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Draft A

200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program

United States
Department of Energy
Richland, Washington

For External Review

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EXECUTIVE SUMMARY

The 200 Areas Remedial Investigation/Feasibility Study Implementation Plan addresses approximately 700 soil waste sites (and associated structures such as pipelines) resulting from the discharge of liquids and solids from processing facilities to the ground (e.g., ponds, ditches, cribs, burial grounds) in the 200 Areas and assigned to the Environmental Restoration Program. This Plan does not address the waste storage tank farms located in the 200 Areas (or the waste constituents in the vadose zone resulting from their leakage), other waste management programs, decontamination and decommissioning of facilities or buildings, and previously contaminated groundwater. Individual sites within the 200 Areas fall under the auspices of different regulatory agencies and drivers (e.g., *Resource Conservation and Recovery Act of 1976* [RCRA] Past Practice Sites); RCRA treatment, storage and/or disposal units are regulated by the Washington State Department of Ecology, and *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) sites are regulated by the U.S. Environmental Protection Agency. The U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology teamed to establish a streamlined approach resulting in a mutual commitment to define and implement a common regulatory, characterization, documentation, and communication strategy which is described in this Implementation Plan.

The Implementation Plan outlines the framework for implementing assessment activities in the 200 Areas to ensure consistency in documentation, level of characterization, and decision making. The Implementation Plan also consolidates background information and other typical work plan materials, to serve as a single referenceable source for this type of information. This Implementation Plan does not provide detailed information about the assessment of individual waste sites or groups. Site-specific data needs, data quality objectives (DQOs), data collection programs, and associated assessment tasks and schedules will be defined in subsequent group-specific (i.e., operable unit-specific) work plans.

A common regulatory framework is established that integrates the RCRA, CERCLA, Federal Facility Regulations, and *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology, et al., 1996) requirements into one standard approach for 200 Areas cleanup activities. A description of the programmatic and regulatory requirements of the RCRA and CERCLA programs is provided for the public and stakeholders who are unfamiliar with the two programs. Special emphasis is given to Hanford-specific application of RCRA and CERCLA as specified in the Tri-Party Agreement, local policy and programmatic requirements, and the basis for integrating these requirements for implementation in the 200 Areas. The CERCLA process will be used as the basis for assessment and remediation activities in the 200 Areas, with modification as needed to concurrently satisfy requirements specific to RCRA permitting for RCRA Past Practice sites and treatment, storage, and/or disposal units. This integration process for the two regulatory programs is a modification and advancement over that which has been applied in the 100 and 300 Areas that incorporates improvements that have been identified.

Significant efficiencies are also achieved by reducing the number of operable units from 32 geographical-based groupings to 23 process-based, waste site operable units. Within each of these groups, representative sites will be selected, treatment, storage, and/or disposal units will be included, and the analogous site approach used to obtain characterization information. The grouping of waste sites and selection of candidate representative sites was the first step in developing a consistent characterization strategy that applies the analogous site approach used previously in the 100 and 300 Areas. These groupings can be used to focus the characterization effort on a limited number of specific waste sites that represent the group. The representative site data can then be used to make remedial action decisions for all sites within a group. Sampling of individual waste sites is expected to be required before remedial design to verify the applicability of the representative waste site conceptual model, to confirm that remedial action decisions are appropriate, and to provide data needed to design the remedy. The use of the analogous site approach is critical due to the large number of waste sites that exist in the 200 Areas. Field analytical data would ultimately be required at all waste sites, but the collection of this confirmatory data will coincide with the commencement of remedial design activities. Following remediation, verification sampling will also be performed to confirm that cleanup goals have been achieved.

The Implementation Plan also streamlines work plans that are required for each waste site group by consolidating background information and providing a single referenceable source for this information. This allows the information in the group-specific work plans to focus on waste group or waste site-specific information. The background information includes an overview of the 200 Area facilities and processes, their operational history, contaminant migration concepts, and a list of contaminants of concern. It also documents and evaluates existing information to develop a site description and conceptual model of expected site conditions and potential exposure pathways. With this conceptual understanding, preliminary potential applicable or relevant and appropriate requirements, preliminary remedial action objectives, and remedial action alternatives are identified. The alternatives are broadly defined but represent potential alternatives that may be implemented at the site. The identification of potential alternatives helps ensure data needed to fully evaluate the alternatives are collected during the remedial investigation. The type and quality of data are defined through the DQOs and form the basis for the data collection program.

The strategy for implementation of the DQO process and definition of characterization requirements is critical. Flexibility is needed in these activities to account for the differences in site-specific waste site groupings. The Implementation Plan provides a common foundation for the starting point to allow for collection of comparable sets of characterization data while still providing the flexibility needed to address the different waste sites. The Implementation Plan contains a summary of the group-specific work plan process to establish DQOs, followed by a description of the analogous site approach to characterization and a description of characterization techniques that have been used at the Hanford Site.

The Implementation Plan also specifies project management activities, and includes a project schedule. Appendices provide supporting information that is applicable to all waste site groups in the 200 Areas. These sections include the general elements of quality assurance, health and safety, data management, and remedial action technologies that may be referenced and/or expanded upon in future characterization work plans. These appendices provide a mutually agreed upon foundation to ensure that future work plans are focused on the group-specific details and not the 200 Areas-wide discussions and requirements.

This 200 Areas strategy recognizes the interrelationships between the various activities in the area and the need to integrate with other Environmental Restoration and Hanford project/programs. The plan describes the approach to interfacing with other programs and agencies, the integrated schedule of activities that addresses both RCRA and CERCLA program requirements, and the public participation process.

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ACRONYMS

AAMS	aggregate area management study
AEC	Atomic Energy Commission
ACL	alternative concentration level
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BFMS	Baseline Funds Management System
BHI	Bechtel Hanford, Inc.
CAMU	Corrective Action Management Unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CMI	corrective measures implementation
CMS	corrective measure study
COPC	contaminants of potential concern
CPP	CERCLA Past Practice
D&D	decontamination and decommissioning
DCG	derived concentration guide
DOE	U.S. Department of Energy
DQA	data quality assessment
DQO	data quality objective
DWP	detailed work plan
Ecology	Washington State Department of Ecology
EDTA	ethylenediaminetetraacetic acid
EE/CA	engineering evaluation/cost analysis
EMI	electromagnetic induction
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ERC	Environmental Restoration Contractor
ERDA	Energy Research and Development Administration
ERDF	Environmental Restoration Disposal Facility
ESD	explanation of significant difference
FS	feasibility study
GPH	ground penetrating holography
GPR	ground penetrating radar
GWP	group-specific work plan
GW/VZ	groundwater and vadose zone
HASP	health and safety plan
HCRL	Hanford Cultural Resources Laboratory
HEDTA	N-hydroxyethylenediaminetriacetic acid
HEPA	high-efficiency particulate air
HEIS	Hanford Environmental Information System
HPPS	*Hanford Past Practice Strategy*
HRA-EIS	Hanford Remedial Action-Environmental Impact Statements
HSWA	*Hazardous and Solid Waste Amendments of 1984*
HTRW	Hazardous, Toxic, and Radiological Waste
HWMA	*Hazardous Waste Management Act of 1976*
ICP	inductively coupled plasma
LIBS	laser-induced breakdown spectroscopy

LRP	long range plan
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MTCA	*Model Toxics Control Act*
NCP	National Oil And Hazardous Substance Contingency Plan
NEPA	*National Environmental Policy Act*
NESHAP	National Emission Standards For Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NPH	normal paraffin hydrocarbons
NRC	U.S. Nuclear Regulatory Commission
NPL	National Priorities List
NRDWL	Nonradioactive Dangerous Waste Landfill
O&M	operation and maintenance
PA	preliminary assessment
PCB	polychlorinated biphenyls
PFP	Plutonium Finishing Plant
PMII	Project Managers Implementation Instructions
PNNL	Pacific Northwest National Laboratory
PRG	preliminary remediation goal
PUREX	plutonium/uranium extraction
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RAO	remedial action objectives
RA	remedial action
RARA	Radiation Area Remedial Action
RAWD	Remedial Action Waste Disposal
RAWP	Remedial Action Work Plan
RCRA	*Resource Conservation and Recovery Act of 1976*
RCW	*Revised Code of Washington*
RD	remedial design
RDR	remedial design report
REDOX	reduction oxidation
RFA	RCRA facility assessment
RFI	RCRA facility investigation
RI	remedial investigation
RL	U.S. Department of Energy, Richland Operations Office
RLS	radionuclide logging system
ROD	Record of Decision
RPP	RCRA Past Practice
S&M	surveillance and maintenance
SAP	sampling and analysis plan
SDWA	*Safe Drinking Water Act*
SEPA	*State Environmental Policy Act*
SI	site inspection
SWL	solid waste landfill
SWMU	solid waste management unit
TBC	to be considered
TBP	tributyl phosphate
TCE	trichloroethylene
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*

Tri-Parties	U.S. Department of Energy, Richland Operations Office, U.S. Environmental Protection Agency, Washington State Department of Ecology
TRU	transuranic
TSCA	*Toxic Substance Control Act*
TSD	treatment, storage, and/or disposal
UNH	uranyl nitrate hexahydrate
UR	Unplanned Release
URP	Uranium Recovery Project
WAC	Washington Administrative Code
WBS	work breakdown structure
WESF	Waste Encapsulation And Storage Facility
WIDS	Waste Inventory Data System
VOC	volatile organic compound

1.0 INTRODUCTION

The Hanford Site, managed by the U.S. Department of Energy (DOE), encompasses approximately 1,450 km^2 (560 mi^2) in the Columbia Basin of south-central Washington State. The Hanford Site is divided into a number of operational areas such as the 200 Areas. In 1989, the U.S. Environmental Protection Agency (EPA) placed the 100, 200, 300, and 1100 Areas on the National Priorities List (NPL) pursuant to the *Comprehensive Response, Compensation, and Liability Act of 1980* (CERCLA). The 200 Areas, located near the center of the Hanford Site, are the focus of this Remedial Investigation/Feasibility Study (RI/FS) Implementation Plan. The 200 Areas NPL site consists of the 200 West Area and 200 East Area (Figure 1-1), which contain waste management facilities and inactive irradiated-fuel reprocessing facilities, and the 200 North Area, formerly used for interim storage and staging of irradiated fuel. Waste sites in the 600 Area located near the 200 Areas are also included in the 200 Area NPL site. There are approximately 700 waste sites organized into 23 waste site groups that will be addressed as part of this Implementation Plan.

This Plan addresses the assessment and remediation of waste sites and associated soil contamination (surface and vadose zone) that resulted from past discharges of wastewater to the ground (via ponds, ditches, and cribs) and the burial of solid waste in the 200 Areas. Furthermore, the Plan applies to only those 200 Area waste sites (and associated structures such as pipelines) assigned to the Environmental Restoration (ER) Program consisting of past practice sites and inactive *Resource Conservation and Recovery Act of 1976* (RCRA) treatment, storage, and/or disposal (TSD) units designated for closure. Monitoring and remediation of 200 Area groundwater is not within the scope of this plan (including the groundwater monitoring required as part of TSD unit closures). Although potential impacts to groundwater from vadose zone contamination will be addressed, any groundwater-specific activities are managed under separate groundwater operable units. For purposes of compliance with TSD unit closure requirements, reference will be made as appropriate to the groundwater operable unit activities. In addition to excluding groundwater, this plan does not address the waste storage tank farms located in the 200 Areas (or the waste constituents in the vadoze zone resulting from their leakage), other waste management programs, and decontamination and decommissioning (D&D) of facilities or buildings. The use of the term "200 Area waste site" in this document is consistent with this description and scope.

The 200 Areas is the last NPL site on the Hanford Site requiring a major characterization effort. With the 200 Areas assessment and remediation program being in an early and formative stage, the opportunity exists to incorporate and build on efficiencies achieved at other recent cleanup activities at the Hanford Site (particularly the 100 and 300 Area remediation activities). Because of the importance of this effort, the DOE, the EPA, and the Washington State Department of Ecology (Ecology) teamed to develop a more streamlined approach to completing 200 Area waste site cleanups. A series of workshops starting in 1996 between the EPA, Ecology, and the DOE resulted in an overall strategy for characterization and remediation of the 200 Areas. The workshops culminated in the *200 Areas Soil Remediation Strategy – Environmental Restoration Program* (DOE-RL 1996a). Follow-on workshops have continued to more fully develop the streamlining concepts of the strategy. The team's effort focused on three aspects or elements of the cleanup process where meaningful improvements to the process could be achieved. These key elements include integration of regulatory requirements, consolidation of information and streamlining of documents, and application of a consistent approach to characterization.

The teaming of the EPA, Ecology, and the DOE has resulted in a mutual commitment to define and implement a uniform regulatory, documentation, and characterization approach to cleanup in the 200 Areas. This 200 Area RI/FS Implementation Plan addresses each of the key elements and defines the framework for their implementation. Among other things, the implementation plan is intended to provide a sufficient amount of detail to ensure consistency in future 200 Area work considering the broad range of conditions present and realizing that waste site-specific details are to be addressed in work plans. Because additional efficiencies are expected to be seen as the first characterizations are completed, a degree of flexibility is provided to accommodate future improvements.

1.1 GENERAL OVERVIEW OF 200 AREA ASSESSMENT AND REMEDIATION APPROACH

Figure 1-2 provides an overview of the assessment and remediation process that will be followed in the 200 Areas. This includes preparation of documentation (work plans and RI/FS reports), sampling, evaluation of data, preparation of proposed plans, issuance of Record of Decisions (ROD) and RCRA permit modifications, remediation activities, and final closeout of waste sites. This process is explained in further detail in the remainder of the sections of this document, beginning with the development of an integrated regulatory approach.

A regulatory framework is needed that integrates the RCRA, CERCLA, and *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994) requirements into one standard approach to direct cleanup activities in a consistent manner and to ensure that applicable regulatory requirements will be met. Consistency is desired because it facilitates the preparation, review, and approval process, and focuses the effort on achieving the end product rather than on the process. The framework must be sufficiently complete such that all assessment and remediation steps are addressed with an emphasis on near-term needs for characterization.

Similar to regulatory requirements, a common approach is needed to ensure consistency in defining characterization requirements for the various waste groups (i.e., source operable units). Important components in developing the characterization framework include the data quality objective (DQO) process, data collection strategy and methodology, and use of the analogous site approach. As part of the work planning process, assumptions are made regarding land use, the conceptual model, applicable or relevant and appropriate requirements (ARARs), remedial action objectives (RAOs), and remedial action alternatives because they influence characterization requirements. For example, the identification of preliminary remedial alternatives helps ensure that data needed to evaluate the alternatives are collected. These types of initial assumptions are not expected to vary considerably between work plans and can be defined early in the assessment process to promote a consistent characterization approach.
The consolidation of 200 Area-wide information was identified as an important streamlining element that is intended to simplify future documents (e.g., work plans, closure plans) and to bring together the significant amount of available 200 Area information. Work plans in the past required generic, as well as site-specific or operable unit-specific, information. Generic information included background information about the Hanford Site or NPL site that was repeated in work plan after work plan. A significant amount of historical information on the 200 Areas has been generated over the years. However, the information is often scattered among various types of reports, plans, or drawings. As a result, the need exists to consolidate background and historical information in a single reference. By compiling these types of materials early, work plans need only focus on group-specific or site-specific details.

A determination on how to best organize waste sites in the 200 Areas was the focus of the *Waste Site Grouping for 200 Areas Soil Investigations* report (DOE-RL 1997). It was concluded that 23 process-based groupings would be a more efficient approach to characterization than the existing 32 geographically based source operable units. The selection of these 23 waste groups is based on the type of discharge (e.g., solid waste, cooling water, process water, uranium-rich waste) and waste site type (e.g., pond, crib, ditch, burial ground). Table 1-1 identifies the 23 waste groups. These waste groups formed the basis for the change package that modified Tri-Party Agreement operable unit milestones to align with the 23 waste site groupings.

The process-based waste site groupings facilitate the use of the analogous site approach to characterization. The use of the analogous site approach is fundamental to streamlining in the 200 Areas, due to the large number of waste sites (approximately 700) present. This approach allows data collected from representative sites to be extrapolated to similar or analogous sites in the early stages of assessment to support remedial alternative evaluation and selection. Sampling data would ultimately be required at all waste sites, but the collection of this data would be integrated with remedial design data needs to serve a dual purpose. This analogous site approach has been applied effectively in the 100 and 300 Areas.

1.2 PURPOSE, SCOPE, AND OBJECTIVES OF THE IMPLEMENTATION PLAN

1.2.1 Purpose and Objectives

The purpose of the 200 Areas RI/FS Implementation Plan is to define the framework for implementing soil characterization activities in the 200 Areas to ensure consistency in applying regulatory and documentation requirements and in defining characterization requirements, and reaching remedial action decisions. The framework includes, where appropriate, specific direction such as RCRA/CERCLA integration general plans, such as for data management, and assumptions needed to formulate a consistent path forward, such as land use. The Implementation Plan consolidates background information (200 Area geology and operational history) and other work plan materials (preliminary RAOs and remedial action alternatives), allowing future work plans to be more concise.

This Implementation Plan is not intended to provide detailed instructions for the assessment of individual waste sites or groups, but rather direction to be followed in developing group-specific work plan. Site-specific data needs, DQOs, data collection programs, and associated assessment tasks and schedules will be defined as part of the work planning process. The scope of this Implementation Plan is limited to the 23 waste site groups (i.e., source operable units) in the 200 Areas identified in Table 1-1.

The primary objectives of the Implementation Plan include the following:

- Define a regulatory framework for assessment and remediation of 200 Area waste sites.
- Consolidate information on 200 Area site conditions and operational history to serve as a common source of background information.
- Define governing assumptions important to developing a consistent assessment approach or as baseline information common to all work plans including potential ARARs, preliminary land use, preliminary RAOs and remedial action alternatives, and risk assessment.
- Define a consistent approach to waste site characterization.

Sections 1.2.2 through 1.2.5 provide an additional level of discussion on these objectives and indicate where they are addressed within this document.

1.2.2 Regulatory Framework

Defining the regulatory framework allows for a consistent application of the regulatory requirements for all 200 Area waste sites that are covered under this Implementation Plan. This document provides a readily available resource that has been approved by Ecology, the EPA, and the DOE that defines a streamlined and integrated mechanism for addressing the major regulatory drivers for cleanup (RCRA, CERCLA, and the Tri-Party Agreement). This framework will apply to all waste sites, regardless of the regulatory designation (i.e., CERCLA Past Practice [CPP], RCRA Past Practice [RPP], TSD Unit) assigned.

Section 2.0 provides a discussion of the CERCLA and RCRA processes to develop an understanding of the unique requirements of each, as well of the commonalities they share. This is followed by a discussion on how the two sets of requirements will be integrated, documents to be prepared, and opportunities for public involvement. The discussion is organized by the major steps in the cleanup process, starting from work plan development through remediation with an emphasis on near-term characterization activities. A discussion of the entire process is provided to ensure that the approach prescribed in the Implementation Plan accounts for all elements contained in the regulatory drivers.

1.2.3 Background Information, Supporting Plans, and Common Work Plan Materials

A major focus of the streamlining effort was the need to simplify group-specific work plans. Work plans are required by the Tri-Party Agreement (Ecology et al. 1994) and define characterization and remedial decision-making requirements. The contents of these work plans are often prescriptive based on regulatory guidance documents. For example, work plans in the past required discussions of the physical setting (e.g., geohydrology) and operational history, both at the Hanford Site and at the NPL level (i.e., general level), as well as waste site-specific details. Rather than duplicating the general information in all 23 work plans, the Implementation Plan consolidates this material to serve as a primary reference for this information. This allows work plans to focus on group- and site-specific details resulting in a product that is much more concise. Other sections of work plans that are amenable to this approach because they are not expected to vary significantly between work plans include such topics as ARARs and preliminary remedial action alternatives (see Section 1.2.4), and various secondary plans (e.g., data management plan).

Secondary plans provided in the Implementation Plan include the following:

- Appendix A, Quality Assurance Project Plan, which provides the overall quality assurance framework that will be used to prepare group-specific quality assurance plans for characterization.

- Appendix B, General Health and Safety Plan, which provides the general health and safety requirements for field activities for all waste site groups. Activity-specific health and safety plans will be prepared prior to beginning field work.

- Appendix C, Information Management Overview, which describes how data from all assessment activities will be organized. This plan will be applied to all waste site groups; group-specific plans will not be required.

- Appendix E, Waste Management for the 200 Areas Implementation Plan, which describes the general waste management processes and requirements for waste types that might be generated during the course of assessing 200 Area waste sites. Activity-specific waste control plans will be prepared as necessary to identify the specific type, volume, and disposal of wastes.

Section 3.0 summarizes the 200 Area physical setting (Section 3.1) , provides an overview of the operational history of the 200 Areas, and identifies major potential contaminants of concern (Section 3.2).

Detailed discussions of these subjects in provided in Appendices F, G, and H, which include the following:

- Appendix F, Physical Setting, includes the general 200 Area topography, meteorology, vadose zone hydrogeology, and groundwater. It also presents natural background concentrations of chemical and radiological analytes and discussions on environmental and cultural resources of the 200 Areas. These data support both the preliminary physical conceptual model and the conceptual exposure model in demonstrating how contaminants are expected to move through the environment and to potential receptors. This section also promotes an understanding of the constraints and adjustments to characterization activities. These details are intended to supplement the summary information presented in Section 3.1. This information will be referenced as needed in future group-specific work plans.

- Appendix G, Waste Site Listing, tabulates all of the 200 Area waste sites included in the scope of this Implementation Plan. It also provides a detailed explanation of each waste site group. Representative waste sites for characterization activities are identified in Table G-1. In addition, information on the history, engineering, and operational features of each various type waste site is presented. This appendix thus summarizes the types of waste streams and waste sites which, in turn, supports understanding of both the waste site groupings and the physical conceptual model. These details are intended to supplement the summary information presented in Section 3.2. This information will be referenced as needed in future group-specific work plans.

- Appendix H, Process Descriptions and Flow Diagrams, describes the organization and historical evolution of the chemical separation processes and waste management activities in the 200 Areas. A series of figures are used to help illustrate the complexities of the major processes undertaken in the canyon buildings, evaporators, and support facilities around the major processing plants. This appendix demonstrates the origin and range of radionuclides in waste streams and shows why certain radionuclides are not considered as analytes. This discussion demonstrates the connection/similarities between processes on site, the resulting similarities in waste stream chemistries/contaminants, and the general interconnectedness that allows waste sites to be grouped. This information is also intended to supplement the summary information presented in Section 3.2.

Finally, Section 3.3 discusses the physical and chemical interactions that may occur when waste is introduced to the soil column including the fate and transport of contaminants, and summarizes the results of previous soil investigations in the 200 Areas. This is used to form a conceptual understanding of contaminant migration in the vadose zone for major contaminants of concern. Section 3.0 and supporting appendices are intended to be sufficiently comprehensive to satisfy the general information requirements of upcoming group-specific work plans and consolidate a large number of diverse references in a readily available primary document.

A recommended outline for group-specific work plans that incorporates the streamlining elements discussed above is provided in Appendix I. Plates I through III identify the locations of the waste sites, by waste group, and also highlight those that are representative sites or TSD units.

1.2.4 Baseline Assumptions

Several components of the work-planning process function as guiding assumptions to the cleanup process. These assumptions are established early in the process, at least in a preliminary manner because they influence characterization needs. Those assumptions that can be addressed early in the process and are not expected to vary considerably among work plans include ARARs, the conceptual exposure model, RAOs, remedial action alternatives, and risk assessment approach.

ARARs capture those regulatory requirements that are pertinent to the cleanup process. Because ARARs form the basis for establishing cleanup levels, the characterization effort (e.g., detection limits) must be compatible with those requirements. A listing of the ARARs considered important to the 200 Areas is included in Section 4.0. Specific ARARs that may change due to site-specific conditions such as land use, exposure pathways, and remediation goals will be addressed in the group-specific work plans.

Section 5.0 develops a preliminary conceptual exposure model that integrates the waste site categories (source terms) identified in Section 3.2, general contaminant transport phenomena presented in Section 3.3, and land-use considerations with potential exposure pathways and receptors to provide a basis for evaluating current or potential future risks. These risks are then addressed by preliminary RAOs and preliminary remediation goals (PRGs) that are protective of human health and the environment. Based on the RAOs, viable remedial action alternatives are assembled in Appendix D. The remedial alternatives are general and cover a range of technologies to reflect the potential contamination conditions present in the 200 Areas. Appendix D is intended to satisfy the requirements of a screening phase feasibility study (FS) (i.e., Phase I and II FS) by providing the necessary basis to prepare group-specific detailed FSs. Site-specific refinements of the alternatives presented in Appendix D will be made in final group-specific FSs. By completing a screening-level FS in Appendix D and identifying viable alternatives now, a more streamlined RI/FS can be performed. Characterization needs can be more focused if a range of expected remedial alternatives are identified early, and treatability testing needs can also be evaluated and implemented early in the process. The final group-specific FS can then be focused on the detailed analysis of a few viable alternatives.

Sections 4.0 and 5.0 are intended to satisfy work plan requirements for ARARs, the conceptual exposure model, and preliminary RAOs and remedial action alternatives. As such, these subjects will be referenced in future work, although some refinement may be needed based on group-specific conditions.

1.2.5 Characterization Approach

A consistent framework for defining characterization needs for each of the waste site groups is a critical element to a more streamlined cleanup process. Important components of this framework include the following:

- Integration of past practice and RCRA TSD unit characterization needs into a single approach (addressed in Section 2.0)
- Grouping of waste sites based on historical process information and waste site type (ponds, cribs, burial grounds, etc.) (addressed in Section 3.0)
- Prioritization of waste groups according to both technical and administrative criteria (addressed in Section 3.0)
- Development of a preliminary conceptual exposure model (addressed in Section 5.0)
- Recognizing that ARARs, RAOs, remedial alternatives, and land use influence characterization needs (addressed in Sections 4.0 and 5.0)

- Consistent uniform process of developing DQOs with a team composed of representatives from DOE, EPA, Ecology, and support contractors
- Application of the analogous site concept supported by a phased approach to data collection
- Use of proven characterization methodologies.

The first four bullets lay the foundation for establishing characterization needs and were discussed previously. The last three bullets focus on specific aspects of the characterization approach for waste sites and associated soil contamination (i.e., source term) and are addressed in Section 6.0.

Section 6.0 establishes the process that will be used in group-specific work plans to establish DQOs. This is followed by a description of how characterization for all waste site groups will use the analogous site approach, which focuses characterization efforts on a limited number of specific waste sites that best represent the group. The representative site data will then be used to make remedial action decisions for all sites within a group. A phased approach to data collection is defined that acknowledges the need to sample all waste sites to confirm that remedial action decisions, based on the analogous site approach, are appropriate, as well as providing data needed to design and implement the remedy. Following remediation, verification sampling will be performed to confirm that cleanup goals have been achieved. This phased approach to data collection allows for more efficient use of available resources.
This framework provided in Section 6.0 serves a common starting point that will result in consistent data sets for consistent remedial decision making throughout the 200 Areas and to ultimately support site close-out and cumulative effects analyses.

1.3 PROJECT MANAGEMENT AND INTEGRATION

The objectives of project management during the implementation of the RI/FS plans are to ensure the safety of the work force and the affected environment, direct and document project activities, ensure that data and evaluations meet the goals and objectives of the project, and to administer the project within budget and schedule. Section 7.0 describes the approach to management of the 200 Area remediation project, the current project schedule, and the public participation process. As group-specific tasks are defined during the work planning process, task-specific project management plans will be prepared, as needed.

Section 7.0 also contains a discussion of programmatic integration needs with respect to programs inside the ER project, as well as other non-Environmental Restoration Contractor (ERC) programs involved in the 200 Areas. This aspect to project management is necessitated by the diversity of activities (e.g., groundwater pump and treats and tank waste remediation) in the 200 Areas. Although each of these programs has it's own unique mission and functions independently, there are also commonalities and shared objectives (e.g., cleanup) that can be integrated to enhance overall effectiveness. In recognition of the diversity of activities on the Hanford Site and the high priority placed on the protection of groundwater and the Columbia River, the DOE has established the Groundwater/Vadose Zone (GW/VZ) Integration Project. The GW/VZ project is responsible for integrating all activities, in various DOE programs, associated with characterization and cleanup activities of the vadose zone and groundwater on the Hanford Site, and protection of the Columbia River. The *Management and Integration of Hanford Site Groundwater and Vadose Zone Activities* (DOE-RL 1998a) report, describes the GW/VZ Project team approach for (1) achieving effective integration of current and planned site-wide activities and (2) sustaining management control of that integration. The 200 Area soil assessment and remediation work addressed by this Implementation Plan is one portion of the ER project that will interface with the GW/VZ Project.

Although groundwater contamination is an essential component of any source term evaluation and impacts to groundwater from vadose zone contamination will be assessed as part of the 200 Area waste site characterization effort, the implementation of groundwater remedial actions is managed under the Environmental Restoration Project's Groundwater Remediation Project. One situation where integration is required pertains to RCRA TSD units where groundwater must be addressed as part of a waste site's closure plan. Because of these kinds of interrelationships, DOE has created the GW/VZ Integration Project. This Implementation Plan outlines how assessment and remediation activities will be performed at 200 Area waste sites assigned to the ER program and, as such, will serve as an important coordinating document to support GW/VZ Integration Project efforts.

Figure 1-1. Hanford Site and Area Designations.

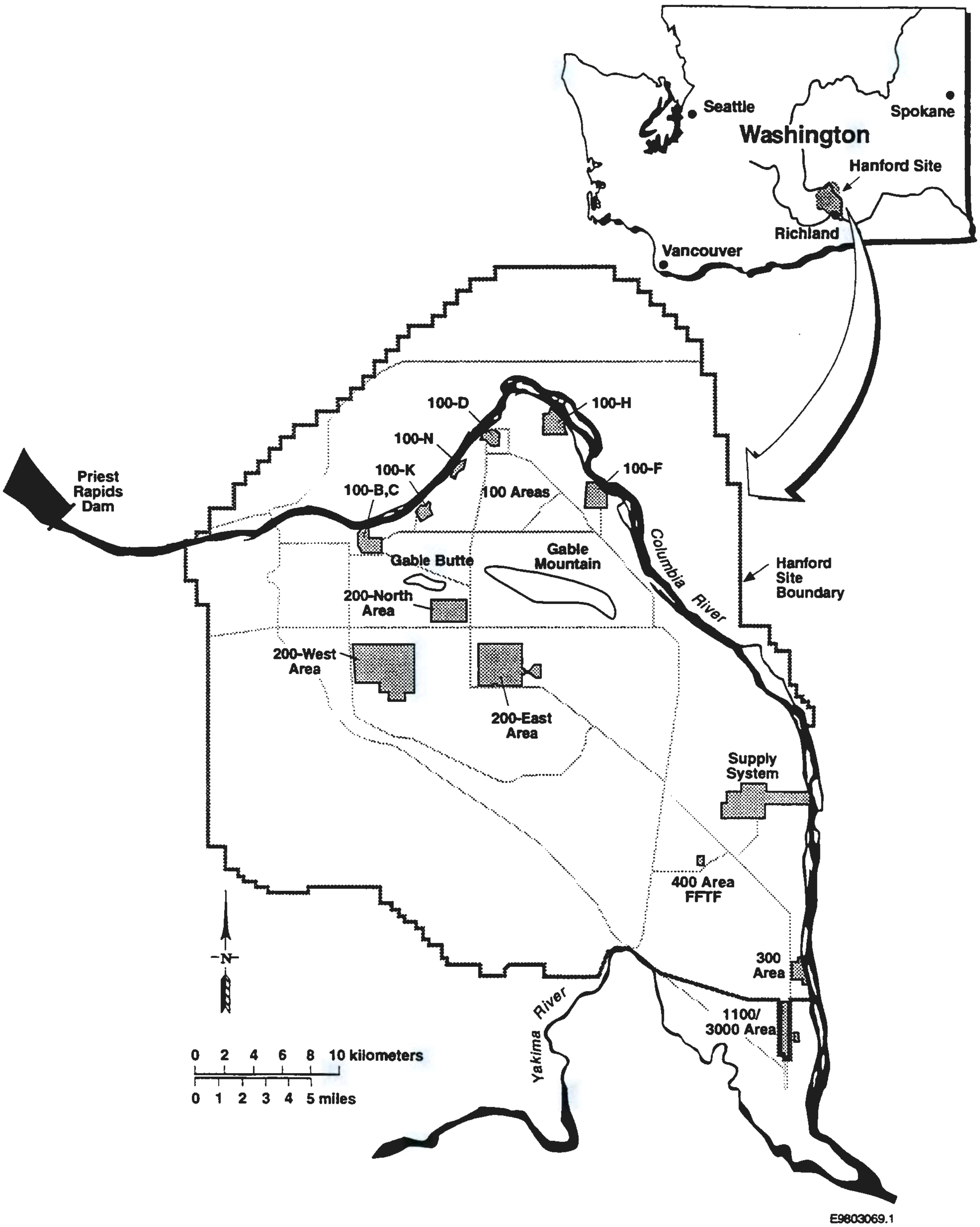
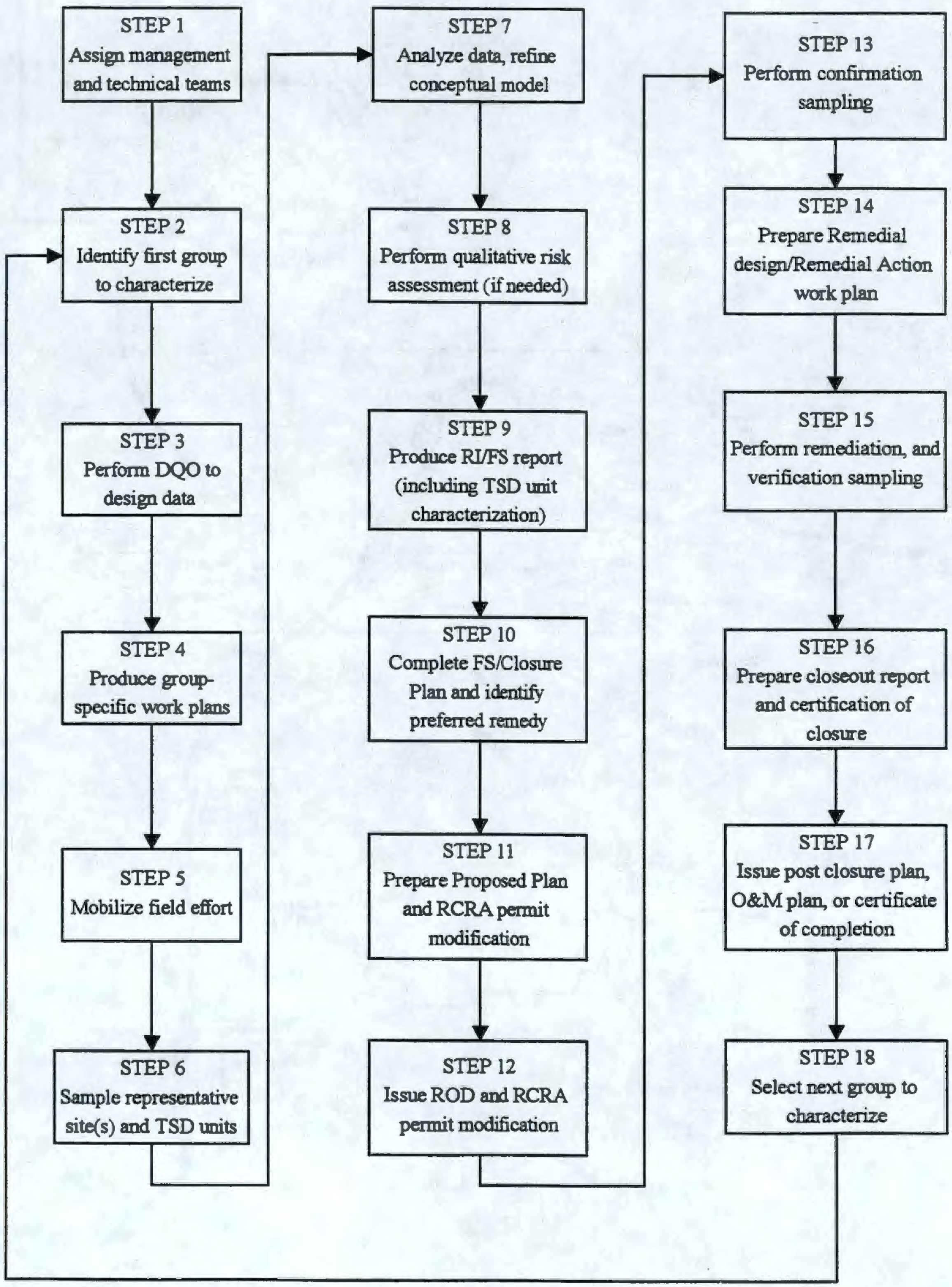


Figure 1-2. General RCRA/CERCLA Past Practice Waste Site and RCRA TSD Unit Process Flow.



Note: Assumes TSD Units are included in the group being worked.

Table 1-1. 200 Area Strategy Waste Site Groupings List.

Process Condensate/Process Waste Category	
Plutonium/Organic-Rich Process Waste Group	200-PW-1
Uranium-Rich Process Waste Group	200-PW-2
Organic-Rich Process Waste Group	200-PW-3
General Process Waste Group	200-PW-4
Fission Product-Rich Process Waste Group	200-PW-5
Plutonium Process Waste Group	200-PW-6
Steam Condensate/Cooling Water/Chemical Sewer Category	
Gable Mountain/B-Ponds and Ditches Cooling Water Group	200-CW-1
S Pond and Ditches Cooling Water Group	200-CW-2
200 North Cooling Water Group	200-CW-3
T Pond and Ditches Cooling Water Group	200-CW-4
U-Pond/Z-Ditches Cooling Water Group	200-CW-5
Steam Condensate Group	200-SC-1
Chemical Sewer Group	200-CS-1
Chemical Waste Category	
300 Areas Chemical Laboratory Waste Group	200-LW-1
200 Areas Chemical Laboratory Waste Group	200-LW-2
Miscellaneous Waste Category	
Miscellaneous Waste Group	200-MW-1
Tank/Scavenged Waste Category	
Scavenged Waste Group	200-TW-1
Tank Waste Group	200-TW-2
Tanks/Lines/Pits/Diversion Boxes Category	
Tanks/Lines/Pits/Boxes Group	200-IS-1
Unplanned Releases Category	
Unplanned Releases Group	200-UR-1
Septic Tank and Drain Fields Category	
Septic Tank and Drain Fields	200-ST-1
Landfills and Dumps Category	
Non-Radioactive Landfills and Dumps Group	200-SW-1
Radioactive Landfills and Dumps Group	200-SW-2

CS – Chemical Sewer
CW – Cooling Water
IS – Infrastructure Systems
LW – Chemical Waste
MW – Miscellaneous Waste
PW – Process Wastes
SC – Steam Condensate
ST – Septic Tank and Drain Fields
SW – Solid Waste
TW – Tank/Scavenged Waste
UR – Unplanned Release

2.0 RATIONALE AND APPROACH TO INTEGRATION OF RCRA AND CERCLA PROCESSES

2.1 INTRODUCTION

2.1.1 Purpose

The purpose of this section is to describe the RCRA and CERCLA processes, provide an integrated regulatory process for remediation of waste sites in the 200 Areas, and to identify regulatory approaches that will be incorporated into the work planning to streamline waste site assessment and provide flexibility in remediation.

Two major regulatory programs govern cleanup of contaminated waste sites at the Hanford Site, RCRA (as amended by the *Hazardous and Solid Waste Amendments of 1984* [HSWA]) and CERCLA. The authority to implement the majority of the RCRA program has been delegated to the State of Washington and is implemented via the *Hazardous Waste Management Act of 1982*. The Tri-Party Agreement, first issued in 1989, was developed by the DOE, the EPA, and Ecology to establish how these programs would be applied at the Hanford Site. As part of the Tri-Party Agreement development, all waste sites at Hanford were designated as either RCRA or CERCLA sites. The 200 Area waste sites addressed in this Implementation Plan are a mix of the types. The RCRA and CERCLA programs have similar objectives and overall approaches for making and implementing cleanup decisions, but there are many procedural elements of the two programs that are dissimilar. The differences can lead to inconsistency and redundant work. As part of the *200 Areas Soil Remediation Strategy* (DOE-RL 1996a), the Tri-Parties committed to integrating RCRA and CERCLA to the fullest extent allowable within the regulatory requirements. This is consistent with the Tri-Party Agreement, which states that the RCRA and CERCLA cleanup programs are functionally equivalent and encourages integration of the two. However, the Tri-Party Agreement does not define a clear and detailed process for integration.

The details of the integrated process are provided in this section. Section 2.1.2 provides basic background information concerning RCRA, CERCLA, the Tri-Party Agreement, and the Hanford Facility RCRA Permit. Sections 2.2 and 2.3 describe the RCRA and CERCLA programs, respectively, at the Hanford Site. Section 2.4 presents the detailed requirements of the standard RCRA and CERCLA programs and of Hanford-specific regulatory agreements, then describes the details of the integrated approach and how that approach satisfies the requirements of the individual programs. For ease of presentation, the requirements and integrated approach are divided into five remediation elements: characterization, evaluation of alternatives, decision-making, implementation, and closeout.

Several regulatory streamlining concepts that have been successfully used at the Hanford Site can be considered in the 200 Areas to reduce the time and budget required for waste site assessment and provide flexibility to address changes needed during remediation. Section 2.5 describes these regulatory approaches and discusses applying them within the integrated regulatory framework.

This integrated regulatory process will support development of future documents, from the work planning phase through RCRA permitting commitments and removal of the 200 Area waste sites from the NPL. It is intended that this section be incorporated by reference in future documents, avoiding the necessity to provide detailed integration discussions in individual waste group specific documents.

2.1.2 Regulatory Overview

This section provides an overview of the RCRA and CERCLA programs and the two Hanford-specific regulatory agreements by which they are implemented, the Tri-Party Agreement and the Hanford Facility RCRA Permit. In general, RCRA was enacted to prevent and address releases at active facilities that generate, store, treat, transport, or dispose of hazardous wastes or hazardous constituents. CERCLA was enacted to investigate and respond to releases and potential past releases of hazardous substances. Cleanup under the RCRA and CERCLA programs is similar in several key respects:

- A primary objective of both programs is to ensure that environmental impacts associated with past and present activities are investigated and that appropriate response actions are taken to protect the public health, welfare, and the environment.
- Many similar criteria are used to evaluate cleanup of contaminated sites.
- Both programs rely on involvement from the public to determine the most appropriate actions for site cleanup.
- Cleanup processes are somewhat similar in both programs. The common steps are:
  - Characterization
  - Evaluation
  - Decision-making (including public involvement)
  - Implementation
  - Closeout.

The programs have differences as well, including:

- Radionuclides are not regulated under the RCRA program. CERCLA, on the other hand, does have authority over cleanup of radionuclides.
- The degree of public involvement may differ. Under RCRA, the responsible owner may independently evaluate cleanup alternatives and provide a recommendation to the public for consideration. CERCLA encourages public involvement throughout the evaluation process such that the public is more integrally involved in determining the recommended response action. However, with both programs, the regulatory agency generally cannot make a final decision without public input.
- No permits are required under CERCLA, but permits are required under RCRA.
- The State of Washington has been delegated authority to oversee a major portion of RCRA. There are currently no provisions in CERCLA to delegate authority to the state.

The Tri-Party Agreement, initially issued in May 1989, contains provisions governing RCRA and CERCLA cleanup activities at the Hanford Site and delineates the roles of the EPA, Ecology, and the DOE. The general purposes of the agreement are to:

- Ensure environmental impacts associated with activities at the Hanford Site are investigated and that appropriate response actions are taken to protect human health and the environment

- Provide a framework for permitting RCRA treatment, storage, and disposal (TSD) units and provide an orderly and effective investigation and cleanup at the Hanford Site
- Ensure compliance with RCRA and the *Washington Hazardous Waste Management Act of 1976*, as amended
- Establish a procedural framework for developing, prioritizing, implementing, and monitoring appropriate response actions in accordance with CERCLA and RCRA
- Facilitate coordinated participation of the parties in carrying out actions
- Minimize duplication of analysis and documentation.

A key feature of the Tri-Party Agreement is that it encourages integrating RCRA and CERCLA requirements to the greatest extent practicable.

The Hanford Facility RCRA Permit became effective in September 1994 and governs RCRA issues at Hanford. It is composed of two portions: a Dangerous Waste Portion, issued by Ecology, and a HSWA portion, issued by the EPA (see Table 2-1 for a summary of the Permit). (Subsequent to issuance of the Permit, the State of Washington was authorized to oversee portions of HSWA, but Ecology has not yet incorporated HSWA requirements into its portion of the Permit.)

