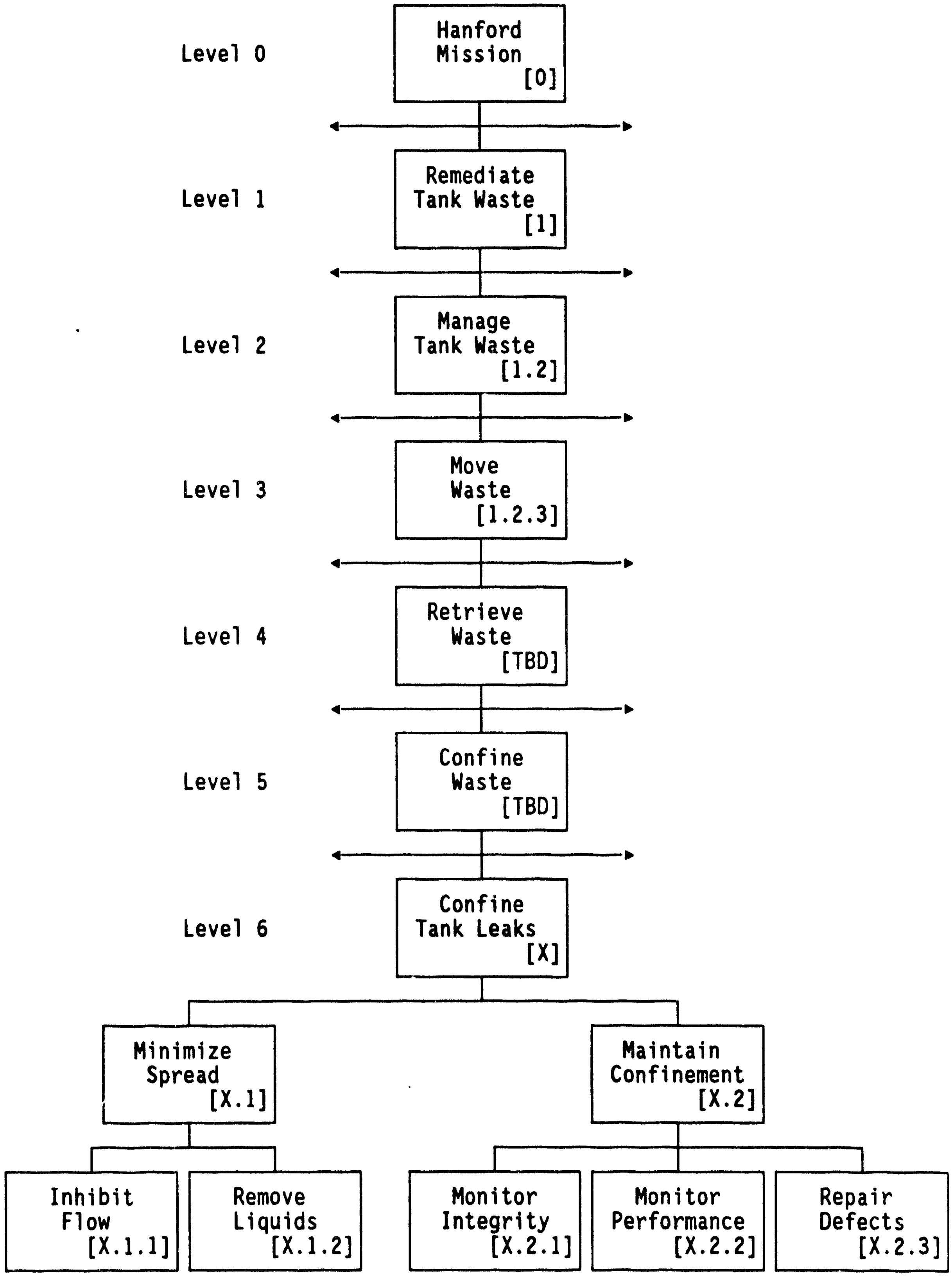

Table 1. Function Descriptions for Barriers.

No.	Function Name	Function Description
[X]	Confine Tank Leaks	Operate and maintain a system to confine tank leaks during retrieval of waste from SSTs. Prevent migration of existing contamination due to tank leaks. Verify that effective confinement is provided.
[X.1]	Minimize Spread	Prevent the movement of leaked waste from the vicinity of a leak site. Leaked waste includes waste from tank leaks and existing contamination from previous leaks and spills.
[X.1.1]	Inhibit Flow	Prevent or restrict the physical movement of leaked waste (e.g., reduced permeability).
[X.1.2]	Remove Liquids	Remove the liquid portion of leaked waste or limit the volume of liquid available to cause movement of leaked waste (e.g., waste drying).
[X.2]	Maintain Confinement	Monitor and control system operation to ensure effective overall confinement. Generate operating records.
[X.2.1]	Monitor Integrity	Monitor operation to determine integrity of confinement system. Compare results to standards. Identify needed integrity adjustments. Report integrity data.
[X.2.2]	Monitor Performance	Monitor operation to determine performance of confinement system. Compare results to standards. Identify needed performance adjustments. Report performance data.
[X.2.3]	Repair Defects	Adjust confinement system to meet integrity and performance standards.

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3.0 BARRIER REQUIREMENTS

Requirements analysis is the systematic identification and allocation of requirements for each function and subfunction. The process identifies potential sources of requirements for each function, divides the sources into discrete statements of individual requirements, and allocates the requirements to functions. Requirements that apply to subsurface barriers have been classified as either external or internal to the mission, commitments and other negotiated requirements, or mission-driven. A broad selection of requirements is initially needed with all the various barrier technologies being considered. As the scope of the Retrieval Program is further developed, a unique set of requirements will evolve.

3.1 EXTERNAL REQUIREMENTS

External requirements are imposed on the program by outside sources. These requirements constrain the program regardless of its mission or configuration. Their general purpose is to protect the environment, ensure the safety and health of workers and the general public, and provide for effective management commensurate with risk. Sources of external requirements include federal, state, and local codes and regulations; DOE orders, directives, and implementing procedures; company-wide practices and procedures, etc. A list of the external requirements which apply to subsurface barriers is provided in Table 2.

3.2 INTERNAL REQUIREMENTS

Internal requirements define the interfaces within the program, and between the program and the remainder of the Hanford Site cleanup mission. The work to be accomplished at the Hanford Site has been broken down into the following mission areas: Environmental Restoration, Waste Tank Operations and Disposal, Solid and Liquid Waste, Nuclear Facilities, Science and Technology, Site Support, and Special Initiatives (RL 1993b). The Retrieval Program will interface directly with several of these mission areas (e.g., closure of the SST farms by the ER Program). A list of the internal requirements which apply to subsurface barriers is provided in Table 3.

3.3 COMMITMENTS AND OTHER NEGOTIATED REQUIREMENTS

Commitments have previously been made to regulatory agencies as to the scope and schedule of the cleanup effort at the Hanford Site. The Tri-Party Agreement (Ecology et al. 1990) contains milestones which specifically apply to retrieval of waste from SSTs. However, the Tri-Party Agreement is presently being renegotiated and these milestones are subject to change. Waivers may be sought to existing regulations or the compliance approach negotiated with the lead agency in order to provide a more expedited cleanup. Requirements may also be imposed by regulatory agencies in the course of issuing construction and operating permits; these then become conditions of the permit. A list of the commitments and other negotiated requirements which apply to subsurface barriers is provided in Table 4.

3.4 MISSION-DRIVEN REQUIREMENTS

Mission-driven requirements are unique to the Retrieval Program. They impose performance, design, and other technical constraints on the system and its configuration. Mission-driven requirements result from analysis of the mission and are generally derived from engineering studies and evaluations. Included are extended requirements to allow for uncertainties in the program (e.g., robustness, contingency). A list of the mission-driven requirements which apply to subsurface barriers is provided in Table 5.