Because it was not possible to permit all of the RCRA units at the Hanford Site simultaneously, the initial Permit was issued for only some units at the facility, with the expectation that additional units will be added over time until all RCRA units at Hanford are covered.

2.2 RESOURCE CONVERSATION AND RECOVERY ACT PROCESS DESCRIPTION

In 1976, Congress enacted RCRA to provide cradle-to-grave management of hazardous waste by generators, transporters, and owners of hazardous waste TSD facilities. The federal RCRA program has jurisdiction over waste with chemical constituents (hazardous waste) and mixed waste (mixtures of hazardous waste and radiological constituents), but does not have jurisdiction over waste containing only radiological contaminants. Only waste that has been generated or managed after the effective date of RCRA authority is designated as hazardous waste, and only waste units that managed hazardous waste are referred to as TSD units[1]. TSD units are subject to the closure and post-closure provisions of RCRA.

The HSWA amendments to RCRA were enacted in 1984. HSWA provides for corrective action at RCRA past practice (RPP) units[2] at the Hanford Site. Federal regulations implementing RCRA corrective action have been proposed but have not been finalized.

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[1] "TSD units" are units that store hazardous waste onsite for greater than a 90-day period or that treat hazardous waste, or that manage hazardous waste in land-based units such as surface impoundments, landfills, or waste piles after the effective date of RCRA.

[2] Under state and federal authorities, corrective action applies to all solid waste management units (SWMUs) within a facility that is subject to a RCRA permit, irrespective of the date that wastes were placed in the units. SWMUs are discernible locations where solid wastes have been placed at any time, irrespective of whether the location was intended for the management of solid or hazardous waste. SWMUs include any area where solid wastes, including spills, have been routinely and systematically released. Under the state corrective action regulations, the definition of SWMU encompasses TSDs and single spill sites. It can also include sites that are regulated under CERCLA authority. At the Hanford Site, SWMUs fall into three categories: TSDs (sites defined by the date of waste disposal), CERCLA past practice (CPP) (sites that are being addressed under CERCLA authority), and RPPs (SWMUs that are not being addressed as either TSDs or CPPs).

In 1986, pursuant to Section 3006 of RCRA, the EPA authorized the State of Washington to administer and enforce a state hazardous waste management program in Washington. The state dangerous waste[3] management program is similar to, but in some cases broader and more restrictive than, the federal RCRA program. For example, the state program defines a broader scope of constituents to be addressed during corrective action. In addition, in 1996 the state received authority to carry out key portions of HSWA. Ecology implements the dangerous waste management and corrective action programs via the *Washington Hazardous Waste Management Act of 1976*, the Dangerous Waste Regulations, Chapter 173-303 of the *Washington Administrative Code* (WAC), and facility-specific permits.

Any facility in the State of Washington where it is proposed to treat, store, or dispose of dangerous waste must be permitted under state regulations[4]. Ecology may issue a permit for a dangerous waste facility after review of the permit application documentation, which is submitted by the proposed owner/operator of the facility. The permit typically specifies closure requirements for TSD units and corrective action requirements for SWMUs at the facility. TSD units at Hanford are permitted either for operation, closure, or post-closure care. Existing facilities normally operate under interim status while they await a final permit. An application for interim status was submitted for each known active and inactive TSD at Hanford. The Dangerous Waste Portion of the Hanford Facility RCRA Permit initially incorporated five TSD units. The HSWA Portion contained no non-TSD SWMUs managed by the DOE. The Permit subsequently has been modified to incorporate additional TSD units, and will continue to be modified at least annually to incorporate the remaining Hanford TSD units. The schedule for this incorporation process is included in the Hanford Facility RCRA Permit. Until TSD units are incorporated, they remain in interim status. The 200 Area TSD units that are addressed in the 200 Areas Strategy are listed in Table 2-2 along with their status. All TSD units ultimately must be incorporated into the permit. None of these units are continuing to receive dangerous waste, and they will be permitted for closure and, as appropriate, post-closure care rather than operation.

2.2.1 TSD Closure

TSD closure is addressed by the state regulations, the Tri-Party Agreement, and the Hanford Facility RCRA Permit. State TSD closure requirements apply to all units used to store, treat, or dispose of hazardous waste after November 19, 1980; state-only dangerous waste[5] after March 12, 1982; and units at which such wastes will be stored, treated, or disposed in the future, except where otherwise excepted in the regulations. The Hanford TSD units are listed in Appendix B of the Tri-Party Agreement, which also provides criteria by which the units will be scheduled for permitting and closure. Figure 2-1 graphically summarizes the standard TSD unit closure including key documentation, approvals, and public involvement processes. Closure requirements are specified in WAC 173-303-610 and focus on closure performance standards and the preparation, content, and approval process of a closure plan. Closure plan requirements are described in Section 2.4.3. General TSD closure performance standards are specified in WAC 173-303-610(2)(a). They require that TSD units be closed in a manner that:

- Minimizes the need for further maintenance

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[3] The State of Washington uses the term "dangerous waste" to encompass both those wastes that would be designated as hazardous wastes under the federal RCRA program and other wastes that would not be designated under the federal RCRA program but that the state has determined require similar management.

[4] An exception is onsite CERCLA units, such as the ERDF, that do not require permitting and that may receive RCRA-regulated wastes if authorized by a CERCLA decision document.

[5] "State-only" dangerous waste refers to waste that would not be designated as hazardous waste under the federal RCRA program but that is designated as a dangerous waste under the more broadly applicable state program implementing RCRA.

- To the extent necessary to protect human health and the environment, controls, minimizes, or eliminates post-closure escape of dangerous waste, dangerous constituents; leachate; contaminated run-off; or dangerous waste decomposition products to the ground, surface water, groundwater, or the atmosphere

- 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.

WAC 173-303-610(2)(b) identifies specific closure performance standards, including the following:

- For clean closure, soils, groundwater, surface water, and air must attain the numeric cleanup levels calculated using residential exposure assumptions, according to *Model Toxics Control Act* (MTCA) Method B (WAC 173-340).

- Clean closure standards for structures, equipment, bases, and liners shall be established on a case-by-case basis by Ecology in accordance with WAC 173-303-610(2)(a).

Closure requirements for individual types of waste units (e.g., tanks, surface impoundments) contain provisions wherein the unit can be closed with waste in place in accordance with the closure and post-closure requirements for landfills found in WAC 173-303-665(6). The mechanism for selecting landfill closure depends on the type of waste unit.

Section 6.0 of the Tri-Party Agreement addresses TSD closure and includes the following requirements:

- When a TSD is included in an operable unit, the information necessary for performing RCRA may be provided in coordination with other operable unit cleanup documentation.

- TSD units containing mixed waste will normally be closed with consideration of all hazardous substances, including radioactive constituents. However, provision is made that the CERCLA process can be used to address any radioactive constituents not addressed during the TSD unit closure process. Standard practice for 200 Area TSD units closed under the 200 Areas Strategy will be to address all hazardous substances. However, there have been situations in the past in which a 200 Area TSD unit was closed without addressing all the hazardous substances (e.g., radioactive waste). Any CERCLA hazardous substances remaining at those units will be addressed as part of the past practice process as designated for that operable unit (e.g., waste sites 216-B-3A, -3B, and -3C were clean closed previously; remaining radiological waste will be addressed during cleanup of the 200-CW-1 waste group).

- Clean closure must include an evaluation to demonstrate that groundwater and soils have not been adversely impacted by the TSD unit as described in WAC 173-303-645.

- Procedural closure can be used for TSD units that were designated, but were never used, for the treatment, storage, or disposal of dangerous waste. Procedural closure requires a written notification to Ecology stating that the unit never handled dangerous wastes. Ecology will either approve or deny the procedural closure. If procedural closure is denied, permitting and/or another type of closure action would be initiated.

The Dangerous Waste Portion of the RCRA Permit also addresses TSD closure. It reiterates the performance standards of WAC 173-303-610(2) described above and specifies the following options for closure (Section II.K):

- A TSD unit closed to the cleanup levels specified in WAC 173-303-610(2)(b) for all media including waste, debris, soil, and groundwater is deemed a "clean closure."

- TSD units may be closed to background levels as defined in the Hanford Site Background Documents if background concentrations exceed the standards of WAC 173-303-610(2)(b). Closure to these background levels is also deemed a "clean closure."

- If dangerous waste constituents present at the TSD unit at the completion of closure are above MTCA Method B levels but below MTCA Method C levels (WAC 173-340) for all affected media, then a "modified closure" option may be used. A modified closure requires (1) institutional controls to restrict access to the TSD for a minimum of 5 years following completion of closure, (2) periodic assessments to determine the effectiveness of closure, including a compliance monitoring plan, and (3) a post-closure permit.

- When clean closure or modified closure are not chosen, the TSD unit will be closed as a land disposal unit (landfill closure) following the requirements in WAC 173-303-610. For closure as a land disposal unit, a post-closure permit will be required that addresses maintenance and inspection activities, groundwater monitoring requirements, and corrective actions.

Section II.K.7 of the Permit indicates that, where agreed to by Ecology, integration with other cleanup actions can be accommodated by the Permit, and that all, or appropriate parts of multipurpose cleanup documents can be incorporated into the Permit via the Permit modification process. Further, cleanup conducted under any statutory authority that is equivalent to the technical requirements of Permit Section II.K may be considered to satisfy the Permit requirements.

Most of the TSD units addressed in the 200 Areas Strategy are interim status units for which a closure plan and, as appropriate, post-closure plan will be required. The TSD unit-specific schedule for closure is required to be provided in the closure plan. In accordance with the RCRA Permit, activities to complete closure will be scheduled within 180 days of the permit modification adding the closure plan to the permit, unless otherwise agreed upon in the closure plan. A few TSD units addressed in this Implementation Plan are final status units that have been clean-closed for wastes managed at the units. Within 60 days of final closure of any TSD unit, RL must submit a certification of closure to Ecology. Typically, a post-closure plan is submitted at the same time the closure plan is submitted (for land-based TSD units).

2.2.2 RCRA Corrective Action

State corrective action requirements apply to all SWMUs, irrespective of the date waste was received. The state corrective action regulations found in WAC 173-303-646 do not specify detailed process or schedule requirements. General corrective action requirements found in WAC 173-303-646(2) specify that corrective action must protect human health and the environment for all releases of dangerous wastes and dangerous constituents, including releases from all solid waste management units at the facility. Numeric performance standards for corrective action are not specified; however, WAC 173-303-646(3)(c) states that Ecology will incorporate corrective action requirements pursuant to MTCA into permits for those facilities required to have permits. Typically, Ecology establishes corrective action cleanup levels using methods outlined in the MTCA regulation (WAC 173-340).

Section 7.0 of the Tri-Party Agreement (Ecology et al 1996) states that cleanup of past practice sites will be conducted according to either the CERCLA process or RCRA corrective action process. It further states that the two processes are functionally equivalent and, although either process may be used, information contained in any RCRA documents is required to be functionally equivalent to information that would be gathered under CERCLA. Section 7.4 details the RCRA corrective action process, based on proposed federal regulations and guidance. Figure 2-1 graphically summarizes key document preparation, approval, and public involvement processes involved in corrective action.

As stated above, the EPA portion of the Hanford Facility RCRA Permit defines a process for implementing RCRA corrective action at the Hanford Site. However, the EPA section also states that RCRA corrective action that is being performed in accordance with the Tri-Party Agreement is not subject to the process in the permit, and that decisions made via the Tri-Party Agreement process will be incorporated by reference into the permit. Since issuance of the permit, Ecology has been delegated authority for RCRA corrective action. Ecology has not yet defined and incorporated Hanford-specific HSWA requirements into the Permit.

Corrective measures in this Implementation Plan will address waste sites and associated contamination within the 200 Areas. It is probable that releases beyond the boundaries of the 200 Areas have occurred. The DOE is undertaking studies of the impacts of these releases and how they will need to be addressed in the final actions for the Hanford Site. Although corrective measures taken in the 200 Areas will reduce the potential for future offsite releases, this performance standard will be addressed in a more comprehensive manner during final remediation of the Hanford Site.

2.3 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT PROCESS DESCRIPTION

In 1980, CERCLA was enacted to address past releases or potential releases of hazardous substances[6], pollutants, and contaminants to the environment. Pursuant to CERCLA Section 120 and Executive Order 12580, EPA is the federal agency responsible for oversight of DOE's implementation of CERCLA. At the Hanford Site, wastes sites managed under CERCLA are referred to as CERCLA past practice (CPP) units. There is significant overlap between the state corrective action program and CERCLA, and many waste units are subject to remediation under both programs.

The CERCLA program is implemented via the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP), Title 40 Part 300 of the Code of Federal Regulations (CFR). The NCP establishes procedures for responding to releases, including notification and initial assessment of the nature of the release, specific processes for characterization, evaluation, and remediation, and special provisions for federal facilities. Section 7-3 of the Tri-Party Agreement addresses CERCLA implementation at Hanford and is generally consistent with the NCP process. Figure 2-1 graphically summarizes the CPP key document preparation, approval, and public involvement processes.

The CERCLA program does not establish specific cleanup levels; rather, it defines acceptable risk levels that form the basis for developing cleanup levels. However, CERCLA does require that all cleanup actions comply with the substantive requirements of federal and state laws and regulations. These substantive requirements are categorized and evaluated for the extent to which they are directly applicable to the CERCLA action or, if not applicable, relevant and appropriate for consideration in evaluating the action. The CERCLA ARARs typically establish the cleanup standards that ensure that the selected

[6] "Hazardous substances" means those substances defined by Section 101 (14) of CERCLA. It includes a wide variety of chemicals and radioactive constituents, but excludes petroleum products.

remedial action protects human health and the environment. For example, at Hanford a key ARAR in establishing cleanup levels for chemical contaminants is MTCA. Other potential sources of ARARs that provide cleanup standards would be RCRA, the *Safe Drinking Water Act*, and *the Clean Air Act*. Nonpromulgated standards, including DOE orders, proposed regulations, and regulatory guidance, are not ARARs but may be to-be-considered (TBC) materials. An example of a key TBC material used on Hanford cleanups is the EPA policy statement entitled *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination* (EPA 1997a). Only the substantive, rather than administrative, requirements, of ARARs apply, and CERCLA specifically exempts onsite[7] cleanup actions from obtaining federal, state, or local permits.

2.4 PROCESS FOR RCRA/CERCLA INTEGRATION

Because the 200 Areas are composed of CPP, RPP, and TSD sites, the Tri-Parties have committed that the cleanup strategies will be integrated to the maximum extent possible. This is consistent with specific recommendations for integration in the Tri-Party Agreement and can be accommodated under the Hanford Facility RCRA Permit. In developing an integrated approach, certain assumptions were made that provide the logic for the recommended process:

- Because of the similarities and the grouping logic, characterization of representative sites and/or TSD units within each of the 23 waste groups will be used to make cleanup decisions for the entire group. All TSD units will be characterized, and if a TSD unit is considered to be representative of the waste group, it will be used as a representative site for characterization of the waste group. TSD units that are already clean closed will only require additional characterization for radioactive constituents and any other hazardous substances or constituents not characterized during the clean closure activity.

- In general, the preferred waste disposal option is the Environmental Restoration Disposal Facility (ERDF), for Hanford Site-generated remediation waste that meets the ERDF waste acceptance criteria. A CERCLA decision document is required to allow disposal of waste at the ERDF.

- Within each waste group, it is desirable to streamline the document preparation and integrate the public review process.

Figure 2-2 graphically illustrates the integration process that will be used for the 200 Areas Strategy. The CERCLA process will be used as the basis for assessment and remediation activities in the 200 Areas, with modification as needed to concurrently satisfy requirements specific to RCRA permitting for RPP and TSD units. The Tri-Parties selected the CERCLA process for the overall format because it best accommodates an integrated approach. It should be noted, however, that implementing conditions for corrective action are still being developed and will be incorporated into the Hanford Facility RCRA Permit in the future. It is the intent of the Tri-Parties to implement the most efficient cleanup process. While CERCLA is the preferred process, other options do exist and can be implemented by Ecology to address RPP and TSD sites.

The following sections described the detailed requirements of the individual TSD closure, RCRA corrective action, and CERCLA programs as they are implemented at the Hanford Site, and the integrated process that will be used in the 200 Areas to address the requirements of all three. The sections are

[7] "Onsite" in this context means the area of contamination and areas in close proximity required to implement the cleanup action.

divided into five elements: characterization, evaluation of alternatives, decision-making, implementation, and closeout.

2.4.1 Characterization

TSD Closure. WAC 173-303-610 requires that closure plans include an estimate of the maximum waste inventory managed at a TSD, but there are no specific regulatory requirements for characterization of environmental contamination prior to closure of a TSD unit. However, Ecology guidance specifies that closure plans must include a sampling and analysis plan (SAP) to define the nature, degree, and extent of contamination "to the fullest extent possible." The SAP must include information necessary to ensure proper planning and implementation of sampling activities including (1) purpose and objectives; (2) organization and responsibilities; (3) project schedule; (4) information on types and volumes of samples needed; (5) information on sampling locations; (6) specific sampling approach and methods; (7) sampling and analysis procedures to confirm decontamination of tanks, concrete structures; and other media or equipment; and (8) procedures for analysis and reporting results.

By regulation, TSD closure must consider all dangerous constituents generated or managed at the unit. For some units, this may include all the constituents listed in Appendix IX of 40 CFR 264 and/or WAC 173-303-9905[8]. The Ecology guidance encourages the use of a DQO process to focus the characterization effort. Indicator constituents may be proposed, but the selection of indicator units first must be based on relatively broad-based sampling and analysis for the full range of constituents that might be present. Under the Tri-Party Agreement, TSD closure at the Hanford Site should also normally consider radioactive constituents.

The following standard methods are generally applicable to characterization for TSD closure:

- *Test Methods for Evaluating Solid Waste, Physical Chemical Methods* (EPA 1986)
- *Methods for Chemical Analysis of Water and Wastes* (EPA 1979)
- *Standard Methods for the Examination of Water and Wastewater* (APHA and AWA 1992)

RCRA Corrective Action. The characterization process for RCRA corrective action consists of three parts: the initial assessment, planning, and characterization/reporting. The initial assessment is called a RCRA facility assessment (RFA). At the Hanford Site, the lead regulatory agency may require an RFA of some or all of the RPP units within an operable unit. The requirement is based on whether there is sufficient knowledge about the unit to determine if a facility investigation is needed. If there is already sufficient knowledge indicating that a facility investigation will be required, the RFA process can be bypassed. If the RFA is required, the results of the assessment are documented in a written report.

Under corrective action, the work-planning phase results in a RCRA facility investigation (RFI)/corrective measures study (CMS) work plan. The RFI/CMS work plan generally addresses all sites within an RPP operable unit. As required by the Tri-Party Agreement, TSD units that are also contained within an operable unit should be investigated along with the past practice units, and RFI/CMS work plan should be functionally equivalent to the CERCLA RI/FS work plan. The RFI/CMS work plan assembles

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[8] The dangerous waste constituents identified in WAC 173-303-9905 were derived from 40 CFR 261, Appendix VIII, Dangerous Constituents. Appendix VIII was used by EPA to develop the Appendix IX list of constituents for the purposes of defining constituents that can be analyzed in groundwater. However, Appendix VIII constituents for which analysis is not feasible are not included in Appendix IX. Also, Appendix IX added a few constituents common at Superfund sites that were not included in Appendix VIII. Thus, from a practical standpoint, the Appendix IX will capture the WAC 173-303-9905 dangerous waste constituents to be analyzed during characterization activities. Dangerous waste constituents also include constituents that cause a waste to be regulated under state-only criteria (WAC 173-303-100) due to biological toxicity or persistence.

available site data that assist in developing a conceptual understanding of the site or operable unit, identifies additional data needs, and identifies potential corrective measure technologies. It also includes a SAP, health and safety and project management plans, and proposed work schedules. The RFI/CMS work plan requires approval from the lead regulatory agency; there is no regulatory or Tri-Party Agreement requirement for a public review.

Corrective action authority applies to all releases of dangerous waste and/or dangerous constituents from SWMUs (WAC 173-303-646[1]). Dangerous wastes are identified via WAC 173-303-070; dangerous constituents are those constituents defined in WAC 173-303-9905 or 40 CFR 264 Appendix IX, or which cause a waste to be listed or designated as a dangerous waste under WAC 173-303, or any hazardous substance under MTCA (RCW 70.105D.020[5])[9]. Although there is no regulatory requirement to sample and analyze for the full universe of dangerous constituents, all of these sources may be considered in identifying constituents that should be characterized. As required by the Tri-Party Agreement, RCRA corrective action at Hanford must also consider radioactive constituents. Sampling and testing methods are identified in WAC 173-303-110 and refer to several guidance documents that provide approved methods to be employed for specific sampling and analysis situations.

The field investigation is called an RFI. The general purpose of the RFI is to characterize the nature, extent, direction, rate, movement, and concentration of releases; determine the potential need for corrective measures; and aid in the selection and implementation of those measures. The results of the RFI are presented in an RFI report. Based on the results of the RFI, the lead regulatory agency may determine that no further investigation or corrective action is required for each past practice unit within the operable unit, or may determine that a corrective measures study is required. The RFI also includes descriptions of human and ecological receptors; analyses of current concentrations and extrapolations of future movement, degradation, and fate of contaminants; preliminary treatability studies; and assessment of risks. The RFI can be phased to accommodate smaller functional units (i.e., operable units, waste groups) at large facilities, such as is done at the Hanford Site.

CERCLA. The characterization process under the CERCLA program is very similar to that for RCRA corrective action. It begins with a preliminary assessment/site inspection that is used as the first screening step to determine whether a site should be placed on the CERCLA NPL. The preliminary assessment/site inspection has been completed at the Hanford Site. For the Hanford Site, the information needed to make that determination was provided to the EPA in 1987. Based on this information, the 100, 200, 300, and 1100 Areas were placed on the NPL as distinct facilities.

The scoping activity and work planning occur next and result in an RI/FS work plan. Existing data and information about the individual waste sites within each operable unit are assembled and evaluated. These data are used to support the logic for the RI/FS work plan. The RI/FS work plan involves the assembly and evaluation of available site data and identification of additional data needs, and includes a SAP, data management, quality assurance (QA)/quality control (QC), development of a conceptual understanding of the site or operable unit, and identification of likely RA technologies. The work plan should identify all CERCLA hazardous substances[10] present at the waste site. Specific characterization

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[9] MTCA defines a state list of hazardous substances that includes the federal definition of hazardous substances, dangerous waste, petroleum or petroleum products, and any other substance, including solid waste decomposition products, that is determined to be a threat to human health and the environment when released into the environment (for example, MTCA has determined that secondary drinking water contaminants under the federal Safe Drinking Water Act are contaminants of concern). State RCRA corrective actions encompass all of these MTCA hazardous substances.

[10] The CERCLA program applies to all hazardous substances as defined by CERCLA §101(14) and §101(33). The CERCLA hazardous substances list captures most of the Appendix IX list of 40 CFR 264 but includes many other federal program contaminants of concern as well,

requirements are identified during the DQO. The RI/FS work plan also establishes health and safety requirements, project management plans, community relations, and proposed work schedules. The RI/FS work plan must be reviewed and approved by the lead regulatory agency; there is no statutory or regulatory requirement for public review. As necessary, the schedule in the work plan is incorporated into Appendix D of the Tri-Party Agreement. As additional information becomes available during the RI/FS process, work plans may be revised.

Once the work plan is finalized, the RI is initiated. It may be presented in a single RI report or, as described in the Tri-Party Agreement, as a series of reports. The purpose of the RI is to define the nature and extent of the contamination and assess needs for treatability tests. The RI first focuses on field sampling and laboratory analysis including characterization of waste types, migration routes, volume, and concentration ranges. CERCLA allows for the characterization constituents to be determined by various methods such as process knowledge, waste disposal history, and previously collected data. CERCLA guidance documents provide methods for specific sampling and analysis situations. The RI includes researching cleanup alternatives and laboratory-, bench-, and field testing cleanup alternatives to evaluate performance and cost. The information obtained ultimately is used to assess risks, identify potential ARARs, establish potential remedial action objectives and cleanup levels, and evaluate remedial alternatives in the FS.

The schedule for the RI is specified in the work plan.

Integrated Process for Characterization. The characterization process for each waste group will consist of the following:

- Preparing this Implementation Plan and a waste group-specific RI/FS work plan, that together will satisfy the requirements for an RI/FS and RFI/CMS work plan
- Conducting the RI, that will also satisfy the requirements for an RFI
- Preparing a waste group-specific RI report, that will also satisfy the requirements for an RFI report.

This Implementation Plan provides general information and approaches applicable to all of the 200 Area waste groups that can satisfy elements of the work planning process or be incorporated by reference in the waste group-specific work plans. The Implementation Plan specifically includes elements that will not be repeated in waste group-specific work plans such as facility background information, potential ARARs, preliminary RAOs, and identification and preliminary screening of remedial technologies.

The waste group-specific work plans will address all waste sites in the group and may include any combination of the three site types (TSD, RPP, and CPP). The waste group-specific work plans will be developed on a schedule that has been agreed upon by the Tri-Parties and incorporated into the Tri-Party Agreement. An abbreviated outline of a waste group-specific work plan is provided in Appendix I. The work plans will document background information specific to the waste group and sites within the group and define group-specific characterization and assessment activities and schedule based on the framework established in this Implementation Plan. A DQO will be conducted in support of each work plan as described in Section 6.0 of this Implementation Plan. The DQO will be used to define the chemical and radiological constituents to be characterized and details regarding number, type, and location of samples at representative sites within the waste group and specific analytical requirements not otherwise provided

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such as those from the Federal Water Pollution Control Act, the Clean Air Act (which includes radionuclides), and the Toxic Substances Control Act. This list also includes all federally regulated hazardous wastes.

in the Quality Assurance Project Plan (QAPP) included in Appendix A of this Plan. In identifying chemical constituents to be considered, the universe of constituents will be defined as CERCLA hazardous substances (including radionuclides) and MTCA hazardous substances (including dangerous waste criteria constituents, petroleum/petroleum products, secondary drinking water contaminants). The integrated list of CERCLA and MTCA hazardous substances will be used as the starting point for determination of site-specific contaminants of concern. Available characterization data (e.g., waste stream analyses) and information regarding historical processes will be used to the extent that they are documented to identify the contaminants that might be present in the specific waste group. The DQO process will then be used to further refine this list and determine which of these constituents should be considered potential contaminants of concern (COPC) for the waste group. These COPCs will be sampled and analyzed for during site characterization activities (see Section 6.0).

A SAP will be prepared based on the DQO. The Ecology closure plan guidance will be consulted to ensure that the SAP addresses the elements required in a TSD SAP. The work plan will compile available data, summarize the DQO, provide the SAP, and establish the schedule for conducting future phases of work.

This Implementation Plan contains an initial screening of the universe of remedial technologies (Appendix D). That screening will be incorporated by reference and refined as needed in the waste group-specific work plans.

The waste group-specific RI/FS work plan will fulfill the requirements of an RFI/CMS work plan and an RI/FS work plan. For those waste groups where TSD units are present, it will also be used to fulfill several TSD closure plan requirements by providing the following:

- A pre-closure SAP
- Facility description and location information
- Process information
- Waste characteristics
- Groundwater monitoring (a summary and evaluation of data collected as part of the existing monitoring programs).

Before or during the work-planning process, all CPP and RPP sites will be evaluated to determine whether there are any sites that may be reclassified as "rejected," "closed out," "deleted from NPL," or "no action" sites. Tri-Party Agreement Handbook Guideline (DOE-RL 1990) TPA-MP-14 will be used for this purpose to reclassify sites. Reclassified sites will be kept in a separate list for tracking purposes. Candidates for reclassification may include instances where:

- Waste disposal facilities were constructed but not used
- Duplicate labeling exists for a waste site produced by an unplanned release
- Sites have been cleaned up
- Contamination has decayed to background levels
- Sites were misclassified as a waste site
- Voluntary action such as a housekeeping activity may be used to remediate the site.

After the work plan is approved, the RI will be initiated. Field efforts for characterization of CPP, RPP, and TSD units in a given waste group will be conducted concurrently to take advantage of mobilized field personnel. The results of the RI will be documented in a group-specific RI report for all TSD, RPP, and CPP units characterized during RI in the waste group. The RI report will be submitted to the lead regulatory agency for review and approval in accordance with the schedule specified in the work plan.

Although there is no specific requirement for public review of RFI/CMS or RI/FS work plans, it is the intention of the DOE and the regulatory agencies to provide both this Implementation Plan and the first several waste group-specific work plans for public review and comment. Any public comments received will be used to help identify improvements in the work planning process.

2.4.2 Evaluation of Alternatives

TSD Closure. A RCRA closure plan (WAC 173-303-610 and –806) is developed to address and ensure compliance with the closure requirements of the Dangerous Waste Regulations (WAC 173-303) and the Hanford Facility RCRA Permit. The closure plan is a detailed description of proposed procedures to close a dangerous waste unit or facility. The plan must describe methods for removing, transporting, treating, storing, or disposing of all dangerous waste, when such waste will be generated as part of closure. The closure plan consists of nine basic chapters that provide facility description and location information, process information, waste characteristics, groundwater monitoring, closure strategy and performance standards, planned closure activities, and the post-closure plan. It also includes a SAP that addresses pre-closure characterization and post-closure verification that the closure has met the required performance standards. Ecology's review of the closure plan evaluates information such as the following in determining whether to approve the plan:

- How and when the facility will be closed
- How closure requirements will be carried out
- An estimate of the maximum amount of dangerous wastes that can or have been treated or stored at the facility
- The steps proposed to decontaminate facility equipment
- The expected year closure will begin and a schedule for the completion of closure
- Estimates of costs for closure (for information purposes only).

A closure plan only needs to identify a single closure option that meets the performance standards and requirements; there is no requirement to discuss other closure alternatives. However, as described in Section 2.2.1, there are several closure strategies available at Hanford consisting of clean closure, modified closure/post-closure, and landfill closure/post-closure. One or all closure options may be applicable for closure of a TSD. Part of the closure plan development is an evaluation to determine the closure option that will be used. Section II.K.5 of the Hanford Facility RCRA Permit requires that the selected option consider potential future site use for the TSD site/area.

State regulations and section II.W of the Hanford Facility RCRA Permit require that any work performed under the Permit (including TSD closures) comply with any other applicable laws and regulations (e.g., air emission standards). This includes provisions to obtain permits. These other requirements and permits are typically identified in the closure plan.

Facilities that will leave wastes in the ground and/or contamination in groundwater after closure must be closed as a modified or landfill closure and must prepare a post-closure plan (WAC 173-303-610 and - 806). This plan details how the owner/operator will maintain the facility to ensure wastes remain where they were placed. Post-closure plans must be written to meet final status standards and are required for any regulated unit that received waste after July 26, 1982, or that certified closure after January 26, 1983. Post-closure requirements are applicable to land-based TSD units, tank systems that must be closed as land-based units, and any area that cannot be cleaned up to meet closure standards, if dangerous waste constituents will be left on site. Post-closure plans are subject to public review. The approved post-closure plan becomes a part of the permit via the permit modification process.

The closure plan is provided to Ecology for review and approval. It is then made available for public review and comment during the public comment period on the draft permit modification (see Section 2.4.3).

RCRA Corrective Action. Under RCRA corrective action, the evaluation of cleanup alternatives is performed in a CMS. Unlike a TSD closure, consideration of two or more alternatives is generally part of the CMS. A CMS includes identification and development of the corrective measure alternatives, an evaluation of the alternatives, and a justification for a recommended alternative. It also includes a cost estimate for each alternative considered. The CMS concludes by recommending an alternative. The CMS report becomes the basis for revision of the RCRA permit through the modification process in which the recommended corrective action is documented. The Tri-Party Agreement requires that the information obtained through the CMS must be functionally equivalent to the information obtained in the CERCLA FS process. The CMS report is made available for public review and comment as part of the draft permit modification package.

Activities conducted as part of RCRA corrective action must comply with any other applicable laws and regulations (e.g., air emission standards).

CERCLA. Under CERCLA, cleanup alternatives are evaluated and reported in an FS. The FS typically summarizes information on the nature and extent of contamination and the risk assessment from the RI report, identifies and screens potential cleanup technologies, and provides a detailed evaluation and comparison of potential cleanup alternatives. The FS may be conducted in a single step or, as described in the Tri-Party Agreement, in multiple phases. If the cleanup action is focused on a limited area, a limited set of constituents, or a limited set of cleanup technologies, a focused FS may be prepared.

The first step in the FS involves identifying all possible remedial technologies that are applicable to the type of contaminants and conditions found at the waste site. This step can be performed before the RI has been completed. The technologies are then screened to reduce the number of cleanup/treatment alternatives that will be evaluated in detail. This process is accomplished by considering the technologies based on effectiveness, implementability, and cost. Finally, the most promising technologies are assembled into alternatives, analyzed against nine CERCLA evaluation criteria, then compared to one another. The nine criteria are (1) overall protection of human health and the environment; (2) compliance with the ARARs; (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility, or volume through treatment; (5) short-term effectiveness; (6) implementability; (7) cost; (8) state acceptance; and (9) community acceptance. These criteria are divided into three categories: threshold, balancing, and modifying criteria. The first two criteria (threshold criteria) determine which alternatives are eligible for consideration. The next five criteria (balancing criteria) help describe relative technical and cost differences. The last two criteria (modifying criteria) may prompt remediation plan changes based on the state's and community's comments and concerns. DOE Order 451.1 requires DOE CERCLA documents to incorporate NEPA values, such as analysis of cumulative, off-site, ecological, and socioeconomic impacts, to the extent practicable in lieu of preparing separate NEPA documentation for CERCLA activities. At the Hanford Site, this is accomplished by evaluating the alternatives against NEPA values as a tenth criterion, in addition to the nine CERCLA criteria.

In contrast to the CMS, no specific recommendation is made in the FS regarding a preference for any of the alternatives. The FS is then submitted to the lead regulatory agency for review and approval. Once the regulatory agency has accepted the report, it is made available to the public during the comment period on the proposed plan.

As discussed in Section 2.3, CERCLA activities are required to comply with both applicable *and* relevant and appropriate requirements contained in other laws and regulations. However, onsite CERCLA activities are only required to comply with the substantive portions of those requirements and not administrative requirements, such as requirements related to obtaining permits.

Integrated Process for Evaluation of Alternatives. After characterization is complete, remedial alternatives/closure strategies will be developed and will be evaluated against performance standards and evaluation criteria. This evaluation will be used to satisfy the TSD requirement for determining what type of closure is practicable and can be achieved.[11] The results from this process will be a waste group-specific FS/closure plan. The format will follow the standard format of a CERCLA FS with the following modifications:

- If the waste group includes a TSD unit(s), a closure plan addressing the TSD units will be added to the FS as an appendix. The closure plan will do the following:
  - Incorporate by reference the waste group-specific work plan for Facility Description and Location, Process Information, Waste Characteristics, Groundwater Monitoring, and the pre-closure SAP
  - Incorporate by reference the waste group-specific work plan and the RI report for information on the nature and extent of contamination
  - Incorporate by reference the body of the FS for Closure Performance Standards
  - Include the Closure Strategy and general Closure Activities. Some of the detail regarding closure activities normally found in a closure plan will be deferred to the remedial design.
  - Include a general post-closure plan (if modified or landfill closure options will be used), with an acknowledgement that this will be updated as necessary (using appropriate public involvement) after the completion of closure. For example, the detailed requirements for post-closure groundwater monitoring may be determined after the final condition of the TSD is determined.
  - Include a commitment to prepare a post-closure verification SAP as part of remedial design.

[11] As described in Section 1.0, groundwater remediation is not within the scope of this Implementation Plan; groundwater is being addressed as separately because of the difficulty in distinguishing the specific waste units that contributed to groundwater contamination and the efficiency gained in addressing the groundwater as a whole, rather than addressing individual plumes of contamination that overlap. If a TSD contributed to groundwater contamination and that contamination has not yet been addressed as part of the overall groundwater remediation, the TSD cannot be clean closed, even if wastes and soils have been remediated. In that case, the TSD will be closed under modified closure/post-closure requirements until groundwater remediation is complete.

- To satisfy RCRA corrective action requirements, a chapter will be added that presents a recommendation for corrective action alternatives for regulatory agency consideration. Similarly, the closure plan only identifies the closure strategy that the responsible agency deemed appropriate after conducting its evaluation; there is no requirement to discuss the other closure alternatives. Therefore, to integrate this phase, the document will be developed to meet the RCRA CMS specifications and the applicable closure plans will be included.

However, should it be determined to be more effective (e.g., because of an imminent threat associated with the TSD, milestone commitments), the TSD unit closure plan may be submitted separately from the FS.

Other key features of the FS/closure plan will include the following:

- ARARs will be identified in the FS/closure plan, and ability to comply with the substantive ARARs will be an evaluation criterion for all TSD, RPP, and CPP sites. A key ARAR for developing nonradioactive constituent cleanup levels at all CPP, RPP, and TSD units will be MTCA (WAC 173-340), which is the state's performance standard for both TSD closure and RCRA corrective action and which is an ARAR at Hanford for cleanup under the CERCLA program. A key TBC material for developing radioactive constituent cleanup levels will be EPA guidance supporting a cleanup level of 15 mrem/yr.

- The CERCLA permitting exemption for onsite activities will be extended to CPP, RPP, and TSD units (e.g., air permits will not be required) except that RPP and TSD units will be incorporated into the Hanford Facility RCRA Permit.

- Remedial action objectives will consider future land use and will address protection from direct exposure to contaminants, protection of groundwater from migrating contaminants, and protection of the Columbia River.

- NEPA values such as cumulative, off-site, ecological, socioeconomic impacts, and environmental justice will be evaluated for each remedial alternative.

2.4.3 Decision-Making

TSD Closure. Under the strategy developed for the Hanford Facility RCRA Permit, TSD units that are not already in the Permit and that will not actively operate in the future are added as units undergoing closure via the permit modification process. This consists of preparing a draft permit modification, seeking public comment, and making a final permit modification pursuant to WAC 173-303-830 and -840.

At Hanford, a permit modification adding a closure plan is typically initiated by Ecology. The draft permit modification identifies permit conditions applicable to the closure and is based on the closure plan. The draft permit modification, together with the closure plan, are provide for public comment and review. The TSD closure schedule typically must be submitted as part of the permit modification package. Information regarding the permit modification request is sent to the Hanford mailing list and appropriate units of state and local government, and must be published in a major local newspaper. In addition, the notices and request must be placed in a location accessible to the public, and a public hearing must be held within the public comment period. Public notice of the hearing must be provided at least 30 days prior to the hearing. The comment period is 45 days.

Following the public comment period, the decision regarding the TSD closure is conveyed by Ecology in an approved permit modification. Ecology considers and responds to all significant written comments from the public on the modification request, and either grants or denies approval of the modification. Approved modification requests are incorporated into the Hanford Facility RCRA Permit and become effective 30 days after the decision is made.

RCRA Corrective Action. As with a TSD closure, under RCRA corrective action the decision-making process consists of preparing a draft RCRA permit modification seeking public comment, and making a final RCRA permit modification. The recommended corrective measure(s) is presented as a draft modification to the Hanford Facility RCRA Permit and is based on the results of the CMS. The permit modification identifies specific corrective action activities and a schedule for implementation. The public comment period and hearing process and Ecology approval process are the same as for a permit modification to add a TSD unit undergoing closure. The CMS is made available to the public during the comment period, providing support to the permit modification request.

CERCLA. Under CERCLA, the decision-making process consists of a proposed plan and a ROD. Based on the evaluation of alternatives in the FS and in accordance with the Tri-Party Agreement, the DOE and the lead regulatory agency, in consultation with the supporting regulatory agency, select a proposed alternative and present it for public review and comment in a document called a proposed plan. The proposed plan provides a brief summary of all of the alternatives studied in the FS, highlighting how the alternatives satisfy the CERCLA criteria and the key factors that led to the identification of the proposed alternative. Under CERCLA, the required comment period is 30 days. Because the CERCLA process is also used at Hanford to satisfy NEPA requirements, the required comment period for proposed plans at Hanford is 45 days. The FS is made available to the public during the review, providing support to the information in the proposed plan. The DOE and the lead regulatory agency may modify the proposed alternative after reviewing public comments and/or concerns.

After the public comment period on the proposed plan has closed, the ROD is prepared by the lead regulatory agency. The ROD describes the decision-making process for selecting the cleanup action, summarizes the alternatives developed and evaluated in accordance with CERCLA and the NCP, and identifies the selected cleanup action(s). It also provides any statutory determinations such as identification of ARARs for the cleanup. The lead regulatory agency is responsible for reviewing the public comments received and preparing responses that will accompany the ROD. Although all of the CERCLA processes up through drafting the ROD are the responsibility of the lead regulatory agency, which may be Ecology on Ecology-lead operable units, the ROD must be signed by the EPA. The lead regulatory agency will continue its role after issuance of the ROD.

The ROD may be modified after it is issued. The process for modification depends on the magnitude of the change. Changes that result in no significant difference in the cleanup (e.g., correcting typographical errors) can be documented in the administrative record. A change that results in a significant impact on the cleanup requires preparation of an Explanation of Significant Differences (ESD). An ESD may be appropriate, for example, when new information is generated during the remedial design or remedial action phases that could affect the scope, performance, or cost of the remedy presented in the ROD. The public must be notified of an ESD and be provided an opportunity to review it. The ESD, however, represents only a notice of change and is not a formal opportunity for public comment because the overall remedy is not being reconsidered. When new information becomes available after a ROD is signed and results in fundamental changes to the selected remedy, an amendment to the ROD is required. Fundamental changes include selection of a new remedy that is fundamentally different than the remedy selected in the ROD. A ROD amendment must be preceded by a proposed plan that is submitted to the public for review and comment.

Integration Process for Decision-Making. The decision-making process for the 200 Area waste sites will be based on the use of waste group-specific proposed plans and RODs. Once the FS/closure plan has been finalized, a single document, the group-specific proposed plan, will be prepared that will:

- Identify the preferred alternative(s) for remediation of waste sites in that group based on the FS, and how that alternative satisfies the CERCLA criteria

- Identify criteria by which sites not in the original waste group can plug in to the remedy for that waste group (see Section 2.5.3 for further discussion of the "plug-in" approach)

- Identify, as part of the preferred alternative, criteria by which analogous sites within the waste group will be evaluated post-ROD to verify that they meet the conceptual model for the waste group, and identify a process where sites can be moved to another waste group (see Section 2.5.2 for further discussion of contingent remedies)

- Identify performance standards and ARARs applicable to the waste group

- When the operable unit includes TSD or RPP units, include a draft permit modification with unit-specific permit conditions for incorporation of those units into the RCRA permit.

After approval by the regulatory agencies, the proposed plan will be presented to the public for review and comment. The public comment period will be 45 days. A combined public meeting/public hearing will be held during the comment period to provide information on the proposed action and permit modification and to solicit public comment. The combined meeting will avoid the confusion of two meetings and allow the public to obtain a complete picture of cleanup activities in the waste group.

After the public comment period ends, the lead regulatory agency will respond to the comments and, in consultation with the supporting agency and the DOE, make a final decision on the proposed action. The CERCLA ROD will be used to document not only the selected remedy for the CPP sites, but also the TSD unit closure strategy and the RPP corrective action decisions. The ROD will also identify the criteria for evaluating waste sites against the waste group conceptual model, the contingency process for moving waste sites to other waste groups, and criteria by which a waste site not originally in the waste group can plug-in to the selected remedy for the group. In addition, the ROD will identify ARARs for the action (and ARAR waivers for any sites in the group) and statutory determinations (such as the availability of ERDF for all wastes generated). The RCRA permit will subsequently be modified by Ecology to incorporate the ROD (and any subsequent amendments) by reference, authorizing the RCRA actions. Specific elements incorporated by reference will include performance standards, cleanup schedules, and the selected cleanup action.

2.4.4 Implementation

TSD Closure. TSD closure proceeds in accordance with the activities identified in the closure plan and the permit conditions. No additional documentation is required during implementation of the closure activity, except that permits (e.g., air emissions permits) must be obtained as appropriate. The DOE must notify Ecology at least 60 days before beginning closure activities at a surface impoundment, waste pile, land treatment, or landfill TSD unit, and at least 45 days before beginning closure at other TSD units. Under the Hanford Facility RCRA Permit, upon initiation of closure activities, closure must be completed within 180 days unless an approved alternate schedule was included in the closure plan.

Waste generated during closure is subject to all applicable laws and regulations relative to waste management. For example, dangerous waste must be disposed at an RCRA-permitted facility (e.g., a permitted TSD unit) and solid waste must be disposed at a solid waste landfill. An exception is that, at Hanford, the Tri-Parties have determined that TSD closure waste is eligible for disposal at the ERDF under certain conditions. To be disposed at ERDF, the waste must meet ERDF waste acceptance criteria and a CERCLA decision documents (e.g., CERCLA ROD or Action Memorandum) must be in place such that waste disposal is conducted under CERCLA authority (EPA et al. 1996)[12].

RCRA Corrective Action. RCRA corrective action is implemented in accordance with the requirements and schedule specified in the permit modification. In accordance with the Tri-Party Agreement, implementation of corrective action at RPP units is guided by a corrective measures implementation (CMI) work plan and a corrective measures design report. The Tri-Party Agreement specifies that at Hanford the content of the CMI work plan will be functionally equivalent to the CERCLA remedial action (RA) work plan (described below).

Management of corrective action wastes is similar to TSD closure wastes except that under state regulations, RCRA corrective action waste that is designated as dangerous waste can be managed at a corrective action management unit (CAMU). A CAMU is an area within a facility that is designated by Ecology for the management of RCRA corrective action waste (WAC 173-303-646[5] and [6]). No CAMUs have been designated at the Hanford Site.

CERCLA. Under CERCLA, cleanup is implemented via a remedial design (RD) report (RDR) and a RA work plan (RAWP). The RD is an engineering phase during which technical drawings, specifications, construction budget estimates, and preparation of all necessary and supporting documents are developed for the chosen cleanup action. These items are based on the selected remedy, performance standards, ARARs, and other requirements specified in the ROD and are documented in the RDR. The RDR is provided to the lead regulatory agency for review and approval. A SAP is prepared along with the RDR for use after remedial action is complete.

The RA includes the actual construction or implementation of the cleanup action. The RA includes construction of any support facilities as specified in the RD. A RAWP is developed for each operable unit detailing the plans for the RA. The RAWP is provided to the regulatory agency for review and approval. At Hanford, the RDR and RAWP often are combined into a single report. Included in either the RD or RA are the SAPs describing the requirements for sampling and analysis for samples taken for the purpose of determining whether the cleanup action levels specified in the ROD have been achieved. Substantial continuous onsite remedial action at an NPL-listed federal facility must begin within 15 months after the first ROD for that facility is signed. The 200 Areas is one of four such facilities at the Hanford Site listed on the NPL. The progress of remedial action is typically defined in a schedule included in the RDR.

Contaminated waste generated during CERCLA cleanup actions must be disposed at an EPA-approved onsite and/or offsite facility. Onsite facilities must comply with the action-specific ARARs (e.g., RCRA standards) for waste management including those that establish controls and/or restrictions for waste disposal. At the Hanford Site, the ERDF is the approved CERCLA waste disposal facility. The

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[12] *The U.S. Department of Energy Environmental Restoration Disposal Facility, Hanford Site, Benton County, Washington-Explanation of Significant Differences* (ESD) (EPA et al. 1996) modified the ERDF ROD (EPA et al. 1995) to clarify the eligibility of waste generated during cleanup of the Hanford Site. The ESD makes eligible for disposal at ERDF any environmental cleanup waste generated as a result of CERCLA or RCRA cleanup actions provided it meets ERDF waste acceptance criteria and that the appropriate CERCLA decision documents are in place. Additionally, the ESD allows the disposal at ERDF of nonprocess wastes generated from closure of inactive RCRA TSD units provided that (1) closure wastes are sufficiently similar to CERCLA or RPP wastes placed in ERDF, (2) the ERDF waste acceptance criteria are satisfied, and (3) the appropriate CERCLA decision documents are in place.

construction and operation of ERDF was authorized via a separate ROD as issued January 1995 and amended December 1997 (EPA et al. 1995, EPA et al. 1996).

Integrated Process for Implementation. Implementation will consist of confirmatory sampling and preparation and implementation of an RDR/RAWP. A SAP will be prepared that will define the characterization requirements for confirming whether sites within a waste group that were not characterized as representative sites meet the conceptual model for the waste group. Sampling, analysis, and evaluation will be performed before the RDR/RAWP is completed. If confirmatory sampling does not support a site in a given waste group, the contingency element of the ROD will be implemented and the site will be moved to another waste group.

An RDR/RAWP will be prepared for each waste group that encompasses implementation of the selected remedy for CPP, RPP, and TSD units. The RDR/RAWP will be formatted as described under the CERCLA program. It may be phased to accommodate the award of construction packages for the remedial action. If phased, the general requirements for the RD/RA would be documented in the initial issue of the RDR/RAWP. Design details for individual waste sites would be added in progressive revisions until all waste sites were addressed. The RDR/RAWP will be submitted to the lead regulatory agency for review and approval.

The RDR/RAWP will be accompanied by a SAP for each waste group for verification sampling and analysis. This SAP will define the requirements for verifying that remedial action at a site has met the requirements of the ROD. It will also satisfy the TSD closure plan requirement for a verification SAP. A DQO process will be used to determine sampling and analytical needs.

The RDR/RAWP will include a schedule for remediation activities for the waste group, including the schedule for TSD closure. Integration of the remedial action/closure schedules for CPP, RPP, and TSD will provide for efficiencies and cost-savings in mobilizing equipment and conducting field activities. Per CERCLA requirements, continuous onsite remedial action must begin within 15 months of the issuance of the first ROD for the 200 Area CERCLA facility. DOE will provide notice to Ecology 60 days before beginning closure of any TSD units in a waste group.

Contaminated materials generated during the remedial action will be disposed at the ERDF provided the elements of the ERDF waste acceptance criteria are satisfied.

2.4.5 Closeout

TSD Closure. Within 60 days of completion of closure of a TSD unit, the owner or operator must submit a certification of closure to Ecology (WAC 173-303-610(6), RCRA Permit II.J.1). The certification must be signed by the owner and an independent registered professional engineer. Documentation that the closure has been in accordance with the approved closure plan must accompany the certification. The documentation is usually in the form of a closure activities evaluation report or a verification package, which evaluates the closure activities and compares them to the regulatory and closure plan requirements. Additional notifications that must be made after certification of closure are the submission of survey plats and notices in deed to the zoning authority.

If the closure is a clean-closure, Ecology then initiates a permit modification to acknowledge that the unit has been clean-closed and initiates withdrawal of the unit from the EPA national database for TSD units. These requirements are detailed in WAC 173-303-610.

If dangerous constituents will remain onsite above clean closure standards, a post-closure plan will have been prepared as part of the closure plan and will be implemented at this time. When the need for post-closure care ends, a certification of completion of post-closure care is submitted to Ecology using the same process as described for certification of closure. As with clean-closure, Ecology will then initiate a permit modification and withdrawal of the unit from the national database.

RCRA Corrective Action. State regulations do not define a closeout process for corrective action units. The Tri-Party Agreement states that upon satisfactory completion of the CMI phase, the lead regulatory agency will issue a certificate of completion of the corrective action.

CERCLA. Remedial action is considered complete when the lead regulatory agency determines that the following have been met:

- Remedy is fully operational and performing to design specifications
- Remaining activities only involve operation and maintenance (O&M).

At this time, the DOE completes a Superfund Site Closeout Report. A facility is eligible for NPL deletion when the EPA has determined that all required response actions (with the exception of O&M) have been implemented. (Partial deletion is possible where only that portion of a CERCLA facility that has been remediated is deleted.) The site shall not be deleted from the NPL until the state in which the site is located has concurred on the proposed deletion. The EPA shall provide the state 30 working days for review of the deletion notice prior to its publication in the *Federal Register*. Once the state agrees with the deletion notice, the EPA publishes a notice of intent to delete in the *Federal Register* and seeks public comment for a minimum of 30 calendar days. Copies of the proposed deletion notice are placed in the local repositories available for public viewing. After the public comment period, the EPA shall respond to significant comments and include this response document in the final deletion package. Once the notice of final deletion has been published in the *Federal Register*, the site(s) are deleted from the NPL and the package is placed in the local information repositories.

An O&M plan is initiated at each operable unit when remedial action implementation has been completed and it is determined that the remedy is to be fully operational. The O&M plan includes inspections and monitoring. The O&M plan is provided to the lead regulatory agency for review and approval. When waste is left in place as part of the RA, O&M is expected to be a long-term activity. In cases where all waste is removed or treated, a short O&M period still may be specified by the lead regulatory agency. The lead regulatory agency may, where appropriate, allow for O&M to be discontinued for certain units, within an operable unit, while requiring O&M to continue at other units.

When waste is left in place at the completion of remedial action, the operable unit will be evaluated by the lead regulatory agency at least every 5 years (CERCLA Part 121[c]) to determine whether the remedy continues to be protective or further RA is required. In accordance with the Tri-Party Agreement, the lead regulatory agency will issue a Certificate of Completion to the DOE when the remedial action work is completed.

Integrated Process for Closeout. The closeout process to be followed for each waste site will consist of preparing a closure certification (for TSD units), a site- or group-specific site closeout report and, as appropriate, O&M plan; deletion from the NPL; and removal from the permit.

The site closeout report will summarize the cleanup activities conducted at any CPP, RPP, or TSD units in the waste group, present the results of verification sampling, and compare those results to the remediation goals specified in the ROD. If contaminants are left in place above the remediation goals, the report will specify the nature and extent of that contamination. The site closeout report will be submitted to the lead regulatory agency for review and approval. When the lead agency has determined that there has been satisfactory completion of remedial action activities, the agency will issue a certificate of completion. At that time, Ecology will initiate a permit modification for RPP units to acknowledge that corrective action activities have been completed.

Within 60 days of completing closure activities at any TSD unit within the waste group, DOE will submit a certification of closure for the TSD signed by an independent registered professional engineer. The site closeout report may be used as supporting documentation. Ecology then will initiate a permit modification whereby the permit will be changed either to acknowledge clean closure of the unit or to implement the post-closure plan, whichever is applicable.

If contaminants are left onsite above protective levels, an O&M plan will be prepared. The O&M plan will detail post-remediation operation, inspection, and/or monitoring necessary, including groundwater monitoring, for affected CPP, RPP, and TSD units. If the waste group contains a TSD unit that was not clean closed, the RCRA TSD unit post-closure plan will be reviewed to ensure consistency with closure results and the O&M plan. (The TSD unit post-closure plan is prepared and submitted at the same time as the closure plan.) Changes to the post-closure plan will be documented via a RCRA permit modification. If the post-closure plan requires significant modification, it will be submitted for public review. The group-specific O&M plan will not be submitted for public review. If O&M is required for RPP units, a RCRA permit modification also will be done for those units to incorporate by reference the O&M plan.

Upon completion of the remedial action (not including O&M), the waste site/group can be deleted from the NPL. The EPA will prepare a deletion notice and provide it to the state 30 working days prior to its publication in the *Federal Register*. Once the state agrees with the deletion notice, EPA will publish a notice of intent to delete in the *Federal Register* and seek public comment for a minimum of 30 calendar days. Copies of the proposed deletion notice will be placed in the Hanford regional repositories available for public viewing. After the public comment period, the EPA shall respond to significant comments and include this response document in the final deletion package. Once the notice of final deletion has been published in the *Federal Register*, the site(s) will be deleted from the NPL and the package will be placed in the local information repositories.

Although CERCLA allows facilities or portions of facilities to be deleted from the NPL while contaminants remain onsite undergoing O&M, RCRA does not have a similar provision. TSD and corrective action units will remain under the RCRA permit as long as post-closure or O&M continues. Therefore, if contaminants remain onsite above cleanup levels, sites might be deleted from the NPL but remain in the Hanford Facility RCRA Permit. A certification will be prepared by DOE for review by the regulatory agency upon completion of all activities required in the post-closure plan (for TSD units) or O&M plan (for RPP units). Upon acceptance by Ecology of the certification, Ecology will prepare a permit modification to delete the unit(s) from the permit.

2.4.6 Short-Term Action

TSD Closure. There are no specific provisions for interim action as part of TSD closure. State regulations and the Tri-Party Agreement defer to the corrective action program in the event that a release from a TSD is detected.

RCRA Corrective Action. A short-term response called an interim measure may be implemented under RCRA to provide immediate response for sites that pose an immediate threat to public health or the environment. This process is defined in the Section 7.2.4 of the Tri-Party Agreement. Interim measures are used when information indicates that an expedited response is needed because of an actual or threatened release from a past practice unit. The lead regulatory agency may require RL to submit a proposal for an expedited response at a unit, or the RL may voluntarily submit a proposal. The interim measure process will be used in cases where early remediation will prevent the potential for an imminent and substantial endangerment or imminent hazard to develop. It may also be used in cases where a single unit within an operable unit is a high priority for action, but the overall priority for the operable unit is low. In this way, a specific unit or release at an operable unit can be addressed on an expedited schedule when warranted. To the extent practicable, interim measures shall be consistent with the anticipated alternatives for final selection of corrective measures at the unit.

All interim measures are first approved by the lead regulatory agency. Public participation and documentation for interim measures are in accordance with Sections 9.0 and 10.0 of the Tri-Party Agreement or the RCRA permit modification process.

CERCLA. The process used under CERCLA to address sites that present an imminent and substantial danger to the public health or the environment is the removal action process (40 CFR 300.415). Removal actions can occur at a site not listed on the NPL, or they can occur as part of the initial response to seriously contaminated NPL sites that will become the subject of a more formal and extensive remedial action. The EPA has categorized removal actions in three ways: emergency, time-critical, and non-time-critical. These categories are based on the type of situation, the urgency and threat of release, and the subsequent time frame in which the action must be initiated. Emergency and time-critical removal actions respond to the releases requiring action within 6 months; non-time-critical actions respond to releases requiring action that can start later than 6 months after it has been determined that a response is warranted.

In carrying out emergency and time-critical removal actions, the federal agency implementing CERCLA removal action authority allows work to begin as soon as possible to abate, prevent, minimize, stabilize, mitigate, or eliminate the threat to the public health or the environment. Because these are considered emergency actions, public involvement is not required prior to performing the action. However, during or after the removal action the public must be informed of the action being taken. If the removal action is determined to be non-time-critical, an engineering evaluation/cost analysis (EE/CA) is performed. The goals of the EE/CA are to identify the objectives of the removal action and to analyze the various alternatives that may be used to satisfy objectives for cost, effectiveness, and implementabilty. While an EE/CA is similar to the RI/FS conducted for RAs, it is less comprehensive. Like the RA process, the EE/CA is provided to the public for review and comment. After the comment period, the implementing agency prepares the decision document called an Action Memorandum. The Action Memorandum documents the selected removal action and provides the approval to begin the work activities.

Integrated Process for Interim Action. In the event that it is discovered during the field investigation or remedy implementation that a site or contamination source presents a threat to the public health or the environment, a CERCLA removal action will be initiated. Action will be taken as soon as possible to abate, prevent, minimize, stabilize, mitigate, or eliminate the threat to the public or the environment. Depending on the criticality of the situation, during or after the removal action, an EE/CA will be performed and an action memorandum pursued.

2.5 STREAMLINING APPROACHES

This section presents various strategies that are available for streamlining the regulatory pathway and documentation requirements when addressing Hanford waste sites in accordance with CERCLA and RCRA. Implementation of these strategies on previous cleanup projects at the Hanford Site indicates that their use results in efficient use of resources, both human and financial, allows for earlier selection of a remedial alternative, and allows actual waste site cleanup to be performed in an expedited manner. Opportunities for streamlining exist during both characterization and assessment, in the selection of the type of decision document, and during remedial design and remedial action. The following discussion summarizes the streamlining strategies and impacts during each of these phases.

2.5.1 Analogous Site Concept

Facilities can sometimes have many source sites that are geologically similar and have similar process and waste disposal histories. In these situations, the analogous site concept can be used to reduce the amount of site characterization and evaluation required to support remedial action decision making. For the analogous site approach, waste sites are combined into groups of sites with similar location, geology, waste site history, contaminants, etc. Within each group, one or more representative sites are then selected for comprehensive field investigations, including sampling. Findings from site investigations at representative sites are extended to apply to other sites in the waste group that were not characterized. Sites for which field data have not been collected are assumed to have similar or "analogous" chemical characteristics to the site(s) that were characterized. Confirmatory investigations of limited scope can be performed at the sites not selected as representative sites, rather than full characterization efforts.

The evaluation of remedial alternatives focuses on the representative sites but is acknowledged to extend to other sites in the group. A remedy is selected for all of the sites in the group, based on the evaluation of the representative sites. Confirmation sampling of the analogous sites after remedy selection may be required and is built into the remedial design planning to demonstrate that analogous conditions exist. Depending on the level of confidence in the analogous site classification, a contingent ROD may be beneficial to address those instances where it is determined during confirmation sampling that a site is not analogous (see Section 2.5.2). Although the analogous site concept introduces a degree of uncertainty, there is a substantial benefit in the early selection of a remedy that allows early cleanup action to take place.

The 200 Areas Strategy and this Implementation Plan build on the analogous site concept. As part of the initial strategy, the waste sites in the 200 Areas were organized into waste groups based on similar processes, waste disposal histories, and type of site. Representative sites have been identified within each group (DOE-RL 1997). The waste groups are discussed further in Section 3.0. Section 6.0 reflects a characterization effort that focuses on the representative sites, and the RI and FS reports will be written based on information regarding these representative sites. A proposed plan and ROD will be written for the entire waste group, identifying the proposed remedy for sites in that group. The ROD will include criteria for post-ROD confirmation sampling and analysis to be used to verify that all remaining sites in the group (sites other than the representative sites) meet the conceptual model for the waste group. If a waste site fails to meet the conceptual model such that the selected remedy is not appropriate, it will be removed from the group and reassigned to another waste group. If a contingent ROD is prepared that clearly defines criteria for removing a waste site from the original waste group, no modification of the ROD will be required.

2.5.2 Contingent Remedy

In general, the CERCLA proposed plan identifies a preferred alternative and the lead regulatory agency selects a single remedy in the ROD. There are some situations, however, where greater flexibility may be required to ensure implementation of the most appropriate remedy for the site. This is the case where there is significant uncertainty associated with the remedy selection. In such situations, a contingent remedy may accompany the selected remedy in a decision document. The contingent remedy would be available if the selected remedy was determined to be inappropriate for a waste site.

In the proposed plan, the alternative proposed for selection and the contingent alternative should both be discussed in the Preferred Alternative section. Also, the criteria that would prompt implementation of the contingent remedy should be clearly identified. In the ROD, the Comparative Analysis of Alternatives section should discuss both alternatives and the Selected Remedy section should establish the parameters of each and provide criteria by which the contingent remedy would be implemented.

A potential application in the 200 Areas would be to address the uncertainty inherent in the analogous site approach. A potential disadvantage of the analogous site approach is that a site that is thought originally to fit into one waste group may be determined during post-ROD verification sampling not to be analogous to sites in that group. A contingent ROD could be used to specify what happens to such a site. For the 200 Areas, it is envisioned that the site would be removed from that waste group and reassigned to another, more appropriate waste group. The criteria for making this determination and reassignment could be specified as the contingent remedy in the proposed plan and ROD.

2.5.3 Plug-In Approach

Traditional CERCLA and RCRA corrective action cleanup methodology dictates that individual waste sites be clearly identified during characterization, evaluation, and public involvement. Remedy selection for these specific sites is then documented in the decision document. Because of the large number of generally similar, yet individual waste sites at some facilities, such as Hanford, such an approach can result in many redundant characterization, evaluation, and remedy selection documents with attendant schedule and budget impacts. For example, the analogous site approach discussed in Section 2.5.1 streamlines the characterization and evaluation phases, but ultimately all of the waste sites within a waste group will be specifically listed in the proposed plan and ROD. A newly identified site that fits the general profile of the waste group could not be covered by the ROD because it was not specifically identified in the ROD. At a minimum, a new proposed plan, and possibly a new ROD, would be required.

For facilities such as these, the need for a streamlined, consolidated approach led to the development of the "plug-in approach." The plug-in approach specifies and analyzes remedial alternatives for a group of sites that have similar characteristics (e.g., physical attributes, contaminants, and contaminated media) designated as the "site profile." A ROD is issued with a remedy selected based on the site profile. If it is determined that a new individual site is sufficiently similar to, or compatible with, a site group for which the alternatives have already been developed and analyzed, the subject site is said to "plug-in" to the analysis for that group. Confirmation sampling of the site might be required to determine whether it fits the criteria for plug-in. Thus, remedy selection for a large number of sites can be accomplished expeditiously and in a cost-effective manner using the plug-in approach to eliminate the time and cost required to produce multiple, redundant site-specific FSs.

The effective use of the plug-in approach requires a plug-in ROD. A plug-in ROD specifies the criteria that a specific waste site must meet in order to "plug-in" to the process and be remediated in accordance with the remedy selected in the ROD. The plug-in ROD also describes the process for determining whether conditions at a particular site are consistent with the plug-in criteria. Under this approach, a remedy is selected that applies to similar conditions (site profile), rather than to specific sites. Many waste sites can be incorporated into a plug-in ROD following a demonstration that site conditions conform to the site profile. A single plug-in ROD, therefore, can replace many waste site-specific RODs that would otherwise be required but would ultimately be redundant.

The plug-in approach can be combined with the analogous site and contingent ROD approaches to provide a comprehensive and streamlined approach for 200 Area remediation. A ROD prepared for a given waste group would identify the selected remedy for that waste group and criteria by which a site that was not originally part of that waste group could plug-in to the waste group. The following example illustrates how the approaches work together:

> Waste site X is originally assigned to waste group A, and a ROD is obtained for waste group A. During post-ROD confirmation sampling, it is determined that X does not fit the conceptual model for waste group A but is analogous to waste group B, which already has a ROD. ROD A has a contingent remedy that specifies that waste sites can be reassigned if they do not meet the conceptual model for waste group A. ROD B contains criteria for when a site can plug-in to ROD B. Waste site X could thus be moved from ROD A to ROD B without additional remedy selection documentation. Information regarding this reassignment would be placed in the administrative record.

A plug-in approach allows implementation of remedial actions at multiple waste sites without expending resources to initially characterize similar sites before a ROD is issued. By use of a plug-in approach, remediation can begin earlier with considerable cost savings through reduction in documentation and focused characterization.

The EPA has recognized certain categories of waste sites across the country that have many common characteristics (e.g., contaminants present, past waste disposal practices) that are suited to cleanup using a prescribed or "presumptive" cleanup remedy. This recognition stems from the results of detailed evaluations of many of the sites. The presumptive remedy approach for remedy selection at a particular type of site also recognizes that remediation of some types of waste sites by use of other remediation options is impractical or cost prohibitive. The presumptive remedy ROD, therefore, selects a response action that the EPA has prescribed for that particular type of site. An example is the use of containment as a presumptive remedy for municipal landfills. A presumptive remedy ROD can be obtained for those types of sites that the EPA has prescribed presumptive remedies, after a particular site has been shown to conform to characteristics of those sites for which the presumptive remedy is applicable. Use of the presumptive remedy process in obtaining a ROD can simplify the evaluation of alternatives in the assessment and streamline the remedy selection process considerably.

None of the waste sites in the 200 Area fit the profiles for presumptive remedies issued by the EPA to date. However, the plug-in approach described above is built on concepts similar to the presumptive remedy approach.

2.5.4 Focus Package

Focus packages are used to streamline the characterization and assessment process. Focus packages are used when it is determined that there is a minimal need for remediation or that remedial action would follow a path similar to that already followed at similar waste sites. The focus package explains why additional evaluation/analysis and documentation of remedial alternatives is not required, provides the site-specific information need to complete the remedy selection process, and supports the issuance of a proposed plan followed by a new ROD or modification of an existing ROD.

Under the 200 Areas Strategy, a focus package may be appropriate when it is determined that a waste site does not fit the conceptual model for its assigned waste group but does fit the conceptual model for another group for which a ROD has already been issued. The information collected during confirmation sampling could be used to prepare a focus package supporting modification of the ROD for the other waste group.

2.5.5 Observational Approach

The "observational approach" is a method of planning, designing, and implementing a remedial action that uses a limited amount of initial field characterization data (e.g., from the analogous site concept) to create a general understanding of site conditions. Additional information gathered during remedial actions is used to make "real time" decisions in the field to guide the direction and scope of remedial actions, based on contingency planning performed before mobilization into the field. The observational approach requires effort during the remedial design planning to identify uncertainties that might be encountered in the field and develop contingency plans for dealing with a range of conditions that might be encountered. The contingency plans are typically documented in the RD/RA work plans.

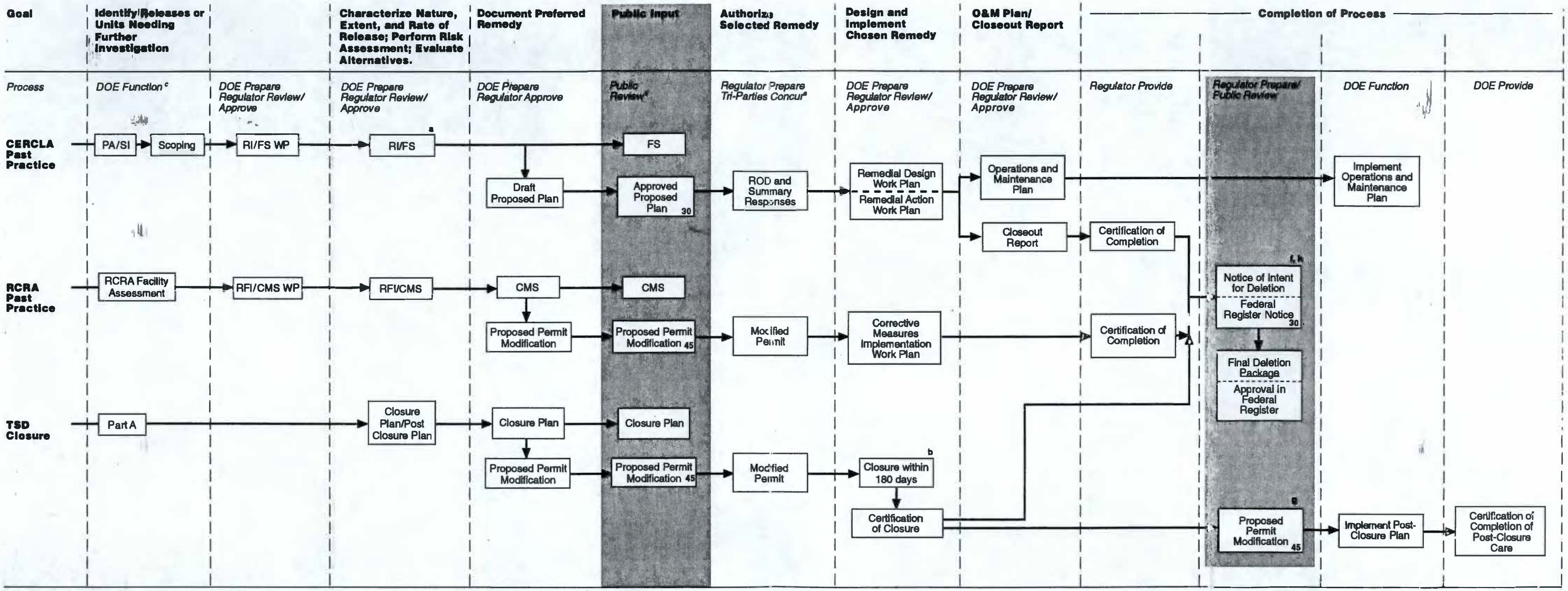
When initiating remedial actions under this set of conditions, it is recognized that unforeseen conditions may be found that require additional remedial actions to be undertaken. If conditions are found to be sufficiently different than had been expected and a modification to the cleanup remedy is required or a different cleanup approach is required, this change can be implemented by use of an ESD or a ROD amendment. Alternatively, remedial actions may determine that levels of contaminants are significantly below what had been expected, and that further remedial actions are not necessary. The observational approach in cleanup actions provides the flexibility in the field necessary to adapt to actual site conditions encountered during remedial actions by scaling the level of effort to conditions encountered. Remediation proceeds until it can be demonstrated through a combination of field screening and verification sampling that cleanup goals have been achieved.

Thus, the observational approach is a "learn as we go" methodology. This method of streamlining is considered to be more cost- and time-effective than traditional approaches that require substantial amounts of initial characterization data to make very detailed plans and engineering designs before initiating remedial actions.

2.5.6 Limited Field Investigation/Focused Feasibility Study/Interim Action ROD

When the scope of the remedial action is limited (e.g., few contaminants, a limited range of alternatives) or targeted to address a specific exposure pathway rather than all pathways, it may be appropriate to "focus" characterization and assessment activities. Focusing is achieved by limiting the characterization effort to collect only those data needed to address the scope, initiating formal evaluations of remedial technologies during work scope development, and reducing the number of alternatives to be evaluated during FSs. Further efficiencies can sometimes be realized if treatability studies are initiated early in the program. The number of alternative treatment technologies that would be evaluated in a focused FS could be limited because the existence of few known effective and technically feasible remedial technologies available to address the particular site problems, recent remedial action experience at similar sites, or applicability of particular ARARs that might constrain the number of alternatives capable of meeting ARARs as required by the NCP.

Figure 2-1. Typical Regulatory Processes at the Hanford Site for CERCLA, RCRA Past Practice and RCRA TSD Closure.



TSD = treatment, storage, and disposal
PA/SI = preliminary assessment/site investigation
RI/FS (WP) = remedial investigation/feasibility study (work plan)
RFI/CMS WP = RCRA facility investigation/corrective measure study work plan
ROD = Record of Decision
RD/RA = Remedial Design/Remedial Action
CMI = corrective measures implementation
O&M = Operations and Maintenance

30 Days for Public Review.

Public Review.

Legend:

a) Could be conducted in phases.

b) Unless otherwise stated in closure plan.

c) These steps would be applicable to newly discovered sites, however this phase has been completed at Hanford, which resulted in the 200 Area being placed on the NPL. The TPA designates operable units within the 200 Area as either CPP, RPP or TSD. A Part A permit application has been submitted for all known TSDs. Additionally, a separate Community Relations Plan has been developed that meets the requirements for having such a plan at NPL sites, and also covers all community relations needs of the TPA, including RCRA public involvement requirements.

d) During Public Review, a public meeting must be held for the Proposed Plans, and, if requested, a public hearing will be held for Permit Modifications.

e) Although it is technically the responsibility of the lead regulatory agency to prepare these documents, DOE typically collaborates with the appropriate agency to prepare the text.

f) The entire 200 Area is on the NPL. Individual sites or groups of sites may be proposed for deletion from the NPL prior to completion of cleanup and/or post-remediation care. However, all sites will have to be completed prior to removal of the 200 Area from the NPL.

g) Permit modification to either identify unit as clean-closed or modify post-closure plan, if necessary, for post-closure care.

h) EPA prepares for State Regulator 30 working-day review. After EPA announces intent in Federal Register, public review occurs for 30 days.

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Figure 2-2. 200 Areas Integrated Regulatory Process for CERCLA, RCRA Past-Practice, and RCRA TSD Unit Closure.

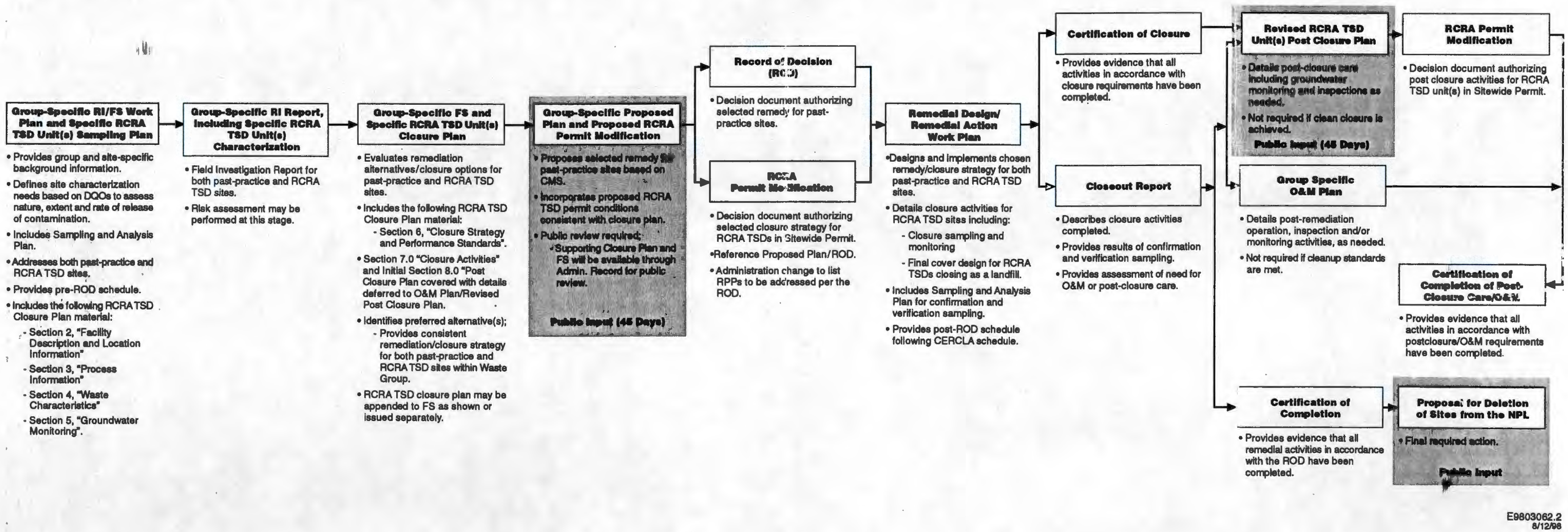


Table 2-1. Overview of the Hanford Facility[a] Dangerous Waste Portion of the Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste.

The Washington State Department of Ecology issued a permit to the U.S. Department of Energy to authorize[b] the treatment, storage, and disposal of dangerous waste at the Hanford Facility. The Hanford Facility RCRA Permit consists of six major parts and a number of attachments as summarized below:	
Part I – Standard Conditions	This part provides the legal conditions of the permit such as severability and duties and requirements of the parties.
Part II – General Facility Conditions	This part provides conditions that are applicable to the entire Facility. For example, it discusses on-site transportation and waste manifesting requirements, land disposal restrictions, record keeping and reporting, etc.
Part III – Unit-Specific Conditions for Final Status Operations	This part contains individual chapters that provide the specific conditions applicable to *active* treatment, storage, and disposal units. Currently, there are six such units that have been incorporated into the permit[c].
Part IV – Correction Actions for Past Practices	This part states that the HSWA Permit is issued by the EPA in conjunction with this Permit. Upon delegation of the Corrective Action requirements of the HSWA by the EPA to Ecology, the Permit shall be modified via a Class 3 modification to incorporate the specific requirements of the HSWA Permit into this Permit. Until this modification is complete, compliance with the terms of the referenced provisions, shall be deemed as compliance with WAC 173-303-646.
Part V – Unit-Specific Conditions for Units Undergoing Closure	This part contains individual chapters that provide the specific conditions applicable to storage, treatment, and disposal units that are *undergoing closure*. Usually, the individual chapters incorporate, by reference, the closure plans of the specific units. Currently, there are 14 such units that have been incorporated into the permit, 10 of which have already been clean closed.
Part VI – Unit-Specific Conditions for Units in Post-Closure	This part contains individual chapters that provide the specific conditions applicable to storage, treatment, and disposal units that *have already been closed, but that require a post-closure care period*. Generally, land-based units that were not clean closed are subject to post-closure requirements such as groundwater sampling and monitoring. Currently, there are two such units that have been incorporated into the permit.
Attachments	There are currently 39 attachments to the Permit, most of which are the closure or post-closure plans or Part B permit applications for specific TSD units. The attachments also include the Tri-Party Agreement, which is an enforceable portion of the Permit. Other pertinent attachments include such things as the Facility Contingency Plan, Purgewater Management Plan, and the Hanford Legal Description. Units are incorporated into the Permit or are moved to other parts of the Permit via the Permit modification process. There are several types of modifications that can occur, categorized by class. Typically, major modifications, such as the incorporation of a new unit into the Permit, require a Class III modification. Class III modifications require that the public be involved in the decision-making process concerning operation, closure, and/or post-closure procedures for a specific unit.

[a] For the purposes of the Permit, the Hanford Site is considered to be a single facility consisting of over 60 TSD units. Approximately 25% of the TSD units are or are anticipated to be operating, while approximately 50% are closed or are undergoing closure. The remaining TSD units are being dispositioned through other options under the Tri-Party Agreement.

[b] Authority for the permit is pursuant to Chapter 70.105 RCW, the *Hazardous Waste Management Act* of 1976, as amended, Chapter 70.105D RCW, the *Model Toxics Control Act*, and regulations promulgated thereunder by the Washington State Department of Ecology, codified in Chapter 173-303 *Washington Administrative Code*.

[c] Information presented in this box is based on Revision 4A of the Dangerous Waste Portion of the Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste, issued by the Washington State Department of Ecology on February 25, 1998.

Table 2-2. 200 Areas RCRA TSD Units Associated with Waste Groups.

TSD Unit	Status
200 West Area Ash Pit Demolition Site	Clean Closed 10/26/95 – In Part V of Permit
207-A South Retention Basin	Interim Status
2101-M Pond	Clean Closed 10/26/95 – In Part V of Permit
216-A-10 Crib	Interim Status
216-A-29 Ditch	Interim Status (Mod F – 2000[a])
216-A-36-B Crib	Interim Status
216-A-37-1 Crib	Interim Status
216-B-3 Expansion Ponds (216-B-3A, -3B, and –3C)	Clean Closed 6/27/95 – In Part V of Permit
216-B-3 Main Pond (216-B-3 and 216-B-3-3)	Interim Status (Mod F – 2000)
216-B-63 Trench	Interim Status (Mod F – 2000)
216-S-10 Pond and Ditch	Interim Status
216-U-12 Crib	Interim Status
218-E-8 Borrow Pit Demolition Site	Clean Closed 10/26/95 – In Part V of Permit
222-S Laboratory Complex (222-SD only) (Part B[b])	Interim Status (Mod E – 1999)
241-CX Tank System	Interim Status
241-Z Treatment and Storage Tanks	Interim Status
Double-Shell Tank System (Part B)[c]	Interim Status (Mod E – 1999)
Hexone Storage and Treatment Facility (276-S-141/142)	Interim Status
Low-Level Burial Grounds[d] (Part B)	Interim Status
Nonradioactive Dangerous Waste Landfill	Interim Status
PUREX Storage Tunnels 1 and 2 (Part B)	In Part III of Permit
Single-Shell Tank System[e]	Interim Status

[a] TSD units will be incorporated into the permit according to the annual schedule as shown through year 2000 in accordance with applicable requirements in WAC 173-303-830. All TSD units that do not have a specific year shown will be incorporated after 2000 in a schedule that is negotiated by the Tri-Parties.

[b] A Part B Permit Application has been submitted for units with (Part B) following the name.

[c] Only part of the TSD Unit, the 244-S Double-Contained Receiver Tank, is included in this Implementation Plan.

[d] This Implementation Plan includes waste sites for the Low-Level Burial Grounds as follows: 218-W-6, 218-E-10, 218-E-12B, 218-W-3A, 218-W-3AE, 218-W-4B, 218-W-4C, 218-W-5.

[e] Only the diversion boxes within this TSD unit are included in this Implementation Plan: 240-S-151, 240-S-152, 241-B-154, 241-BX-154, 241-BX-155, 241-C-154, 241-TX-155.

3.0 200 AREAS SETTING AND BACKGROUND

This chapter summarizes data related to the physical setting (Section 3.1), site operations and waste generation (Section 3.2), and contaminant fate and transport (Section 3.3) in the 200 Areas. Detailed supporting information on the physical setting, waste sites, and chemical processes is provided in Appendices F, G, and H, respectively. The background information presented in this chapter and supporting appendices is common to all 200 Area waste sites and is included in the Implementation Plan to serve as a primary reference for the 23 group-specific work plans. Consolidating this generic information is part of the commitment to streamline production of the work plans, which will focus on the detailed, site-specific data.

Data on the physical characteristics of the 200 Areas (Section 3.1) are needed to define potential contaminant transport pathways, from the disposal sites toward groundwater and potential receptors, and to support engineering, development, and screening of remedial action alternatives. The emphasis is to identify the geological, hydrological, and meteorological parameters that control the migration of contaminants in the subsurface.

The overview of operations (Section 3.2) provides data on the sources of contaminants in the 200 Areas. Brief explanations of the site processes, operational history, waste management philosophies, and major potential contaminants used since 1943 support the identification of the types and volumes of wastes disposed to the soil column, the logic underlying the waste site grouping process, and the contents of the major potential contaminants lists.

Physical and chemical interactions between the contaminants and the soil (Section 3.3) affect the distribution of contaminants in the vadose zone. The typical expected distribution of contaminants is summarized in the preliminary physical conceptual model of contaminant distribution, which in turn supports the preliminary conceptual exposure model (Chapter 5.0).

Hanford Site Background. The Hanford Site (Figure 1-1) lies within the semiarid Pasco Basin of the Columbia Plateau in southeastern Washington State. The Hanford Site, approximately 50 km (31 mi) north to south and 40 km (25 mi) east to west, encompasses approximately 1,450 km^2 (560 mi^2) north of the confluence of the Yakima and Columbia Rivers. This land, with restricted public access, provides a buffer for the smaller fenced areas currently used for storage of nuclear materials, waste storage, and waste disposal. Only about 6% of the land area has been disturbed and is actively used. The Columbia River flows eastward through the northern part of the Hanford Site and, after turning south, forms part of the Site's eastern boundary. The Yakima River runs near the southern boundary of the Hanford Site and joins the Columbia River at the city of Richland, which bounds the Hanford Site on the southeast. Rattlesnake Mountain, Yakima Ridge, and Umtanum Ridge form the southwestern and western boundaries. The Saddle Mountains form the northern boundary of the Hanford Site. Adjoining lands to the west, north, and east are principally range and agricultural land. The cities of Kennewick, Pasco, and Richland (Tri-Cities) constitute the nearest population centers and are located southeast of the Hanford Site (Neitzel 1997).

Established in 1943, the Hanford Site was originally designed, built, and operated to produce plutonium for military nuclear weapons. Uranium metal billets were received in the 300 Area and fabricated into jacketed fuel rods suitable for loading into nuclear reactors. The fuel rods were placed in the reactors in the 100 Areas and irradiated under nuclear fission reactions. The fuel rods were then taken to the 200 Areas, where plutonium and uranium were separated from the residual activation and fission products using liquid chemical processes. The 600 Area includes portions of the Hanford Site not included in the 100, 200, or 300 Areas and served primarily as transportation corridors and buffer zones between the fabrication, irradiation, and chemical processing areas. Other designated areas of the Hanford Site include the 400 Area (Fast Flux Test Facility), 700 and 3000 Areas (RL and contractor offices in Richland), and the 1100 Area (equipment maintenance).

Chemical separations process facilities were sited in both the 200 East and 200 West Areas. The 200 North Area temporarily stored irradiated fuel rods, allowing certain short-lived radionuclides to decay before being shipped to separations plants. With the startup of the separation plants, large quantities of liquid wastes (primarily water) containing minor concentrations of radionuclides and chemicals were discharged to the soil column and percolated into the vadose zone. Depending on contaminant concentrations and a consequent need for isolation, liquid wastes were discharged either to surface ponds and ditches or to underground cribs, reverse wells, and french drains. These infiltration facilities were generally located in the 200 Areas near the processing plants and in the surrounding 600 Areas.

Key radionuclides with half-lives longer than 10 years that were discharged to the soil column include cesium-137 (Cs-137), barium-137m (Ba-137m), iodine-129 (I-129), strontium-90 (Sr-90), yttrium-90 (Y-90), technetium-99 (Tc-99), uranium, carbon-14 (C-14), americium-241 (Am-241), plutonium (Pu-239/240), and tritium (H-3 [as tritiated water]). Two-thirds of the radioactivity in liquids discharged to the ground is from tritiated water, which has a 12.3-year half-life. The radioactive material flow diagram for the Hanford Site is shown schematically in Figure 3-1. The least contaminated liquids were discharged to surface ponds and ditches, but comprise over 90%, by volume, of all liquid waste discharges. Conversely, the low volume streams carried 95% of all radionuclides into the vadose zone.

Major chemicals in liquids discharged to ground (based on quantities) include nitrate, sodium, phosphate, sulfate, ammonia, carbon tetrachloride, and fluoride. Inorganic chemicals were used and discharged in much greater quantities than organics. The greatest amount of hazardous chemicals were contained in the liquids discharged from 1945 to 1958 (WHC 1991).

Solid waste such as failed equipment, tools, and protective clothing containing radionuclides and hazardous materials have also been buried in the ground. The radioactive inventory in solid waste burial grounds represents approximately 1% of the total Hanford Site radioactivity (WHC 1991).

The vadose zone underlying these waste sites consists of sediment particles of various sizes and geochemical constituents, soil moisture, vapor, and organic or vegetative matter. The flow of liquid waste through the unsaturated soils in the vadose zone depends in complex ways on several factors, including most significantly the moisture content of the soil and its hydraulic properties. Lateral and vertical gradations or discontinuities in soil-column parameters result in site-specific infiltration characteristics. In addition, waste-stream-specific characteristics of the liquid wastes, such as viscosity and volume, affect the ability of the liquid itself to infiltrate and migrate within the soil column. Contaminants will be transported by migrating water or, in the case of volatile contaminants, by the soil vapor. The resulting distribution of contaminants in the soil column depends on the degree to which different contaminants are retained by adsorption to soil particles or precipitated from the fluid along the migration pathway.