Table 2. External Requirements for Barriers.

SOURCE	REQUIREMENT	FUNCTION
40 CFR 265	Migration of Leaks. For tank systems in interim status from which there has been a leak, the owner or operator must prevent further migration of the leak or spill to soils or surface water. Basis: 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended. [Sec 265.196(c)(1), "Response to Leaks or Spills and Disposition of Leaking or Unfit-for-Use Tank Systems"]	X.1 X.2
DOE Order 5400.5 WHC-CM-7-5 Sec 6.0 Para 6.3.2.1	Migration of Leaks. Liquid discharges, even though uncontaminated, are prohibited in inactive release areas to prevent the further spread of radionuclides previously deposited, unless the discharge is part of an interim or final cleanup response. Basis: DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, D.C. [Ch II, para 3c(2), "Management and Control of Radioactive Materials in Liquid Discharges and Phaseout of Soil Columns"] WHC-CM-7-5, *Environmental Compliance*, Westinghouse Hanford Company, Richland, Washington.	X.1 X.2
DOE Order 5400.5	Radionuclide Limits in Groundwater. The liquid effluents from DOE activities shall not cause private or public drinking water systems downstream of the facility discharge to exceed the drinking water radiological limits of 40 CFR 141. These systems shall not cause persons consuming the water to receive an effective dose equivalent greater than 4 mrem/yr. Combined ^{226}Ra and ^{228}Ra shall not exceed 5E-09 µCi/mL and gross α activity (including ^{226}Ra but excluding radon and uranium) shall not exceed 1.5E-08 µCi/mL. Basis: DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, D.C. [Ch II, para 1d(3), "Impact on Other Systems"]	X.2.1 X.2.2

Table 2. External Requirements for Barriers (cont'd).

SOURCE	REQUIREMENT	FUNCTION
WHC-CM-7-5 Sec 2.0 Para 2.5.2.2	<u>Radioactive Airborne Emissions</u>. The annual average concentration of radionuclides released to the environment shall not exceed an administrative control value (ACV) of 1 times the DCG public value (unity rule applies) at the point of emission, as specified in WHC-CM-7-5, *Environmental Compliance*, Appendix C. <u>Basis</u>: The ACVs are WHC ALARA goals. The ACVs restrict emissions of airborne radionuclides to ALARA levels using currently available, reliable, effluent treatment technology. The ACVs also ensure that WHC airborne radionuclides emissions are well below the required levels for compliance with all applicable federal, state, and local authority airborne radionuclides emission limits. DOE/EV/1830-T5, "A Guide to Reducing Radiation Exposure to As Low As Reasonably Achievable," U.S. Department of Energy, Washington, D.C. 40 CFR 61, "National Emissions Standards for Hazardous Air Pollutants," Subpart H, *Code of Federal Regulations*, as amended. [40 CFR 61.93] DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, D.C. [Ch II, para 1b, "Airborne Emissions Only, All DOE Sources of Radionuclides"]	X.2.1 X.2.2
WHC-CM-7-5 Sec 2.0 Para 2.5.2.2	<u>Radioactive Airborne Emissions</u>. The weekly average (any consecutive 7-day period) concentration of radionuclides released to the environment in airborne emissions should not exceed 10 times the annual average ACV concentration specified for that stack at the point of emission. <u>Basis</u>: WHC best management practice. Imposed to ensure that minor plant upsets and degradation of emissions abatement systems are not allowed to persist to the point of violating the ALARA goals.	X.2.1 X.2.2

Table 2. External Requirements for Barriers (cont'd).

SOURCE	REQUIREMENT	FUNCTION
WHC-CM-7-5 Sec 2.0 Para 2.5.2.1	Radioactive Airborne Emissions. Individual airborne emissions shall not result in the annual average concentration at any ground-level ambient location or other occupied area exceeding any derived concentration guides (DCG) public value specified in WHC-CM-7-5, *Environmental Compliance*, Appendix C. Facilities shall enforce appropriate administrative controls that consider atmospheric conditions relative to operations for the purpose of ensuring compliance with this requirement. Basis: WHC best management practice. Imposed to assure compliance with the radiation exposure limit to the public of 100 mrem for all exposure modes as specified in DOE Order 5400.5. [Ch II, para 1a, "DOE Public Dose Limit--All Exposure Modes, All DOE Sources of Radiation"]	X.2.1 X.2.2
WHC-CM-7-5 Sec 2.0 Para 2.4.1.1	Other Airborne Emissions. Emissions of contaminants which do not have specified maximum permissible emission standards for work environments shall be controlled to ensure the threshold values found in WHC-CM-4-40, *Industrial Hygiene Manual*, are not exceeded in work places anywhere outside an emissions unit. Basis: WHC best management practice. Emissions may occur as a result of barrier installation and operation.	X.2.1 X.2.2
WHC-CM-7-5 Sec 2.0 Para 2.5.1	Radioactive Airborne Emissions. Work involving expected dispersal of airborne radioactive materials shall be performed in an enclosed facility or in a temporary enclosure. Outdoor work involving equipment or emissions units too large to reasonably enclose shall be regulated by the applicable requirements of WHC-CM-1-6, *WHC Radiological Control Manual*, and by the radiation work permit (RWP) controlling the equipment and/or work to be performed. Basis: WAC 246-247, "Radiation Protection - Air Emissions," *Washington Administrative Code*, as amended.	X.1

Table 2. External Requirements for Barriers (cont'd).

SOURCE	REQUIREMENT	FUNCTION
WHC-EP-0063	Solid Waste. Radioactive solid waste (which includes low-level waste, transuranic waste, high-level waste, spent nuclear fuel, and radioactive mixed waste) must meet the characterization, packaging, and acceptance criteria in WHC-EP-0063 for on-site storage and disposal. Hazardous-only contaminated solid waste must be disposed of off-site. Basis: Radioactive solid waste may be generated as a result of barrier installation, operation, and (if needed) removal (e.g., contaminated soil, failed equipment). WHC, 1991, *Hanford Site Solid Waste Acceptance Criteria*, WHC-EP-0063-3, Westinghouse Hanford Company, Richland, Washington.	X.1
DOE Order 5820.2A	Waste Minimization. The quantity of waste being sent to storage shall be reduced. Basis: Significant volumes of radioactive solid waste may be generated as a result of barrier installation, operation, and (if needed) removal. DOE Order 5820.2A, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C. [Ch I, para 3b(7)(a), "Waste Treatment and Minimization"]	X.1
WAC 173-160	Well Drilling. Monitoring wells and other bore holes shall be appropriately sealed after use so as to not provide a pathway for contamination to the groundwater. Basis: Barrier installation will likely involve some type of drilling (e.g., vertical, angle, or horizontal bore holes). WAC 173-160, "Minimum Standards for Maintenance and Construction of Wells," *Washington Administrative Code*, as amended.	X.1

Table 2. External Requirements for Barriers (cont'd).

SOURCE	REQUIREMENT	FUNCTION
DOE Order 5820.2A	Leak Detection. Monitoring and leak detection capability shall be incorporated in engineering systems to provide rapid identification of leaks and to assess system integrity. Basis: DOE Order 5820.2A, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C. [Ch I, para 3b(3)(a,c)]	X.1.1 X.1.2 X.2.1 X.2.2 X.2.3
RCRA	Barrier Materials. Hazardous materials shall be managed in accordance with the requirements of RCRA. Hazardous materials shall not be applied or placed on the land in a manner that constitutes disposal. Basis: *Resource Conservation and Recovery Act of 1976*, as amended, 42 USC 9601, et seq.	X.1
NEPA, SEPA	Environmental Protection. The environmental impact associated with a project shall be considered. Materials introduced during barrier installation, operation, and testing shall be evaluated. Basis: *National Environmental Policy Act of 1969*, as amended, 42 USC 4321, et seq. *State Environmental Policy Act of 1971*, Revised Code of Washington, RCW 43.21C, Olympia, Washington.	X
WHC-CM-4-9	Radiological Design. The radiation safety design requirements in WHC-CM-4-9 shall be incorporated in the design of barrier equipment and facilities which store, handle, or process radioactive materials. Basis: Existing contamination from past leaks and waste which leaks during retrieval will affect barrier installation, operation, and (if needed) removal. WHC-CM-4-9, *Radiological Design*, Westinghouse Hanford Company, Richland, Washington.	X.1

Table 2. External Requirements for Barriers (cont'd).