Data Sources. A large volume of historical data is available to present a reasonable idea of the general waste site conditions, local geology, and hydrology for the 200 Areas (Table 3-1), and in a few cases, for specific sites. Since 1947, a large number of boreholes have been drilled, sampled and geologically logged, examined by borehole logging tools, and where deep enough, sampled for groundwater contamination. Soil, vegetation, surface water, and biotic samples have been gathered from the start of plant operations to assess operations impacts on the environment in and around the 200 Areas. Much of this data has been summarized in monthly, quarterly, or annual reports over the last 20 years. In addition, the Pacific Northwest National Laboratory has reported on the Hanford Site's environmental status in its environmental and groundwater annual reports.

A large quantity of this historical data was summarized in the ten 200 Areas AAMS reports. These documents addressed the eight geographically-based source areas and the 200 East and 200 West groundwater regimes. Each source AAMS report included descriptions of the generating facilities, waste site and processes; meteorological, geographic, geologic and hydrologic settings: environmental resources (flora and fauna); and existing environmental conditions as determined through routine soil, sediment, vegetation, air, groundwater, surface water and external exposure conditions. This data collection was conducted to monitor radionuclide transport around the site, to determine if exposure limits were being exceeded, and to detect potential problems. The data was of a sufficient quality for these intended purposes, but most of it lacked the analytical and data certification rigor needed for remediation or characterization decisions. However, this data did provide a strong background for defining sites requiring remedial action and allowed better planning of future characterization activities. In more recent years, some qualified data has been made available as a result of characterization activities at RCRA TSD sites and at the 200-BP-1 Operable Unit.

In addition, each AAMS report identified the major potential contaminants and the potential contaminants of concern, and provided conceptual models of contaminant fate and transport as well as exposure and risk assessments. Health and environmental concerns, ARARs, and preliminary remediation alternatives were also presented. The reports also addressed data quality objectives, data gaps, and proposed data-gathering activities. Waste sites were ranked in each AAMS source report based on the state of contamination at each and a path for remediation was proposed, following the Hanford Past Practice Strategy (DOE-RL 1991).

Site data for the source AAMS reports were gathered in technical baseline documents, which were prepared prior to the AAMS reports and which served as the primary reference for them. These documents included the then-current Waste Inventory Data System (WIDS) database entries for each waste site covered in the respective operable units. Additional data were compiled into each site description along with descriptions of plant operations. Key drawing lists, references, and photographs of each waste site were also provided.

Technical manuals prepared for each major processing plant provide discussions of the chemical processes, equipment, waste streams, health and safety requirements, and general plant layout as conceived at the start of operations. However, process modifications are generally difficult to track over the course of a plant's operating life. Historical overviews for most plants are available over the internet at the DOE-RL Hanford home page (www.hanford.gov) under "Hanford History." These documents include a comprehensive bibliography that can help identify older contractor-generated information, which are available through onsite databases and libraries.

Even though a large quantity of information exists, there are still a number of data gaps. Uncertainties are evident in such areas as the process descriptions, discharge records associated with the operations, the types and quantities of waste generated and sent to individual waste sites, and the interactions of those wastes with the environment at the disposal sites. Current fate and transport models do not adequately quantify the chemical and geochemical interactions influencing the distribution of contaminants in the soil column. It is for these reasons and those discussed above that characterization information is still required.

3.1 PHYSICAL SETTING

A brief summary of the significant characteristics of the physical setting is included in this section to support development of the preliminary conceptual models of contaminated distribution (Section 3.3) and exposure pathways (Chapter 5). A more detailed description of the physical setting is provided in Appendix F.

Disposal of low-level, radioactively contaminated waste water to the ground in the 200 Areas was based on the assumption that the radionuclides would be largely retained in the vadose zone through sorption to sediment particles as the water migrated toward groundwater. (As will be discussed in Section 3.3, subsequent site-specific observations showed that this broad assumption could not be applied in all circumstances.) Because the 200 West, 200 East, and 200 North Areas are located on an elevated, flat area, often referred to as the 200 Areas Plateau, the underlying vadose zone is relatively thick, providing additional opportunities for sorption during migration. The increased thickness of the vadose zone in the 200 Areas also increases the travel time for contaminants to reach groundwater. The vadose zone beneath the 200 West Area ranges in thickness from less than 50 m (165 ft) to more than 100 m (328 ft); the vadose zone beneath the 200 East Area ranges in thickness from 37 m (123 ft) to about 104 m (317 ft); and the vadose zone beneath the 200 North Area ranges in thickness from about 49 m (160 ft) to 50 m (165 ft). The inland location of the 200 Areas, relative to the Columbia River, also increases the travel time for contaminants that do reach groundwater to migrate to the river.

The vadose zones underlying the 200 Areas are relatively permeable, which allows waste fluids to infiltrate, to migrate downward, and to come into contact with sediment particles. Under all three areas, the vadose zone includes the uncemented, unconsolidated gravels and sands deposited by cataclysmic flood waters released from western Montana and northern Idaho when ice dams were breached during the last ice age. In the 200 West Area only, the vadose zone also includes an underlying and less permeable layer of finer grained silt and cemented gravels, which in turn is underlain by consolidated gravels deposited by the ancestral Columbia River system. This less permeable layer acts as a temporary barrier to the vertical movement of liquids and vapors and may cause lateral spreading of contaminated fluids along its upper surface.

Liquid wastes that flow through the vadose zone along preferential pathways may carry contaminants directly to the groundwater with minimal interaction with sediments. Preferential pathways may be artificial, such as poorly sealed wells, or natural, such as clastic dikes and fault zones. Vapor-phase contaminants may also flow along preferential pathways, but in addition to flowing downward may also be released to the atmosphere as a result of barometric pressure fluctuations.

The discharge of large volumes of liquid wastes to the soil columns under the 200 Areas provided the primary driving force for liquid and contaminant migration through the vadose zone toward groundwater. With the nearly complete cessation of these liquid discharges, this driving force has been largely eliminated, and the principal driving force has become natural recharge provided by rainfall and snowfall. Because the mean annual precipitation, approximately 17.3 cm/year (6.8 in./year), is relatively low at the Hanford Site, the natural recharge of water that can drive contaminants through the vadose zone toward groundwater is relatively low.

Plants may redistribute and concentrate contaminants through root uptake followed by either transpiration to the atmosphere or consumption by animals. Contaminants brought to the surface by burrowing animals may be further redistributed by wind or other animals. The maximum depth to which plant roots penetrate and animals burrow is approximately 3 m (10 ft). Most of the more radioactively contaminated liquids were discharged to structures buried to depths of 4 to 10 m (12 to 35 ft), but have not always been beyond the reach of surface-based organisms.

3.2 OPERATIONAL OVERVIEW

The section presents summaries of the generation and disposal of radiological and chemical contaminants in the 200 Areas subsurface (Sections 3.2.1 and 3.2.2) to support development of the waste site grouping rationale (Section 3.2.3), the waste site grouping prioritization (Section 3.2.4), and the lists of major potential contaminants (Section 3.2.5). Characteristics of the waste site groups are described in more detail in Appendix G. The major chemical separation processes and waste management activities in the 200 Areas are described in more detail in Appendix H.

3.2.1 Uranium-Plutonium Production Cycle

Radionuclides brought to the 200 Areas within irradiated fuel rods have three primary sources: naturally occurring uranium isotopes remaining in the fuel rods, products of U-235 fission, and products of neutron activation.

Naturally Occurring Uranium Isotopes. Uranium exists as a naturally occurring element and is commonly found as a trace component of granitic rocks. Economically valuable deposits in the southwestern United States are most commonly found in sandstones. In nature, uranium is comprised of three isotopes: U-238 (99.283% by weight) and trace quantities of U-235 (0.711%) and U-234 (0.006%) (CRC 1980). For reactor use, uranium was concentrated and refined into a pure metal form. The uranium fuel rods initially contained uranium isotopes U-238, U-235, and U-234 in the same naturally-occurring relative abundances.

Throughout the history of Hanford reactor operations, the primary fuel used was metallic uranium. Unique properties of the various uranium isotopes were essential to the production of nuclear weapons. For example, U-238 can be transmuted to U-239 by neutron bombardment; U-239 then decays to Neptunium-239 (Np-239), which in turn decays to Pu-239. Although neutrons may be generated by a number of atomic-scale particle interactions, U-235 fission is the primary source for neutrons in a fuel rod. Two neutrons are released when a U-235 nucleus captures a neutron and fissions, or splits, into smaller nuclei. This two-for-one neutron exchange is the basis for fuel rod enrichment and the power reactor operations. Similarly, the neutrons given off in this reaction may be captured by the nucleus in a U-238 atom, thereby converting it to Np-239. However, in a single, isolated fuel rod, the frequency of neutron capture is miniscule as the neutrons primarily escape from the rod.

A self-sustaining neutron flux, or criticality, can be engineered when a "critical mass" of uranium is assembled. The critical mass assures that the free neutrons will encounter more U-235 nuclei, thus multiplying the number of neutrons generated. When placed in a reactor filled with a large number of closely spaced fuel rods, the neutrons have a much greater opportunity to also encounter U-238 atoms in other fuel rods, and the generated neutron flux begins to transmute U-238 to Pu-239. In practical terms, the amount of plutonium generated at Hanford was dictated by reactor power levels and residence time the fuel rods spent in the reactors, but usually didn't amount to much more than 0.05-0.2% Pu-239, by weight. Because reactor operations consumed U-235 through nuclear fission, its concentration was reduced in the discharged fuel rods by approximately 15% to 25%. Similarly, U-238 was also consumed through transmutation to Pu-239, but at a much smaller scale.

When uranium is found in nature, it is in equilibrium with nearly 30 radioactive daughter isotopes that are created by decay of a radioisotope to a new isotope (either radioactive or stable); the new isotope is the "daughter" of the "parent" isotope from which it descended, as illustrated by isotope-specific decay "chains" (Figure H-9). Chemical separation and purification of uranium prior to fabrication of fuel elements removed all daughter isotopes except U-234, which is a daughter of U-238. The removed daughters begin to be formed again immediately as (1) uranium decay produces radioactive daughters and then as (2) those daughters decay to additional products further along the decay chain. Most uranium daughters "grow-in" very slowly because of the occurrence of several long-half-life daughters early in the decay chain. As a result, daughter isotopes in the lower portions of the decay chain with mass numbers less than 231 (e.g., thorium-230 and radium-226) require greater than 1,000 years (often greater than 10,000 years) before returning to even 1% of the activity of the parent uranium. The daughters lower in the decay chain may be present naturally at low levels but are not considered to be abundant in the 200 Areas.

Products of U-235 Fission. A broad spectrum of fission products form from the splitting of the U-235 nucleus. Although the fission process is randomly able to form any lower element in the periodic table, the U-235 nucleus tends to split into two elements (binary fission) whose atomic mass numbers (= the number of protons and neutrons in the nucleus) usually lie between 72 and 166. Occasionally, the U-235 nucleus will split into three elements (ternary fission) which tends to yield radionuclides with low atomic mass numbers. Most of the resulting isotopes are radioactive, with half-lives ranging from seconds to thousands of years in duration. However, in general terms, 90% or more of the fission products generated from uranium disintegrations possess half-lives less than 1 year long and 50% possess half-lives less than 1 month long. It was for these short-lived radionuclides that cribs and reverse wells were constructed to isolate the waste streams to the site work force and the accessible environment.

After 15 years of decay, more than 99% of the initial fission product activity has been exhausted. The high-activity fission products initially present in irradiated fuel (and of greatest importance during processing) have decayed to insignificance in Hanford materials. Due to their half-lives (approximately 30 years) and significant production during nuclear fission, Cs-137, Sr-90, and their primary daughters, Ba-137 and Y-90 and Zr-90, now account for over 99% of all remaining nonactinide radioactivity (i.e., not from uranium, plutonium, neptunium, americium, etc.) from the fuel materials brought to the 200 Areas.

Two other fission products may be included as potential contaminants because of their half-lives, yields, and potential for concentration or potential for high mobility: tritium (H-3) and technetium-99 (Tc-99). As tritiated water, tritium behaves chemically as any other waste in separation processes. The potential exists for condensate from any contaminated aqueous streams to have H-3 as the primary (or only) radionuclide present. Tc-99 tended to behave chemically the same way uranium did in the chemical processes used at the 200 Areas and potentially contributes significantly to the total radioactivity of uranium-containing streams and wastes.

Products of Neutron Activation. The primary purpose of irradiation of the uranium fuel rods at Hanford was neutron activation of U-238 to ultimately form Pu-239. Neutron activation is the production of a radioactive isotope by absorption of a neutron. During irradiation, however, neutron activation of other isotopes, including newly formed isotopes, also occurred. For example, a fraction of the Pu-239 was converted to Pu-240 and a fraction of the Pu-240 was converted to Pu-241. Because Pu-241 has a short half-life (14.4 years), much of the Pu-241 generated at the Hanford Site has already decayed to americium-241 (Am-241), which must be considered as a potential contaminant of concern whenever plutonium is known or expected to be present. The vast majority of potentially formed activation products have short to very short half-lives. Decay since discharge from the reactors has reduced the number of isotopes potentially present at levels of potential concern to cobalt-60 (Co-60), nickel-63 (Ni-63), carbon-14 (C-14), and H-3 (which may also be present as a fission product). Co-60 has the shortest half-life of these (5.27 years) and is currently approaching its practical detection limits for routine analytical techniques.

Relationship Between Activity and Chemical Concentration. The relationship between the activity of a radionuclide and its mass is called the specific activity, defined as the number of Curies per gram of radionuclide. (A Curie is the activity of that mass of a radionuclide in which 3.7×10^{10} atoms decay per second.) A very low-activity radionuclide such as U-238, with a half-life of 4.51×10^9 years, requires 3,000,000 g to generate this number of disintegrations per second. Conversely, a high-activity radionuclide such as ruthenium-106 (Ru-106), with a half-life of 1.004 years, requires only 0.0003 g to produce 1 Ci of activity. In other words, the activity measured in a sample corresponds to a smaller mass of radioactive material if the sample contains a high-activity radionuclide and to a larger mass of radioactive material if the sample contains a low-activity radionuclide. In particular, for high-activity radionuclides, the mass required to produce the measured activity may be too small to affect the chemical and physical properties of the sample as a whole. The specific activity for each radionuclide provides the conversion factor between chemical concentration and activity for that isotope.

The end products of radionuclide decay chains are stable elements. For example, uranium isotopes will eventually decay to lead, while strontium and cesium decay to zirconium and barium, respectively. For most of the high-activity/short half-life isotopes, concentrations of the decay chain stable products are very low because the concentrations of the radioactive parents are very low. For low-activity/long half-life isotopes, the formation of stable decay products can be very slow. Therefore, the radiological health hazards overshadow the chemical toxicity of the stable daughter products for any foreseeable time scale. However, for "heavy" elements, both the parent and the daughter elements (e.g., uranium and lead, respectively, which are both heavy metals) will have similar nonradioactive toxicological properties.

3.2.2 Operational History

Plutonium production began at the Hanford Site with the delivery of cylindrical metal uranium billets to the 300 Areas. The metal was heated, forced through an extrusion die, and formed into a cylindrical rod before air quenching and inspection. The rods were machined and cut into slugs 20 cm (8 in.) long. The slugs were then canned inside aluminum jackets and bonded to the material with an aluminum-silicon alloy. The canned slugs were machined, degreased, inspected, and tested prior to being loaded into nuclear reactors in the 100 Areas.

The slugs were placed in the reactor pile and irradiated for variable periods of time, typically for 100 to 120 days, in the early years of operations. Following irradiation, the slugs were pushed out from the reactor pile and collected in basins for initial cooling. The slugs were then loaded into water-cooled casks and taken by railcar to the 200 North Area, where the casks were unloaded into cooling pools. Aging the slugs for 40 to 60 days in the cooling pools allowed the decay of certain high-activity radionuclides such as iodine-131 (I-131) and other short-lived emitters. Additionally, neptunium-239 (Np-239) would also decay rapidly, forming much of the slug's Pu-239 content. The 200 North Area was used between 1945 and 1952, after which aging in reactor cooling basins became standard practice.

The fuel rods were next taken to either the 200 East Area or 200 West Area for processing in one of the separations plants. The various separations processes are described in more detail in Appendix G of this plan. All separations processes required decladding of the fuel slugs by caustic dissolution of the aluminum jacket. Following that, the uranium fuel rod was dissolved in a bath of nitric acid in preparation for the particular separations process steps. The initial bismuth phosphate ($BiPO_4$) process at B and T Plants separated and concentrated plutonium from the rest of the dissolved material by multiple steps of carrier precipitation. The $BiPO_4$ preferentially attracted the plutonium from the rest of the solution and, as a precipitate, was physically separated by centrifuging. Repeated dissolution and precipitation, using both $BiPO_4$ and lanthanum fluoride (LaF), led to recovery of over 99% of the plutonium and removal of 97% to 99% of the uranium and fission products. This process generated large volumes of uranium- and fission product-rich wastes, which were stored in the 241-B, C, T, and U tank farms. Most low-level liquid wastes generated by this process were sent to ponds. The B Plant operations ended in late 1952, and T Plant operations ended in late 1956.

The $BiPO_4$ process was a relatively slow, stepwise approach to recovering plutonium and required large volumes of tank storage space for high activity wastes.. Organic solvent extraction processes were evolving during the 1940s and were applied in the late 1940s with implementation of the Reduction Oxidation (REDOX) process at the 202-S Plant. Immediate benefits in production were observed from the plant's ability to operate continuously. This plant used the organic compound, methyl isobutyl ketone (MIBK or hexone), as a solvent to remove both plutonium and uranium from the dissolved fuel rod solution. The process passed the dissolved, acid fuel rod solution down tall columns by gravity flow, through a less dense, rising countercurrent of organic liquids. Through mixing, both plutonium and uranium were stripped out of the acid by the hexone, which was pulled off at the top of the column. Next, plutonium was removed from the uranium-rich hexone solution and purified, in this case using inorganic acids to preferentially bond with the plutonium in similar countercurrent flow columns. Uranium was recovered using similar extraction processes in a separate set of process columns. Recovery and reuse of the solvent and acid was also achieved through this process. High fission-product wastes generated at REDOX were stored in tank farms. Because it operated continuously, the plant also generated significant quantities of low-level wastes, which were discharged to ponds and cribs. The REDOX process operated from 1951 to 1967, and a waste concentrator was active through 1973.

The Plutonium/Uranium Extraction (PUREX) process at the 202-A Building was the final large-scale separations process developed. It utilized the same countercurrent flow principles of solvent extraction as at REDOX, but benefited from significant design and process improvements. Again, as at REDOX, both plutonium and uranium were recovered and purified, as were the solvents and acids. The plant used a much less flammable two-part organic mix, tributyl phosphate (TBP) in a normal paraffin hydrocarbon (NPH-a.k.a. kerosene), to separate plutonium and uranium from the nitric acid-dissolved fuel rod solution. The TBP process was much more efficient in the rate of processing, and was also safer and cleaner in operation. PUREX began operation in late 1955 and ran continuously to 1972. Following an 11-year hiatus, the plant was restarted in 1983 and ran intermittently through 1988. High fission-product wastes generated at PUREX were stored in tank farms. The plant also generated significant quantities of low-level wastes, which were discharged to ponds, cribs, and french drains.

The recovered, purified plutonium was refined to one of several forms depending upon the era and the available process. At the start of Hanford operations, plutonium was refined in the 231-Z Building where it was converted to a nitrate paste prior to shipment offsite. Shortly thereafter, however, a more elaborate plant, the Plutonium Finishing Plant (PFP), was constructed with the capability to convert plutonium into metal, nitrate, or oxide forms. A number of process lines in the 234-5Z Building were used between 1949 and 1989. Initially, batch inorganic chemical steps were used to refine and convert plutonium to the desired form. Later, more elaborate extraction processes were developed. The PFP was also used to fabricate plutonium into shapes for direct installation into weapons and for reprocessing scrap plutonium, using solvent extraction techniques based on TBP mixed with carbon tetrachloride.

In the first 7 years of $BiPO_4$ operations, over 4,000 tons of uranium were accumulated in the existing tank farms serving the B and T Plants (Gustavson 1950). A dependency on overseas uranium reserves led to the first application of the TBP process, later implemented as the PUREX process, at the 221/224-U Plants in late 1951. The Uranium Recovery Project (URP) and its plant was the focus of an effort to pump out all tanks bearing uranium-rich, high-level wastes in both the 200 East and 200 West Areas. The process was also intended to free up large volumes of tank space. The 221-U Plant recovered the uranium from the various forms of tank farm feed and concentrated it as uranyl nitrate hexahydrate (UNH). The UNH was then sent to the 224-U Building where it was combined with REDOX and later with PUREX uranium solutions. The 224-U Plant used furnaces to convert and calcine the uranium into a dry trioxide powder.

High-level waste storage was an operational concern for production facility operation throughout the 200 Areas. The $BiPO_4$ process generated large quantities of liquid waste, which necessitated construction of four additional tank farms. An initial approach to declining tank space was to pump the least contaminated low-activity supernatant of the stored waste streams to nearby cribs. Next, evaporators were built in 1952 at the 241-B and -T tank farms to reduce the volume of liquids in storage. The URP was expected to significantly decrease the volume of liquids in tanks. However, due to high concentrations of Cs-137 and Sr-90, the process increased the volume of waste requiring tank farm storage. A treatment was found in 1954 to reduce the amount of fission products (especially Sr-90) in the high-level URP wastes by scavenging (precipitation through chemical additions), and the treated liquids were determined to be suitable for discharge to the soil column. In addition, certain tank farm waste streams discharged by REDOX and PUREX were found to be self boiling from the high fission product concentrations and were able to receive more waste over time. At about the same time, more tank space was freed-up in 1954-1955 by discharging another of the less contaminated high-level waste stream supernatants to the ground. This option was acceptable as the waste had been stored for a number of years and much of the fission product contamination had naturally precipitated-out in the tanks. In-tank evaporation was implemented at the 241-BX Tank Farms in the 1960s, and two new evaporators were built at the 241-S (1973) and 241-A (1978) Tank Farms.

Several waste fractionization campaigns were conducted between 1963 and 1983 to recover certain radionuclides, including Cs-137, Sr-90, and certain rare-earth isotopes, for which specific uses or applications had been identified. The program was implemented at the 221-B facility and used a variety of chemical processes, including solvent extraction and ion exchange, to recover target isotopes. The program was superseded by the Waste Encapsulation and Storage Facility (WESF), which concentrated cesium and strontium into dry salt compounds. The powders were then placed in doubly welded capsules and stored in cooling pools.

Many of the full-scale production processes described above were developed in laboratories, both at experimental and bench-scale levels, using small quantities of nonradioactive elements or small quantities of radioactive isotopes. Prior to full plant implementation, tests were performed in near full-scale vessels and at working concentrations to examine problems in scaling-up the chemical principles and processes. This "semi-works" scale of testing was conducted at one of two places. The earliest $BiPO_4$ developmental testing was conducted in the "Headend" section of the 221-T Building. However, much more extensive development work for REDOX, URP, PUREX, and the fission product fractionization processes were undertaken at the 201-C Building, also known as the Hot Semi-Works facility. This area was originally intended to be a fourth $BiPO_4$ plant, but construction was canceled after U Plant was started. The remaining facilities then under construction were modified and completed to allow safely working with significant quantities and concentrations of radionuclides and chemicals.

Additional details of these and other, secondary operations are presented in Appendix H.

3.2.3 Waste Site Grouping Rationale

The waste site grouping strategy used in this Implementation Plan is summarized from a broader discussion presented in the *Waste Site Grouping for 200 Areas Soil Investigations* (DOE-RL 1997). The strategy is an implementation of the analogous site approach advanced in the *Hanford Past Practice Strategy* (DOE-RL 1991) in which the results of characterization activities at one or several sites in a waste group are extended to all sites in that group. At the core of the grouping approach is the recognition that there are a limited number of liquid waste types generated by any given facility or process. The concentrations of both radiological and chemical contaminants in each stream type were fairly distinct, as typified by the types of waste sites to which the liquids were discharged. In general, liquid wastes with small quantities of radionuclides were discharged to subsurface structures such as cribs and reverse wells. Waste streams with negligible quantities of radionuclides were discharged to surface structures such as ponds and ditches.

The use of analogous site data reduces the amount of investigation needed at individual waste sites by performing characterization activities for groups of similar waste sites. This analogous site approach concept is a key element in the 200 Areas soil remediation process because many of the 200 Areas waste sites share similarities in process history, contaminants of concern and geological conditions. The *Waste Site Grouping for 200 Areas Soil Investigations* (DOE-RL 1997) identified logical waste site groups based on waste stream type (e.g., solid waste, cooling water, process waste), followed by waste site type (e.g., burial ground, pond, crib). It was determined that the waste stream categories and specific groups within the categories would provide the most efficient method of grouping waste sites, based on current knowledge about the facilities generating the waste and the waste site types themselves. In addition, it was recognized that while the 200 Areas contain a large number of waste sites, only a limited number of chemical separations or waste treatment processes and waste disposal structure types were actually used. More detailed information on waste streams and waste sites is presented in Appendix G. Plant processes are discussed in detail in Appendix H.

A subteam with representatives from the Environmental Restoration Contract (ERC), Ecology, the EPA, and the RL developed waste site categories and criteria. Chemical processes, type of contamination (e.g., uranium, plutonium, organics), and waste site type (e.g., pond, crib, burial ground) were identified as the primary factors used to categorize sites. The following waste categories were developed:

- Process condensate and process waste sites
- Steam condensate, cooling water, and chemical sewer sites
- Chemical laboratory waste sites
- Miscellaneous waste sites
- Tank and scavenged wastes sites
- Septic tanks and drain fields
- Unplanned releases
- Tanks, lines, pits, and boxes
- Landfills and dumps.

Individual waste site data were reviewed for:

- Location
- Waste source and associated chemical process
- Volume of liquids received
- Type of contaminant(s) received and associated cumulative inventory
- Waste site type/structure.

Sites that were not addressed included those inside and ancillary to the single- and double-shell tank farms and the respective process or waste management buildings. These sites will be addressed as part of the TSD closure activities at the respective tank farm operable units or as part of the D&D activities at major process buildings.

The ***Process Condensate and Process Waste*** category includes waste sites that are typically below ground liquid waste disposal structures (e.g., cribs and trenches). Process condensate is generally water condensed from the closed process system and was in direct contact with radioactive and chemical materials. Process waste is low-level and/or hazardous waste that directly contacted radioactive material and may contain organic complexants that could enhance their mobility. Due to the generally higher concentrations of radionuclides compared to other waste types, this waste was disposed to underground sites such as cribs, reverse wells, and trenches. The primary contaminants noted in this category include H-3, I-129, Cs-137, Sr-90, Ru-106, Tc-99, U-238, Pu-239/240, organics, nitrates, and a number of inorganic components.

This category was subdivided into six groups, based primarily on the respective amounts of key constituents (uranium, plutonium, organics, fission products [e.g., Sr-90 and Cs-137]) and other process-related information. Available inventory data for each process condensate/process waste site was evaluated to determine how that site compared with others where high inventories for uranium, plutonium, fission products, or organics were present. Lower bound values for each constituent were established, and sites with less-than inventories were considered either for inclusion in other constituent groups or, if still less-than, were placed in the General Process Condensate/Process Waste Group. An arbitrary hierarchy of constituents emerged with uranium-rich, plutonium-rich, and plutonium/organics-rich groups regarded as the more important due to the longer half-lives associated with each. Organic and fission product-rich groups were considered next in importance, and the General Process Condensate/ Process Waste Group served as the catch-all for sites with small inventories. Inventory data are presented in Appendix A, Table 1, of the Waste Site Grouping for 200 Areas Soil Investigations Report (DOE-RL 1997). These groups are:

- **Plutonium/Organic-Rich Process Condensate/Process Waste Group (200-PW-1).** This is one of two process condensate/process waste groups with both contaminant-based and facility-based relationships. These sites are associated with the 234-5Z PFP and 236-Z PRF buildings and are known or suspected to have received quantities of both carbon tetrachloride and plutonium. Carbon tetrachloride is considered to have indirectly assisted plutonium movement, although it did not bind with the plutonium.

- **Uranium-Rich Process Condensate/Process Waste Group (200-PW-2).** This group addresses those sites that received large quantities of total uranium (U-238), primarily from waste streams generated during the dissolution of fuel rods. The uranium inventory may range up to 38,500 kg, but a minimum inventory of 150 kg was used as the lower bound.

- **Organic-Rich Process Condensate/Process Waste Group (200-PW-3).** This group encompasses all sites that are known to have received methyl isobutyl ketone (MIBK, a.k.a. hexone), normal paraffin hydrocarbons (NPH), and tributyl phosphate from the PUREX, REDOX, URP, or Semiworks plants. These compounds were used in solvent extraction processes and are suspected of increasing radionuclide mobility in the soil column. Most organics are expected to have vaporized or biodegraded after entering the environment, but others may persist. The minimum organic cutoff quantity is 2,900 kg.

- **General Process Condensate/Process Waste Group (200-PW-4).** This group includes the remaining sites that received process condensates and wastes with lesser quantities of chemical and radiological constituents than the lower bound values for the other groups in this category.

- **Fission Product-Rich Process Condensate/Process Waste Group (200-PW-5).** Large curie inventories of Sr-90 and Cs-137 were recognized for process condensate/process waste sites across the 200 Areas. A minimum inventory of 20 Ci for either cesium or strontium qualified a site for inclusion in this group, based on potential for direct exposure.

- **Plutonium Process Condensate/Process Waste Group (200-PW-6).** This group is defined by its proximity to the 231-W plant and addresses waste sites where plutonium was the primary contaminant. Up to 340 g of Pu-239/240 and 1,373 g of Am-241 were discharged to the soil column at these sites. There is no minimum cutoff of inventory for plutonium in this group.

The ***Steam Condensate, Cooling Water and Chemical Sewer Waste*** category includes site types that were typically, but not exclusively, constructed at ground level (e.g., ponds, ditches, retention basins). In all cases, the waste streams were run in a noncontact manner; that is, a barrier separated the liquids in this category from contaminated process liquids, with little consequent potential for routine radiological contamination. However, contamination did enter these streams in generally negligible to very small quantities through pinhole leaks or through rare pipe ruptures. By virtue of the quantities of liquids used, significant inventories of contaminants were built up at the waste sites.

All separations facilities generated these three waste stream types, but only the REDOX, PUREX, and B Plant waste fractionization processes had waste sites specifically dedicated for each stream. The $BiPO_4$ processes at B, T, and U Plants discharged the three waste streams to their pond systems. Cooling water accounted for over 90% of all liquids discharged to the soil column. Chemical sewers, typically discharged to unlined ditches, were intended to receive nonradioactive, dilute chemical waste from the major solvent extraction processing facilities. Steam was used to heat process solutions at certain steps in all major process facilities, and the condensed liquid was usually discharged to cribs. There are a total of seven groups in this category, of which five are cooling water groups based on geographic locations related to major process facilities. The waste groups in this category are:

- **Gable Mountain Pond/B-Pond and Ditches Cooling Water Group (200-CW-1).** Waste sites in this group received primarily cooling water from all major facilities in the 200 East Area. Many sites are outside the fence line. The waste sites also received chemical sewer and steam condensate wastes from 221/224-B operations during $BiPO_4$ processing.

- **S-Pond/Ditches Cooling Water Group (200-CW-2).** Several ponds and ditches were used to percolate REDOX cooling water. The ponds and ditches are located south and southwest of the 200 West Area fence line.

- **200 North Cooling Water Group (200-CW-3).** Waste sites in this group include a series of cooling water ponds and cleanout trenches for the 212-Fuel Storage Basin facilities used to age "green" irradiated fuel rods. These waste sites are an isolated set of units located in the 200 North Area.

- **T-Pond/Ditches Cooling Water Group (200-CW-4).** Several ponds and ditches are associated with the multiple activities conducted at the T Plant facilities. These sites also received chemical sewer and steam condensate wastes during the $BiPO_4$ operations at 221/224-T. The waste sites are located inside the northern part of the 200 West Area fence line.

- **U-Pond/Z-Ditches Cooling Water Group (200-CW-5).** Waste sites in this group are commonly inside the 200 West Area fence line and received cooling water steam condensate and chemical sewer waste from the major process facilities in the central part of 200 West Area.

- **Chemical Sewer Group (200-CS-1).** The waste group consists primarily of ditch waste sites that received unknown quantities of inorganic and/or organic chemicals. Radionuclide inventories are very small to negligible, although several sites have a uranium component.

- **Steam Condensate Group (200-SC-1).** This group encompasses those crib waste sites to which radiologically contaminated condensate steam was discharged. These cribs tend to have significant radiological inventories due to failures or leaks in heating coils.

The ***Chemical Laboratory Waste*** category includes sites that received laboratory process wastes or laboratory decontamination wastes. Two groups were developed for this category, based largely on the potential differences in the nature of chemicals used at the 200 and 300 Area laboratories.

- **300 Area Chemical Laboratory Waste Group (200-LW-01).** Developmental laboratories in the 300 Area (324, 325, 327, 328, and 331 Laboratories) generated significant quantities of liquid wastes that were collected at the 340 Complex and transported to selected 200 Area cribs and trenches by truck or rail. In addition, cooling water contaminated by a 1965 fuel rod rupture at the 309 Reactor facility was trucked to the 216-BC Cribs area. More recently, the 340 Complex wastes have been shipped to the 204-AR Vault for disposal to the 241-A Tank Farms. The waste inventory is generally very low for all radionuclides, but instances of significant values of uranium, plutonium, and fission products are known. Several waste sites in the 200 Laboratory Waste Group (216-Z-7 and 216-S-20 Cribs) are suspected to have received this waste stream, but radiological/chemical/ volume characteristics do not allow a differentiation between the groups.

- **200 Areas Chemical Laboratory Wastes Group (200-LW-02).** In the 200 Areas, the 222 Laboratory facilities at the S, T, U, and B Plants provided analytical services for process control to the major processing plants and generated liquid wastes that were discharged to french drains, cribs, reverse wells and, for solid wastes, to underground vaults. Chemical laboratory waste sites are also known at PUREX and PFP, but are grouped elsewhere because they were combined with other waste streams at the soil column disposal sites. These waste streams are generally very low in radionuclide concentrations, although significant inventories of plutonium, uranium, and fission products are known. Sodium dichromate is reported at several waste sites. Liquid volumes are typically low.

The ***Miscellaneous Waste*** category (200-MW-1) contains most of the french drains onsite plus a few cribs and reverse wells. Most streams in this category are very low in radionuclide and chemical constituents, except for several waste streams associated with the PUREX facility, and were not routinely monitored. These sites received liquid wastes associated with plant ventilation and stack drainage, equipment decontamination, and a number of small-to-medium volume radioactive waste streams from multiple sources. Four french drains inside the 241-A Tank Farms (216-A-16, 216-A-17, 216-A-23A, and 216-A-23B) received liquids from the 241-A-431 Fan House building, but are placed in the PUREX Tank Farms Operable Unit (200-PO-3). Likewise, the 216-A-39 Crib, associated with a release at the 241-AX Tank Farms, is also grouped in 200-PO-3. Several unused sites that were built but never used (216-A-38, 216-B-56, and 216-B-61 Cribs) have been placed in this category for completeness. This category was not further subdivided into groups.

The ***Tanks/Scavenged Waste*** category consists of two groups of streams that have received the most highly contaminated wastes sent to the ground. These wastes are associated, directly or indirectly, with tank wastes collected from the $BiPO_4$ process. Both streams are characterized by significant concentrations of both radionuclides and inorganic chemicals.

- **Scavenged Waste Group (200-TW-1).** The Scavenged Wastes group was derived from certain uranium-rich $BiPO_4$ wastes generated by the URP at the 221-U Plant. The wastes were treated with a scavenging agent, ferrocyanide, that precipitated out most of the fission products remaining after uranium extraction. Treatment was initiated at the tail end of the URP and also in the 241-CR vault at the 241-C Tank Farms. Scavenged wastes were sent to the ground in limited quantities at a number of 200 East Area cribs and trenches under a specific retention discharge philosophy that restricted the volume of liquids released at any one site.

- **Tank Waste Group (200-TW-2).** The Tank Wastes Group consisted of lower activity liquids overflowed to the ground at cribs and trenches from two of the less contaminated, $BiPO_4$ high-activity tank farm waste streams. In addition, a medium-level waste stream derived from process vessel rinses and drainage was sent to the ground at cribs and reverse wells. Fission products in the waste were precipitated out during cooling and storage in the tanks, and the residual liquid was released to the ground in small to moderate quantities.

The ***Tanks/Lines/Pits/Boxes Waste*** category (200-IS-1) consists of structures used to convey or control the conveyance of waste from source generating facilities to tank farms or other processing facilities. The category consists of those facilities used to handle the high-level plant wastes generated from separations or volume reduction processes. No wastes were intentionally released to the ground from this category, but a number of unplanned releases are known. The category was established as a means to identify high-level waste lines outside tank farms and processing facilities, but with the recognition that remediation of these facilities will ultimately be associated with tank farms stabilization. Note that diversion boxes, valve pits, sampler pits, pipelines, and other waste site types constructed in support of a soil column disposal waste site will be considered within the group that waste site has been placed in.

The ***Unplanned Release*** category (200-UR-1) are waste sites resulting from the loss of control over a liquid, gaseous, or solid, radiological or hazardous material in the course of processing, handling, or shipping the material onsite. All unplanned releases not specifically associated with a waste site were categorized under the Unplanned Release category. Unplanned releases that are associated with particular waste sites are placed in that group and will be characterized with the respective waste site. No groups within this category were identified.

The ***Septic Tanks and Drain Fields Waste*** category (200-ST-1) contains sites that have received or continue to receive largely nonradioactive, nonhazardous, sanitary sewer waste. Wastes include human waste as well as shower water, janitorial and lunchroom water, and drinking water. The potential for radiological contamination does exist through the shower and janitorial sink sources, and where present, is very small. Chemical constituents such as soaps and detergents are expected in very small quantities. The quantities of liquids discharged were not tracked.

The ***Landfills and Dumps Waste*** category contains solid waste burial and debris sites and was subdivided into the following groups based on radiological inventory:

- **Nonradiological Landfills and Dumps Group (200-SW-1).** This group covers a number of waste sites including large volume contaminants placed in specific engineered locations, such as powerplant flyash at the 284-E and 284-W ashpits, and the Nonradioactive Dangerous Waste Landfill (NRDWL) and Solid Waste Landfill (SWL) for unused laboratory and plant chemicals. Small to medium construction debris and dump sites are known, and recent discovery sites are tracked in the WIDS.

- **Radiological Landfills and Dumps Group (200-SW-2).** Sites included in this group consist of constructed or excavated sites (218 Burial Grounds) that received either low-level or transuranic (TRU) wastes. Ten major burial grounds with a number of trenches in each were or continue to be used in both the 200 East and 200 West Areas. Prior to 1970, TRU and low-level wastes were disposed to the same burial ground trenches, but wastes were thereafter segregated according to the low-level or TRU designation. TRU was placed in underground concrete caissons at burial grounds after 1970. Wastes were largely solid materials and mostly from onsite; but off-site and liquid wastes (tightly packed and sealed in drums) are known. These waste sites have the highest inventory of radionuclides of soil column disposal sites.

Plate I provides a pictorial overview of the waste sites included in the 200 Areas Implementation Plan and reflects the locations of waste sites contained within each waste site group. Only the Unplanned Releases Group (200-UR-1) has not been included due to the diversity of locations where these waste sites are found. This plate also identifies areas that are outside of the 200 East and 200 West Areas, such as 200 North and other outlying 600 Area locations that are included in the scope of this document. In addition to color coding the sites within a group and providing the WIDS designation for each waste site, the boundary locations of the former geographically based operable units are also provided. Sites that have been selected as representative sites, and RCRA TSD units, are also shown. Plates II and III provide a closer view of the locations of the waste sites within the 200 East and 200 West Areas, respectively.

The waste sites assigned to groups were based on information available at the time the *Waste Site Grouping for 200 Areas Soil Investigations* (DOE-RL 1997) was prepared. It is possible that new information may be discovered that would indicate the site belongs in a different group, or that the waste site designation is duplicated elsewhere in WIDS. A number of changes would be necessary, including group redesignation in the WIDS, which is considered to be part of the Tri-Party Agreement. Such changes would require approval of Tri-Party Agreement signatories and alteration to Appendix C of the Tri-Party Agreement. A procedure for revising the WIDS is presented in the Tri-Party Agreement Handbook, RL-TPA-90-0001, Management Procedures "Maintenance of the Waste Identification Data System," Guideline Number TPA-MP-14 (DOE-RL 1990).

The evaluation in the Waste Site Grouping for 200 Areas Soil Investigation report (DOE-RL 1997) was based on a systematic review of available historical data including AAMS reports, the WIDS, and other documents. Each waste site's waste stream description, as well as chemical and radiological inventory data, was used to determine its placement within one of the 23 groups. Representative typical and worst-case waste sites were selected, based on inventory, operational history, notable unplanned releases, and volumes of liquid received to provide a balanced, yet bounded, set of characterization data.

3.2.4 Waste Group Prioritization Process

The Waste Site Grouping for 200 Areas Soil Investigation report (DOE-RL 1997) provided an initial prioritization of the 23 waste groups, according to a broad set of technical criteria that address a number of factors related to groundwater impacts and level of characterization and chemical knowledge, geographic location, implementability of characterization and remediation, and the ability to show progress. The factors weighted the highest included the potential for future degradation of groundwater, the presence of mobile contaminants, poor understanding of chemistry affecting contaminant fate and transport, the presence of several good representative sites for a large group, and sites/groups where characterization/remediation would be relatively easy. The prioritization weighed the current level of knowledge of a waste group's contamination inventory and migration potential and the ability to easily improve on that knowledge versus the risk associated with that group.

Table 3-2 provides the complete list of the prioritization criteria. Each question was posed for each group and was applied for all waste sites in that group. A YES answer was scored according to the relative importance of the question (Low = 1, Medium = 3, Medium-High = 4, High = 5, NO = 0, maximum score = 42). The sum of the individual scores for each group became the basis for the "technical" prioritization of all groups.

The ability to demonstrate significant progress in the 200 Areas characterization and remediation program was considered to be important. Factors considered important to prioritizing groups for this purpose included geographic (outside 200 Area fence lines, broad contamination areas) and waste site types (shallow contamination, more easily and cost-effectively characterized and remediated) considerations. This led to the selection of the next most highly prioritized groups, typically the cooling water pond and ditch systems. Several groups were not ranked or ranked very low, because of the potential for long-term uses of the specific waste sites (e.g., operational considerations). The Radioactive Landfills and Dumps, Septic Tanks and Drain Fields and Tanks/Lines/Pits/Boxes categories/groups were regarded as being required "long-term" for future facility cleanup efforts, represented little threat for environmental/exposure hazards, and were not easily closed until other work on site was completed.

A second administrative screen was then applied to the technical prioritization of waste groups. The administrative prioritization was conducted with the intent of melding existing TPA requirements for performing both RCRA TSD and CERCLA operable unit characterizations. The Tri-Party Agreement (Ecology et. al, 1994) has specified the following items as important to prioritizing remediation efforts:

- Volume of wastes or hazardous substances,
- Hazardous substances identification and classification,
- Toxicity or health effects of the hazardous substances,
- Potential for migration to receptors via all environmental pathways,
- Available technology to investigate/remediate operable unit,
- Operation considerations (timing of decommissioning activities),
- Considerations to those operable units that include TSD Units.

The first six TPA criteria are consistent with the criteria applied in DOE-RL 1997. The last bullet "Considerations to those operable units that include TSD Units", and the objective of coordinating RCRA closure plans and CERCLA work plans, was the primary criteria used to adjust the technical ranking. The TPA major milestones M-20-00 requires that all RCRA TSD Closure/Postclosure plans will be submitted for approval by 2004.

The first consideration was whether there was any immediate need for an Expedited Response Action at sites/groups where chemical or radiological contamination posed an imminent threat to human health and the environment. The carbon tetrachloride plume at 200-ZP-1 and the uranium/technetium-99 groundwater plume at 200-UP-1 were considered to have the greatest impact but were considered to be adequately addressed by the respective pump-and-treat programs and by the 200-ZP-2 soil vapor extraction program. Assuring that there was no longer an imminent health threat, the remaining criteria from the TPA "consideration of those Operable Units that contain TSDs" was then applied to the technical prioritization list. As a result, those waste site groups with RCRA TSD units scheduled for closure were given a higher ranking. Although it has no TSDs, the 200 North Cooling Water Group was placed first as it is analogous to 100 Area sites which are currently in the process of being remediated. Table 3-3 provides a comparison between old and new waste group prioritization.

Additional considerations were also factored into this prioritization list revision. The groups chosen will provide the opportunity to begin characterizing and remediating large areas outside the 200 Area fence lines. A wide variety of both fate and transport contaminant models, as well as conceptual exposure models can be tested with the wide variety of sites and waste streams in these first six groups. The groups chosen will allow testing and refinement of the RCRA/CERCLA integration techniques discussed in Section 2.0 of this document. Other groups will be prioritized in expected accordance with the technical prioritization list in DOE-RL 1997 at a later date.

Only the first six of the 23 waste groups have been specifically defined in the TPA, along with a schedule for the remaining 17 waste groups (see Figure 7-1). As progress is made and additional knowledge is gained in the 200 Areas, more priorities will be established and the remaining 17 waste group priorities will be defined. At least annually, waste group prioritization will be reviewed to consider the additional knowledge gained, and groundwater and vadose zone integration needs across the site.

3.2.5 Major Potential Contaminants

The preceding discussions in Section 3.2 and Appendices G and H present the sources of radionuclides and major processing chemicals used in the 200 Areas. The following summarizes those constituents introduced to the 200 Areas in sufficient quantities to potentially require remediation activities. In addition, this section helps identify additional contaminants that, while not introduced in large quantities, may impact remediation activities due to their extreme toxicity or other potential hazards. Not all identified contaminants will need to be measured at all sites. Specific DQO activities are expected to identify those contaminants on the "master" list that are appropriate for each waste group. The "master" list may be added to, as needed, to reflect new information or site-specific data needs.

3.2.5.1 Radionuclides. Potential radionuclide contaminants are listed in Table 3-4. Note that while samarium-151 (Sm-151) has received little attention in the past, it becomes a significant fraction of total fission product activity after approximately 25 years of decay and will remain significant for up to 1,000 years (100-year half-life). The necessity for analysis of Sm-151 is being evaluated at this time.

All other radionuclides potentially present in the 200 Areas but not included in Table 3-4 are (1) directly tied to the isotopes identified above as descendent daughters (e.g., Sr-90 daughter yttrium-90 [Y-90]) and may be calculated from the parent activity; (2) fission/neutron activation products with less than 0.01% of the Cs-137 or Sr-90 activity (e.g., I-129, selenium-79 [Se-79]) that cannot be readily separated from the major fission product activity contributors for analysis; or (3) alpha-emitting isotopes of the same element in concentrations less than 1% of the primary isotope (e.g., Pu-242 in Pu-239) that cannot be resolved during analysis. It is assumed that minute amounts of additional activity potentially present from radionuclides that are not analyzed for will have no significant effects on remediation decisions.

3.2.5.2 Inorganic Chemicals. Most of the chemicals used in the 200 Area processing were inorganic. The potential inorganic chemicals of concern are listed in Table 3-5. Analyses for inorganic chemicals do not routinely determine chemical compounds (e.g., sodium nitrate), but rather the ionic building blocks that comprise the compounds (e.g., sodium and nitrate separately). Analyses for metals routinely detect a suite of metals that include many relatively innocuous metals (e.g., sodium, iron, aluminum) introduced in large quantities in the 200 Areas. They have not been included in Table 3-5 because even massive concentration levels are not expected to impact remediation decisions.

3.2.5.3 Organic Chemicals. Unlike inorganic chemical analyses, most organic chemical analyses determine specific chemical compounds (or compound groups [e.g., PCBs]). Table 3-6 lists the potential organic contaminants of concern in the 200 Areas.

3.2.5.4 Other Chemicals. Chemicals loosely identified as "complexants" were used in the 200 Areas. These materials range from components of laundry detergents to boiler water treatment compounds to specific complexants such as ethylenediaminetetraacetic acid (EDTA), N-hydroxyethylenediaminetriacetic acid (HEDTA), and citric acid. The largest process use of specific complexants was in the waste fractionation processes (1963-1983) at B Plant. However, these materials were also used in other facilities for cleanout operations and, potentially, cleaning up after plant process upsets. In general, complexants were used to help solubilize materials or assist in keeping components in solution. Most of these compounds are, in themselves, low in toxicity (most of the complexants used at B Plant are available in "food grade" specification). The concern at the 200 Areas is that these materials may increase the solubility of toxic, radioactive, or hazardous materials normally strongly retained on Hanford soils. Unfortunately, there are no simple or readily available analytical techniques for detecting complexant compounds in environmental-type samples. Strategies for dealing with complexants will be developed during group-specific DQOs and sampling and analysis plans.

3.3 CONTAMINANT/SOIL INTERACTIONS

This section presents an overview of the physical and chemical interactions that may occur when wastes from various sources come into contact with the soil column in the vadose zone underlying the source disposal facilities. The characteristics of the waste streams and the sediments, the properties and behavior of the radiological, inorganic, and organic contaminants, and the principles that affect contaminant distribution within the vadose zone provide guidance for (1) designing characterization and remediation activities and (2) assessing the potential for groundwater contamination. The objective of this discussion is to provide the generalized physical conceptual model of contaminant distribution within the 200 West and 200 East Areas. The contaminant fate and transport phenomena are used to support identification and exposure pathways for the major categories of 200 Areas waste streams in Chapter 5.0.

This discussion provides generalized information common to all waste site groups. Preliminary physical conceptual models of contaminant distribution are presented for each waste group in the *Waste Site Grouping for 200 Area Soil Investigations* (DOE-RL 1997). Collectively, this information will provide the foundation for developing consistent site-specific conceptual models of contaminant distribution in individual group-specific work plans.

3.3.1 Physical and Chemical Interactions in the Vadose Zone

The vertical and horizontal distribution of a contaminant in the soil column beneath waste sites is generally dependent on the waste stream's physical properties, which determine how easily and far the waste stream (e.g., water) can migrate, and on the contaminant's chemical properties, which determine its ability to adhere to or react with soil particles along the migration pathway. The major processes affecting transport or retention of chemicals discharged to the vadose zone include precipitation/dissolution, adsorption/desorption, filtration of colloids and suspended particles, and diffusion into micropores within mineral grains (Serne and Wood 1990). Of these processes, precipitation/dissolution and adsorption/desorption are considered the most important.

Other characteristics that can affect the contaminant/soil interaction include the operational characteristics of the disposal unit and the site-specific geological and geochemical properties of the soil column. Because the 200 Area waste streams were generally low salt and neutral to basic pH and because Hanford sediments are generally basic in nature, the behavior of specific contaminants in the soils is generally the same from site to site and primarily dependent on the contaminant's own chemical properties. However, some waste streams contained other constituents such as organics or acids that can alter the contaminant's soil affinity, resulting in either greater or lesser mobility relative to the "typical" situation. The impact of 200 Area site conditions on the mobility of waste water and associated contaminants is summarized conceptually in Table 3-7.

The generalized physical conceptual model of contaminant distribution focuses primarily on the deposition and distribution of contaminants that occurred during the active water discharge phase of the waste site operations. However, wastes discharged to the soil column included solid wastes and volatile liquids that produce vapor-phase contaminants. Both solid and vapor-phase contaminants may be dissolved and carried downward by migrating water. Vapor-phase contaminants may also be transported downward, upward to atmosphere, and/or laterally by migrating soil vapor and may spread by diffusion within soil vapor.

Active discharges provided the primary driving forces for contaminant transport through the vadose zone and in some cases to groundwater. Since cessation of waste discharges, only natural recharge and, in some cases, influences from currently minor artificial sources of recharge are available for continued contaminant transport. However, these driving forces are considered to be much less significant now and in the future relative to the past active discharges.

3.3.1.1. Factors Affecting Contaminant Mobility. A general measure of a contaminant's distribution between soil and water is the soil-water distribution coefficient K_d. This coefficient is experimentally derived and is usually expressed in units of milliliters per gram. A relatively high K_d value indicates that the contaminant will tend to be retained on the soil particles and thus indicates a relatively low mobility whereas a relatively low K_d value indicates that the contaminant will tend to remain dissolved in the water and thus indicates a relatively high mobility (Appendix F). The relative mobility of specific radiological, inorganic, and organic contaminants commonly discharged to 200 Area waste sites is summarized in Table 3-8.

The K_d for a contaminant can be significantly affected by the following:

- The pH of the wastewater and the ionic strength
- The mineral and organic composition of the soil
- The ionic composition of the soil pore water
- Other site-specific factors such as the formation of chemical complexes.

Examples of variation in K_d values for selected radionuclides based on the salt content of the waste solution are presented in Table 3-9.

Effects of pH and Ionic Strength. The pH of the wastewater can increase the mobility of radionuclides such as plutonium and cesium. However, the alkaline nature of the Hanford sediments (due to carbonate content) tends to buffer acidic waste discharges such that the acidity is neutralized quickly near the point of discharge. For example, Johnson (1993) showed that for the 216-Z-20 Crib in the 200 West Area, a 1-m thickness of soil beneath the crib was capable of neutralizing 4×10^9 L of pH 5 water. Contaminants in acidic wastewater are driven deeper into the soil column as the buffering capacity of the soil is exceeded by higher discharge volumes.

Although many contaminants may become more mobile in an acidic environment, increased alkalinity can also increase mobility of some contaminants. For example, although plutonium is typically one of the least mobile of the Hanford contaminants, plutonium mobility is known to increase moderately at pH values above 8.

For some inorganic contaminants, ion exchange is the dominant mechanism leading to desorption. High ionic strength (high salt content) tends to drive the equilibrium toward desorption rather than sorption.

Effects of Composition of Soil. Because Hanford soils are generally neutral to alkaline, there is a net negative charge on the soil particles that facilitates sorption of positively charged cations. Conversely, anionic species that have negative charges are either only weakly sorbed or not sorbed at all.

Mineralogy affects the abundance of sorption sites as well as the availability of ions for precipitation. For example, clays are more sorptive than sands. Also, the clay minerals (e.g., montmorillonite) present in Hanford sediments are the varieties with the greatest exchange capacities.

Sorption increases as soil (sorbent) particle size decreases. Filtration and ion exchange also increase with decreased soil grain size. Filtration effects are more pronounced for contaminants that form insoluble precipitates.

For organic contaminants, partitioning to the soil from the water is affected by the organic carbon content of the soil. The soil/organic matter partition coefficient K_{oc} is an empirical measure of distribution between organic carbon content of the soil and the water phase. K_d is related to K_{oc} according to the relationship $K_d = K_{oc}f_{oc}$, where f_{oc} is the fraction of organic carbon present in the soil. Hanford soils are low in organic carbon content, less than 0.1 wt%, and therefore, estimated K_d s for the principal organics of concern are generally less than 1, indicating high mobility.

In general, the organic compounds that are more soluble in water (acetone, hexone, alcohols, acetone, organic acids, methyl ethyl ketone, chloroform, aldehydes, and ketones) are less likely to adhere to soils, whereas the compounds that are less soluble in water (carbon tetrachloride, trichloroethylene [TCE], TBP) will adsorb more strongly to soils. Clays and organic matter will favor adsorption of organic solutions.

Effects of Organics and Chemical Complexes. Discharges of organic compounds may also affect mobility by complexing the contaminants. Organic mixtures containing compounds such as hexone, tributyl phosphate (TBP), and carbon tetrachloride were used in the chemical processing plants to separate product components (e.g., plutonium, uranium, americium) from irradiated fuel and its processed derivatives. These organic solvents were effective extractants because of their ability to form stable complexes with the extracted components. Disposal of wastes containing residual concentrations of these organic complexes may have increased the mobility of the contaminants relative to streams not containing the organics.

Sites receiving liquid wastes with surfactants (soaps and detergents) may have contamination at greater depths.

Other Effects. Effects of other factors on contaminant mobility include:

- Valence state. Generally, multivalent ions are more strongly sorbed than univalent ions with similar ionic radii.

- Chemical process. Uranium mobility is affected by the specific form of the uranium compound present as a result of the chemical process that created the waste. Uranium associated with phosphates can form insoluble precipitates that are not mobile. However, in nitrate form or in combination with carbonates, uranium tends to be highly mobile. For example, the transport of uranium to groundwater in the 216-U-1/U-2 Crib system is believed to have resulted from mobilization of uranium present in the crib as a phosphate precipitate by acidic wastes that were discharged to an adjacent crib.

- Contaminant particle size. Deposition of the contamination increases with increasing particle size through precipitation and filtration in the soil media.

- Volume of discharge. Hydrostatic forces are the primary driving force for contaminant migration, so that discharges that maintain saturated conditions in the vadose zone result in more rapid downward migration.

- Lithology. Variations of the soil stratigraphy with depth, such as the presence of low-permeability layers, may increase the length of the flowpath for contaminant migration and thereby slow the rate of descent.

- Wells. Poorly sealed wells may provide a conduit by which contaminants may flow through the vadose zone to the groundwater, bypassing the soil column.

- Clastic Dikes. Clastic dikes, which occur most frequently in the Hanford formation, may provide preferential pathways or barriers for liquid and vapor flow.

- Vegetation. Vegetation or other organic matter (e.g., algae) present in sites such as ponds and ditches may provide some uptake of radionuclides. Alternately, root action in pond or ditch sediments is regarded as maintaining or improving percolation rates.

Natural Attenuation. Natural attenuation relies on natural processes to lower contaminant concentrations through physical, chemical, and/or biological processes, including biodegradation, sorption, oxidation-reduction reactions, and radioactive decay (Appendix D). Contaminants in the discharged waste streams may be reduced or immobilized as a result of interactions with the soils in the vadose zone, thus contributing to natural attenuation of the contaminants.

Biodegradation affects the persistence of organics in the subsurface. Biodegradation of water-soluble organics is more rapid under the oxidizing conditions found in Hanford soils, whereas the rate of biodegradation of the less soluble organics tends to be very slow.

Because of their lower soil adhesion and greater biodegradability, solvents such as hexone and NPH do not generally persist in Hanford soils, whereas solvents such as carbon tetrachloride, because of higher soil interaction and low biodegradability, are generally highly persistent.

Increased volatility generally decreases the persistence of organic contaminants. Organics such as carbon tetrachloride, TCE, and chloroform are highly volatile, whereas TBP and NPH are less volatile. Volatile contaminants may be naturally removed from the vadose zone to atmosphere through "barometric pumping."

Sorption may immobilize contaminants within the vadose zone, minimizing or preventing their further migration. For radioactive contaminants, sorption may provide sufficient time for decay to reduce the concentration to negligible levels.

Oxidation-reduction reactions between contaminants and natural soil constituents can transform contaminants into less mobile or less toxic forms. For example, iron is immobile in an oxidized state, whereas chromium is immobile in a reduced state. Oxidation-reduction conditions can affect the extent and rate of breakdown of chlorinated organic contaminants.

Persistence data for radionuclides are based on their decay rates, or half-lives. Half-lives of some of the principal radionuclides are listed in Table 3-9.

3.3.1.2. Factors Affecting Contaminant Distribution. Contaminant distribution below disposal units is generally affected by the volume discharged and the type of disposal unit. The volume of liquid discharged to a waste site impacts the distribution of contaminants through its effect on the moisture content of the soil column. Discharges that maintain saturated conditions in the vadose zone result in deeper contaminant distributions. Relative volumes of waste streams, organized by waste site group, are summarized in Table 3-10 based on dates from DOE-RL 1992a, Appendix A. The type of disposal unit is also indicated for each group. Appendix G, Section G1.2.2, discusses aspects of waste site design on contaminant distribution in more detail.

The overview of waste site group characteristics provided in Table 3-10 uses a relative scale (high, medium, low). For example, a bold circle under the characteristic "volume" indicates generally high volume. Relative volume was ranked by calculating the average water volume discharged to soil column sites. In general, a volume ranking of "high" indicates greater than 2 billion L/site (500 million gal/site); a ranking of "medium" indicates between 2 billion L/site and 60 million L/site (between 500 million gal/ site and 20 million gal/site); and a ranking of "low" indicates less than 60 million L/site (less than 20 million gal/site). Relative contaminant concentration was ranked primarily on the basis of radionuclide concentrations. Relative contaminant mobility was ranked based primarily on the presence of uranium or organics (Table 3-8).

The waste stream characteristics ranked in Table 3-10 also indicate general similarities among waste groups within a single category. For example, waste groups in the process condensate/process waste category tend to be low to medium volume with a high concentration of radionuclides, providing a medium to high contaminant mass. For isolation purposes, these waste groups were discharged primarily to cribs or trenches. Waste groups in the steam condensate/cooling water/chemical sewer category tend to be high volume with a low concentration of radionuclides, providing a low to medium cumulative contaminant mass. These waste groups were all discharged to ditches and ponds.

Contaminant distribution below waste disposal units is also affected by the type of disposal unit and the source of wastewater. Some generalizations with regard to these aspects are:

- Pond sites (and associated ditches) may have accumulated significant inventories of contaminants due to the large quantities of water discharged to the sites.
- Cribs generally received waste streams with somewhat higher concentrations of radionuclides for long periods of time.
- Reverse wells received smaller quantities of more contaminated wastes relative to crib waste and introduced that waste deeper into the soil column.
- Specific retention trenches and cribs were used with the intent of not saturating the soil column so that small volumes of some of the most contaminated waste streams could be discharged to the ground. Trenches and cribs tended to receive waste with higher levels of chemical constituents.
- French drains received small volumes of waste from miscellaneous nonprocess sources that had generally low concentrations of contamination.

Some of the concepts associated with the migration of contaminants in the 200 Area vadose zone are illustrated schematically in Figure 3-2. For the purposes of this discussion, two disposal scenarios are illustrated: near-surface infiltration and deep injection (through engineered or natural preferential pathways that bypass much of the vadose zone). Although intentional deep injection of contaminated liquids did occur in the 200 Areas, it was rare; near-surface infiltration was the usual disposal method.

The placement of monitoring wells relative to the waste disposal site can affect the interpretation of the contaminant distribution. For example, a well that is closer to the disposal site and relatively shallow will tend to encounter the less mobile contaminants. The least mobile contaminants may not have migrated laterally beyond the "footprint" of the disposal site or very far vertically within the vadose zone.

The degree of lateral spreading of waste water and contaminants is affected by the characteristics of the sediments: in coarser grained gravels, which typically are homogeneous and isotropic, lateral spreading tends to be minimal; in finer grained sands and silts, which typically are inhomogeneous and anisotropic, lateral spreading tends to extend further. Lateral spreading is usually most significant at contacts between coarser and finer grained layers.

3.3.1.3 Preliminary Physical Conceptual Model of the Contaminant Distribution. A generalized physical conceptual model of contaminant distribution within the 200 West and 200 East Areas, incorporating the concepts included in the individual waste group physical conceptual models (DOE-RL 1997), is presented in Figure 3-3. The vadose zone stratigraphy and a depiction of how contaminants may be distributed on the basis of typical relative mobility are illustrated separately for the 200 West Area and 200 East Area. Identifying specific information that is available or needed for each waste site group will be addressed through the DQO process that is an integral part of developing the individual group-specific work plans. The key characteristics that are used to model contaminant migration in the vadose zone and groundwater flow in the aquifer are listed for reference in separate boxes on the right-hand side of the figure.

The physical conceptual model of contaminant distribution in the 200 Area vadose zone includes the following, more specific predictions and assumptions:

- Highly mobile contaminants (tritium, I-129, and Tc-99) are believed to have already migrated to the groundwater from the waste sites for as long as active liquid waste discharge kept the intervening soil column saturated. Significant migration of these contaminants beyond the cessation of discharges (and some period of residual drainage following the cessation) is not expected unless a new and significant driving force is added at the sites.

- Lateral spreading will occur in stratified soils and where the vertical permeability is less than the horizontal permeability. However, lateral spreading of contaminants at depth is not expected to exceed 15 to 30 m beyond the facility centerline unless there is a significant impermeable zone beneath the waste site that creates a perched water condition. High-volume streams where continuous discharges or large-volume batch releases occurred favor greater lateral spreading when compared to those sites that received lower volumes of waste. The contaminant concentrations generally decrease as distance increases from the point of discharge. Although data are limited, lateral spreading is known at the 216-B-7A/7B, 216-B-57, 216-B-43/47, and 216-S-1/2 Cribs (Fecht et al. 1972).

- Maximum radionuclide contaminant concentrations are generally expected beneath the point at which the waste stream enters the soil column or waste site and decrease with depth. Typically, the highest concentrations of contaminants such as plutonium, cesium, and strontium are expected within 2 to 3 m below the point of discharge and are at near-background levels 20 m below the bottom of the waste site.

- Radionuclide contaminants generally concentrate in and just above fine-grained horizons rather than the coarser units. In general, whether in coarse or fine-grained units, the radionuclides are found to be associated with the silts and clays in the formations, which are present as 1% to 10% of the units by weight. The 200 East Area geologic units are composed of more coarse-grained units than those in the 200 West Area. The 200 West Area is further distinguished by the presence of the Plio-Pleistocene (caliche) unit, which has a much lower hydraulic conductivity than adjacent units because of the presence of calcium carbonate cemented silts, sands, and gravels. Lateral spreading is most common when facilities overlie these units.

- Downward contaminant movement may have been accelerated at several cribs by poorly sealed wells or continuous clastic dikes.

- Moderate half-life contaminants (Cs-137, Sr-90) are expected to have decayed or will decay to negligible quantities for most sites within 100 to 200 years. Shorter half-life contaminants such as Co-60, Ru-106, or tritium will decay to negligible levels in even shorter time frames.

3.3.2 Vadose and Groundwater Contamination

Completed vadose zone and groundwater characterization studies in the 200 Areas are summarized in Table 3-11 and represent the existing RI/FS data, based on laboratory analytical results. These characterization results indicate that contaminant concentrations are generally highest within approximately 6 m (20 ft) below the bottom of the waste disposal facility and that concentrations tend to decrease with depth. This document's physical conceptual model of contaminant distributions was formulated to include these specific examples of documented contaminant distributions and the general understanding of contaminant response in the Hanford soil column.

A physical conceptual model of contaminant distribution will be developed for each waste group in the group-specific work plans to describe how the contaminants are believed to be distributed within the soil column. For each waste group, the representative worst-case and typical sites will be carefully characterized to provide bounding cases for testing the conceptual model. The specific characterization plans will be determined through group-specific DQO sessions and further documented in group-specific sampling and analysis plans. The results of these detailed characterization activities will be used to further refine and strengthen the group-specific conceptual models. Prior to implementing any proposed remediation for the waste group, each site in the waste group will be characterized to confirm that it is consistent with the conceptual model for the entire waste group. Based on this confirmatory characterization, the conceptual model will be further refined or the specific waste site will be moved to a waste group with an appropriate conceptual model.

The purpose of the initial characterization of the representative waste sites and the follow-on confirmatory characterization of all of the waste sites is to ensure that any unexpected circumstances affecting contaminant distribution are investigated prior to selecting a remedial alternative. During the DQO sessions, careful consideration will be given to all contaminants of concern, including those believed to be typically less mobile, so that characterization depths and analytes are not based on broad assumptions. Thorough, specific characterization will proceed based on the consensus of the DQO participants.

The principal waste sites that have been associated with contamination of the vadose zone in the 200 Areas, as presented in the *Hanford Site Groundwater Monitoring Report for FY 1997* (Hartman and Dresel 1998), are shown in Figure 3-4. The sites shown are the subsurface disposal and storage sites with the largest contaminant inventories. The figure includes listings of the major contaminants for various groups of waste sites and an indication of each contaminant's relative mobility in the vadose zone. As indicated in the figure, special conditions may increase the relative mobility of a contaminant. In addition, if a preferential pathway is available (e.g., an open borehole or a borehole with an incomplete annular seal), relatively immobile contaminants could still be found at depth in the vadose zone. Numerous other waste sites not shown in Figure 3-4 may also have contributed to deep vadose zone contamination underlying the 200 Areas. A comprehensive list of waste sites that have impacted groundwater is not known at this time.

The contaminants that are most mobile in the vadose zone are carbon tetrachloride, chromium, cyanide, I-129, nitrate, Tc-99, H-3, and uranium. These contaminants are most likely to reach groundwater and, therefore, groundwater monitoring programs are designed to detect these constituents.

The chemical and radiological groundwater contaminant plumes for the Hanford Site are shown in Figures 3-5 and 3-6, respectively (Hartman and Dresel 1998). These figures portray the distribution of contaminants that have been detected in groundwater at concentrations exceeding the limits stated in the legend. The figures also indicate that the less mobile contaminants are not associated with groundwater plumes.

It is clear from these plume maps that contaminants from former waste disposal activities in the 200 Areas have migrated, in a dissolved phase, vapor phase, and/or separate organic liquid phase, through the vadose zone to groundwater. The widespread plumes for certain contaminants are the product of (1) past disposal practices, which involved much greater volumes of water than current waste streams, and (2) the time available since those practices ended for groundwater to disperse the contamination. It should be noted that the capacity for Hanford soils to adsorb radioactive contaminants was integral to the original design of the disposal facilities. Unanticipated production demands, which influenced volumes and characteristics of wastes, occasionally caused these facilities to receive more wastes than originally planned.

The likelihood of creating new plumes of equal magnitude to those created during the operating years is low. The absence of a mechanism to drive contaminants downward to groundwater (i.e., massive volumes of liquid waste that can saturate significant portions of the vadose zone) supports this conclusion. However, future scenarios that could result in significant amounts of new contamination reaching groundwater are plausible. These scenarios could include a catastrophic loss of liquid wastes from containment facilities; a preferential pathway through the vadose zone to groundwater, such as improperly sealed boreholes; and/or increased infiltration of moisture from the surface, which in some areas might remobilize contamination remaining in the vadose zone from former disposal activities. Increased infiltration could be caused by human activities (e.g., major water line leaks or future irrigation) and/or natural events (e.g., future climate changes).

The less mobile constituents in the vadose zone, Cs-137, Sr-90, and Pu-239/240, have each reached groundwater in the 200 Areas based on localized detections, often at single wells or associated with a 200 East Area injection well (Hartman and Dresel 1998). Because even the less mobile constituents still have a general tendency to move downward in the vadose zone, continued groundwater monitoring for their presence remains important.

Three expedited or interim response remediation activities have been undertaken in the 200 West Area to contain the existing groundwater plumes and remove contaminant mass. Soil vapor extraction has been in use since 1992 to remove carbon tetrachloride from the vadose zone at its source disposal sites to prevent further degradation of groundwater quality. Groundwater pump and treat has been in use since 1994 to remove carbon tetrachloride from the aquifer in the zone of highest dissolved carbon tetrachloride concentrations. Groundwater pump and treat has also been in use since 1994 to remove primary contaminants uranium and Tc-99 and secondary contaminants carbon tetrachloride and nitrate from the aquifer in the zone of highest dissolved uranium and Tc-99 concentrations.

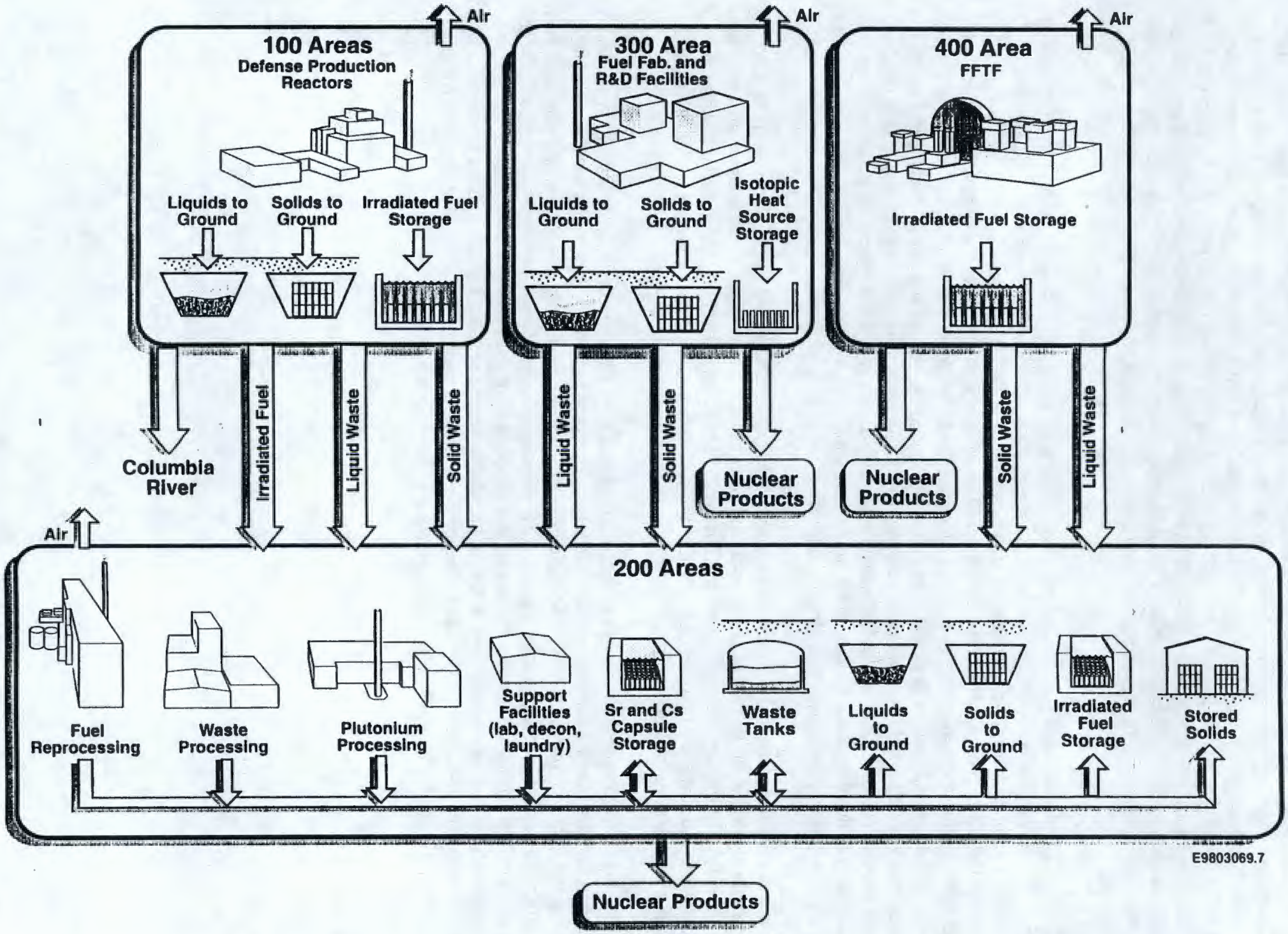
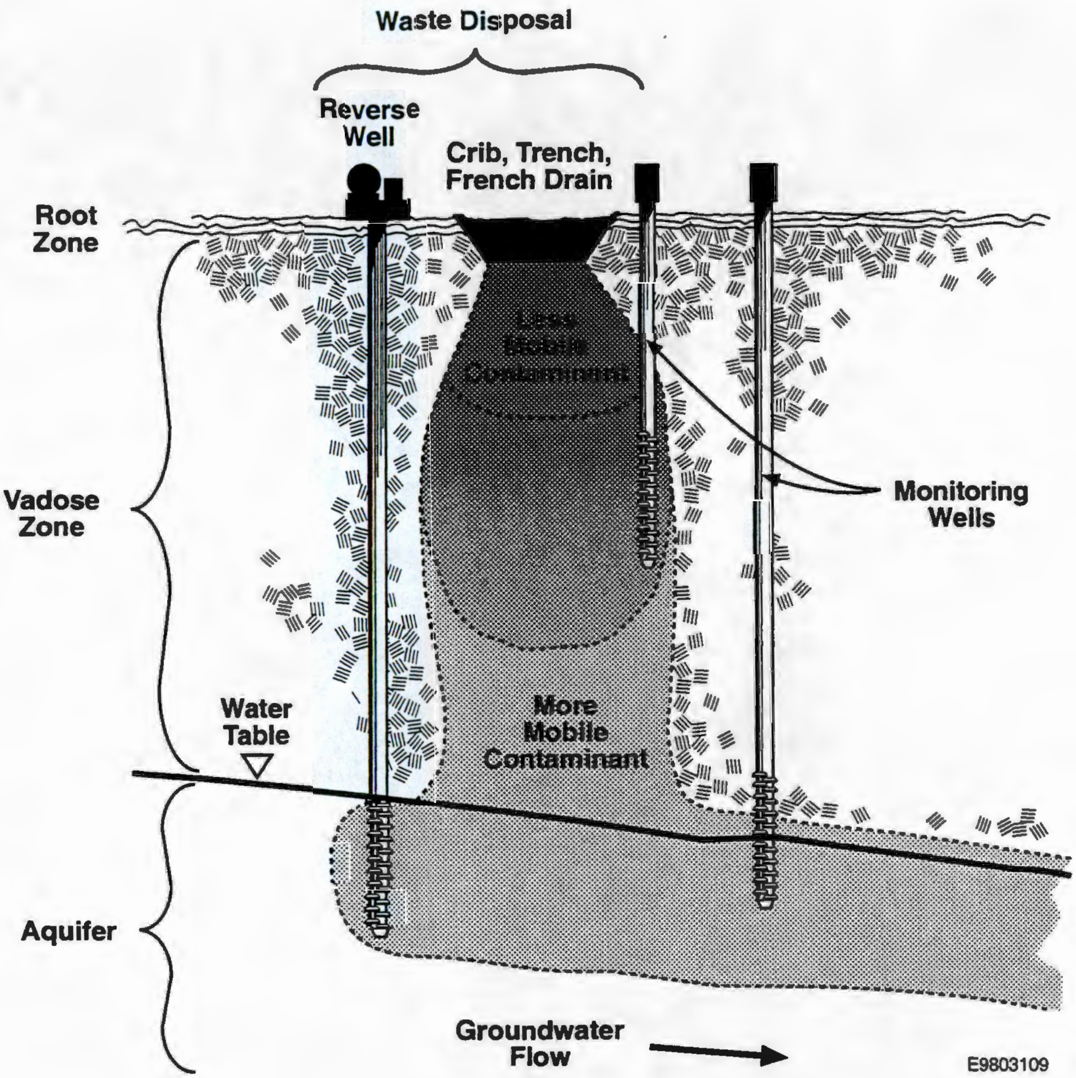


Figure 3-1. Hanford Site Radioactive Material Flow Diagram.

Figure 3-2. General Concepts of Contaminant Distribution Beneath 200 Areas Disposal Facilities.



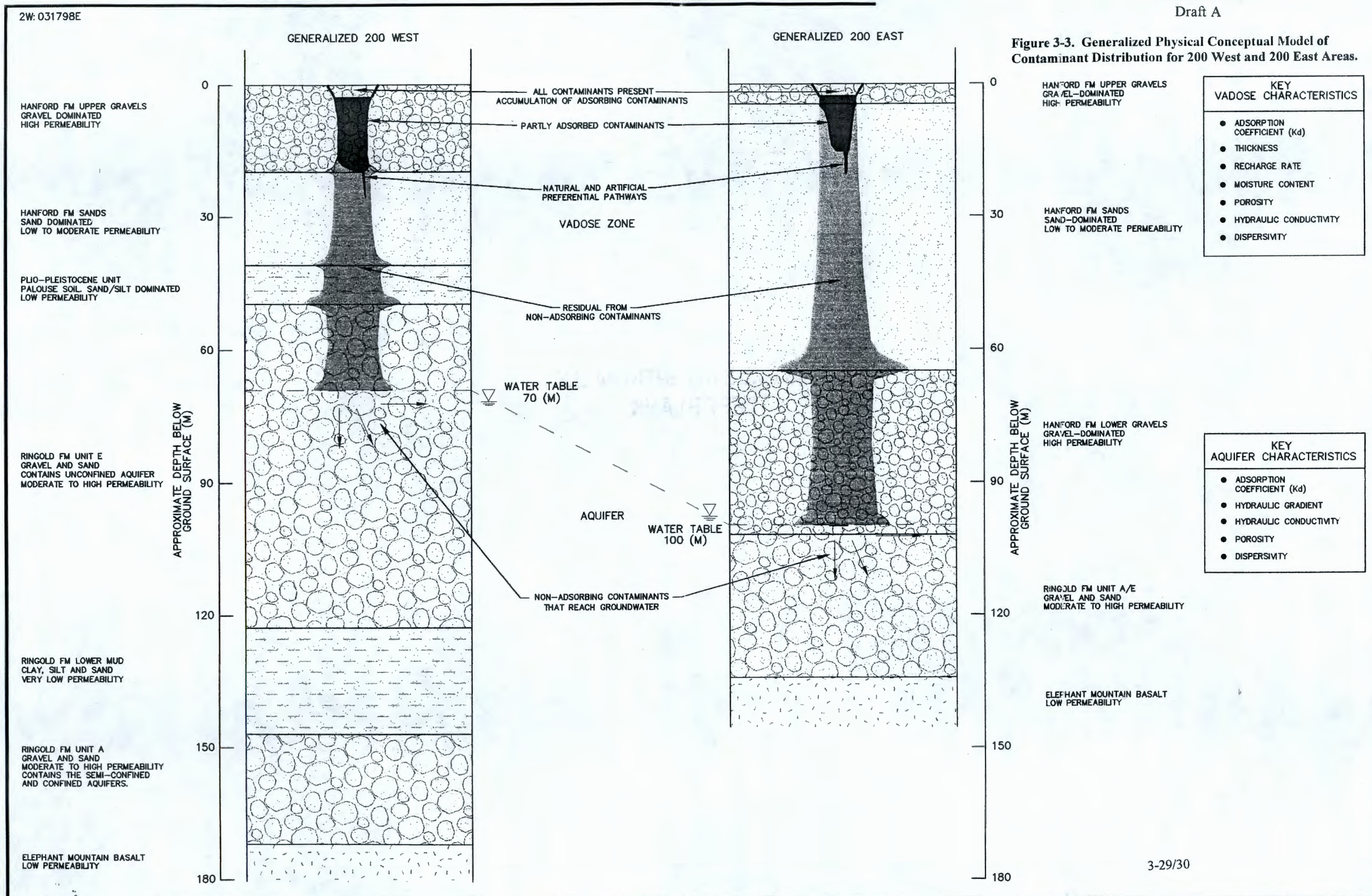


Figure 3-3. Generalized Physical Conceptual Model of Contaminant Distribution for 200 West and 200 East Areas.

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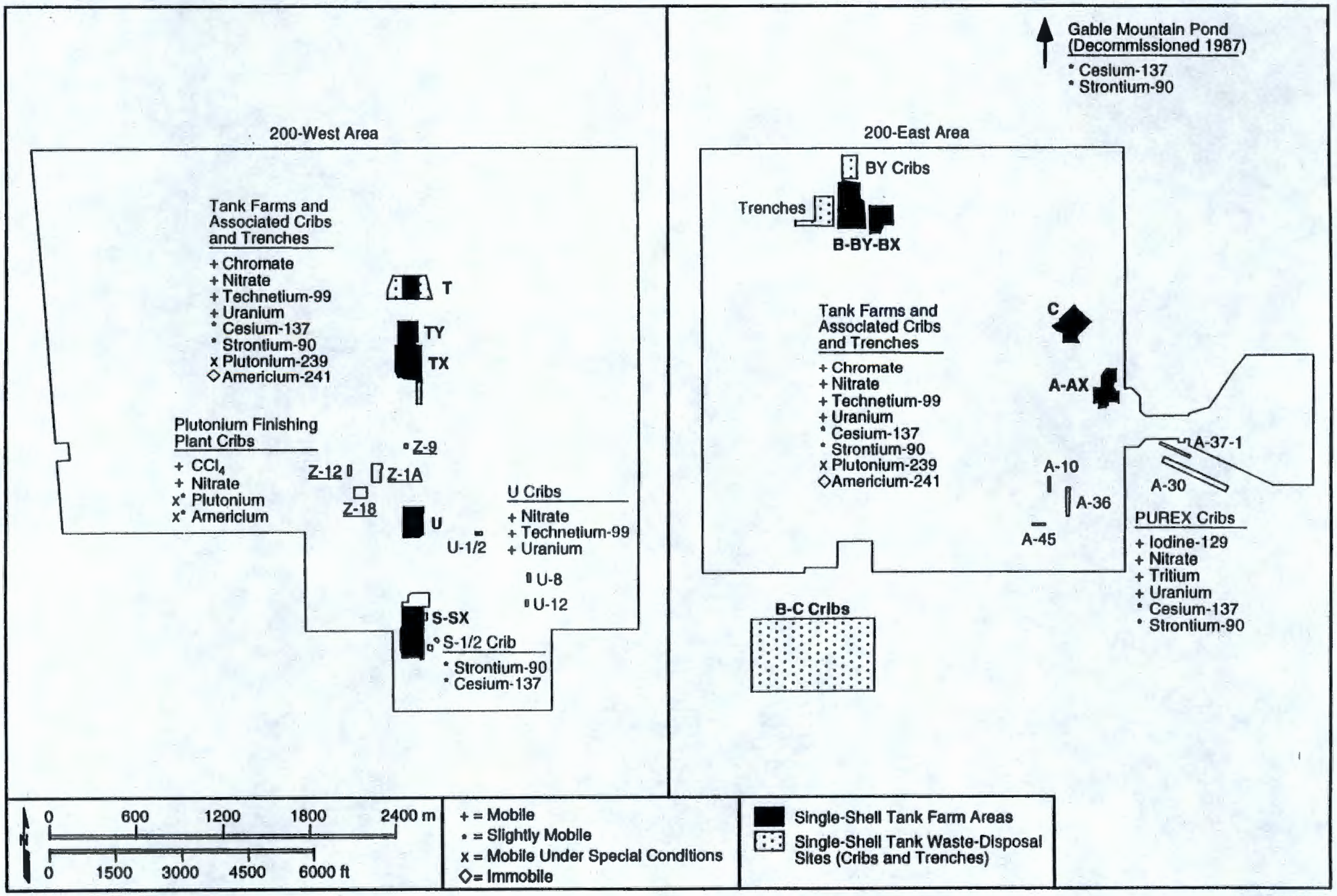

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Figure 3-4. Major Vadose Zone Contamination Sites in the 200 Areas (from Hartman and Dresel 1998).

Figure 3-5. Distribution of Hazardous Chemical Contamination in Groundwater, Hanford Site (from Hartman and Dresel 1998).

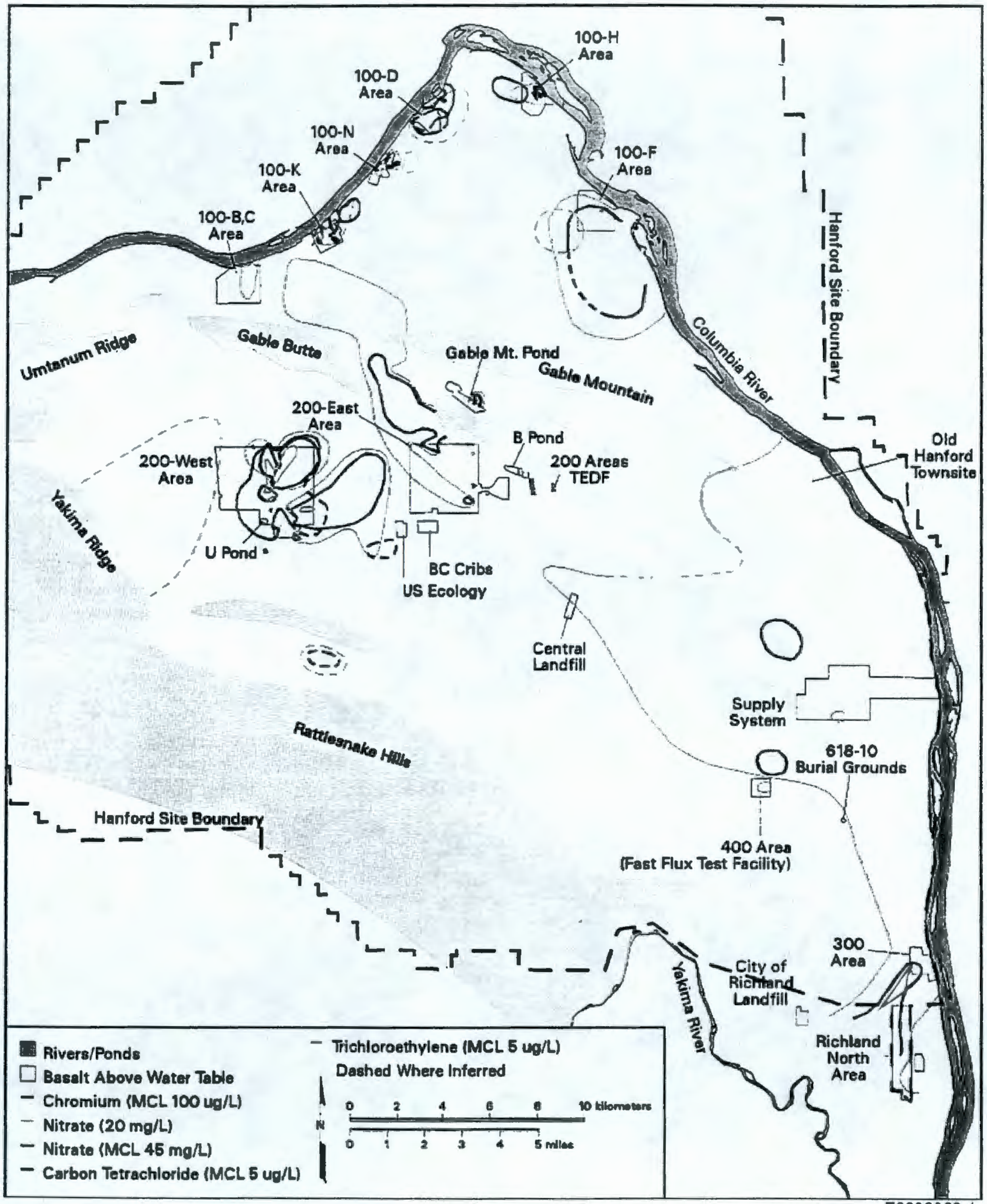

Figure 3-6. Distribution of Radionuclide Contamination in Groundwater, Hanford Site (from Hartman and Dresel 1998).