SOURCE	REQUIREMENT	FUNCTION
WHC-CM-4-11	Radiation Protection. The "as low as reasonably achievable" (ALARA) guideline in WHC-CM-4-11 shall be implemented in the design of equipment, components, or assemblies, and in the planning of construction, installation, operation, maintenance, and decommissioning activities. Evaluations and cost-benefit analyses for determining that the radiation exposure levels are ALARA shall used the methodologies established in International Commission on Radiological Protection 37, "Cost-Benefit Analysis in the Optimization of Radiation Protection." Basis: WHC-CM-4-11, *ALARA Program Manual*, Westinghouse Hanford Company, Richland, Washington.	X
WHC-CM-1-3	Safety Class. The safety class shall be determined in accordance with the criteria and methodology in MRP 5.46, "Safety Classification of Systems, Components, and Structures." Basis: WHC-CM-1-3, *Management Requirements and Procedures*, Westinghouse Hanford Company, Richland, Washington.	X
WHC-CM-4-2	Quality Assurance. Quality assurance program requirements for project-type activities associated with design, procurement, and construction shall be defined and documented in a project-specific quality assurance program plan (QAPP). Applicable requirements shall be selected from ASME NQA-1, "Quality Assurance Program Requirements for Nuclear Facilities." Quality assurance planning shall be commensurate with the safety class of the items involved. Basis: WHC-CM-4-2, *Quality Assurance Manual*, Westinghouse Hanford Company, Richland, Washington.	X

Table 2. External Requirements for Barriers (cont'd).

SOURCE	REQUIREMENT	FUNCTION
DOE Order 5480.19	Conduct of Operations. Directives, plans, and procedures shall be developed relating to the conduct of barrier operations for the purpose of improving quality and to ensure uniformity of operations. Basis: DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities*, U.S. Department of Energy, Washington, D.C.	X
RL Order 6430.1C	Natural Phenomena. The design shall meet the natural phenomena loading criteria in Standard Design Criteria (SDC) 4.1, "Design Loads for Facilities," Revision 11, as required by the safety class of the items involved. The equipment is not required to operate during or immediately following a safe-shutdown earthquake. Basis: RL Order 6430.1C, *Hanford Plant Standards (HPS) Program*, U.S. Department of Energy - Richland Field Office, Richland, Washington.	X.1 X.2
RL Order 6430.1C	Design Basis Accidents. The system shall be designed to withstand the effects of design basis accidents (DBA) including severe natural phenomena and man-made events, with confinement of radioactive and toxic materials within allowable limits. Basis: RL Order 6430.1C, *Hanford Plant Standards (HPS) Program*, U.S. Department of Energy - Richland Field Office, Richland, Washington.	X.1 X.2
RL Order 6430.1C	All-weather Operation. Equipment located outdoors and exposed to the elements shall be designed to operate under adverse open-field conditions identified in SDC 4.1, "Design Loads for Facilities," and SDC 5.1, "Heating, Ventilating, and Air Conditioning." Basis: RL Order 6430.1C, *Hanford Plant Standards (HPS) Program*, U.S. Department of Energy - Richland Field Office, Richland, Washington.	X.1 X.2

Table 3. Internal Requirements for Barriers.

SOURCE	REQUIREMENT	FUNCTION
TBD	Tank Design. Barrier design shall accommodate the different single-shell tank designs and tank farm configurations. Basis: SSTs vary in size from 55,000 gal to 1 million gal. Tank farm configurations vary from 4 tanks to 18 tanks.	X.1
WHC-EP-182 -60	Leaked Waste. Barrier design shall accommodate the different waste compositions, and potential leak volumes and leak rates. Basis: The composition and volume of drainable liquid in the SSTs varies considerably from tank-to-tank. The structural integrity of each tank will depend on its past operating history. WHC, 1993a, *Tank Farm Surveillance and Waste Status Summary Report for May 1993*, WHC-EP-182-62, Westinghouse Hanford Company, Richland, Washington.	X.1
TBD	Interferences: Interferences within and around the tank farms (e.g., buried transfer lines, site services and utilities, etc.) shall be considered in the barrier design. Basis: Interferences may impair barrier integrity and are potential pathways for contamination to migrate.	X.1
WHC-SD-EN -TI-012, WHC-SD-EN -TI-008	Site Geology. Barrier design shall accommodate variations in subsurface geology which occur both locally and across the Hanford Site. Basis: Lindsey, K. A., et al., 1992a, *Geologic Setting of the 200 East Area: An Update*, WHC-SD-EN-TI-012, Revision TBD, Westinghouse Hanford Company, Richland, Washington. Lindsey, K. A., et al., 1992b, *Geologic Setting of the 200 West Area: An Update*, WHC-SD-EN-TI-008, Revision TBD, Westinghouse Hanford Company, Richland, Washington.	X.1

Table 3. Internal Requirements for Barriers (cont'd).

SOURCE	REQUIREMENT	FUNCTION
PL 101-510	Tank Farm Operations. Installation and operation of barriers shall not interrupt or otherwise conflict with essential tank farm operations. Safety measures identified for watch-list tanks are included. Basis: *Defense Authorization Act*, Public Law 101-510, "Safety Measures for Waste Tanks at Hanford Nuclear Reservation," Section 3137 (also known as the Wyden Amendments). [Para a, Ensure that "...continuous monitoring to detect a release or excessive temperature or pressure..." is being carried out.]	X.1
OSD-T-151 -00013	Tank Dome Loading. Total live loads on the tank dome are limited to a maximum of 50 tons for 20-ft diameter tanks, and 100 tons for 75-ft diameter tanks. These loads are assumed to occur on the soil covering the tank within a 10-ft radius of the tank center. Loads in excess of these shall be evaluated on a case-by-case basis and require approval by Single-Shell Tank Process Engineering and Tank Farm Operations. Loads imposed during barrier installation and operation, and other loads (e.g., waste retrieval equipment) shall be considered. Basis: WHC, 1992, *Operating Specifications for Single-Shell Waste Storage Tanks*, OSD-T-151-00013, Revision D-1, Westinghouse Hanford Company, Richland, Washington. [Sec 13.2.1, para C(2), "Structural Limitations - Dynamic Dome Loading"]	X.1
TBD	Loading of Tank Sidewall and Bottom. Live loads imposed on the tank sidewall and bottom during barrier installation and operation are limited to a maximum of (TBD). Basis: Load limits are set to prevent structural damage to the tank which could cause the tank to leak.	X.1

Table 3. Internal Requirements for Barriers (cont'd).

SOURCE	REQUIREMENT	FUNCTION
OSD-T-151 -00013	Temperature of Concrete Encasement. The temperature of the concrete encasement during barrier installation and operation is limited to a maximum of 250°F (HOLD). The rate of temperature change is limited to a maximum of 20°F/day (HOLD). Basis: Temperature limits are set to prevent structural damage to the tank which could cause the tank to leak. WHC, 1992, *Operating Specifications for Single-Shell Waste Storage Tanks*, OSD-T-151-00013, Revision D-1, Westinghouse Hanford Company, Richland, Washington. [Sec 13.2.1, para E(1), "Waste Temperatures"]	X.1
TBD	Existing Contamination. Barrier deployment and operation shall not exacerbate or cause existing contamination to spread (e.g., mud rotary drilling). Basis: Significant portions of the tank farms are contaminated from previous leaks and spills.	X.1
RCRA, WAC 173-303	Closure. Use of barriers to confine leaks during waste retrieval shall not preclude closure actions. Basis: *Resource Conservation and Recovery Act of 1976*, as amended, 42 USC 9601, et seq. WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.	X.1

Table 4. Commitments and Other Negotiated Requirements for Barriers.