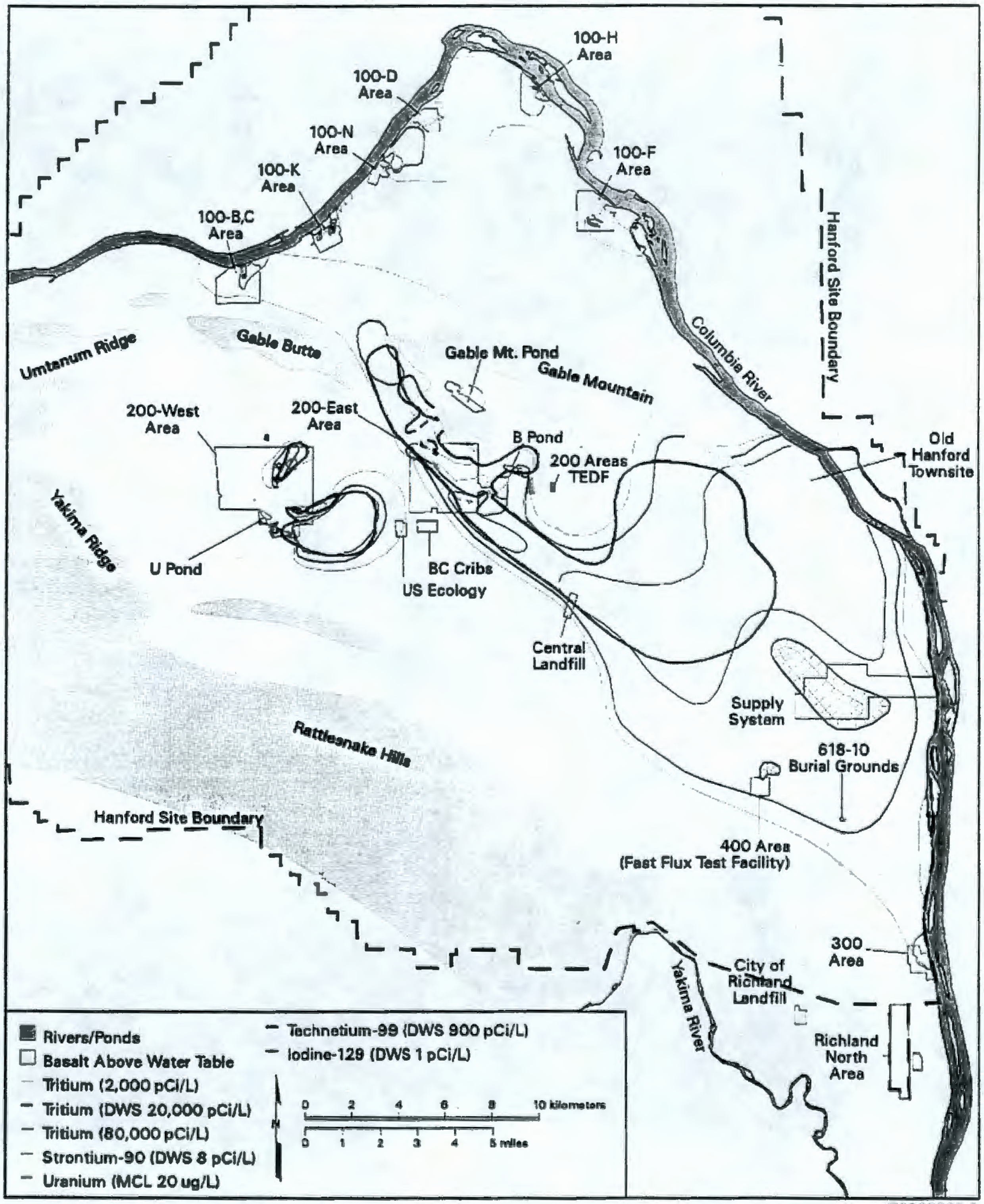

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Table 3-1. Information Sources for the 200 Areas.

Source Operable Unit Area	AAMS Report	Technical Baseline Document	Technical Manual	Other
200-North	DOE/RL-92-17, (DOE-RL 1993b)	WHC-SD-EN-ES-020 (DeFord 1991)	HW-10475-C (GE 1945)	Numerous PNNL -and Site Contractor Operational Groundwater and Environmental Annual Reports
T-Plant	DOE/RL-91-61 (DOE-RL 1992b)	BHI-00177 (BHI 1995d)	HW-10475-C (GE 1945)	Same
B-Plant	DOE/RL-92-05 (DOE-RL 1993d)	BHI-00179 (BHI 1995a)	HW-10475-C (GE 1945) ISO-100 (Isochem 1967)	Same
Z-Plant	DOE/RL-91-58 (DOE-RL 1992d)	BHI-00175 (BHI 1995f)	HW-10475-C (GE 1945)	Same
Semi-Works	DOE/RL-92-18, (DOE-RL 1993h)	WHC-SD-EN-ES-019 (DeFord 1992)	HW-22955, 1951 (GE 1951a)	Same
S-Plant	DOE/RL-91-60 (DOE-RL 1992a)	BHI-00176 (BHI 1995c)	HW-18700, 1951 (GE 1951d)	Same
U-Plant	DOE/RL-91-52 (DOE-RL 1992c)	BHI-00174 (BHI 1995e)	HW-19140 (GE 1951c) HW-19400, 1950 (GE 1950)	Same
PUREX	DOE/RL-92-04, (DOE-RL 1993g)	BHI-00178 (BHI 1995b)	HW-31000 (GE 1951b) RHO-MA-116 (RHO 1983)	Same
200-West Groundwater	DOE/RL-92-16 (DOE-RL 1993c)			Same
200-East Groundwater	DOE/RL-92-19 (DOE-RL 1993a)			Same

PNNL = Pacific Northwest National Laboratory
PUREX = plutonium uranium extraction process.

Table 3-2. Characterization Priorities.

Specific Criteria	Criteria Ranking
Groundwater has been impacted in the past.	Low
Groundwater is presently being impacted.	Medium
Groundwater will be impacted in the immediate future (5 to 10 years).	High
Mobile constituents (versus less mobile constituents) are present.	Medium-High
Driving forces exist that are external to the waste sites.	Low
Characterization information, including historical data, is limited or nonexistent.	Medium
The chemistry promoting contaminant migration (increasing mobility) is poorly understood.	Medium-High
Good representative sites (maximum number of sites addressed) are available.	High
Long-lived (versus short-lived) contaminants are present.	Low
Sites pose a current risk (surface threat); assumes Radiation Area Remedial Action Program provides short-term action to lower its priority.	Low
Low levels of contamination are expected over a large area.	Medium
Sites are located near perimeter of plateau/outside the 200 Area fencelines (versus inside the fenceline).	Medium
Easier (versus more difficult) to characterize and/or remediate.	High
Suitable for testing promising technologies.	Medium

(See Table 5-1, DOE-RL 1997, p. 5-2)

Table 3-3. Comparison of Technical and Administrative Prioritizations (circa 1998).

Priority Ranking	Technical Ranking (DOE-RL 1997)	Current Administrative Ranking (TPA, Milestone Change Package M-13-97-01)
1	Scavenged Waste Group	200 North Ponds Cooling Water Group
2	Chemical Sewer Group	Gable Mtn/B-Pond and Ditches Cooling Water Group
3	Plutonium/Organic-Rich Process Waste Group	Chemical Sewer Group
4	Gable Mtn/B-Pond and Ditches Cooling Water Group	U-Ponds/Z-Ditches Cooling Water Group
5	S-Pond/Ditches Cooling Water Group	Uranium-Rich Process Waste Group
6	200 North Cooling Water Group	General Process Waste Group
7	300 Areas Chemical Laboratory Waste Group	
8	T-Ponds/Ditches Cooling Water Group	
9	Miscellaneous Waste Group	
10	U-Ponds/Z-Ditches Cooling Water Group	
11	Uranium-Rich Process Waste Group	
12	Organic-Rich Process Waste Group	
13	Tank Waste Group	
14	Nonradioactive Landfills and Dumps Group	
15	Steam Condensate Group	
16	200 Areas Chemical Laboratory Waste Group	
17	Radioactive Landfills and Dumps Group	
18	General Process Waste Group	
19	Fission Product-Rich Process Waste Group	
20	Plutonium Process Waste Group	
21	Septic Tanks and Drain Fields Group	
22	Tanks/Lines/Pits/Boxes Group	
23	Unplanned Releases Group	

Table 3-4. Potential Radionuclides of Concern in the 200 Areas.

Radionuclide	Source	Comments
H-3	Neutron Activation/ Fission	
C-14	Neutron Activation	
Co-60	Neutron Activation	Approaching practical detection limits for routine analytical technologies.
Ni-63	Neutron Activation	
Sr-90	Fission	
Tc-99	Fission	
Cs-137	Fission	
Sm-151	Fission	Currently no analytical methods available for analysis
Eu-154	Fission	
Eu-155	Fission	
Th-228	Natural	Special case from thorium processing
Th-232	Natural	Special case from thorium processing
U-233	Neutron Activation	Special case from thorium processing
U-234	Natural	
U-235	Natural	
U-238	Natural	
Pu-238	Neutron Activation	
Pu-239	Neutron Activation	
Pu-240	Neutron Activation	
Pu-241	Neutron Activation	Primarily a beta emitter, routinely addressed via Am-241 (daughter) analysis
Am-241	Decay of Pu-241	

Table 3-5. Potential Inorganic Chemicals of Concern in the 200 Areas.

Analyte	Primary Source	Comments
Nitrate	All Processes	
Sulfate	All Processes	
Chloride	All Processes	
Fluoride	$BiPO_4$, PUREX , PFP, WESF	
Phosphate	$BiPO_4$, decontamination, Laundry	
Mercury	Al fuel decladding	
Lead	Shielding – all processes	
Manganese	All processes	Typically from permanganate materials
Chromium	All processes	From chromates and stainless steel corrosion
Cadmium	PUREX and 234-5 Z	Neutron poisons
Cyanide	Tank Scavenging	Added as ferrocyanides
Ammonia	PUREX and Waste Fractionizaton	
pH	All processes	Measurement of potential high corrosion due to acids or bases
Asbestos	All processes	Primarily from insulation and building materials

$BiPO_4$ = bismuth phosphate
PUREX = plutonium uranium extraction process
PFP = plutonium finishing plant process
WESF = Waste Encapsulation and Storage Facility.

Table 3-6. Potential Organic Chemicals of Concern in the 200 Areas.

Analyte	Primary Source	Comments
Kerosene range Hydrocarbons	PUREX, URP, Waste Fractionation	Covers all pure hydrocarbon-based diluents including NPH, Shell Solvent, kerosene, etc.
Tributyl Phosphate	PUREX, URP, PFP	
Carbon tetrachloride	PFP	Routine volatile organic analysis will identify and quantitate this compound
Chlorinated Solvents	Decontamination activities	Routine volatile organic analysis will identify and quantitate all potential solvents used in the 200 Areas
Hexone	REDOX	Routine volatile organic analysis will identify and quantitate this compound
PCBs	All processes	From hydraulic fluids, electrical equipment, insulation

NPH = normal paraffin hydrocarbon.
PCBs = polychlorinated biphenyls
PFP = Plutonium Finishing Plant
PUREX = Plutonium Uranium Extraction
REDOX = Reduction Oxidation
URP = Uranium Recovery Process

Table 3-7 Summary of Site Conditions That May Affect Contaminant Fate and Transport. (2 Pages) (from DOE-RL 1997)

Parameter/ Property	Representative Values/Conditions for 200 Area Sediments	General Considerations
Natural recharge	0 to 10 cm/yr via precipitation	Low annual precipitation and low precipitation intensity provides little to no recharge. Recharge may be impacted by episodic events including high-intensity rainfall events and rapid snowmelt. Evapotranspiration potential is moderate to high depending on time of year. Recharge via precipitation is affected by surface soil type, vegetation, topography, and year-to-year variations in precipitation. Gravelly surface soils with no or minor shallow-rooted vegetation facilitate recharge. Well-vegetated, fine-grained surface soils minimize recharge. Waste sites that are capped with fine-grained soils (Radiation Area Remedial Action interim-stabilized sites) or impermeable covers should have little to no net precipitation recharge or leachate generation. Granular nature of surface soils maximizes infiltration. In instances where precipitation or snow melt is sufficient to generate runoff, low-lying areas and gravelly surface soils/fill occupying may serve as collection basins for runoff and locally increase infiltration.
Vegetation	Sparse to moderate densities	Vegetation of the 200 Areas Plateau is characterized by native shrub steppe interspersed with large areas of disturbed ground with a dominant annual grass component. Associated transpiration potential is low to moderate. The vegetation in and around active ponds and ditches (riparian zone) on the 200 Areas Plateau is significantly different and higher in density than that of the surrounding dryland areas. Vegetation may remove chemicals upward in or from the soil, bring them to the surface, and subsequently introduce them to the food web. Vegetation supported by active ponds and ditches provides locally higher evapotranspiration potential and radionuclide uptake.
Soil moisture	2% to 10% by volume	At low ambient moisture contents, moisture flux is minimal and the capacity of the soil to store infiltrating liquids is high. Low soil moisture results in higher capillary forces that inhibit downward migration of water. As a result, moisture from infiltrating precipitation is retained close to the surface where it is removed by evapotranspiration. Ambient moisture contents are typically higher in finer grained sediments than in coarse-grained sediments. Contaminated pore water can be transported to groundwater by drainage under unsaturated conditions but requires an extended time frame relative to saturated conditions because hydraulic conductivities are much lower under low moisture conditions. Waste sites that received sufficient discharges to maintain localized saturated conditions in the vadose zone maximize downward pore water velocities and associated contaminant movement.
Vadose zone thickness	55 to 104 m (central plateau)	The thicker the vadose zone, the greater the potential for contaminants to interact with sediments. Vadose zone thins out from the 200 West and 200 East Areas north to Gable Gap.

Table 3-7 Summary of Site Conditions That May Affect Contaminant Fate and Transport. (2 Pages) (from DOE-RL 1997)

Parameter/ Property	Representative Values/Conditions for 200 Area Sediments	General Considerations
Soil chemistry	Alkaline pH Low oxidizing REDOX state Ion-exchange capacity dependent on contaminant and % fine-grained soil particles Very low organic carbon content, <1%	The mobility of radionuclides and other inorganic elements depends on the chemical form and charge of the element or molecule, which in turn depends on waste- and site-related factors such as the pH, REDOX state, and ionic composition. Buffering or neutralizing capacity of the soil is correlated with the calcium carbonate content of the soil. 200 Area sediments generally have carbonate contents in the range of 0.1% to 5%. Higher carbonate contents (10%) are observed within the Plio-Pleistocene caliche layer. Additional buffering capacity is provided by hydroxides of iron, aluminum, manganese, and silicon. Acidic solutions are buffered to more neutral basic pH values when contacting Hanford sediments. Many constituents/contaminants precipitate or adsorb to the soil under neutral to basic pH conditions. The vadose zone is generally an oxidizing environment. REDOX-sensitive elements from highly oxidized waste streams may become less mobile (are reduced) when contacting the vadose zone, which has a relatively lower oxidizing potential. Conversely, reduced waste streams could be oxidized when introduced into the vadose zone and thereby increase the mobility of REDOX-sensitive elements. Many contaminants of concern in 200 Area waste streams are present as cations. Sediments have sufficient cation-exchange capacity to adsorb many of these cations. Considering the substantial thickness of vadose zone (50 to 140 m), the total cation-exchange capacity of a column of soil is substantial. 200 Area sediments have a poor affinity for anions because of their negative charge. Sorption to organic components is considered to be minimal considering the low organic content. Sorption to the inorganic fraction of soils may dominate over sorption to soil organic matter. Mineralogy affects the abundance of sorption sites as well as the availability of ions for precipitation. Soil components that contribute to adsorption of inorganic compounds such as clays and organic matter are generally minor components in 200 Area sediments. Diffusion of contaminants into micropores of minerals can occur. Microorganisms in the soil may degrade organic chemicals and inorganic chemicals.
Soil texture	High sand and gravel content (~70 to 80 wt%), moderate in silt content (10 to 20 wt%), and low clay content (<1 to 10 wt%) and stratified	Coarse-grained nature of sediments generally provides for a quick-draining media. However, variations of the soil stratigraphy with depth, such as the presence of low-permeability layers, impedes the downward movement of liquids. Sediments are generally more permeable in the horizontal direction than in the vertical direction because of the stratified nature of the sediments. This facilitates the lateral spreading of liquids in the vadose zone and reduces the downward movement. Under unsaturated conditions, coarse-grained layers overlain with finer grained materials retard the movement of pore water because of the capillary barrier effect. Under saturated conditions, layers of finer grained soil such as silt layers and the Plio-Pleistocene unit function as localized aquitards. Where substantial quantities of liquid waste were disposed, perched water may form above these layers. These phenomena increase the potential for lateral movement of liquids. If perched water is laterally expansive, it can mobilize wastes beneath adjacent waste sites. Sorption to sediments increases as particle size decreases. Suspended solids/particulates in waste streams are likely to be physically filtered by the sediments at the boundary of the waste site.

REDOX = Reduction Oxidation

Table 3-8. Relative Contaminant Mobility in Hanford Soils. (2 Pages) (from DOE-RL 1997)

Contaminant	Normal Relative Mobility	Factors Affecting Mobility
Cobalt-60	Low	Highly sorbed by cation ion exchange at pH<9; readily reacts with organics and inorganic ions to form more mobile complexes (e.g., with ferrocyanide or phosphates).
Strontium-90	Moderate	Sorbs by cation ion exchange, but competes for sites with calcium. May immobilize as a coprecipitate in the mineral apatite formed by phosphate wastes. Highly mobile in acidic conditions. Mobility is increased by organics (e.g., tributyl phosphate).
Technetium-99	High	Generally present as pertechnetate anion, which is relatively nonadsorbing.
Ruthenium-106	High	Highly influenced by presence of nitrite or nitrate; short (1-year) half-life offsets high mobility.
Cesium-137	Low	Highly sorbed by cation ion exchange. Competes for sites with potassium and sodium. Mobile. Does not tend to form soluble inorganic or organic complexes. More mobile at low pH.
Uranium-238	High	Highly mobile at low pH and at pH>8 where soluble anionic carbonate complexes can form. However, uranium forms insoluble precipitates with phosphate that are highly immobile.
Plutonium-239/240	Low	Maximum sorption occurs in pH range of 4 to 8.5 as a result of formation of insoluble precipitates. Sorption is less at low pH (<4) and high pH (>8.5). Plutonium can form more mobile complexes with codisposal of organics (e.g., tributyl phosphate, hexone, dibutyl butyl phosphonate).
Americium-241	Low	Behaves similarly to plutonium.
Cadmium	Moderate to high	Mobile as a dissolved metal for most waste streams in Hanford soil column conditions.
Carbon tetrachloride	High	Used as diluent for Plutonium Finishing Plant separations processes. Not highly sorbed by Hanford soils, which are low in organic carbon content.
Chloroform	High	Degradation product of carbon tetrachloride; may be formed during chlorine treatment of potable water supplies.
Chromium	High	Generally present as an anion (chromate), which is mobile in the +6 valence state.

Table 3-8. Relative Contaminant Mobility in Hanford Soils. (2 Pages) (from DOE-RL 1997)

Contaminant	Normal Relative Mobility	Factors Affecting Mobility
Cyanide	High	Anionic species that is essentially nonadsorbing; forms complexes with cationic species, increasing their mobility.
Dibutyl butyl phosphonate	[a]	Used as a solvent with carbon tetrachloride diluent in Plutonium Finishing Plant separations process for americium-241 removal. Potential for increased mobilization of americium-241 and plutonium-239/240 due to complexation.
Hexone (methyl isobutyl ketone)	[a]	Used as solvent for plutonium and uranium in REDOX separations process. May increase radionuclide mobility due to formation of organic complexes.
Hydrazine	[a]	Strong reductant, soluble in water. Breaks down into mobile amines or ammonium ions in water.
Nitrate	High	Anionic species, nonadsorbing, considered to travel with water.
Tributyl phosphate	[a]	Used as solvent in extraction of plutonium and uranium in PUREX and Uranium Recovery Program and for plutonium in Plutonium Finishing Plant separations processes. May increase radionuclide mobility in soil column due to formation of organic complexes.
Trichloroethylene	High	Not highly sorbed by Hanford soils, which are low in organic carbon content.

Mobility factor: High = K_d 0 to 5; Moderate = K_d 5 to 100; Low = K_d >100.
K_d = soil-water distribution coefficient
[a]Organic compounds: Generally considered to be mobile due to low organic carbon content of Hanford soils.
PUREX = Plutonium Uranium Extraction
REDOX = Reduction Oxidation

Table 3-9. Radionuclides - Physical/Chemical Data.

Radionuclide	Half-Life[a] (yr)	Mode of Decay	Mobility Factors (K_d) (mL/g)	
			Neutral/Basic, Low Salt, Low Organic, Oxic Solution[b]	Neutral/Basic, High Salt, Low Organic, Oxic Solution[c]
Cobalt-60	5.27	Gamma	1,200 - 12,500	222 - 4,760
Strontium-90	29.1	Beta	5 -173	0.3 - 42
Technetium-99	2.13×10^5	Beta	0 - 1.3	0 - 0.01
Ruthenium-106	1.02	Beta	27 - 274	0 - 10
Cesium-137	30.2	Gamma	540 - 3,180	64 - 1,360
Uranium-238	4.47×10^9	Alpha	0.08 - 79.3	0 - 4
Plutonium-239/240	2.41×10^4	Alpha	80 - >1,980	10 - >98
Americium-241	432.7	Alpha	67 - >1,200	280 - >1,200

[a]Walker et al. (1989).
[b]Kaplan et al. (1995), Table 6.1.
[c]Kaplan et al. (1995), Table 6.3.

Table 3-10 General Characteristics of Waste Streams and Waste Site Groups.

Category	Liquid Waste (Relative Scale: **O** = High, O = Medium, o = Low)					Solid Waste	Receiving Site				
Group	Volume	Contaminant Concentration	Contaminant Mass	Contaminant Mobility	Groundwater Plume?		Pond, Ditch	Trench	Crib, French Drain	Reverse Well	Burial Ground
I. Process Condensate/ Process Waste											
a. U-rich	O	**O**	**O**	**O**	Y			X	X		
b. Pu-rich	o	**O**	O	o					X	X	
c. Pu-organic rich	O	**O**	**O**	**O**	Y				X		
d. Organic-rich	O	**O**	**O**	**O**					X		
e. Fission product-rich	O	o	o	o					X		
f. General	o	o	o	o					X		
II. Steam Condensate/Cooling Water/Chemical Sewer											
a. Steam Condensate	**O**	O	O	O			X		X		
b. Chemical Sewer	**O**	o ?	o ?	**O** ?	?		X				
c. U-Pond/Z-Ditches	**O**	O	O	O	Y		X				
e. Gable Mt/B-Pond	**O**	O	O	O	Y		X				
f. 200 North Ponds	O	o	o	o			X	X			
g. S-Ponds and Ditches	**O**	O	O	**O**	Y		X				
h. T-Pond and Ditches	**O**	o	O	O			X				
III. Chemical Waste											
a. 200 Area	O	O	O	O					X		
b. 300 Area	o	O	o	O				X	X		
IV. Miscellaneous	o	o	o	o				X	X	X	
V. Tank/Scavenged											
a. Tank	o	**O**	**O**	O	Y			X	X		
b. Scavenged	o	**O**	**O**	**O**	Y			X	X	X	
VI. Tanks/Lines/Pits/Boxes	o	**O**		O							
VII. Unplanned Releases	o	o - **O**	O	o			X		X		
VIII. Septic Tanks and Drain Fields	o	o	o	o					X		
IX. Landfills and Dumps											
a. Radioactive						X					X
b. Nonradioactive						X					X

Source: DOE/RL-96-81

Table 3-11. Results of Vadose Zone Characterization Studies in the 200 Areas. (2 Sheets)

				BACKGROUND INFORMATION				
Waste Site Name	200-BP-1 OU (216-B-43-B-50, 216-B-57, 216-B-61)	218-E-8 Borrow Pit Demolition Site	200 West Ash Pit Demolition Site	216-B-3/-3A/-3B/-3C	2101-M Pond	216-U-4/U-4A	216-U-12	216-U-8
Waste Group	Scavenged Waste Group, Fission Product-Rich Group (200-TW-1)	Non-Radioactive Landfills and Dumps Group (200-SW-1)	Non-Radioactive Landfills and Dumps Group (200-SW-1)	Gable Mtn/B-Pond & Ditches Cooling Water Group (200-CW-1)	200 Area Chemical Laboratory Waste Group (200-LW-2)	200 Area Chemical Laboratory Waste Group (200-LW-2)	Uranium-Rich Process Condensate/Process Waste Group (200-PW-2)	Uranium-Rich Process Condensate/Process Waste Group (200-PW-2)
Site Type	Cribs	Burial Ground/ Detonation Site	Coal Ash Pit/ Detonation Site	Ponds	Pond (U – Shaped)	Reverse Well/French Drain	Crib	Crib (wood and gravel)
Bottom Dimensions of Structure and Depth	9.1m x 9.1 m x 4.3 m (30 ft x 30 ft x 14 ft)	6.3 m x 6.3 m (20 ft x 20 ft)	6.3 m x 6.3 m (20 ft x 20 ft)	161,875 m^2, 40,470 m^2, 40,470 m^2, 165,900 m^2	64 m. x 21.3 m. x 2.7 m (210 ft x 70 ft x 9 ft)	7.6 cm x 22.9 m/1.3 m x 3.1 m (3" x 75')/ (4.25' x 10')	30.5 m x 3.1 m x 4.6 m (100 ft x 10 ft x 15 ft)	48.8 m x 15.3 m x 10.3 m (150 ft x 50 ft x 31 ft)
Dates of Operation	1954-1957, 1965-1974, NA	1984	1984-86	1945-1994, 1983-1995, 1983-1995, 1985-1997	1960's-1988	1947-1955/1955-1970	1960-1988	1952-1960
Major Potential Contaminants	Uranium, fission products and other radionuclides.	VOAs, SVOAs	VOAs, SVOAs	Pesticides, VOAs, SVOAs, metals	Metals	Fission products, uranium, plutonium	Total uranium, fission products, pH, $CaCO_3$, nitrate	Uranium, fission products and other radionuclides
Additional Potential Contaminants Likely	Yes. Cyanide, Nitrates and hazardous waste constituents possible.	Yes. Other hazardous waste constituents possible.	Yes. Other hazardous waste constituents possible.	Yes. Other hazardous waste constituents possible.	Yes. Other hazardous waste constituents possible.	Yes. Hazardous waste constituents possible.	Yes. Hazardous waste constituents possible.	Yes. Hazardous waste constituents possible.
Vertical Extent of Contamination Expected	Surface, vadose zone and groundwater	Surface	Surface	Vadose zone	Vadose zone and groundwater	Shallow vadose zone at french drain. Moderately deep in vadose zone at reverse well.	Vadose zone to groundwater	Vadose zone to caliche layer
Horizontal Extent of Contamination Expected	Moderate lateral spreading	Limited	Limited	Potential for lateral spreading	Limited	Limited	Potential for lateral spreading	Some lateral spreading possible on caliche layer.
Preliminary Conceptual Model	Yes.	Yes.	Yes	Yes.	Yes	Yes.	Yes.	Yes.
				CHARACTERIZATION OBJECTIVES AND PLANNING				
Date of Latest Investigation	1990-1993	1994	1994	1989, 1991, 1992	1988, 1991	1994	1994	1994
Program	CERCLA	RCRA	RCRA	RCRA	RCRA	CERCLA	RCRA/CERCLA	CERCLA
Investigation Type	Vadose zone and groundwater	Vadose zone	Vadose zone	Vadose zone	Vadose zone and groundwater	Vadose zone	Vadose zone	Vadose zone
Primary Objective(s)	- Determine contamination types and vertical/lateral extent. - Determine radionuclides in unconfined and confined aquifers.	- Verify absence of hazardous materials in soil column.	- Verify absence of hazardous materials in soil column.	-Verify absence of hazardous materials in soil column	- Verify absence of hazardous materials in soil column.	- Determine vertical distribution of contamination in soil column.	- Determine vertical distribution of contamination in soil column. - Evaluate a limited RCRA contamination of concern suite	- Determine vertical distribution of contamination in soil column.
				INVESTIGATION APPROACH				
Surface Samples/Test Pits	None	10 Surface Samples	8 Surface Samples	Phase 1, 1989 – Shallow Pond Bottom Sampling, All B-3 Ponds Phase 2, 1992 – Shallow Pond Bottom Sampling in B-3 lobes.	Multiple Pond-bottom samples	1 Surface Sample	None	Surface Samples
No. of Boreholes Planned in Waste Unit	25 – 3 through each active crib, to depths of 30 ft and 1 in inactive crib. Three extended to depths of 70 m (230 ft).	None	None	Phase 3, 1991 – Upper vadose zone boreholes, 81-142 ft deep	4 shallow (5 m.) boreholes into pond bottom + 4 remote background samples	1, in radiation area between the reverse well and french drain.	None	1 – Close to first wooden crib
No. of Boreholes Planned Adjacent to Waste Unit	6 each, 15.2 cm (6 in. dia.), 50-ft deep driven holes at 2 waste sites, used with RLS.	None	None	None.	4 wells, to groundwater	None		None
No. of Cone Penetrometer Pushes Planned	None	None	None	None.	None	None	None	None
No. of Groundwater Monitoring Wells Planned	7 to upper unconfined aquifer, 3 to first confined aquifer	None	None	None.	4 wells	None	None	None
Geophysical Logging	17 new boreholes w gamma spec. 10 old boreholes w/ gamma spec. 10-12 "adj." holes with RLS.	None	None	Yes. Gross gamma logging.	Yes.	Yes. RLS logging	Yes, RLS logging	Yes. RLS logging
				GENERAL CONCLUSION				
	1. Radiological contamination concentrated within crib gravels and within the first 15 ft beneath crib bottom. 2. RLS log showed contaminants to reach 50 to70 ft below crib. Trace contamination detected at 215 ft (i.e., ~GW) below crib. 3. Lateral spreading observed locally at about 50 ft below B-57 crib.	1. No unacceptable levels of inorganic or organic contaminants in soil. 2. Site clean closed	1. 1. No unacceptable levels of inorganic or organic contaminants in soil. 2. Site clean closed.	1. VOAs, SVOAs, metals, pesticides, & PCBs were not found in vadose zone. Sites were clean closed. 2. Radiological contaminants present in pCi/g quantities throughout soil column. No obvious concentration gradients with depth.	1. No unacceptable inorganic or organic contaminants in soil samples. 2. Site clean closed.	1. Most contamination concentrated 6-7 ft below bottom of french drain and up to 25 ft below the 75 ft deep reverse well. 2. Near-background levels of contamination observed below 100 ft.	1. Background levels of contaminants indicate limited lateral spreading in vadose zone 3 m beneath crib bottom.	1. Most contamination found directly beneath crib and to a depth 20 ft below crib bottom. 2. Minor increases in U concentrations above background noted at top of caliche layer. 3. No lateral spreading in soil column below vadose zone. Lateral spreading at top of caliche layer.

Table 3-12. Results of Vadose Zone Characterization Studies in the 200 Areas. (2 Sheets)

BACKGROUND INFORMATION					
Waste Site Name	216-U-10 Pond	216-U-14 Ditch	216-B-2-2 Ditch	216-T-1 Ditch	216-U-1/U-2 Crib
Waste Group	U-Pond//Z-Ditches Cooling Water Group (200-CW-1)	U-Pond/Z-Ditches Cooling Water Group (200-CW-1)	Gable Pond/B-Ponds and Ditches Cooling Water Group (200-CW-1)	T-Pond and Ditches Cooling Water Group (200-CW-4)	Uranium-Rich Process Condensate/Process Waste Group (200-PW-2)
Site Type	Infiltration pond	5860 ft long unlined infiltration ditch.	3,500 ft long unlined infiltration ditch.	1,800 ft long unlined infiltration ditch.	Buried crib.
Bottom of Structure	6.5 ft below ground surface (BGS)	Bottom of structure is 0 to 9 ft below the existing surface.	6-8 ft BGS.	10 ft BGS.	~25 ft BGS
Dates of Operation	1944 -1985	1944 –1995	1963-1970	1944-1995	1951-1967
Suspected Contaminants	Uranium and other radionuclides	Uranium and other radionuclides	Strontium and other radionuclides	Uranium and other radionuclides	Uranium and the radionuclides
Additional Contaminants Likely	Yes. Hazardous waste constituents possible.	Yes. Hazardous waste constituents possible.	Yes. Hazardous waste constituents possible.	Yes. Hazardous waste constituents possible.	Radionuclides are primary contaminants of interests.
Vertical Extent of Contamination Expected	Contaminants may extend to groundwater.	Contaminants may extend to groundwater.	Near surface contamination expected. This is an issue of dispute.	Near surface contamination expected.	Contaminants may extend to groundwater.
Horizontal Extent of Contamination Expected.	Limited	Limited	Limited	Limited	Some lateral spreading has been observed on the caliche layer.
Preliminary Conceptual Model	Yes.	Yes.	Yes.	Yes.	Yes.
CHARACTERIZATION ACTIVITIES AND PLANNING					
Date of Latest Investigation	1994	1994	1998	1995	1994
Program	CERCLA	OPERATIONS	CERCLA	OPERATIONS	CERCLA
Investigation Type	Vadose	Vadose and groundwater	Vadose	Vadose and groundwater	Vadose zone to caliche layer
Primary Objective(s):	1. Determine vertical extent and type of contamination beneath pond. 2. Determine if high concentration of contaminants are in deep zone.	1. Determine vertical extent and type of contamination beneath ditch. 2. Determine horizontal and type of contamination adjacent to ditch. 3. Determine contaminant impact on groundwater. 4. Determine hydrologic impact on groundwater.	1. Determine the vertical extent and type of contamination beneath the ditch .	1. Determine vertical extent and type of contamination beneath ditch.. 2. Determine horizontal and type of contamination adjacent to ditch. 3. Determine contaminant impact on groundwater. 4. Determine hydrologic impact on groundwater.	1 Determine vertical extent of radiological contamination beneath crib. 2. Determine horizontal extent radiological contamination adjacent to crib. 3. Determine if high concentration of contaminants are in deep zone.
INVESTIGATION APPROACH					
Test Pits	1 Test Pit.	6 Test Pits.	None.	3 Test Pits.	NA
No of Boreholes Planned in Waste Unit	1 Borehole.	None.	1 Borehole.	None.	1 Borehole
No. of Boreholes Planned Adjacent to Waste Unit	None.	3 Boreholes.	None.	None.	2 Boreholes
No. of Cone Penetrometer Planned	10 cone penetrometer.	None.	None.	None.	None .
No. of Groundwater Monitoring Well Planned	None.	3 Monitoring Wells	None.	1 Monitoring well.	None.
Geophysical Logging	Yes.	Yes.	Yes.	Yes.	Yes.
GENERAL CONCLUSIONS					
	1. The highest level of contamination is detected within several feet of the bottom of the pond. 2. Contaminant levels generally decrease with depth. 3. The vertical extent of significant contamination appears to be limited. 4. Additional characterization is not needed. 5. Remedial action not required at this time.	1. The highest level of contamination is detected within several feet of the bottom of the ditch. 2. Contaminant levels generally decrease with depth. 3. Elevated levels of contamination are detected associated with the caliche layer. 4. Contaminant transport is principally vertically down beneath the facility. 5. Clastic dikes may transport contaminants preferentially. 6. Additional characterization is not needed.	1. The highest level of contamination is detected within 8 ft of the bottom of the ditch. 2. Contaminant levels fall off rapidly with depth. 3. The vertical extent of significant contamination appears to be limited. 4. Additional characterization is needed.	1. The highest level of contamination is detected within several feet of the bottom of the ditch. 2. Contaminant levels generally decrease with depth. 3. The vertical extent of significant contamination appears to be limited. 4. Contaminant transport is principally vertically down beneath the facility. 5. Additional characterization is not needed.	1. The highest level of contamination is detected within a 20-ft zone beneath the crib. 2. Contaminant levels generally decrease with depth. 3. Contaminant transport is principally vertically down beneath the facility. 4. Low concentrations of uranium contamination are detected associated with the caliche layer. Some lateral spreading on the caliche layer has occurred. 5. Additional characterization is not needed. 6. Remedial action not required at this time.

4.0 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

4.1 INTRODUCTION

This section identifies and evaluates potential ARARs for characterization and remediation activities at 200 Area waste sites. It is intended to capture the major ARARs for all reasonably conceivable activities, but at a more generic level of detail than will occur in the future at the group-specific level. Future group-specific FSs will use this information to further refine ARARs that are pertinent to the remedial alternatives under consideration at each waste site group. ARARs identified in this document have also been used to form the basis for the levels to which contaminants must be cleaned up to be protective of human health and the environment (see Section 5.0, "Conceptual Exposure Model and Risk Assessment").

Because all 200 Area waste sites will be the subject of a CERCLA decision document, all remedial and corrective actions will be required to meet ARARs (see Section 2.2.2). Only the substantive requirements (e.g., use of control/containment equipment, compliance with numerical standards) associated with ARARs apply to CERCLA onsite activities. ARARs associated with administrative requirements, such as permitting, are not applicable to CERCLA onsite activities. This CERCLA permitting exemption will be extended to all CERCLA activities as well as those associated with RCRA corrective action units and TSD units, with the exception that RCRA units will be incorporated into the Hanford Facility RCRA Permit.

The ARAR identification process is based on CERCLA guidance (EPA 1988, 1989a). Final ARARs for remediation will be established in the ROD. Section 121 of CERCLA, as amended, establishes cleanup standards for remedial actions at NPL sites. Section 121 requires, in part, that any applicable or relevant and appropriate standard, requirement, criteria, or limitation under any federal environmental law, or any more stringent state requirement promulgated pursuant to a state environmental statute, be met for any dangerous substance, pollutant, or contaminant that will remain on site after completion of remedial action. The EPA has interpreted the ARAR selection process to apply to all aspects of remedial actions, not just those related to contaminants left in place after completion of those remedial actions.

Potential ARARs are classified into one of three categories: chemical-specific, location-specific, and action-specific. These categories are defined as follows:

- Chemical-specific requirements are usually health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of public and worker safety levels and site cleanup levels.
- Location-specific requirements are restrictions placed on the concentration of dangerous substances or the conduct of activities solely because they occur in special geographic areas.
- Action-specific requirements are usually technology- or activity-based requirements or limitations triggered by the remedial actions performed at the site.

When requirements in each of these categories are identified, a determination must be made as to whether those requirements are applicable or relevant and appropriate. A requirement is applicable if the specific terms (or jurisdictional prerequisites) of the law or regulations directly address the circumstances at a site. If not applicable, a requirement may nevertheless be relevant and appropriate if (1) circumstances at the site are, based on best professional judgment, sufficiently similar to the problems or situations regulated by the requirement, and (2) the requirement's use is well suited to the site.

To-be-considered (TBC) information is nonpromulgated advisories or guidance issued by federal or state governments that are not legally binding and do not have the status of potential ARARs. In some circumstances, TBCs will be considered along with ARARs in determining the remedial action necessary for protection of human health and the environment. TBCs complement ARARs in determining what is protective at a site or how certain actions should be implemented. For example, because drinking water MCLs do not exist for all contaminants, drinking water health advisories, which would be TBCs, may be helpful in defining appropriate remedial action goals.

4.2 WAIVERS FROM ARARS

The EPA may waive ARARs and select a remedial action that does not attain the same level of cleanup as that identified by the ARARs. Section 121 of the *Superfund Amendments and Reauthorization Act* identifies six circumstances in which the EPA may waive ARARs for onsite remedial actions. The six circumstances are as follows:

- The remedial action selected is only a part of a total remedial action (such as an interim action), and the final remedy will attain the ARAR upon its completion.
- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options.
- Compliance with the ARAR is technically impracticable from an engineering perspective.
- An alternative remedial action will attain an equivalent standard of performance through the use of another method or approach.
- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.
- In the case of Section 104 (Superfund-financed remedial actions), compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

4.3 ARARS APPLICABLE TO 200 AREA REMEDIAL ACTIONS

Potential federal and state ARARs are presented in Tables 4-1 and 4-2, respectively. Detailed evaluation and possible modification to these potential ARARs will occur during the FS phase of the RI/FS process for individual waste groups in the 200 Areas.

The chemical-specific ARARs and TBCs likely to be most pertinent to remediation of the 200 Area waste sites are the State of Washington MTCA regulations and EPA's memorandum entitled *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination* (EPA 1997a). MTCA and the EPA memorandum help establish soil cleanup standards for nonradioactive and radioactive contaminants at waste sites. The *Safe Drinking Water Act,* National Primary/Secondary Drinking Water Standards, *Clean Water Act* Water Quality Standards, and state Surface Water Quality Standards are also likely to be pertinent in determining whether waste site remediation is protective of groundwater and the Columbia River. The several federal and state air emission standards are likely to be important in air emission limits and control requirements for any remedial actions that produce air emissions. RCRA land disposal restrictions will be important standards during the management of wastes generated during remedial actions.

Location-specific ARARs potentially pertinent to remediation of 200 Area waste sites include the *National Historic Preservation Act* and the *Archeological and Historic Preservation Act*, which might require protective measures during characterization and remediation.

Action-specific ARARs that could be pertinent to 200 Area remediation are state solid and dangerous waste regulations (for management of characterization and remediation wastes and performance standards for waste left in place), *Atomic Energy Act* regulations (for performance standards for radioactive waste sites), and federal and state regulations related to air emissions.

Table 4-1. Identification of Potential Federal ARARs and TBCs for the 200 Areas Remedial Action Sites. (9 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
CHEMICAL-SPECIFIC			
Safe Drinking Water Act of 1974, 42 USC 300, et seq.			
National Primary Drinking Water Standards, 40 CFR 141	Relevant and appropriate	Establishes maximum contaminant levels (MCLs) that are drinking water criteria designed to protect human health from the potential adverse effects of contaminants in drinking water .	Groundwater in the 200 Areas is not currently used for drinking water, but it could be used in the future, if the site is released from institutional controls. In addition, groundwater in the 200 Areas is hydraulically connected to groundwater that is used for drinking water and to the Columbia River. Remedial alternatives need to ensure that migration of waste site contaminants to groundwater do not cause the groundwater to exceed MCLs and MCLGs pursuant to State MTCA requirements contained in WAC 173-340-720.
National Secondary Drinking Water Standards, 40 CFR 143	Relevant and appropriate/ State	Establishes secondary drinking water standards for use in establishing cleanup levels.	Federal secondary standards are not enforceable standards and are not typically applicable or relevant and appropriate requirements; however, the State of Washington Model Toxics Control Act requires that these standards be considered in establishing cleanup levels protective of groundwater.
Clean Water Act of 1977, 33 USC 1251, as amended			
Designation of Hazardous Substances, 40 CFR 116	Applicable	Designates hazardous substances in Tables 116.4A and 116.4B of the regulation. These are included in the CERCLA list of hazardous substances.	Hazardous substances are present in the 200 Areas.
Water Quality Standards, 40 CFR 131	Relevant and appropriate	Establishes the requirements and procedures for states to develop and adopt water quality standards based on federal water quality criteria that are at least as stringent as the federal standards. 40 CFR 131 provides EPA the authority to review and approve state water quality standards. Washington State has received EPA approval and has adopted more stringent water quality criteria under WAC 173-201A. These criteria are presented in detail as state chemical-specific ARARs.	Cleanup must ensure protection of surface water (the Columbia River) from soil contamination in the 200 Areas.