SOURCE	REQUIREMENT	FUNCTION
Tri-Party Agreement	Retrieval Schedule: Barrier design, installation, and operation shall support the retrieval schedule as defined by the Tri-Party Agreement milestones (HOLD). Basis: Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and the U.S. Department of Energy, Olympia, Washington. [Milestones M-06-00, M-07-00, M-08-00, M-09-00]	X
RCRA	Permitting. Treatment activities other than interim stabilization (e.g., SST waste retrieval) will require issuance of a Notice of Intent and revision of the Part A RCRA permit. Basis: *Resource Conservation and Recovery Act of 1976*, as amended, 42 USC 9601, et seq.	X
Clean Air Act	Permitting. Any new stationary source of radionuclide emissions or modification of an existing source that will result in an increase in emissions of radioactive pollutants to the atmosphere is subject to a pre-construction review and approval by the EPA. Basis: 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, as amended.	X
Wash. Clean Air Act	Permitting. Construction shall not commence on any new or modified source of radioactive air emissions until a notice of construction (NOC) has been approved by the Washington State Department of Health. Use of best available radionuclide control technology (BARCT) is required for all new sources of radioactive air emissions. Basis: WAC 246-247, "Radiation Protection - Air Emissions," *Washington Administrative Code*, as amended.	X

Table 4. Commitments and Other Negotiated Requirements for Barriers (cont'd).

SOURCE	REQUIREMENT	FUNCTION
Wash. Clean Air Act	<u>Permitting</u>. A NOC shall be approved by Ecology prior to construction, installation, or establishment of any new source of toxic air pollutants. <u>Basis</u>: WAC 173-460, "Controls for New Sources of Toxic Air Pollutants," *Washington Administrative Code*, as amended.	X

Table 5. Mission-Driven Requirements for Barriers.

SOURCE	REQUIREMENT	FUNCTION
TBD	<u>Degree of Confinement</u>. The confinement provided by the combination of existing tank(s), subsurface barriers, and any other constraints (e.g., surface barriers) shall be such that soil contamination is minimized, and limits on radionuclides and hazardous chemicals in groundwater are not exceeded. <u>Basis</u>: WHC best management practice. Imposed to assure compliance with 40 CFR 265 and DOE Order 5400.5.	X
TBD	<u>Design Life</u>. The barrier system shall provide effective confinement of tank leaks for a period of 30 years. <u>Basis</u>: Barriers are being considered to support retrieval of waste from SSTs. Barriers may also be needed after retrieval to confine existing contamination and waste residues until closure. Harrington, R. A., 1993, "Subsurface Barrier Workshop, Study Analysis Session Report (letter 9305205 to S. S. Lowe, Westinghouse Hanford Company, June 21, 1993), Kaiser Engineers Hanford Company, Richland, Washington.	X.1 X.2
TBD	<u>Maintenance</u>. The barrier system shall permit repair or replacement of active components to maintain effective confinement of tank leaks. <u>Basis</u>: Harrington, R. A., 1993, "Subsurface Barrier Workshop, Study Analysis Session Report (letter 9305205 to S. S. Lowe, Westinghouse Hanford Company, June 21, 1993), Kaiser Engineers Hanford Company, Richland, Washington.	X.1 X.2
TBD	<u>Leachate Collection</u>. The barrier system shall provide for leachate collection and removal. <u>Basis</u>: Harrington, R. A., 1993, "Subsurface Barrier Workshop, Study Analysis Session Report (letter 9305205 to S. S. Lowe, Westinghouse Hanford Company, June 21, 1993), Kaiser Engineers Hanford Company, Richland, Washington.	X.1 X.2

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4.0 ITEMS NEEDING RESOLUTION

Following is a list of issues related to the use of subsurface barriers to confine leaks when retrieving waste from SSTs. These issues need to be resolved in the course of barrier development and testing.

- Retrieval Schedule. The current retrieval schedule is defined by the TPA milestones. However, the TPA is presently being re-negotiated. The time available to implement barriers is uncertain. Some promising barrier concepts are not being considered because of the limited time available or the technologies are not sufficiently mature.

- Closure Requirements. The closure plan needs to be developed including (1) whether contamination that leaks between the tank and barrier must be cleaned up, (2) the function of barriers after retrieval until closure, and (3) other follow-on remediation work (e.g., waste residue removal, removal of barriers, clean-up general contamination in and around the tank farms.

- Waste Characterization. Information is needed as to the physical and chemical properties and radionuclide content of the SST waste. This data is crucial to efforts to evaluate alternatives for waste treatment and disposal, including subsurface barriers.

- Leak Assessment. Future testing and full-scale demonstration will provide a measure of the effectiveness of barriers. The overall performance of the entire tank-barrier system will be evaluated against established standards for environmental protection. An assessment of the potential leak rate and volume is needed to complete the evaluation.

- Tank Monitoring and Leak Detection. Criteria must be established for detecting tank leaks and controlling the spread of leaked waste. This is a prerequisite to evaluating technologies for the purpose of confining tank leaks.

- Structural Integrity. Assessment of the integrity of the SSTs is needed to determine the range of operating conditions to prevent structural failure. The allowable loads that may be imposed on the tank sidewall and bottom, and the minimum and maximum temperatures of the concrete encasement during barrier installation and operation should be determined.

- Site Characterization. Investigation is needed to determine the extent to which the tank farms are contaminated by previous leaks and spills. This will affect barrier selection and could be a major cost driver.

- Solid Waste. Clarification is needed as to what constitutes 'clean' soil. This will permit consideration of options for disposing of contaminated soil (e.g., soil washing) which may be less costly than current solid waste handling practices.

- Safety Classification. The safety class of items provides a graded approach to applicable design and quality assurance requirements. Requirements are assigned to items commensurate with the function of each system, component, and structure in preventing or mitigating the consequences of hazards and postulated design basis accidents. The safety classification criteria and a summary of safety class 1 and 2 determinations (at the system and major-structure level) is included in preliminary safety documentation [e.g., the preliminary safety evaluation (PSE)] for new projects and facilities. A more complete set of requirements will be available once the safety class of barriers is determined.

5.0 REFERENCES

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APPENDIX

FUNCTIONAL ANALYSIS

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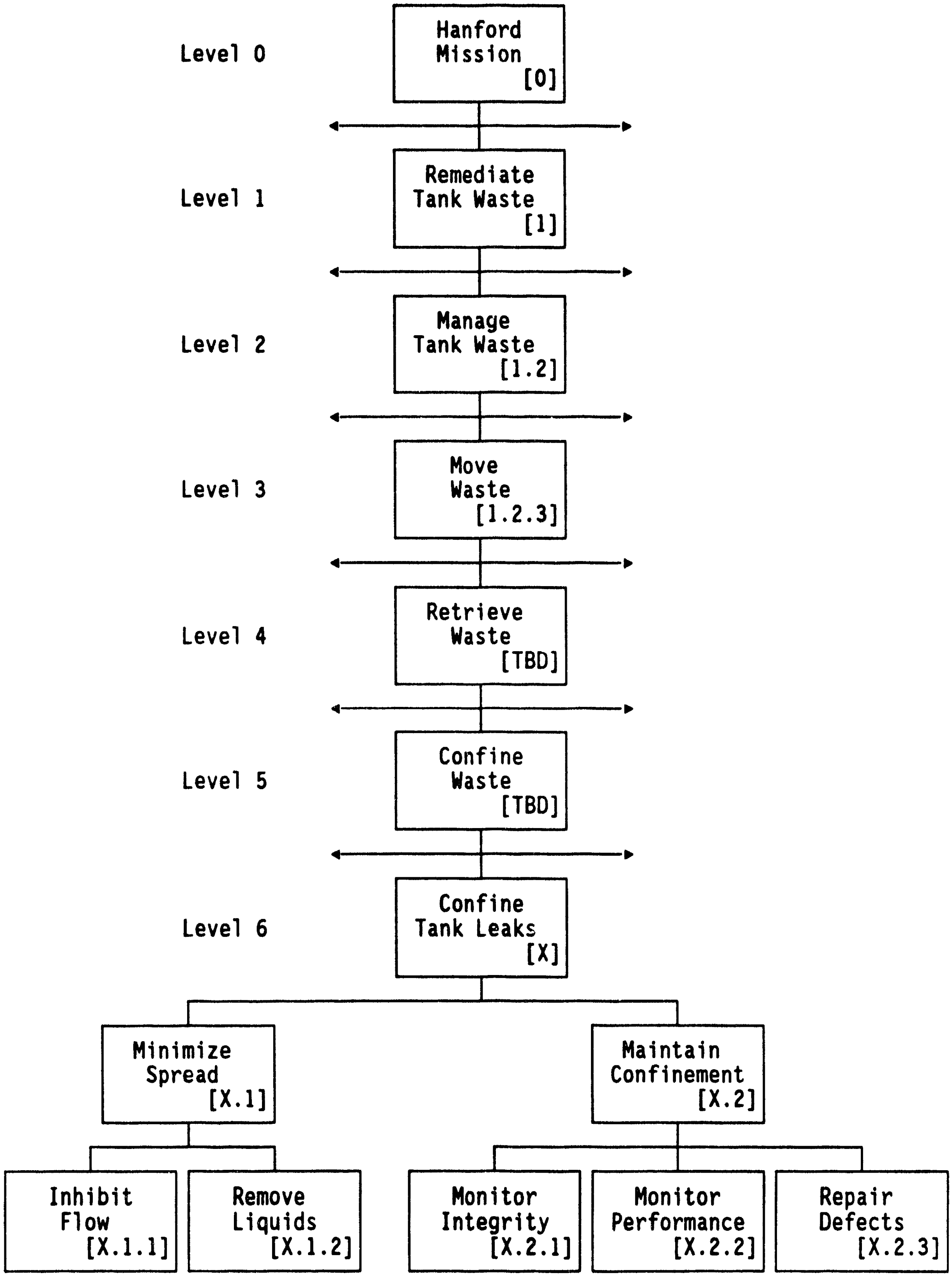
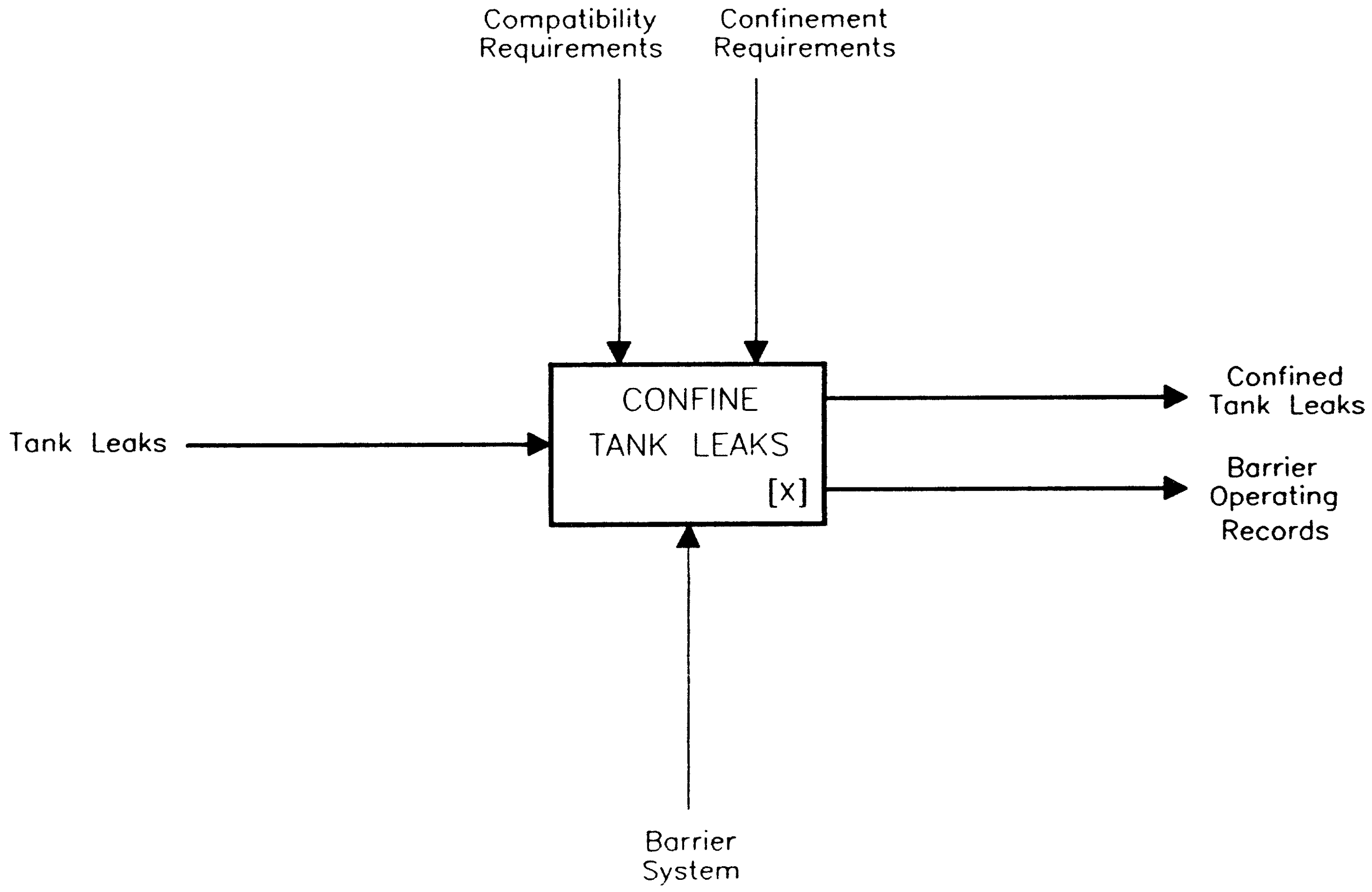
FUNCTION HIERARCHY