Table 4-1. Identification of Potential Federal ARARs and TBCs for the 200 Areas Remedial Action Sites. (9 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Atomic Energy Act of 1954, as amended, 42 USC 2011, et seq.			
Environmental Radiation Protection Standards for Nuclear Power Operations, 40 CFR 190	Relevant and appropriate	Specifies the levels below which normal operations of the uranium fuel cycle are determined to be environmentally acceptable. The standard sets dose equivalents from the facility that are not to exceed 25 mrem/yr to whole body, 75 mrem/yr to thyroid, or 25 mrem/yr to any other organ.	These standards are not applicable since the standard excludes operations at disposal sites and uses a definition of the uranium fuel cycle that focuses on those processes that result in generation of electrical power. However, the standards are relevant and appropriate because they address acceptable dose to the public as a result of planned discharges similar to past activities conducted in the 200 Areas.
Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste, 40 CFR 191	Potentially relevant and appropriate	Establishes standards for management and disposal of spent nuclear fuel, high-level waste, and transuranic wastes at facilities operated by the DOE. The standard addresses all disposal methods. Subpart A applies to facilities regulated by the NRC and sets maximum committed effective dose of 15 mrem/yr for any member of the public. Environmental standards set in Subpart B address protection of individual members of the public and groundwater at certain disposal facilities.	The requirements are potentially relevant and appropriate because transuranic wastes may be generated at 200 Area waste sites.
Nuclear Regulatory Standards for Protection Against Radiation, 10 CFR 20	Relevant and appropriate	The regulation establishes standards for protection of the public against radiation arising from the use of regulated materials. Remedial alternatives need to limit external and internal exposure from releases to levels that do not exceed 100 mrem/yr, or 2 mrem/hr from external exposure in unrestricted areas. These requirements also establish criteria for closing NRC-licensed sites, including a soil remediation standard of 25 mrem/yr.	The regulation establishes standards for protection of the public against radiation arising from the use of regulated materials and as such are relevant and appropriate. Radioactive material from sources not licensed by the NRC are not subject to these regulations; therefore, this standard is not applicable because the Hanford operations are not NRC licensed.
EPA Memorandum, Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination," OSWER No. 9200.4-18	To be considered	This memorandum provides guidance on cleanup levels at CERCLA sites. EPA has determined in this directive that dose limits established by the NRC in 40 CFR 196 (25 mrem/yr) are generally not protective at CERCLA sites and instead states that a cleanup level of 15 mrem/yr is protective of human health and the environment. EPA dose limits are to generally achieve risk levels in the 10^{-4} to 10^{-6} risk range.	This memorandum, although a TBC, is considered by EPA to be more protective than NRC standards; therefore, it will be considered for use at 200 Area remedial actions.
Resource Conservation and Recovery Act, 42 USC 6901, et seq.			
Criteria for Classification of Solid Waste Disposal Facilities and Practices, 40 CFR 257	Applicable	Criteria specified under this standard are used to determine which solid waste disposal facilities and practices pose a reasonable possibility of adverse risk to human health and the environment.	This standard is applicable to remedial actions since the 200 Areas contain solid waste disposal facilities.
Identification and Listing of Wastes, 40 CFR 261	Applicable	This part establishes the framework for determining whether a waste is hazardous. Treatment wastes should be tested using methods established under this section.	These requirements are applicable because hazardous waste may be generated during 200 Area remedial actions.

Table 4-1. Identification of Potential Federal ARARs and TBCs for the 200 Areas Remedial Action Sites. (9 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Ground Water Protection Standards, 40 CFR 264.92	Relevant and appropriate	Three remediation levels of groundwater protection established by this section are background, MCLs, and ACLs. MCLs are set at the same levels as SDWA MCLs, and where no SDWA MCL has been set, health-based ACLs may be established that are protective of human health and environment.	Groundwater restoration goals established by this section are relevant and appropriate to the establishment of soil cleanup levels protective of groundwater.
Corrective Action for Solid Waste Management Units, 40 CFR 264, Subpart S (proposed)	To be considered	Identifies chemical-specific soil cleanup levels that are protective of groundwater. Proposed standards are based on ensuring groundwater protected to MCLs where available.	Groundwater restoration goals established by this section are relevant and appropriate to the establishment of soil cleanup levels protective of groundwater. Because this is a proposed rule, it is to be considered at this time.
Land Disposal Restrictions, 40 CFR 268	Applicable	This section of the hazardous waste regulations prohibits disposal of restricted wastes unless treatment standards have been met.	This section is applicable to the treatment and disposal of RCRA hazardous waste from 200 Areas sites. If remediation occurs as a RCRA Subpart S CAMU, land disposal restrictions would not apply.
Clean Air Act, as amended, 42 USC 7401, et seq.			
National Emission Standards for Hazardous Air Pollutants (NESHAP), 40 CFR 61	Applicable	Establishes emission standards for hazardous air pollutants including radionuclides, other than radon, and asbestos. Subpart H sets emission limits from the entire facility to ambient air that are not to cause any member of the public to receive an effective dose equivalent of 10 mrem/yr. The definition of facility includes all buildings, structures, and operations at one contiguous site. The requirements also set standards to ensure that emissions from asbestos are minimized during collection, processing, packaging, and transportation.	These requirements are applicable to the site because the potential to release radioactive contaminants to unrestricted areas exists. Also, asbestos waste may be generated during cleanup activities.
Uranium Mill Tailings Radiation Control Act of 1978, 42 USC 2022			
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, 40 CFR 192	Relevant and appropriate	Subpart B sets groundwater protection requirements for concentrations of radium-226, radium-228, and gross alpha particle activity at EPA-established levels for drinking water, 5 pCi/L for radium-226 and radium-228 and 15 pCi/L for gross alpha activity excluding radon and uranium. Concentration limits for radium-226 in soils for land cleanup actions are set at 5 pCi/g averaged over the upper 15 cm (6 in.) and 15 pCi/g averaged over any 15-cm- (6-in.) thick layer more than 15 cm (6 in.) from the surface. The level of gamma radiation in any occupiable building is not to exceed 20 microroentgens/hr above background.	Requirements of this act are relevant and appropriate because radium-226 is present in 200 Area soils. The standard is not applicable because the operable unit is not a milling site for uranium or thorium.

Table 4-1. Identification of Potential Federal ARARs and TBCs for the 200 Areas Remedial Action Sites. (9 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
DOE Order 5400.5, Radiation Protection of the Public and the Environment, and 10 CFR 834 (Proposed)	To be considered	This DOE Order sets radiation standards for protection of the public in the vicinity of DOE facilities. The order set limits for the annual effective dose equivalent of 100 mrem, but allows temporary limits of 500 mrem if avoidance of higher exposures is impractical. The standard sets annual dose limits for any organ at 5 mrem. An annual dose equivalent from drinking water supplies operated by DOE is set at 4 mrem and states that liquid effluent from DOE activities will not cause public drinking water systems to exceed EPA MCLs. Where residual radioactive materials remain, the proposed rule states that various disposal modes should address impacts beyond the 1,000-year time period identified in the existing DOE Order.	The DOE Order and proposed rulemaking are to be considered during cleanup actions at the 200 Areas. The DOE published proposed rule, Radiation Protection of the Public and the Environment (10 CFR 834), in the March 23, 1993 Federal Register (58 FR 16268), promulgates the standards presently found in DOE Order 5400.5. The proposed rule identifies DCGs not as "acceptable" discharge limits, but to be used as reference values for estimating potential dose and determining compliance with the requirements of the proposed rule.
Toxic Substances Control Act (TSCA), 15 USC 2601 et seq. Regulation of PCBs, 40 CFR 761	Potentially Applicable	These requirements identify standards applicable to the handling and disposal of PCBs above 50 ppm. Spills that occurred before May 4, 1987 are to be decontaminated to requirements established at the discretion of the EPA.	TSCA requirements are applicable to remedial actions where PCBs are present at a 200 Areas site. However, handling, storage, and disposal requirements are only applicable if PCBs are detected above 50 ppm.
Radiation Site Cleanup Standards, 40 CFR 196 (Advanced Notice of Proposed Rulemaking)	To be considered	On October 21, 1993, the EPA published an Advanced Notice of Proposed Rulemaking for development of Radiation Site Cleanup Standards (proposed as 40 CFR 196, 58 FR 54474). It sets standards for the remediation of soil, groundwater, surface water, and structures at federal facilities. The working draft of the proposed regulations (May 1994) presents a cleanup standard of 15 mrem/yr annual effective dose in excess of natural background radiation levels.	This proposed rule is to be considered during 200 Areas cleanup activities. EPA OSWER Directive No. 9200.4-18 has indicated that the 15 mrem/yr annual effective dose originating from this proposal is to be used for protection of human health and the environment.
LOCATION SPECIFIC			
National Historic Preservation Act of 1966, 16 USC 470	Applicable	Requires that historically significant properties be protected. The act requires that agencies undertaking projects must evaluate impacts to properties listed on or eligible for inclusion on the National Register of Historic Places. The National Register of Historic Places is a list of sites, buildings, or other resources identified as significant to United States history. An eligibility determination provides a site the same level of protection as a site listed on the National Register of Historic Places. The regulations implementing the act require that the lead agency for a project identify, evaluate, and determine the effects of the project on any cultural resource sites that may be within the area impacted by the project. The implementing regulations require that negative impacts be resolved.	This law is applicable to actions at 200 Areas because various buildings/ structures are eligible for the National Register.

Table 4-1. Identification of Potential Federal ARARs and TBCs for the 200 Areas Remedial Action Sites. (9 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Archeological and Historic Preservation Act, 16 USC 469a	Applicable	Requires that actions conducted at the site must not cause the loss of any archeological and historic data. This act mandates preservation of the data and does not require protection of the actual facility. Where a site is determined to be eligible for the National Register and mitigation is unavailable, artifacts and data will be recovered and preserved prior to commencement of the action.	Archeological and historic sites have been identified within the 200 Areas, and therefore these requirements are applicable to actions that might disturb these sites.
Endangered Species Act of 1973, 16 USC 1531, et seq.	Applicable	This act prohibits federal agencies from jeopardizing threatened or endangered species or adversely modifying habitats essential to their survival. If waste site remediation is within sensitive habitat or buffer zones surrounding threatened or endangered species, mitigation measures must be taken to protect this resource.	The Endangered Species Act of 1973 would be considered relevant and appropriate if threatened or endangered species are identified in waste site areas. Their presence could dictate the approach to remedial actions that may be necessary.
ACTION SPECIFIC			
Resource Conservation and Recovery Act, as amended, 42 USC 6901			
Guidelines for Land Disposal of Solid Waste 40 CFR 241	Applicable	Establishes requirements for handling and disposal of solid waste. Included in these requirements are design and closure/postclosure standards for cover systems.	These requirements are applicable because solid waste disposal units may be associated with 200 Area waste sites.
Generator Standards, 40 CFR 262	Applicable	Establishes requirements for facilities that generate hazardous waste. Requirements specify packaging, training, emergency preparedness planning, and recordkeeping procedures.	These requirements are applicable because hazardous waste may be generated during 200 Area actions.
Standards Applicable to Transporters of Hazardous Waste, 40 CFR 263	Applicable	Establishes standards applicable to transporters of hazardous wastes. Transporters must maintain records concerning generator's delivery to treatment, storage, and disposal facilities; proper labeling of transported waste; and compliance with manifest system.	These requirements are applicable because hazardous waste may be generated during 200 Areas remedial actions and require transport to a treatment, storage, or disposal facility.
Standards for Owners and Operators of TSD Units, 40 CFR 264 and 265	Applicable or relevant and appropriate	Sets standards for owners and operators of hazardous waste treatment, storage, and disposal facilities. Standards include general facility requirements for employee training, emergency preparedness and contingency planning and closure and postclosure requirements for applicable units. Unit-specific requirements are contained in various subparts of this regulation and include standards for containers, tanks, waste piles, surface impoundments, landfills, containment buildings, drip pads, and miscellaneous units. Standards for groundwater monitoring, corrective action at sites with releases to groundwater, and corrective action management units/temporary units are also found in this part as are standards for air emissions from process vents and equipment leaks.	These requirements are applicable to the 200 Areas at TSD units. For non-TSD units, the substantive regulatory requirements for owners and operators of hazardous waste storage, treatment, or disposal facilities are relevant and appropriate if hazardous wastes are stored longer than 90 days or treated, or disposed on site in TSD-like units.
Land Disposal Restrictions, 40 CFR 268	Applicable	These requirements prohibit the placement of restricted RCRA hazardous wastes in land-based units such as landfills, surface impoundments, and waste piles until treated to standards considered protective for disposal. Specific treatment standards are included in the requirements.	These requirements are applicable if restricted waste is generated during characterization or remediation.

Table 4-1. Identification of Potential Federal ARARs and TBCs for the 200 Areas Remedial Action Sites. (9 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Clean Air Act of 1977, as amended 42 USC 7401, et seq.			
National Ambient Air Quality Standards, 40 CFR 50	Applicable	Requirements of these regulations are applicable to airborne releases of criteria pollutants specified under the statute. Specific release limits for particulates are set at 50 $\mu g/m^3$ annually or 150 $\mu g/m^3$ per 24-hour period.	Applicable to airborne releases of radionuclides and criteria pollutants that may be generated during 200 Area characterization or remedial actions.
Ambient Air Quality Monitoring, 40 CFR 58	Potentially relevant and appropriate	This regulation presents the criteria and requirements for ambient air quality monitoring and reporting for local air pollution control agencies and operators of new sources of air pollutants.	Not applicable to 200 Areas activities because remedial actions do not meet the regulatory definition of a new source. However, these requirements may be considered relevant and appropriate to remedial actions that have the potential to emit air contaminants.
Standards of Performance for New Stationary Sources, 40 CFR 60	Potentially Applicable	These requirements provide standards for new stationary sources or modifications of existing sources.	Remedial actions may include stationary sources for which the substantive requirements would be applicable.
National Emission Standard for Hazardous Air Pollutants (NESHAP), 40 CFR 61	Applicable	40 CFR 61 provides general requirements and listings for regulated emissions at a regulated facility	These requirements are applicable to remedial actions that release air emissions into unrestricted areas.
Subpart H, National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities, 40 CFR 61	Applicable	Subpart H sets emissions limits to ambient air from the entire facility not to exceed an amount that would cause any member of the public to receive an effective dose equivalent of 10 mrem/yr. The definition of facility for the Hanford Site includes all buildings, structures, and operations collectively as one contiguous site. Radionuclide emission from stacks shall be monitored and effective dose equivalent values to members of the public calculated.	These requirements are applicable to the site and remedial alternatives because the potential to release air emissions to unrestricted areas exists.
National Emission Standards for Asbestos, Standard for Demolition and Renovation, 40 CFR 61.145 – 150	Potentially Applicable	This section specifies that facilities are to be inspected for the presence of asbestos prior to demolition. The standard defines regulated asbestos-containing materials and establishes removal requirements based on quantity present and handling requirements. These requirements also specify handling and disposal requirements for regulated sources having the potential to emit asbestos. Specifically, no visible emissions are allowed during handling, packaging, and transport of asbestos-containing materials.	These requirements may be applicable if remedial actions require demolition of buildings or structures containing regulated asbestos-containing materials
National Emission Standards for Asbestos, Standards for Active Waste Disposal Sites, 40 CFR 61.154	Potentially relevant and appropriate	This regulation establishes operating requirements for landfills that handle asbestos-containing wastes. The standard specifies that management practices for asbestos-containing materials are not to allow any visible emissions of asbestos-containing material.	This standard is not applicable since the operable unit is not considered an active landfill. However, the standard is relevant and appropriate because asbestos-containing materials may be present in the inactive burial grounds within the operable unit.

Table 4-1. Identification of Potential Federal ARARs and TBCs for the 200 Areas Remedial Action Sites. (9 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Radioactive Waste Management, DOE Order 5820.2A	To be considered	These guidelines set performance objectives to limit the annual effective dose equivalent beyond the facility boundary to 25 mrem. Disposal methods selected must be sufficient to limit the annual effective dose equivalent to 100 mrem for continuous exposure or 500 mrem for acute exposures when active institutional controls are removed.	Policies and guidelines established for the management of radioactive waste and contaminated facilities should be considered during selection of remedial alternatives. These standards are TBC under CERCLA because they are not federally promulgated regulations. However, compliance with DOE orders is required at the Hanford Site.
Radiation Protection for Occupational Workers, DOE Order 5480.11	To be considered	DOE Order 5480.11 implements radiation protection standards and program requirements for worker protection at DOE and DOE-contractor operations. These standards were developed to be consistent with EPA standards and are based on recommendations by organizations recognized as authorities in the area of radiation protection. Limiting values for an annual effective dose equivalent to a worker from both internal and external sources received in any year is 5 rem. The limiting value to specific organs and tissues is 15 rem to the lens of the eye or 50 rem to any other organ or extremity of the body. Additional limiting values are established for the unborn (0.5 rem/yr) and children and minors (0.1 rem/yr). Radiation protection standards for the public entering controlled areas are set at 0.1 rem/yr from the committed effective dose equivalent from any external radiation. In addition, exposure shall not cause a dose equivalent to any tissue to exceed 5 rem/yr.	These standards are TBC under CERCLA because they are not federally promulgated regulations. However, compliance with DOE orders is required at the Hanford Site. DOE policy is to maintain radiation exposure ALARA and as low as possible where limiting values have been established.
Atomic Energy Act of 1954, as amended, 42 USC 2011, et seq.			
Licensing Requirements for the Land Disposal of Radioactive Waste, 10 CFR 61	Relevant and appropriate	Requires that disposal systems be designed to limit the annual dose equivalent beyond the facility boundary below 25 mrem to the whole body, 75 mrem to the thyroid, or 25 mrem to any other organ are relevant and appropriate to remedial actions that include land disposal or release radioactive effluent. Inadvertent intruder requirements for land disposal units are also contained in this regulation	The regulation is not applicable because it applies to land disposal of radioactive wastes containing byproduct, source, and special nuclear material received from other persons. However, it is relevant and appropriate if radioactive waste will be left in place following remediation. Requirements to protect inadvertent intruders may also be relevant and appropriate to actions implemented at the site.
Packaging and Transportation of Radioactive Material, 10 CFR 71	Relevant and appropriate	These requirements apply to the packaging, preparation for shipment, and transportation of licensed radioactive material.	The regulations are only applicable for NRC-licensed plants and facilities where material is transported outside the confines of the plant. The Hanford Site is not an NRC-licensed plant; however, potentially radioactive waste will be generated by remedial actions in the operable unit. Subparts of this regulation are relevant and appropriate for packaging, testing, and preparation of packages containing radioactive material.

Table 4-1. Identification of Potential Federal ARARs and TBCs for the 200 Areas Remedial Action Sites. (9 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Wastes, 40 CFR 191	Potentially relevant and appropriate	These requirements state that radionuclide release to the environment for a period of 10,000 years after disposal shall have a likelihood of less than one chance in ten of exceeding the level specified in Appendix A, Table 1 of the regulation, or a likelihood of less than one in 1,000 chance of exceeding 10 times the limit specified in Appendix A, Table 1.	Containment requirements established by this standard are potentially applicable relevant and appropriate because transuranic wastes may be generated during 200 Areas remediation and will require disposal in accordance with this regulation.
Department of Energy Occupational Radiation Protection, 10 CFR 835	Applicable	These requirements set occupational dose limits for adults. Total effective dose equivalent is equal to 5 rem/yr	Standards for occupational dose limits are applicable to 200 Areas remedial actions.
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, 40 CFR 192	Relevant and appropriate	Standards for cleanup are set under this program including groundwater protection requirements for radium-226, radium-228, and gross alpha particle activity, which are set at levels established under state and federal water quality criteria programs.	Standards for cleanup set under this program are relevant and appropriate to remedial actions conducted at the site. The standard is not applicable because the operable unit is not a uranium or thorium milling site.
Hazardous Materials Transportation Act, 49 USC 1801, et seq.			
Hazardous Materials Regulation, 49 CFR 171	Potentially Applicable	These requirements state that no person may offer to accept hazardous material for transportation in commerce unless the material is properly classed, described, packaged, marked, labeled, and in condition for shipment.	These requirements are applicable to hazardous material generated during remediation that would be sent offsite for disposal.
Hazardous Materials Tables, Hazardous Materials Communications Requirements, and Emergency Response Information Requirements, 49 CFR 172	Potentially Applicable	Tables are used to identify requirements for labeling, packaging, and transportation based on categories of waste types. Small quantities of radioactive wastes are not subject to the requirements of the standard if activity levels are below limits established in paragraph 173.421, 173.422, or 173.424. Specific performance requirements are established for packages used for shipping and transport of hazardous materials.	These requirements are applicable if hazardous waste is generated during remediation and is transported offsite. In the event of a discharge of hazardous waste during transportation from the treatment facility to the disposal facility, this section is applicable.
Guidance on Remedial Actions for Superfund Sites With PCB Contamination, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response	To be considered	This document provides guidance for evaluating and selecting a remedy for sites contaminated with PCBs. The guidance presents a range of preliminary remediation goals for the cleanup of PCB-contaminated sites that are protective of human health and intended to meet the goals of the NCP and TSCA. EPA guidance notes that in selecting a response action under CERCLA, cleanup levels and disposal methods should be selected based on the form and concentration found at the site and not according to the TSCA anti-dilution provisions.	This guidance is to be considered during 200 Areas remedial actions. Should PCB wastes be excavated during remediation, specific TSCA treatment and disposal requirements are considered applicable.

Table 4-1. Identification of Potential Federal ARARs and TBCs for the 200 Areas Remedial Action Sites. (9 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Executive Order 12856, Federal Compliance with Right- to-Know Laws and Pollution Prevention Requirements	To be considered	Requires that federal agencies will comply with Emergency Planning and Community Right-To-Know Act of 1986 (EPCRA) and the Pollution Prevention Act of 1990 (PPA) to the extent that private entities would. The EO incorporates by reference all implementing regulations of EPCRA and the PPA. EPCRA requires tracking and reporting information on the storage, use, and release of extremely hazardous substances, hazardous substances, listed chemicals, and toxic chemicals to inform the public about the presence of such hazards in their community and to provide emergency planners and emergency response organizations with information needed to provide appropriate response to potential emergencies at the facilities. The PPA requires entities to implement practices that reduce or eliminate the creation of pollutants through increased efficiency in the use of raw materials, energy, water, or other resources; or protection of natural resources by conservation.	Applicable to federal agencies that either own or operate a "facility" as that term is defined in section 329(4) of EPCRA if such facility meets the threshold requirements set forth in EPCRA. The Hanford Site meets the definition and threshold requirements.
DOE 1998, Draft Hanford Remedial Action Environmental Impact Statement, DOE 1998	To be considered	The draft Hanford Remedial Action EIS will define land-use decisions for the Hanford Site including 200 Areas Burial Ground sites.	As a draft, this EIS is to be considered during remedial action decision making for the 200 Areas Burial Grounds.
DOE 1996b, "Guidance for a Composite Analysis of the Impact of Interacting Source Terms on the Radiological Protection of the Public from Department of Energy Low-Level Waste Disposal Facilities"	To be considered	The Composite Analysis provides an estimate of the cumulative radiological impacts from active and planned low-level radioactive waste disposal actions and other potentially interacting radioactive waste disposal sources that will remain following Hanford Site closure.	This TBC guidance from DOE is pertinent to 200 Area waste sites that will leave radiological contaminants in place following remediation.
Endangered Species Act of 1973, 16 USC 1531, et seq.	Applicable	This act prohibits federal agencies from jeopardizing threatened or endangered species or adversely modifying habitats essential to their survival. If waste site remediation is within sensitive habitat or buffer zones surrounding threatened or endangered species, mitigation measures must be taken to protect this resource.	The Endangered Species Act of 1973 would be considered relevant and appropriate if threatened or endangered species are identified in waste site areas. Their presence could dictate the approach to remedial actions that may be necessary.

ACL = alternate concentration level
ALARA = as low as reasonably achievable
CAMU = corrective action management unit
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulations
DCG = derived concentration guide
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
HCRL = Hanford Cultural Resources Laboratory
MCL = maximum contaminant level
MCLG = maximum contaminant level goal
NESHAP = National Emission Standards for Hazardous Air Pollutants
NCP = National Oil and Hazardous Substance Contingency Plan
NEPA = National Environmental Policy Act
NPDES = National Pollutant Discharge Elimination System
NRC = U.S. Nuclear Regulatory Commission
PCB = polychlorinated biphenyls
RCRA = *Resource Conservation and Recovery Act*
SDWA = Safe Drinking Water Act
TBC = to be considered
TSCA = Toxic Substance Control Act

Table 4-2. Identification of Potential State ARARs and TBCs for the 200 Areas Remedial Action Sites. (8 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
CHEMICAL SPECIFIC			
Hazardous Waste Clean Up/Model Toxics Control Act, Ch. 70.105D RCW			
Model Toxics Control Act, WAC 173-340-700	Relevant and Appropriate	This section identifies the methods used to develop cleanup standards and their use in selection of a cleanup action. Cleanup levels are based on protection of human health and the environment, the location of the site, and other regulations that apply to the site. The standard specifies cleanup goals that implement the strictest federal or state cleanup criteria. In addition to meeting requirements of other regulations, MTCA uses three basic methods for establishing cleanup levels; these methods may be used to identify cleanup standards for groundwater, surface water, soils, and protection of air quality. Cleanup levels for soils may be calculated using Method A - routine, Method B – standard method, and Method C – conditional standards. MCLs, MCLGs, and secondary drinking water standards are identified in the regulation as potential groundwater cleanup criteria.	Requirements of MTCA are relevant and appropriate to 200 Area remedial actions. State requirements that are not authorized through a federal program, such as MTCA, are not applicable to federal facilities.
Dangerous Waste Regulations, Ch. 70.105 RCW			
Dangerous Waste Regulations, WAC 173-303			
Designation of Waste, WAC 173-303-070 through 110	Applicable	Establishes the methods and procedures to determine if solid waste requires management as dangerous waste.	The requirements of this section are applicable because dangerous waste might be generated during characterization and remedial actions.
Releases from regulated units, WAC 173-303-645	Applicable	Establishes action levels for releases to groundwater from dangerous waste management units.	The standard is applicable since TSD units are present in the 200 Areas.
Solid Waste Management, Recovery and Recycling Act, Ch. 70.95 RCW			
Minimum Functional Standards for Solid Waste Handling, WAC 173-304-460	Applicable	Sets groundwater MCLs at the same levels as the drinking water standards under 40 CFR 141.	The standard is applicable since waste management facilities are present in the 200 Areas.

Table 4-2. Identification of Potential State ARARs and TBCs for the 200 Areas Remedial Action Sites. (8 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Water Pollution Control/Water Resource Act of 1971, Ch. 90.48 RCW/Ch. 90.54 RCW			
Surface Water Quality Standards, WAC 173-201A	Applicable	These standards set water quality standards at levels protective of aquatic life.	Groundwater below the 200 Areas discharges to the Columbia River; therefore, surface water quality criteria established under this chapter must be taken under consideration when developing cleanup standards for soil and groundwater associated with 200 Areas remedial actions.
Department of Health Standards for Public Water Supplies, WAC 246-290	Relevant and appropriate	The rule established under WAC 246-290 defines the regulatory requirements necessary to protect consumers using public drinking water supplies. The rules are intended to conform with the federal SDWA, as amended. WAC 246-290-310 establishes MCLs that define the water quality requirements for public water supplies. WAC 246-290-310 establishes both primary and secondary MCLs and identifies that enforcement of the primary standards is the Department of Health's first priority.	The requirements of WAC 246-290-310 are relevant and appropriate to 200 Area remedial actions because groundwater in the 200 Areas is hydraulically connected to current or potential future drinking water supplies.
State Radiation Protection Requirements, Ch. 70.98 RCW			
Radiation Protection Standards, WAC 246-221	Relevant and appropriate	Washington State Radiation Protection Requirements are implemented under specific sections of WAC 246. Chapter 246-221-290 establishes annual average concentration limits for radioactive releases in gaseous and liquid effluent released to unrestricted areas. Occupational dose to adults and minors are set in these requirements. Dose limits that individual members of the public may receive in unrestricted areas from external sources are also set. The standard identifies the methods required to demonstrate compliance and provides derived air concentration and annual limit on uptake values that may be used to determine an individual's occupational dose. The standard specifies requirements for monitoring personnel exposure for both external and internal exposure.	This regulation is not applicable because it does not apply to Federal agencies under the AEA. However, it is considered relevant and appropriate because it establishes standards for acceptable levels of exposure to radiation..

Table 4-2. Identification of Potential State ARARs and TBCs for the 200 Areas Remedial Action Sites. (8 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Washington Clean Air Act, Ch. 70.94 RCW and Ch. 43.21A RCW			
Radiation Protection - Air Emissions, WAC 246-247	Applicable	This regulation promulgates air-emission limits for airborne radionuclide emissions as defined in WAC 173-480 and 40 CFR 61 Subparts H and I. The ambient air standards under WAC 173-480 require that the most stringent standard be enforced. Ambient air standards under 40 CFR 61 Subparts H and I are not to exceed amounts that result in an effective dose equivalent of 10 mrem/yr to any member of the public. The ambient standard in WAC 173-480 specifies that emission of radionuclides to the air must not cause a dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to any critical organ.	This regulation is considered applicable because it sets emission limits for airborne radionuclides.
Radiation Protection at Uranium and Thorium Milling Operations, WAC 246-252	Relevant and appropriate	Radium-226 concentrations are required to be less than 5 pCi/g averaged over the upper 15 cm and not more than 15 pCi/g averaged over any 15-cm interval deeper than 15 cm from the surface. Groundwater protection standards established for gross alpha excluding radon and uranium are set at 15 pCi/L, and for combined radium-226 and radium-228 not to exceed 5 pCi/L.	This is not applicable to 200 Areas remedial actions because sites were not uranium or thorium milling operations; however, the regulation is relevant and appropriate because it contains specific soil cleanup limits for radium-226 and radium-228 and groundwater protection limits.
LOCATION SPECIFIC			
Department of Game Procedures, WAC 232-012	Potentially applicable	This standard defines the requirements that the Department of Game must take to protect endangered or threatened wildlife.	These requirements may be applicable if endangered or threatened wildlife are identified in the 200 Areas during wildlife surveys. The requirements of this chapter will be reevaluated should protected wildlife species be identified within the 200 Areas.

Table 4-2. Identification of Potential State ARARs and TBCs for the 200 Areas Remedial Action Sites. (8 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
National Area Preserves, RCW 79.70			
Washington Natural Heritage Program	To be considered	The Washington State Natural Heritage Program is authorized under RCW 79.70, Natural Area Preserves, and serves as an advisory council to the Washington State Department of Natural Resources, Fish and Wildlife, the Parks and Recreation Commission, and other state agencies managing state-owned land or natural resources. The list of state endangered, threatened, and sensitive plants developed by the program, along with program-recommended levels of protection, are to be used to assist resource managers in determining which species of concern occur in their areas and recommend protection. The designations provided to plants by the Washington State Natural Heritage program are advisory and do not specify a regulatory level of protection.	The requirements of the Natural Heritage Program are TBC guidance for remedial actions at the 200 Areas. No threatened or endangered plant species have been currently identified in the 200 Areas.
ACTION SPECIFIC			
Hazardous Waste Cleanup-Model Toxics Control Act, Ch. 70.105D RCW			
Model Toxics Control Act Cleanup Regulations, WAC 173-340	Relevant and appropriate	Establishes a process for cleanup of contaminated sites in the state. Specifies that all cleanup actions be protective of human health, comply with all applicable state and federal regulations, and provide for compliance monitoring.	Requirements of MTCA are relevant and appropriate to 200 Areas remedial actions. State requirements that are not authorized through a federal program, such as MTCA, are not applicable to federal facilities.
Hazardous Waste Management Act, 70.105 RCW			
Dangerous Waste Regulations, WAC 173-303	Applicable	Establishes the design, operation, and monitoring requirements for management of dangerous waste.	Applicable to 200 Areas TSD units and to dangerous wastes generated during remedial activities. All sections of this chapter may be applicable to dangerous waste management activities during 200 Areas remediation. Key sections are highlighted below.
Land Disposal Restrictions, WAC 173-303-140	Applicable	Identifies dangerous wastes that are restricted from land disposal and describes requirements for state-only restricted wastes, and define the circumstances under which a prohibited waste may be disposed.	Applicable to the disposal of dangerous waste generated during 200 Areas characterization and remedial actions.

Table 4-2. Identification of Potential State ARARs and TBCs for the 200 Areas Remedial Action Sites. (8 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Spills and Discharges into the Environment, WAC 173-303-145	Applicable	Sets forth the requirements that apply when any dangerous waste or hazardous substance is intentionally or accidentally spilled or discharged into the environment such that human health and the environment are threatened, regardless of the quantity of dangerous waste or hazardous substance.	Applicable should dangerous waste or hazardous substances be spilled or discharged into the environment.
Requirements for Generators of Dangerous Waste, WAC 173-303-170 through 230	Applicable	Requirements defined under this section include a 90-day waste accumulation period, specific levels of training, emergency preparedness, and record keeping.	Applicable to actions performed at the site if dangerous waste is generated.
General Requirements for Dangerous Waste Management Facilities, WAC 173-303-280 through 395	Applicable	General requirements include siting standards and procedures for permitting, training, emergency preparedness, security, inspections, contingency planning, waste analysis, and management of containers.	Applicable to remedial actions that include treatment, storage, or disposal of designated dangerous waste.
Treatment, Storage, and Disposal Facility Requirements, WAC 173-303-600 through 695	Applicable or relevant and appropriate	Specifies closure and postclosure standards (which require compliance with MTCA cleanup levels), groundwater monitoring requirements, corrective action management unit/temporary unit requirements, air emission standards for process vents and equipment leaks, and specific unit requirements for: containers; tanks, surface impoundments, land treatment units, waste piles, landfills, incinerators, drip pads, miscellaneous units, and containment buildings.	Applicable to the 200 Areas because permitted TSD units are present and relevant and appropriate because remediation wastes from sites may be managed in units meeting TSD definition.
Solid Waste Management, Recovery, and Recycling Act, Ch. 70.95 RCW			
Minimum Functional Standards for Solid Waste Handling, WAC 173-304	Applicable	These standards establish requirements to be met for the management of solid waste. Solid waste controlled by this Act includes garbage, industrial waste, construction waste, and ashes. Requirements for containerized storage, collection, transportation, treatment, and disposal of solid waste are included.	These regulations are applicable to onsite management and disposal of solid waste that may be generated during characterization or remedial activities.
Water Well Construction, Ch. 18.104 RCW			
Minimum Standards for Construction and Maintenance of Water Wells, WAC 173-160	Applicable	These requirements establish minimum standards for design, construction, capping, and sealing of all wells; sets additional requirements, including disinfection of equipment, abandonment of wells, and quality of drilling water.	These requirements are applicable to actions that include construction of wells used for groundwater extraction, monitoring, or injection of treated groundwater or wastes.

Table 4-2. Identification of Potential State ARARs and TBCs for the 200 Areas Remedial Action Sites. (8 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Rules and Regulations Governing the Licensing of Well Contractors and Operators, WAC 173-162	Applicable	This regulation establishes procedures for the examination, licensing, and regulation of well contractors and operators.	This regulation is applicable to remedial actions where groundwater wells will be installed.
Water Pollution Control/Water Resources Act, Ch. 90.48 RCW/Ch. 90.54 RCW			
Protection of Upper Aquifer Zones, WAC 173-154	Relevant and appropriate	This regulation directs Ecology to provide for protection of upper aquifers and upper aquifer zones to avoid depletions, excessive water level declines, or reductions in water quality.	This regulation is not applicable to remedial actions because it establishes the policy and program for Ecology. However, the regulation is considered relevant and appropriate since protection of the aquifer from adverse impacts caused by waste management units is a primary goal.
State Waste Discharge Program, WAC 173-216	Applicable	The chapter implements a permit system applicable to industrial and commercial operations that discharge to the groundwater, surface waters, or municipal sewerage systems. Specific discharges prohibited under the program are identified. The intent of the law is to maintain the highest possible standards, and the law requires the use of all known available and reasonable methods to prevent and control the discharge of wastes into the waters of the state.	Requirements of this program are applicable to remedial actions that include discharges to the ground.
Washington Clean Air Act, Ch. 70.94 RCW and Ch. 43.21A RCW			
General Regulations for Air Pollution, WAC 173-400	Applicable	The regulation requires that all sources of air contaminants meet emission standards for visible, particulate, fugitive, odors, and hazardous air emissions. This section requires that all emission units use reasonably available control technology, which may be determined for some source categories to be more stringent than the emission limitations listed in this chapter. The regulation requires that source testing and monitoring be performed. A new source would include any process or source that may increase emissions or ambient air concentration of any contaminant for which federal or state ambient or emission standards have been established.	Requirements of this standard are applicable to remedial actions performed at the site that could result in the emission of hazardous air pollutants. Substantive standards established for the control and prevention of air pollution under this regulation are applicable to remedial actions that may be proposed at a site.

Table 4-2. Identification of Potential State ARARs and TBCs for the 200 Areas Remedial Action Sites. (8 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Controls for New Sources of Air Pollution, WAC 173-460	Relevant and appropriate	This standard requires that new sources of air emissions provide emission estimates for toxic air contaminants listed in the regulation. The standard requires that emissions be quantified and used in risk modeling to evaluate ambient impacts and establish acceptable source impact levels. The standard establishes three major requirements for new sources of air pollutants: use of best available control technology, quantification of toxic emissions, and demonstration that human health is protected.	The standard is relevant and appropriate to remedial actions because nonradioactive operable unit contaminants of concern are identified in the regulation as toxic air contaminants.
Ambient Air Quality Standards for Particulate Matter, WAC 173-470	Relevant and appropriate	These requirements set maximum acceptable levels for particulate matter in the ambient air at 150 $\mu g/m^3$ over a 24-hour period, or 60 $\mu g/m^3$ annual geometric mean. It also sets the 24-hour ambient air concentration standard for particles less than 10 μm in diameter (PM_{10}), which are set at 105 $\mu g/m^3$ and 50 $\mu g/m^3$ geometric mean. The section defines standards for particle fallout not to exceed 10 g/m^2 per month in an industrial area or 5 g/m^2 per month in residential or commercial areas. Alternate levels for areas where natural dust levels exceed 3.5 g/m^2 per month are set at 6.5 g/m^2 per month, plus background levels for industrial areas, and 1.5 g/m^2 per month plus background in residential and commercial areas.	These state-authorized requirements are applicable to remedial actions that may emit particulate matter to the air.
Ambient Air Quality Standards and Emission Limits for Radionuclides, WAC 173-480	Applicable	These requirements establish that the most stringent federal or state ambient air quality standard for radionuclides be enforced. The WAC 173-480 standard defines the maximum allowable level for radionuclides in the ambient air, which shall not cause a maximum accumulated dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to any critical organ. However, ambient air standards under 40 CFR 61 Subparts H and I are not to exceed amounts that result in an effective dose equivalent of 10 mrem/yr to any member of the public. Emission standards for new and modified emission units shall utilize best available radionuclide control technology. The standard requires all sources of emissions to meet levels set in 246-220, including determination of compliance using methods established by the Department of Social and Health Services.	Requirements of this standard are applicable to remedial actions performed at the site that may emit radionuclides to the air.

Table 4-2. Identification of Potential State ARARs and TBCs for the 200 Areas Remedial Action Sites. (8 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Emission Standards and Controls for Sources Emitting Volatile Organic Compounds (VOC), WAC 173-490	Potentially relevant and appropriate	This chapter establishes technically feasible and attainable standards for sources emitting volatile organic compounds.	This regulation is probably not applicable to remedial actions conducted at the 200 Areas because the source of potential volatile organic compound emissions generated by remedial actions most likely do not meet the definition of emission sources specified under WAC 173-490-03. However, this regulation may be considered relevant and appropriate if remedial actions have the potential to emit volatile organic compounds into the air.
State Radiation Protection Requirements, Ch. 70.98 RCW			
Radioactive Waste-Licensing Land Disposal, WAC 246-250	Relevant and appropriate	WAC 246-250 establishes the procedures, criteria, and conditions for licensing of low-level radioactive waste land disposal facilities. This section presents specific levels of radiation protection and technical requirements for land disposal of radioactive waste.	These requirements are considered relevant and appropriate if remedial alternatives allow radioactive waste to remain on site.
State Environmental Policy Act, Ch. 43.21C RCW			
SEPA Rules, WAC 197-11	Applicable	These requirements establish compliance with the State Environmental Policy Act.	These requirements are applicable to remedial actions at the 200 Areas.

CERCLA= Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulations
Ecology = Washington Department of Ecology
MCL = maximum contaminant level
MCLG = maximum contaminant level goal
MTCA = Model Toxics Control Act
NPDES = National Pollutant Discharge Elimination System
RCRA = Resource Conservation and Recovery Act
RCW = Revised Code of Washington
SEPA = State Environmental Policy Act
SDWA = Safe Drinking Water Act
TBC = to be considered
TSD = treatment, storage, and disposal
VOC = Volatile Organic Compounds
WAC = Washington Administrative Code.

5.0 CONCEPTUAL EXPOSURE MODEL AND RISK ASSESSMENT

This section introduces a conceptual exposure model for establishing remedial action objectives (RAOs), preliminary remediation goals (PRGs), and an approach to risk assessment that are applicable to environmental remediation of the 200 Areas.

A conceptual exposure model provides critical information to the characterization and remedial alternative selection phases of both the CERCLA and RCRA remediation processes (see Section 2.0). Prior to the characterization phase, a preliminary conceptual exposure model summarizes what is known about a site and serves as a basis for defining characterization needs. After the characterization phase, a refined conceptual exposure model identifies potential exposure pathways that may need to be addressed through remedial action and provides information critical to remedial alternative selection. A risk assessment, by identifying risks to human health and the environment associated with the potential exposures identified in the model, helps determine if remedial action is warranted.

An overall conceptual exposure model was developed for the Implementation Plan which addresses all the environmental restoration sites in the 200 Areas. During group-specific DQO and characterization planning, this preliminary model will serve as a starting point for the development of a conceptual exposure model for each waste group. After waste group characterization is completed, group-specific conceptual exposure models will be verified or revised to help focus future waste site-specific characterization efforts, help determine risk assessment requirements, and aid in the selection of remedial alternatives.

This section begins with a discussion of anticipated land use for the 200 Areas and a presentation of the preliminary conceptual exposure model for the entire 200 Areas. The conceptual exposure model integrates the generalized conceptual contaminant distribution concepts presented in Section 3.3 (Figures 3-2 and 3-3) with potential exposure pathways and routes to provide a basis for evaluating current or potential future risks. These risks are addressed by RAOs intended to protect human health and the environment, and by PRGs, which are typically numerical representations of the RAOs usually based on regulatory standards (e.g., ARARs) or readily available risk-based criteria. The RAOs and PRGs presented in this document are preliminary and general in nature. Group-specific characterization data gathered to verify or revise the group-specific conceptual exposure models will serve to better define the RAOs for a particular waste group. Rather than presenting specific contaminant concentrations, this section presents a range of potentially applicable cleanup standards and points of compliance. Contaminant-specific, numeric PRGs will be developed in future group-specific work plans or FS reports.

This section concludes with an approach for implementing risk assessment during the remediation of the 200 Areas. This approach is general, and it is intended to guide future applications of group-specific risk assessments.

5.1 ANTICIPATED LAND USE

Anticipated future land use helps define a conceptual exposure model and associated exposure scenarios, which in turn influence characterization needs and remedial action decisions. Future land use for the 200 Areas is not definitive at this time. However, industrial land use has been designated for the 200 Areas by the Tri-Parties and has been included in proposals by all of the Natural Resource Damage Assessment stakeholders.

Future land-use alternatives for the Hanford Site proposed by local governments (i.e., county land-use planning agencies), state and federal land management agencies, and Native American governments and included in the *Hanford Remedial Action Environmental Impact Statement and Comprehensive Land Use Plan* (HRA-EIS) (DOE 1996a) are the basis for the DOE proposal for land use at this time. A land-use alternative will be identified in a ROD planned for 1998. Figure 5-1 illustrates the DOE-preferred land-use alternative presented in the HRA-EIS.

All of the HRA-EIS alternatives propose industrial (exclusive) use for land located within the 200 Areas land-use boundary line and preservation and conservation uses for land located immediately outside the boundary line. An industrial (exclusive) land use is defined as an area suitable and desirable for treatment, storage, and disposal of hazardous, dangerous, radioactive, and nonradioactive wastes. However, there is no provision for an "industrial (exclusive)" land use in the regulations at this time. Only an industrial land use is recognized by the EPA and Ecology. Preservation is defined as an area managed for the preservation of archeological, cultural, ecological, and natural resources; no new consumptive uses (e.g., mining) would be allowed within this area. Conservation is defined as an area reserved for the management and protection of archeological, cultural, ecological, and natural resources; limited and managed mining and grazing could occur as a conditional use (e.g., a permit would be required) within appropriate areas (DOE 1998a). MTCA specifies that a site be zoned as "industrial" under the *Growth Management Act* of the State of Washington to be defined as "industrial," but the *Growth Management Act* does not apply to federal facilities. Therefore, it is assumed that the HRA-EIS will be put in place to establish land use for the Hanford Site in parallel with the 200 Areas Implementation Plan.