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Confinement Requirements
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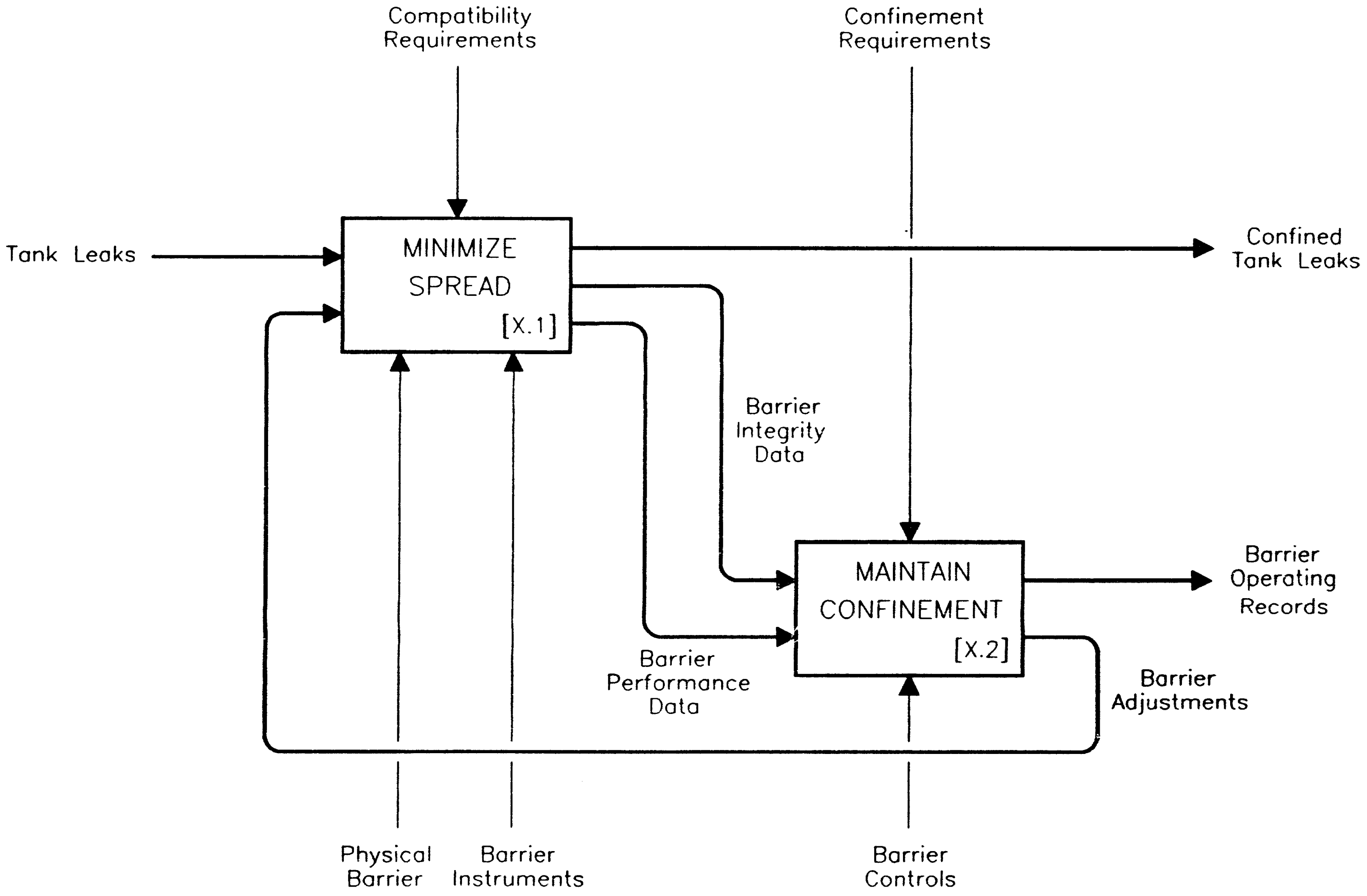
[X]
Confined Tank Leaks
Barrier Operating Records
Barrier System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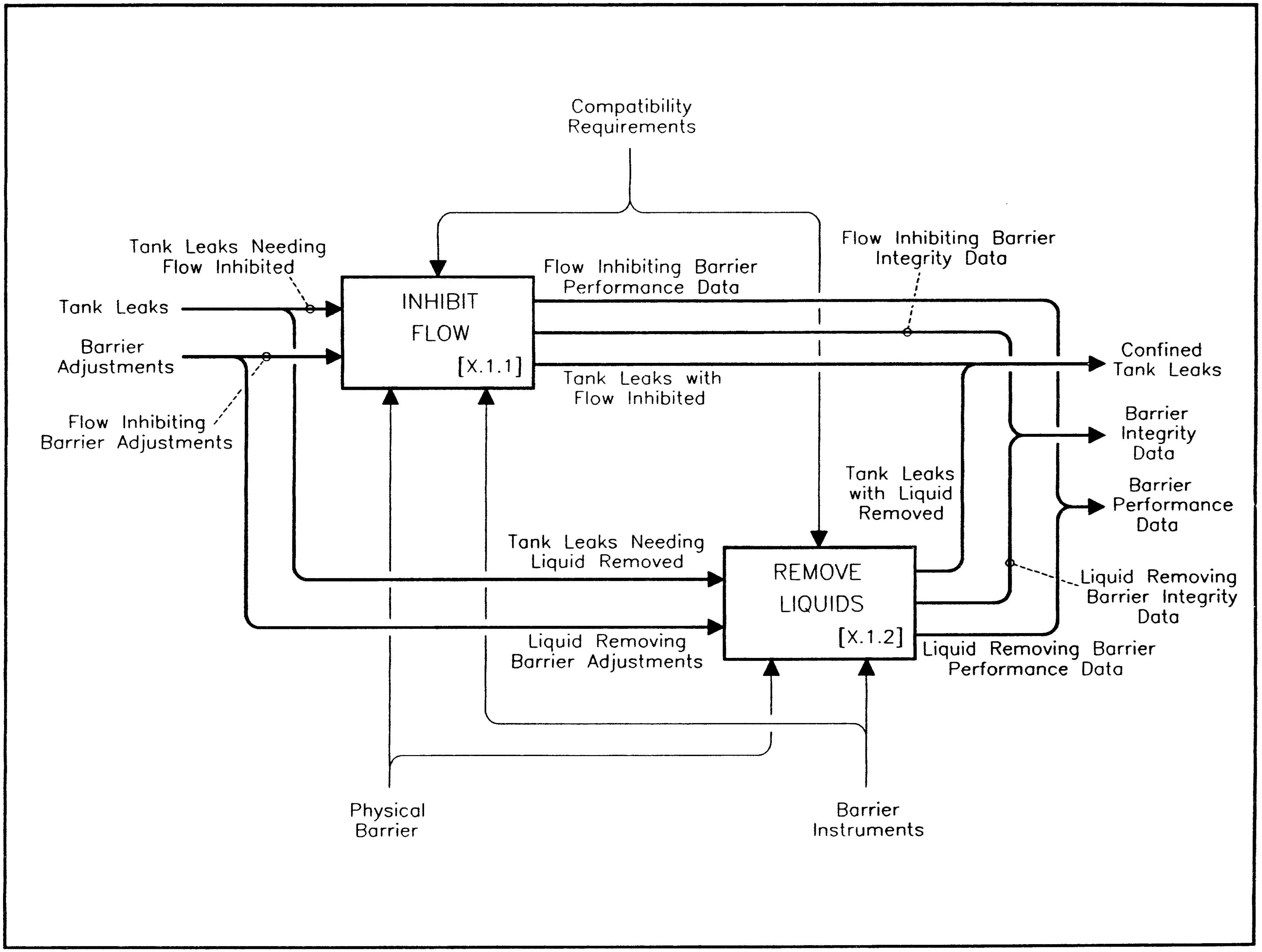
Tank Leaks
MINIMIZE SPREAD
[X.1]
Confined Tank Leaks
Barrier Integrity Data
MAINTAIN CONFINEMENT
[X.2]
Barrier Operating Records
Barrier Performance Data
Barrier Adjustments
Physical Barrier
Barrier Instruments
Barrier Controls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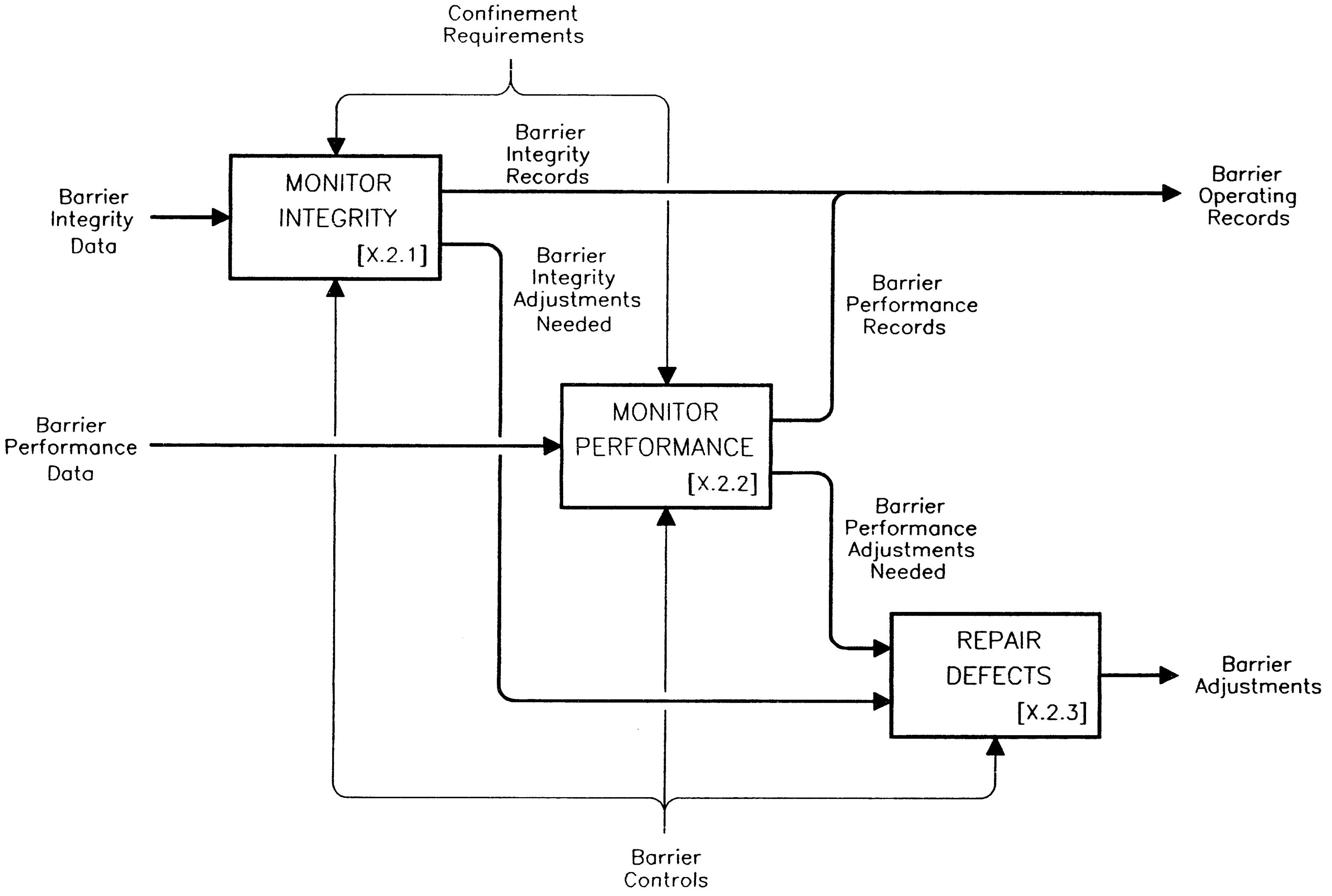
Tank Leaks
Barrier Adjustments
Flow Inhibiting Barrier Adjustments
INHIBIT FLOW
[X.1.1]
Flow Inhibiting Barrier Performance Data
Flow Inhibiting Barrier Integrity Data
Tank Leaks with Flow Inhibited
Confined Tank Leaks
Barrier Integrity Data
Barrier Performance Data
Tank Leaks with Liquid Removed
Tank Leaks Needing Liquid Removed
REMOVE LIQUIDS
[X.1.2]
Liquid Removing Barrier Adjustments
Liquid Removing Barrier Integrity Data
Liquid Removing Barrier Performance Data
Physical Barrier
Barrier Instruments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Barrier Integrity Data
MONITOR INTEGRITY
[X.2.1]
Barrier Operating Records
Barrier Integrity Adjustments Needed
Barrier Performance Records
Barrier Performance Data
MONITOR PERFORMANCE
[X.2.2]
Barrier Performance Adjustments Needed
REPAIR DEFECTS
[X.2.3]
Barrier Adjustments
Barrier Controls

FUNCTION DESCRIPTIONS

Function:	[X] CONFINE TANK LEAKS
Description:	Operate and maintain a system to confine tank leaks during retrieval of waste from SSTs. Prevent migration of existing contamination due to tank leaks. Verify that effective confinement is provided.
Enabling Inputs:	Tank Leaks
Required Outputs:	Confined Tank Leaks Barrier Operating Records
Constraints:	Compatibility Requirements Confinement Requirements
Resources:	Barrier System
Upper-Level Function:	[TBD] Confine Waste
Subfunctions:	[X.1] Minimize Spread [X.2] Maintain Confinement

Function:	[X.1] MINIMIZE SPREAD
Description:	Prevent the movement of leaked waste from the vicinity of a leak site. Leaked waste includes waste from tank leaks and existing contamination from previous leaks and spills.
Enabling Inputs:	Tank Leaks Barrier Adjustments
Required Outputs:	Confined Tank Leaks Barrier Integrity Data Barrier Performance Data
Constraints:	Compatibility Requirements
Resources:	Physical Barrier Barrier Instruments
Upper-Level Function:	[X] Confine Tank Leaks
Subfunctions:	[X.1.1] Inhibit Flow [X.1.2] Remove Liquids

Function:	[X.1.1] INHIBIT FLOW
Description:	Prevent or restrict the physical movement of leaked waste (e.g., by reduced permeability).
Enabling Inputs:	Tank Leaks Needing Flow Inhibited Flow Inhibiting Barrier Adjustments
Required Outputs:	Tank Leaks with Flow Inhibited Flow Inhibiting Barrier Integrity Data Flow Inhibiting Barrier Performance Data
Constraints:	Compatibility Requirements
Resources:	Physical Barrier Barrier Instruments
Upper-Level Function:	[X.1] Minimize Spread
Subfunctions:	(None)

Function:	[X.1.2] REMOVE LIQUIDS
Description:	Remove the liquid portion of leaked waste or limit the volume of liquid available to cause movement of leaked waste (e.g., by waste drying).
Enabling Inputs:	Tank Leaks Needing Liquid Removed Liquid Removing Barrier Adjustments
Required Outputs:	Tank Leaks with Liquid Removed Liquid Removing Barrier Integrity Data Liquid Removing Barrier Performance Data
Constraints:	Compatibility Requirements
Resources:	Physical Barrier Barrier Instruments
Upper-Level Function:	[X.1] Minimize Spread
Subfunctions:	(None)

Function:	[X.2] MAINTAIN CONFINEMENT
Description:	Monitor and actively control barrier system operation to ensure effective overall confinement. Generate operating records.
Enabling Inputs:	Barrier Integrity Data Barrier Performance Data

Required Outputs:	Barrier Operating Records Barrier Adjustments
Constraints:	Confinement Requirements
Resources:	Barrier Controls
Upper-Level Function:	[X] Confine Tank Leaks
Subfunctions:	[X.2.1] Monitor Integrity [X.2.2] Monitor Performance [X.2.3] Repair Defects

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Function:	[X.2.1] MONITOR INTEGRITY
Description:	Monitor operation to determine integrity of confinement system. Compare results to standards. Identify needed integrity adjustments. Report integrity data.
Enabling Inputs:	Barrier Integrity Data
Required Outputs:	Barrier Integrity Records Barrier Integrity Adjustments Needed
Constraints:	Confinement Requirements
Resources:	Barrier Controls
Upper-Level Function:	[X.2] Maintain Confinement
Subfunctions:	(None)

Function:	[X.2.2] MONITOR PERFORMANCE
Description:	Monitor operation to determine performance of confinement system. Compare results to standards. Identify needed performance adjustments. Report performance data.
Enabling Inputs:	Barrier Performance Data
Required Outputs:	Barrier Performance Records Barrier Performance Adjustments Needed
Constraints:	Confinement Requirements
Resources:	Barrier Controls
Upper-Level Function:	[X.2] Maintain Confinement
Subfunctions:	(None)

Function:	[X.2.3] REPAIR DEFECTS
Description:	Adjust confinement system to meet integrity and performance standards.
Enabling Inputs:	Barrier Integrity Adjustments Needed Barrier Performance Adjustments Needed
Required Outputs:	Barrier Adjustments
Constraints:	(None)
Resources:	Barrier Controls
Upper-Level Function:	[X.2] Maintain Confinement
Subfunctions:	(None)

INPUT AND OUTPUT DESCRIPTIONS

Input/Output: BARRIER ADJUSTMENTS

Description: Adjustments to barrier operation by barrier controls to better confine tank leaks based on assessment of barrier integrity and performance, and minimum confinement requirements.

Source Function: [X.2] Maintain Confinement

Enabled Function: [X.1] Minimize Spread

Input/Output: BARRIER CONTROLS

Description: Devices which control barrier operation to better confine tank leaks. Data obtained from barrier instruments is compared with values established for acceptable barrier performance and integrity, and minimum confinement requirements, to generate barrier adjustments.

Source Function: (External)

Enabled Function: [X.2] Maintain Confinement
[X.2.1] Monitor Integrity
[X.2.2] Monitor Performance
[X.2.3] Repair Defects

Input/Output: BARRIER INSTRUMENTS

Description: Devices used to measure properties (e.g., temperature, moisture content) of the barrier or surrounding soil.

Source Function: (External)

Enabled Function: [X.1] Minimize Spread
[X.1.1] Inhibit Flow
[X.1.2] Remove Liquids

Input/Output: BARRIER INTEGRITY ADJUSTMENTS NEEDED

Description: Identified need to improve barrier integrity. Determined by comparing measured barrier integrity data with values established for acceptable integrity and minimum confinement requirements.

Source Function: [X.2.1] Monitor Integrity

Enabled Function: [X.2.3] Repair Defects

Input/Output: BARRIER INTEGRITY DATA

Description: Data and measurements by barrier instruments which are indicative of barrier integrity.

Source Function: [X.1] Minimize Spread

Enabled Function: [X.2] Maintain Confinement

Input/Output: BARRIER INTEGRITY RECORDS

Description: Barrier integrity data which has been collected, analyzed by comparing to confinement requirements, and the results verified and validated. The results establish the confinement effectiveness with regards to barrier integrity.

Source Function: [X.2.1] Monitor Integrity

Enabled Function: (External)

Input/Output: BARRIER OPERATING RECORDS

Description: Barrier integrity and performance records which together establish the overall confinement effectiveness.

Source Function: [X.2] Maintain Confinement

Enabled Function: (External)

Input/Output: BARRIER PERFORMANCE ADJUSTMENTS NEEDED

Description: Identified need to improve barrier performance. Determined by comparing measured barrier performance data with values established for acceptable performance and minimum confinement requirements.

Source Function: [X.2.2] Monitor Performance

Enabled Function: [X.2.3] Repair Defects

Input/Output: BARRIER PERFORMANCE DATA

Description: Data and measurements by barrier instruments which are indicative of barrier performance.

Source Function: [X.1] Minimize Spread

Enabled Function: [X.2] Maintain Confinement

Input/Output: BARRIER PERFORMANCE RECORDS

Description: Barrier performance data which has been collected, analyzed by comparing to confinement requirements, and the results verified and validated. The results establish the confinement effectiveness with regards to barrier performance.

Source Function: [X.2.2] Monitor Performance

Enabled Function: (External)

Input/Output: BARRIER SYSTEM

Description: Consists of the physical barrier, barrier instruments, and barrier controls.

Source Function: (External)

Enabled Function: [X] Confine Tank Leaks

Input/Output: COMPATIBILITY REQUIREMENTS

Description: Criteria which ensure the use of barriers is compatible with other TWRS and Hanford Site activities. These define interfaces and establish limits on the barrier design and operation.

Source Function: (External)

Enabled Function:
[X] Confine Tank Leaks
[X.1] Minimize Spread
[X.1.1] Inhibit Flow
[X.1.2] Remove Liquids

Input/Output: CONFINED TANK LEAKS

Description: Tank leaks whose movement has been effectively confined by inhibiting their flow and/or removing or limiting the available liquid with a physical barrier. Includes leaked waste, contaminated soil, and the barrier (if not removed).

Source Function: [X.1] Minimize Spread

Enabled Function: (External)

Input/Output: CONFINEMENT REQUIREMENTS

Description: The degree of confinement needed. Provides the basis for determining what constitutes acceptable barrier performance and integrity.

Source Function: (External)

Enabled Function:
[X] Confine Tank Leaks
[X.2] Maintain Confinement
[X.2.1] Monitor Integrity
[X.2.2] Monitor Performance

Input/Output: FLOW INHIBITING BARRIER ADJUSTMENTS

Description: Adjustment of flow inhibiting-type barrier controls to better confine tank leaks based on barrier integrity and performance data, and minimum confinement requirements.

Source Function: [X.2.3] Repair Defects

Enabled Function: [X.1.1] Inhibit Flow

Input/Output: FLOW INHIBITING BARRIER INTEGRITY DATA

Description: Data and measurements by barrier instruments which are indicative of flow inhibiting-type barrier integrity.

Source Function: [X.1.1] Inhibit Flow

Enabled Function: [X.2.1] Monitor Integrity

Input/Output: FLOW INHIBITING BARRIER PERFORMANCE DATA

Description: Data and measurements by barrier instruments which are indicative of flow inhibiting-type barrier performance.

Source Function: [X.1.1] Inhibit Flow

Enabled Function: [X.2.2] Monitor Performance

Input/Output: LIQUID REMOVING BARRIER ADJUSTMENTS

Description: Adjustment of liquid removing-type barrier controls to better confine tank leaks based on barrier integrity and performance data, and minimum confinement requirements.

Source Function: [X.2.3] Repair Defects

Enabled Function: [X.1.2] Remove Liquids

Input/Output: LIQUID REMOVING BARRIER INTEGRITY DATA

Description: Data and measurements by barrier instruments which are indicative of liquid removing-type barrier integrity.

Source Function: [X.1.2] Remove Liquids

Enabled Function: [X.2.1] Monitor Integrity

Input/Output: LIQUID REMOVING BARRIER PERFORMANCE DATA

Description: Data and measurements by barrier instruments which are indicative of liquid removing-type barrier performance.

Source Function: [X.1.2] Remove Liquids

Enabled Function: [X.2.2] Monitor Performance

Input/Output: PHYSICAL BARRIER

Description: That portion of the barrier system which physically confines tank leaks by inhibiting their flow or removing the liquid.

Source Function: (External)

Enabled Function:
[X.1] Minimize Spread
[X.1.1] Inhibit Flow
[X.1.2] Remove Liquids

Input/Output: TANK LEAKS

Description: Leakage from SSTs during waste retrieval operations. Includes existing contamination from previous leaks and spills.

Source Function: (External)

Enabled Function: [X.1] Minimize Spread

Input/Output: TANK LEAKS NEEDING FLOW INHIBITED

Description: Tank leaks whose movement can be prevented or minimized by inhibiting their flow.

Source Function: (External)

Enabled Function: [X.1.1] Inhibit Flow

Input/Output: TANK LEAKS NEEDING LIQUID REMOVED

Description: Tank leaks whose movement can be prevented or minimized by removing or limiting the available liquid.

Source Function: (External)

Enabled Function: [X.1.2] Remove Liquids

Input/Output: TANK LEAKS WITH FLOW INHIBITED

Description: Tank leaks whose movement has been prevented or minimized by inhibiting their flow with a physical barrier.

Source Function: [X.1.1] Inhibit Flow

Enabled Function: (External)

Input/Output: TANK LEAKS WITH LIQUID REMOVED

Description: Tank leaks whose movement has been prevented or minimized by removing or limiting the available liquid with a physical barrier.

Source Function: [X.1.2] Remove Liquids

Enabled Function: (External)

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