Most of the waste sites in the 200 Areas (200 East and West Areas) are located within the proposed industrial (exclusive) land-use boundary line of the HRA-EIS (Plate I) and fall under the industrial (exclusive) land-use designation. However, some sites are located outside the proposed industrial (exclusive) land-use boundary (e.g., 200 North Area and Nonradioactive Dangerous Waste Landfill [NRDWL]) and would fall under the preservation or conservation land-use designation proposed by the HRA-EIS. Sites located outside the land-use boundary may be designated as pre-existing, nonconforming use (defined as any lawfully established use that is neither allowed nor conditionally permitted within a land-use designation, but exists therein, having been established prior to the designation [DOE-RL 1998]). Designation of sites located outside the proposed industrial (exclusive) land-use boundary as having had a pre-existing, nonconforming use may result in remediation to an industrial (exclusive) standard.

Under no current or future land-use scenario is it foreseen that groundwater underlying the 200 Areas or contaminated by 200 Area waste sources will be used for potable water or as an irrigation source.

5.2 CONCEPTUAL EXPOSURE MODEL

From a broad perspective, a conceptual exposure model serves as a graphical summary of the physical characteristics and mechanisms that could potentially affect the generation of contamination, its transport, and its impact on other media (e.g., soil, air, water) and receptors (humans and biota). Specifically, a conceptual exposure model identifies potential exposure pathways (to include the sources of contamination, mechanisms of contaminant release [if applicable], transport media [if applicable], potentially affected media, exposure routes, and potential receptors). A conceptual exposure model summarizes information from a physical contaminant distribution model(s), which generally provides additional details regarding contaminants and contaminant fate and transport mechanisms, to identify exposures that may need to be addressed through remedial action. Initially, a conceptual exposure model represents the *a priori* understanding of a site and serves as a basis for determining assessment needs. The potential exposures identified in a conceptual exposure model serve as inputs for a quantitative or qualitative risk assessment. Characterization data are used to refine or verify the conceptual exposure model before risk assessments are conducted or remedial decisions are made. Figure 5-2 illustrates the conceptual exposure model for the entire 200 Areas.

The nine major process categories defined in Section 3.2.3 and the first column of Figure 5-2 are the primary sources of contamination in the 200 Areas. Contaminants were introduced to the environment by surface and subsurface liquid discharges and surface and subsurface solid waste placements, resulting in nine secondary contaminant sources that are primary waste site types identified in the third column of Figure 5-2. Current or potential future secondary release of contaminants occurs through the mechanisms listed in the fourth column of Figure 5-2. Secondary contaminant release can occur through resuspension of contaminated soils via wind erosion or excavation activities; volatilization of contaminants from wastes and soils into the air or as soil gas; biotic uptake of contaminants via direct contact with soils or ingestion of soils, vegetation, or other animals; migration of contaminated liquids through the soil column via infiltration or percolation; leaching of contaminants from soil to groundwater; external radiation (gamma); and excavation or direct contact with contaminated soils. Media potentially contaminated via primary and secondary releases to the environment are listed in the fifth column of Figure 5-2. Potential receptors (humans and biota) may be exposed to contaminated media through several exposure pathways, including inhalation of volatilized contaminants or suspended dust; ingestion of contaminants in soils, vegetation, or animals or of suspended dust; direct dermal contact with contaminants in soils; and/or direct exposure to external radiation (gamma). Potential human receptors include future workers, future occasional users of a site, and an inadvertent intruder. Potential ecological receptors include terrestrial and aquatic plants and animals.

It is important to note that this report does not attempt to quantify potential human health or environmental risks associated with current or potential future exposure to 200 Areas contaminants. Current and future risks will be evaluated, as necessary, using concepts presented in this report after group-specific characterization data have been collected and reported in the RI report (refer to Section 5.5).

5.3 REMEDIAL ACTION OBJECTIVES

Remedial action objectives are general descriptions of what remedial action is expected to accomplish (i.e., media-specific or site-specific goals for protecting human health and the environment). Remedial action objectives are generally defined as specifically as possible and usually include the following components:

- Medium of concern
- Types of contaminants
- Possible exposure pathways
- Potential receptors
- Levels of residual contaminants that may remain following remediation (i.e., contaminant levels below cleanup standards or below a range of levels for different exposure routes [i.e., PRG]).

Remedial action objectives provide a basis to evaluate the capability of a specific remedial alternative to achieve compliance with ARARs and/or an intended level-of-risk protection for human health or the environment (refer to Section 4.0). The overall purpose of establishing RAOs is to help ensure that the selected remedial action will be protective of human health and the environment by eliminating or minimizing exposure and/or by removing contaminants or reducing their levels. As discussed previously, the RAOs for this 200 Areas RI/FS Implementation Plan are preliminary, general in nature, and are applicable for the entire 200 Areas. They are intended as a guide for developing group-specific RAOs in future group-specific work plans or FS reports. The preliminary RAOs for the 200 Areas are:

- Prevent or mitigate risk to human and ecological receptors associated with ingestion of, dermal contact with, inhalation of, and external exposure to contaminants at levels that exceed ARARs or a risk of 10^{-4} to 10^{-6}.
- Prevent or mitigate the migration of contaminants to groundwater such that no further degradation occurs.
- Prevent or mitigate the migration of contaminants to groundwater and through groundwater so that contaminants do not reach the Columbia River at levels that exceed ARARs or a risk of 10^{-4} to 10^{-6}.
- Prevent plants and animals from creating a migration pathway for the contaminants.
- Prevent or mitigate risk to workers performing remedial action.
- Provide conditions suitable for proposed future land use.
- Prevent destruction of significant cultural resources and sensitive wildlife habitat. Minimize the disruption of cultural resources and wildlife habitat in general and prevent adverse impacts to cultural resources and threatened or endangered species.

5.4 PRELIMINARY REMEDIATION GOALS

Preliminary remediation goals (i.e., cleanup levels) are numeric representations of the RAOs. Using the anticipated future land use, the conceptual exposure model, and the RAOs as a basis, PRGs are identified for applicable contaminants and exposure pathways. Preliminary remediation goals are used to define unacceptable risk posed by specific contaminants, to identify the contaminants that are the most likely risk drivers (i.e., contaminants of concern), to provide target cleanup goals for use during remedial design, and to provide guidance during remediation. They are based on acceptable levels of human health and ecological risk, ARARs, TBC guidance, points of compliance, and remediation timeframes. Contaminant-specific, numeric PRGs are not presented in this document. Instead, potentially applicable standards are outlined. Specific PRGs will be defined for individual contaminants in future group-specific work plans or FS reports. An important aspect of establishing these contaminant-specific PRGs will be the availability of background data regarding soil and groundwater chemistry. Available background data is discussed in Appendix F, Section F7.0, and presented in Tables F-3 and F-4. Potential contaminants of concern are listed in Tables 3-2, 3-3, and 3-4.

The RAOs designed to protect human and ecological receptors from exposure to contaminants will be achieved by meeting PRGs based on the following standards:

- The EPA-supported radionuclide soil cleanup standard of 15 mrem/yr above background
- The State of Washington's MTCA standards for nonradioactive contaminants.

The RAOs designed to ensure no further degradation of groundwater and protection of the Columbia River will be achieved by meeting PRGs based on the following:

- Maximum contamination levels (MCLs) promulgated under the *Safe Drinking Water Act* or the State of Washington's Drinking Water Standards or, alternate concentration limits (ACLs) established where groundwater restoration is shown to be impracticable.
- The State of Washington's MTCA standards for nonradioactive contaminants.
- Ambient Water Quality Criteria developed under the *Clean Water Act* or the State of Washington's Surface Water Quality Standards.

The above PRGs are initial goals based on standards derived from existing ARARs. In subsequent FSs, PRGs will be reevaluated to reflect ARARs that are current when the FSs are written. Future characterization data may indicate that the initial PRGs are inappropriate. For example, the EPA's 15 mrem/yr standard may not be practicable or achievable within the confines of the 200 Areas' land-use boundary through the reduction of contaminant concentrations or the elimination of exposure pathways. Alternative solutions, possibly in combination with appropriate institutional controls, may be necessary, such as a 25 mrem/yr or 100 mrem/yr standard.

Setting achievable cleanup levels requires the ability to demonstrate that PRGs have been achieved. Compliance involves specifying the location where the cleanup levels must be attained (i.e., points of compliance) and how long it may take for the cleanup levels to be reached (i.e., restoration time frame). The following is a preliminary discussion of points of compliance and restoration time frames. As with RAOs and PRGs, group-specific or site-specific points of compliance and restoration time frames will be refined in future documents, and ultimately set in a ROD.

For soil cleanup levels based on the protection of groundwater (and the Columbia River), the point of compliance shall be established in the soils throughout the site (WAC 173-340-740 [6] [b]). For soil cleanup standards based on human exposure via direct contact, the point of compliance will be established at a depth of 4.5 m (15 ft), with the ambient surrounding grade at the time of disposal serving as the excavation depth reference. The point of compliance for engineered structures would extend beyond 4.5 m (15 ft) unless it could be shown that the portions below 4.5 m (15 ft) could remain in place without impacts to human health or the environment. The 4.5-m (15-ft) depth represents a reasonable estimate of the depth of soil that could be excavated and distributed at the soil surface as a result of site development activities (WAC 173-340-740 [6] [c]). This point of compliance may not be applicable for sites where containment is selected as the remedial alternative (i.e., contaminants remain on site) (WAC 173-340-360[6][d]) or for sites where, based on designated land use, future development will not occur. For sites covered with a surface barrier or for sites designated for preservation or conservation use, the point of compliance could be less than 4.5 m (15 ft) (e.g., the average maximum depth of an animal burrow or a plant root).

For groundwater cleanup levels or cleanup levels established to ensure no further degradation of groundwater (i.e., MCLs and ACLs, respectively), the point of compliance may be in groundwater underlying a site, at the site boundary or the 200 Areas' land-use boundary (a conditional point of compliance), or some other agreed-upon location. For cleanup levels to protect the Columbia River, the point of compliance may be in groundwater at a near-river well, at the groundwater-river substrate interface, or some other agreed-upon location.

Cleanup actions shall provide for a reasonable restoration time frame. The factors to be considered when establishing a reasonable restoration time frame include (WAC 173-340-360 [6]):

- Potential risks posed by the site to human health and the environment
- Practicability of achieving a shorter restoration time frame
- Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site
- Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site
- Availability of alternative water supplies
- Likely effectiveness and reliability of institutional controls
- Ability to control and monitor migration of hazardous substances from the site
- Toxicity of hazardous substances at the site
- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions.

Restoration time frames will be determined for each waste group or each site as part of the remedial alternative selection process. Current characteristics of the 200 Areas, including known contaminants, may lend support for the assessment of remedial alternatives with reasonable, yet extended, restoration time frames. Examples include the presence of short-lived radionuclides that will decay to protective levels rather quickly and the presence of contaminants that naturally attenuate in site soils or underlying groundwater. Consistent with EPA guidance (EPA 1997b), monitored natural attenuation, including radioactive decay, is an option that may be evaluated with other applicable remedies for achieving the 200 Areas' RAOs (see discussion of remedial technologies in Appendix D). Remedial alternatives would be required to meet RAOs at the completion of the restoration time frame. Remediation time frames will first be discussed in feasibility studies for waste site groups. Specific schedules for remediation will be defined in RDR/RAWPs done in conjunction with the Hanford Site ER program long range plan for specific groups of waste sites.

The remedial action alternatives presented in Appendix D are general and cover a range of technologies to relfect the potential contamination conditions present in the 200 Areas. Appendix D is intended to satisfy the requirements of a screening phase FS (i.e., Phase I and II FS) by providing the necessary basis to prepare group-specific detailed FSs. Site-specific refinements of the alternatives presented in Appendix D will be made in final group-specific FSs. By completing a screening-level FS in Appendix D and identifying viable alternatives now, a more streamlined RI/FS can be performed. Characterization needs can be more focused if a range of expected remedial alternatives are identified early, and treatability testing needs can also be evaluated and implemented early in the process. The final group-specific FS can then be focused on the detailed analysis of a few viable alternatives.

5.5 RISK ASSESSMENT APPLICATION

The application of risk assessment in the characterization and remediation of the 200 Areas will follow a graded approach. As more data are gathered and the level of understanding increases with regard to the nature and extent of contamination and the details of the conceptual exposure model, and as the objectives of risk assessment change with the evolution of the characterization/remediation process, the approach to risk assessment will change. Depending on objectives determined by the group-specific project managers, risk assessments may range from relatively simple screening evaluations (to decide to take action at an individual site or not), to more rigorous assessments (to determine if a waste site can be released), to even more comprehensive cumulative assessments (to determine if a portion of the 200 Areas NPL site can be released). The risk assessment and modeling requirements will be appropriately adjusted to address these variable technical and regulatory requirements. Remediation time frames will first be discussed in feasibility studies for waste site groups. Specific schedules for remediation will be defined in Remedial Design Report/Remedial Action Work Plans done in conjunction with the Hanford Site ER Program long range plan for specific groups of waste sites.

The remedial action alternatives presented in Appendix D are general and cover a range of technologies to reflect the potential contamination conditions present in the 200 Area. Appendix D is intended to satisfy the requirements of screening phase FS (i.e., Phase I and II FS) by providing the necessary basis to prepare group-specific detailed FSs. Site-specific refinements of the alternatives presented in Appendix D will be made in final group-specific FSs. By completing a screening-level FS in Appendix D and identifying viable alternatives now, a more streamlined RI/FS can be performed. Characterization needs can be more focused if a range of expected remedial alternatives are identified early, and treatability testing needs can be evaluated and implemented early in the process. The final group-specific FS can then be focused on the detailed analysis of a few viable alternatives.

Using available information (e.g., WIDS, AAMS report, Hanford Environmental Information System [HEIS]), initial screening evaluations to determine the need for action (i.e., characterization and/or remediation) and site remediation priorities have already been performed. For example, the 200 Areas' AAMS reports screened waste sites as low- or high-priority based on the CERCLA Hazard Ranking System and a qualitative evaluation of potential exposure to an onsite occupational receptor. Using this and other information suggesting current or potential risks, the *200 Area Soils Remediation Strategy - Environmental Restoration Program* (DOE-RL 1996a) and the *Waste Site Grouping for 200 Areas Soil Investigations* (DOE-RL 1997) organized the waste sites into groups and determined action (i.e., characterization) is necessary to further delineate current and potential future risks. These initial efforts helped determine the first six waste site groups to be characterized.

5.5.1 Risk Assessment Approach

Assessment activities under the integrated RCRA and CERCLA approach for the 200 Areas are planned to include a work plan, characterization, RI report, FS, and proposed plan to be performed for each waste site group. These activities will lead to a ROD and will be based on characterization data obtained from typical and worst-case representative sites, and TSD units, within the waste site group. Following receipt of the ROD, a confirmatory sampling effort will be performed to (1) ensure that characterization data are available for all sites within a group, (2) verify that site-specific contaminant distributions are consistent with the conceptual model for the group, and (3) support remedial design.

5.5.1.1 Qualitative Risk Assessment. A qualitative risk assessment will be performed as part of the RI report and FS. The qualitative risk assessment will use historical process and characterization data as well as data collected from the representative site characterization activities. This data set will be sufficient to evaluate the remedial alternatives and ultimately the selection of a remedial action. However, data will not be collected at this time for all the waste sites within a waste site group, but rather will be limited to a few selected sites (i.e., representative sites). Thus, a quantitative risk assessment would generally not be performed as part of the RI/FS activities. However, a limited quantitative risk assessment may be performed at the RI/FS stage if a more complex situation occurs where a large data set is required to be collected due (for example) to multiple waste site interactions, higher levels of contamination requiring more data to be collected, or other drivers where a more detailed evaluation is needed for a specific waste site or location. A qualitative risk assessment would generally not be performed for an entire waste site group.

5.5.1.2 Quantitative Risk Assessment. A quantitative risk assessment will be typically performed once additional data become available for all the waste sites in a waste site group. A quantitative risk assessment will require a sufficient data set to allow for detailed modeling. This may be accomplished possibly as early as the collection of the confirmation data after the ROD, but would typically be performed once the remedial action is completed.

Guidance by the EPA indicates that action is generally warranted at a site when the cumulative carcinogenic risk is greater than 10^{-4} or the cumulative noncarcinogenic hazard index exceeds 1.0 based on assumptions of reasonable maximum exposure. When the cumulative current or future baseline cancer risk for a medium is within the range of 10^{-6} to 10^{-4}, the conceptual model must be examined to determine if further action is necessary. Risk below 10^{-6} is regarded as a point of departure below which no action is taken.

Under MTCA, risk assessment requirements for cleanup and verification stipulate that carcinogenic risk shall be less than 10^{-6} for individual contaminants and less than 10^{-5} for cumulative risk for multiple contaminants and/or multiple exposure pathways. Concentrations of noncarcinogenic chemicals that may pose acute or chronic toxic effects on human health shall not exceed a hazard quotient of 1.0 and a cumulative hazard index of 1.0.

5.5.2 Risk Assessment Implementation

In general, extensive historical process information is available for 200 Area waste sites. However, availability of contaminant-specific data is much more limited. Characterization data will be collected through the implementation of the analogous site approach as outlined in future group-specific work plans. Once characterization efforts at a waste site are completed, a risk assessment will be performed to further delineate current risks posed by a waste site or a waste group. The objective is to better understand site risks in order to determine the need for remedial action and to prioritize future remedial action. This objective can be realized by use of either a quantitative or qualitative risk assessment as discussed in Sections 5.5.1.1 and 5.5.1.2.

It is envisioned that the final stage of risk assessment, as applied to 200 Areas' characterization and remedial action activities, will be the most rigorous and formal. Typically, its purpose will be to evaluate the cumulative risk posed by individual sites (or the 200 Areas' sites in total) to declare that remediation is complete and close out the sites (or the 200 Areas). These risk assessments will be quantitative in nature. Using all the information available, these risk assessments will be designed to account for all potential cumulative risks under future exposure scenarios. It is expected that the characterization data collected as part of the 200 Areas characterization strategy (Section 6.2) will support such an effort.

5.5.3 Sequence of Risk Assessment Activities

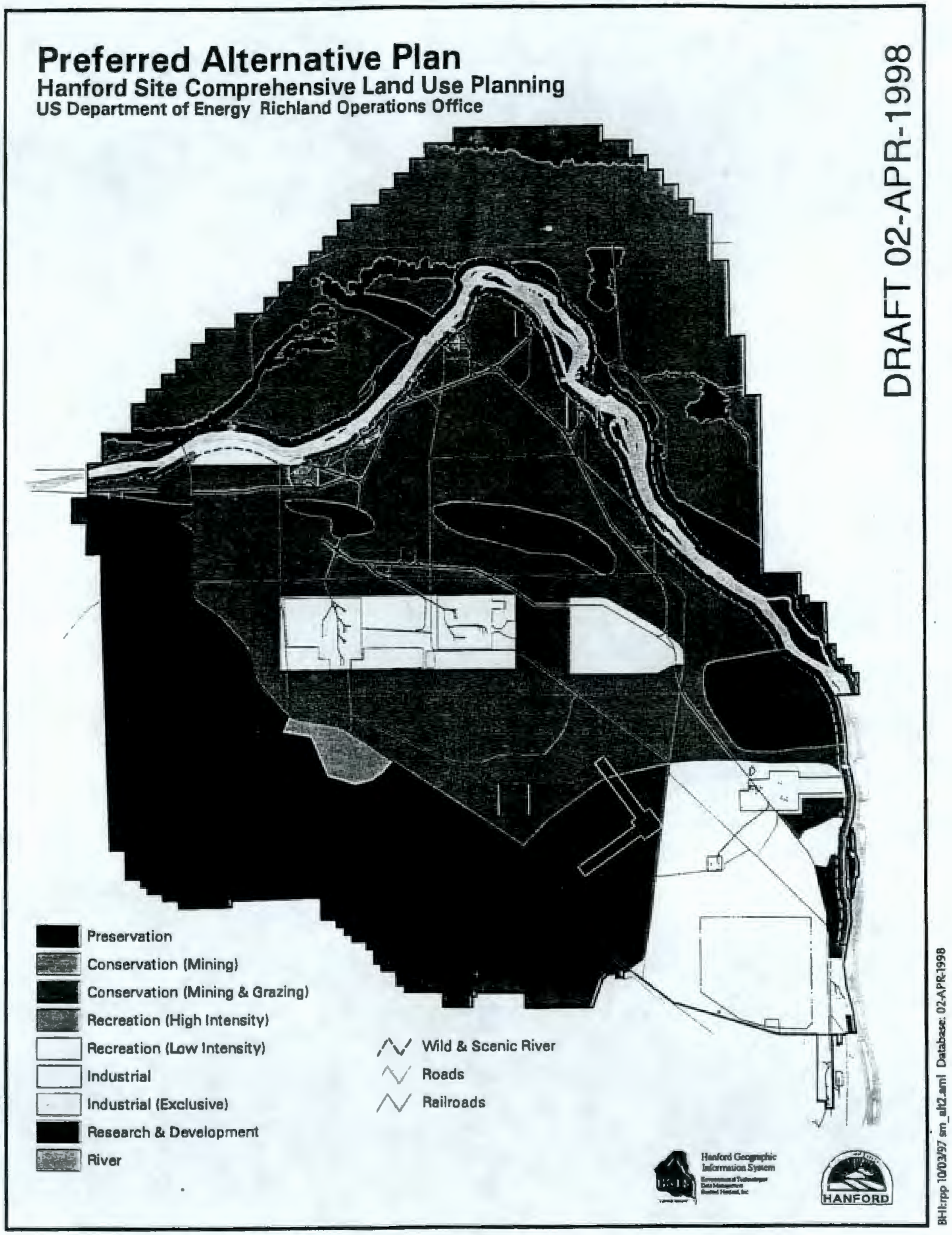
The sequence of activities anticipated for the 200 Area ER waste sites is as follows:

- The first six waste groups are generally considered to be low-activity, medium- to high-volume waste sites. Often a sufficient volume of liquids has been disposed at these types of waste sites to cause contamination to have historically impacted groundwater. Conceptually, these types of waste sites are expected to be simple in nature, where existing contaminant distribution concepts apply. Where contaminants remain at significant levels in the vadose zone, a qualitative risk assessment (typically a one-dimensional model such as RESRAD) will be used during the RI/FS phase. Actual remediation is not anticipated to be performed before FY03; thus, data to support a quantitative risk assessment will not be available until FY03 or beyond.

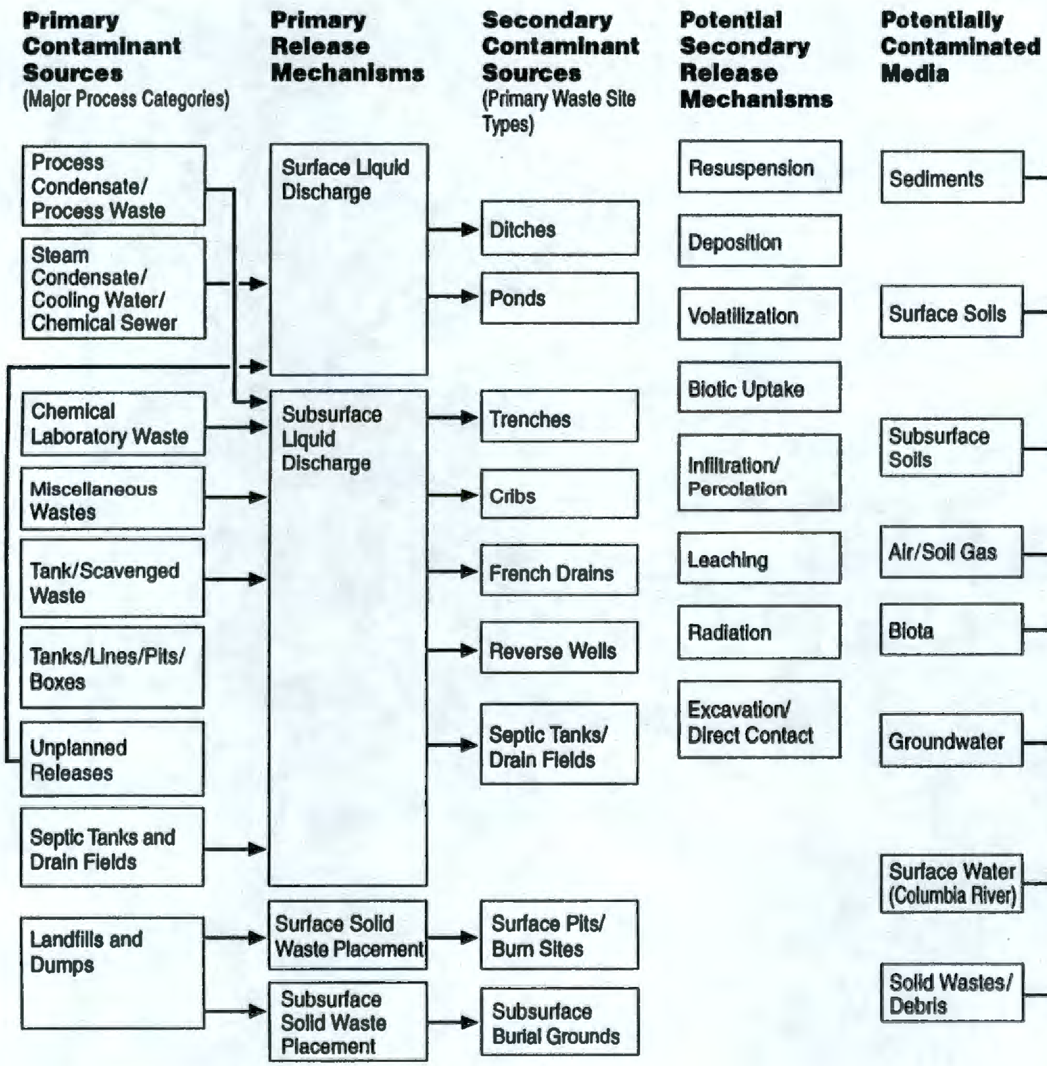
- Although not specifically defined at this time, the characterization of the next set of waste groups could involve sites that received smaller volumes or more highly concentrated or complex wastes or waste sites in close proximity to other waste sites with complex conditions such as the Tank Waste Remediation System (TWRS) tank farms. In order to address complex conditions, a more detailed risk assessment may be needed during the RI/FS stage provided sufficient data will be available to support the more rigorous analysis. This risk assessment could be considered a limited quantitative risk assessment focusing on a single or few waste sites, but would not be sufficiently comprehensive to be considered a cumulative risk assessment. Thus, a more detailed two-dimensional model (or simplistic three-dimensional model) may be required to support this effort in the late FY01 timeframe.

- A cumulative quantitative risk assessment is anticipated to be performed once sufficient data have been collected to allow a comprehensive (area-based) evaluation to be performed, as well as once final remedial actions have been defined and end states established. Any cumulative risk assessment that is required to establish cleanup standards other than those contained in the current regulations is not considered on a waste site-specific basis and must be considered at a site-wide level.

Figure 5-1. DOE Preferred Land-Use Alternative[1].



[1]Presented in HRA-EIS. (DOE 1998)



Potentially Contaminated Media	Potential Exposure Routes	POTENTIAL RECEPTORS: Humans – Current Worker	Humans – Future Worker	Humans – Occasional User	Biota – Terrestrial	Biota – Aquatic
Sediments	Ingestion	●	●	●	●	●
	Dermal Contact	●	●	●	●	●
	External Radiation	●	●	●	●	●
Surface Soils	Ingestion	●	●	●	●	–
	Dermal Contact	●	●	●	●	–
	External Radiation	●	●	●	●	–
Subsurface Soils	Ingestion	●	●	–	●	–
	Dermal Contact	●	●	–	●	–
	External Radiation	●	●	–	●	–
Air/Soil Gas	Inhalation	●	●	●	●	–
Biota	Ingestion	–	–	–	●	●
Groundwater	Ingestion	–	–	–	–	–
	Inhalation	–	–	–	–	–
	Dermal Contact	●	●	–	–	–
	External Radiation	●	●	–	–	–
Surface Water (Columbia River)	Ingestion	–	–	●	●	●
	Dermal Contact	●	●	●	●	●
	External Radiation	●	●	●	●	●
Solid Wastes/ Debris	External Radiation	●	●	●	●	–

LEGEND

● Complete exposure pathway

– Incomplete exposure pathway

E9803078.1

Figure 5-2. Conceptual Exposure Model for the 200 Areas.

6.0 DATA QUALITY OBJECTIVES PROCESS AND CHARACTERIZATION REQUIREMENTS

This section presents a consistent approach to data collection activities associated with 200 Area assessment and remediation activities. The activities include all phases of sampling required to support the completion of the integrated RCRA/CERCLA process outlined in Section 2.3. and depicted in Figure 2-2. Specific activities include:

- Data collection at representative sites defined for the waste group-specific work plan with an emphasis on verifying the conceptual model. This will support preparation of a focused feasibility study and the remedial action decision making.
- Data collection after the ROD to confirm that all other sites in the specific waste group meet the conceptual model. In addition, data collection activities will be included as part of the remedy selected for the waste group and will provide site-specific information for preparation of the remedial design/remedial action (RD/RA) work plan.
- Data collection as defined in the RD/RA to verify that remedial actions associated with a remove, treat, dispose remedy have met the required objectives.
- Data collection defined as part of either a post-closure monitoring plan for closure at a RCRA TSD. For CERCLA sites, remedies where waste is left in place and a barrier cover is installed may include an operations and monitoring plan that requires specific monitoring activities to demonstrate adequacy of the design.

The characterization strategy is designed to optimize all phases of data collection activities. The DQO process provides the foundation for a data collection activity and is presented in Section 6.1. This section provides a basic description of the DQO process that will be used to create a consist design of data collection for all phases of the characterization strategy.

The characterization strategy presented in Section 6.2 is designed to address the multiple phases of data collection in the field in a more streamlined process. The strategy uses valuable experience from previous characterization activities to focus data collection plans on the most cost-effective technique. It also requires a periodic review of advances in technology for sample collection, site monitoring, or analytical techniques to ensure continuous improvement.

The individual sections listed below provide detailed discussions of the elements of the characterization strategy that are expected to form the basis for data collection activities during the remediation of the 200 Areas waste groups.

- Characterization strategy
- Approach for characterization of representative sites
- Confirmation of the analogous site concept and collection of remedial design data
- Verification sampling
- Characterization techniques and emerging technologies
- National *Environmental Policy Act* (NEPA) values associated with characterization.

6.1 DATA QUALITY OBJECTIVES PROCESS TO SUPPORT THE CHARACTERIZATION STRATEGY

The DQO process (EPA 1993) is a planning approach, based on the scientific method,13 that provides a systematic procedure for defining the criteria that data collection should satisfy, including when, where, and how to collect samples, the number and quantity (e.g., volume) of samples, and the type and quality of analyses. The DQO process will be started before, or in parallel with, preparation of each group-specific work plan for each waste group. The DQO process will include group-specific project leads from EPA, Ecology, and DOE, with support by ERC personnel. The DQO process will be used as a planning tool for each group-specific work plan.

The DQO process provides assurance that the type, quantity, and quality of environmental data used in decision making will be suitable for the intended application. It establishes a consistent, cooperative, and streamlined approach that encourages the optimum use of available data and technical resources. The DQO process will take advantage of the characterization strategy outline in Section 6.2 to optimize data collection from characterization through the verification that RAOs have been achieved.

The DQO process consists of seven steps. The output from each step influences decisions that are made in the other steps. Even though the DQO process is typically depicted as a linear sequence of steps, in practice it is iterative; the outputs from one step may lead to reconsideration of prior steps. This iterative process to DQO developments leads to a more efficient data collection design. The seven steps that comprise this process include:

Step 1. State the Problem
Step 2. Identify the Decision
Step 3. Identify the Inputs to the Decision
Step 4. Define the Boundaries of the Study Area
Step 5. Develop a Decision Rule
Step 6. Specify Limits on Decision Error
Step 7. Optimize the Design for Obtaining Data.

The foundation of the DQO process is the collection and organization of historical information, existing analytical data, and other relevant information into a report that is readily accessible by the DQO participants. The information gathered and evaluated as part of this scoping process serves as the basis for much (but not all) of the inputs required to complete the DQO. During the first six steps of the DQO process, the DQO participants (regulators and DOE as decision makers with technical support as required) develop the DQOs necessary to support environmental decision making. The final step of the process involves developing the data collection design based on the DQOs.

The DQO process is enhanced and simplified through the use of an electronically-formatted workbook that includes introductory material, a list of activities that will be performed, and a series of input boxes to assist the participants. The workbook is designed to provide a user-friendly system to prepare for DQO workshops, record information and decisions developed, and document the process.

The outcome of the DQO process will be the establishment of the agreed-upon environmental measurements (type, quantity, quality) needed to support remediation/closure alternative decisions. The DQO workbook is issued as the project DQO process summary report. Portions of the completed workbook are incorporated into the SAP, which will aid in the data quality assessment (DQA) process. The DQA process is the scientific and statistical evaluation of the data collected to determine whether

13 The scientific method involves the principles and processes regarded as characteristic of or needed for scientific investigation, including rules for concept formation, conduct of observations and experiments, and validation of hypotheses by observations or experiments.

they are of the right type, quality, and quantity to support characterizing human/environmental risk and/or cleanup decisions. The DQA process is performed at the conclusion of each sampling event and is used to direct future sampling events.

6.2 CHARACTERIZATION STRATEGIES

This section describes general characterization strategies to be employed during data collection activities at 200 Areas waste sites that are defined by the DQO process. The data collection activities include:

- Initial characterization of representative waste sites within a waste group
- Remedy confirmation and remedial design at individual sites within each waste group
- Verification of effectiveness of the remedy at each waste site after completion of the remedial action(s)
- Post-closure monitoring at sites where residual waste remains after completion of remedial actions.

Also included is a discussion of proven characterization techniques, potential new technologies that can be used to achieve timely and cost-effective collection of the required data, and the NEPA values associated with characterization.

Characterization strategies are closely tied to waste disposal history, waste stream chemical composition, the physical structure of the waste site, and the underlying geology. Based on waste site configuration and characterization requirements, experience from previous 200 Areas characterization activities has shown certain field investigation techniques and technologies will be appropriate for the optimal data collection. Characterization strategies have as their primary focus the determination of the nature and extent of contaminants and the physical and chemical properties of the contaminated media (e.g., soil). Characterization data serve to refine conceptual exposure and contaminant distribution models and define remedial action needs.

6.2.1 Characterization Strategy

The characterization strategy that shapes the application of the DQO process uses a phased approach that collects data to (1) understand the physical contaminant distribution models of the waste site contamination; (2) support the evaluation of remedial alternatives; and (3) select a remedy, and support the design of the remedy. As the project progresses, historical and newly collected data are evaluated to support decisions or determine additional data needs. In general, the strategy envisions three phases of data collection:

1. Collect initial characterization data at the representative waste sites within a specific waste group to adjust and/or verify the physical contaminant distribution conceptual model and support remedy selection.

2. Collect confirmation data at individual waste sites within a specific waste group to ensure that the remedial alternative is appropriate and to support the remedial design.

3. Collect verification data at individual waste sites to determine that the remedy was effective after completion of the remedial action.

The process for grouping individual waste sites into waste groups is based on similar process or sites (e.g., analogous site approach) and supports the use of representative sites to optimize use of process knowledge and previous site investigations to determine the data needs for the initial characterization phase. Characterization requirements, regardless of the phase, are defined as part of the DQO process. Data are generally needed for the following:

- Physical contaminant distribution model refinement
- Treatability tests
- Risk assessments
- Remedial alternatives evaluation
- Waste inventory estimates.

It is expected that characterization requirements will focus on chemical and physical soil contaminant data (including contaminant mobility as the foundation for subsurface data). Contaminant chemical data, including site-specific chemical and/or radionuclide analyses of affected media, will be needed to assess the nature, extent, and level of contamination. Physical properties, including geologic structures, particle size distribution, unsaturated hydraulic conductivity, and moisture content, are obtained from sampling during manpower-intensive drilling or trenching operations. These properties, as needed, will be used with contaminant characteristics (e.g., mobility and persistence) to assess the fate and transport of contaminants. Fate and transport analytical models (computer codes) may be used to facilitate this assessment. As the certainty of the physical and contaminant distribution model increases, based on the phase 1 sampling of representative sites, less intrusive methods such as cone penetrometer/geoprobe testing and more indirect (nonintrusive) data collection techniques (soil gas vapor, borehole geophysics) will be used to guide decisions on remedial design (phase 2) and final verification (phase 3).

One of the inherent checks is that data will be continuously evaluated for uncertainty and adequacy to support decision making or to determine additional data needs. The number of samples required during subsequent waste group DQOs can be optimized to eliminate the collection of redundant data.

The characterization effort for each waste group will always include the RCRA TSD units listed as part of the group. The inclusion of the RCRA TSD units will allow the specific sampling required to meet RCRA TSD closure requirements and to develop the closure strategy for that specific unit and its ancillary equipment. RCRA TSD units that have been previously clean closed will not be recharacterized even though they are contained within specific waste groups.

While the exact interplay between the RAOs and remedial alternatives will be found in group-specific work plans, the following basic principles apply (as discussed in Section 5.3):

- RAOs related to protection of workers and the environment primarily focus characterization activities on surface and near-surface soils, and are concerned with areal extent as well as hot-spot locations.

- RAOs related to the protection of groundwater focus characterization on significant subsurface inventories and distribution through the vadose zone. Because contaminant migration potential and driving force to groundwater is a concern, more information on the physical and chemical properties of the soils and interaction with contaminants is required.

For example, an RAO designed to protect workers from inhalation hazards would focus characterization on surface soil that would most likely be disturbed through resuspension mechanisms. If excavation of piping is expected, for example, then the concentrations of contaminants within the near surface zone would be required to calculate the potential impact to the workers. In this case, since the mechanism for exposure is predominately physical in nature, related to effects from resuspension due to the wind, less information about soil transport properties is required.

For RAOs designed to protect groundwater, characterization is focused on vertical distribution of the contaminants potential driving forces, retardation, physical properties of the contaminants, and how these interact to move contaminants through the vadose zone. If needed, data would be collected to provide modeling inputs to predict the transport of contaminants over time and the projected impact on groundwater.

6.2.2 Approach for Characterization of the Representative Sites

An important feature of the characterization approach is the application of biased sampling. Bias in sampling is the intentional location of a sampling point within a waste site based on process knowledge of the waste stream and expected behavior of the contaminant(s) of concern. Using this approach, a sampling location can be selected that increases the chances of encountering worst-cast contamination conditions in the soil column. This is used to determine the concentrations and distributions of potential contaminants of concern, when there is adequate information to make it a reasonable approach. The bias approach is well suited for the majority of waste sites that received liquid waste streams since their construction tends to provide a predictable pattern of contaminant distribution.

As an example, one type of crib designed in the 1950's consisted of a rectangular excavation within which the influent discharge cascaded through a series of up to three wood or concrete boxes. This resulted in a cascade effect where the majority of liquids and, therefore, contaminants infiltrated in the first cascade, with very little in the second or third. By using bias sampling in the first cascade, a realistic worst-case determination of the vertical distribution of contaminants can be obtained. The bias approach is also supportable by available nonintrusive geophysical methods such as spectral gamma logging in adjacent dry wells or groundwater monitoring wells.

While there is not always a direct correlation with the contaminant distribution models generated for specific sites, traditional statistical analyses may miss significant levels of contamination due to the strong vertical gradient for most contaminant migration and the selective manner in which the liquid was introduced into the site. The statistical sampling design in this early phase of characterization is limited by insufficient data on the distribution of contaminants and the fact that contaminants do not tend to randomly distribute. Therefore, these designs tend to be more costly than bias sampling, which benefits from the historical information that has been collected on the operation of the site and field experience gained from past investigations.

Examples of selected past investigations for various waste sites based on the biased approach are summarized in Table 3-11. The summary is provided to outline the general process and techniques applied to characterize waste sites. In general, conceptual models and contaminant distribution model(s) developed for the 200 Areas based on these investigations suggest there are similarities in the distribution of contaminants among groups of similar liquid waste sites, as described in Section 3.3. The models suggest that:

- Maximum contaminant concentrations are generally detected at the point of discharge or near the bottom of waste sites. Typically, the highest concentration of contaminants (such as plutonium, cesium, strontium, and other contaminants with moderate to low mobility) are detected within several meters of the bottom of the facility. When the volume associated with the discharge is low, contaminants with higher mobilities would also be within several meters of the facility bottom. These higher concentrations are generally seen at the bottom of ponds, ditches, trenches, and cribs (see Table 3-11). In reverse wells, the highest concentrations are near the point of discharge. Most of the moderate to low mobility contaminants that remain at a waste site are within several meters of these locations. The only significant exception to this is carbon tetrachloride, due to its multi-phase flow capabilities.

- At liquid waste sites with high-volume flow, highly mobile contaminants have moved through the sediment and impacted the groundwater. Since the majority of contaminants have already passed through the vadose zone, only trace concentrations remain in the vadose zone.
- Contaminant concentrations typically decrease with depth. However, elevated levels of contamination may be detected within and just above fine-grained layers (retarding strata) with low hydraulic conductivities or silt/clay layers.
- Contaminant transport is primarily vertical beneath liquid waste sites. Lateral spreading is usually limited although, in some cases, it can be significant with high-volume waste streams and significant aquitards.

While experience in the majority of cases is consistent with these models, site-specific anomalies may circumvent the distribution of contaminants through the presence of preferential pathways. Poorly sealed wells and continuous clastic dikes may provide preferential pathways and increase the vertical extent of contamination.

6.2.3 Confirmation of the Analogous Site Concept and Collection of Remedial Design Data

It is expected that the characterization data for representative waste sites will provide sufficient information to select remedies for the waste site group being considered. However, site-specific data are needed to verify that the selected remedial alternatives are appropriate. Confirmation data for individual waste sites can serve as both a validation that the selected remedial alternative is appropriate for the waste site and provides a basis for remedial design.

The collection of confirmation data is expected to be based on a biased approach to optimize the collection of data and be cost effective. While the confirmation process is specific to each site and remedy, it will generally include the following:

- Validate that the individual waste site conceptual model is consistent with the waste group
- Determine waste site distribution of contaminants
- Provide required remedial design inputs (e.g., volume of affected media)
- Provide input to risk assessments.

In the event that the data for a specific waste site do not support the remedial alternative selected, the site will be reassigned to a waste group more closely aligned with its characteristics. Additional confirmatory sampling may be required if a site is reassigned.

The methods for data collection will be similar to those used in the initial characterization of representative sites. Documents will be generated based on the waste group-specific work plans. A DQO focusing on the waste group-specific work plans, and supplemented by requirements to support the remedial design, will be performed to generate a SAP to direct confirmatory sampling efforts.

6.2.4 Verification Sampling

The verification sampling approach will be dependent on the type of remedial alternative selected. Remedial alternatives that involve remove, treat, and dispose options require data collection at the completion of remediation to verify that the RAOs for the specific waste site were achieved. The verification sample design is typically based on information collected during the remedial action (e.g., field screening data). Verification sampling will evaluate contaminants that might remain upon completion of the remedial action. Verification sampling is typically statistically based, and optimized to limit the number of RCRA protocol samples required. Optimization involves the use of field screening techniques and a review of data collected during remedial action.

Based on lessons learned from the 100 Area remediation experience, indicator species have been found to be useful as a part of the remove/treat/dispose actions. Radioactive or chemical indicator species are chosen to be a target analyte for a larger class of constituent analytes with similar mobilities, geochemical properties and associations. The indicator species simplifies and economizes on sampling activities, usually at the stage of waste site remediation or verification. By being easily detected with relatively simple field screening equipment, to low concentrations, and backed up with more rigorous sample data, the indicator can show that one or more additional constituents are present within a given range of concentration, relative to that of the indicator. The field screening data must be supported with defensible analytical data that show that assumed correlations and concentrations ratios between indicator and representative species, are in fact true. The indicator must be demonstrated to show, before any fieldwork is done, that assumed relationships between the species are true for all sites in question. And, confirmatory sampling must be performed after the fact to show that the indicator's use was appropriate. That is, confirmatory sampling must demonstrate successfully that the extent of the indicator species was equal to or greater than the extent of the represented species.

Since most contaminants are collocated with other contaminants, Cs-137 can be used as an indicator in guiding the excavation of contaminated soil. Other contaminants, such as beta emitters Sr-90, Ni-63, and U-238, are not easily detectable with direct-reading instruments at low levels, but since they are usually located with Cs-137, the contaminated soil can be identified and removed.

Surveys for Cs-137 guide day-to-day excavation activities by delineating contaminant plumes and providing information regarding the location for collecting ex-situ samples for rapid turnaround analysis. Use of in-situ radiological surveys minimizes the collection of ex-situ samples during the ongoing excavation process. The data from these measurements provide a basis for determining the distribution of contaminants and allow a cost-effective design for collecting full RCRA protocol verification samples. For remedial alternatives that involve no action, institutional controls, or surface barriers, the verification process would involve some form of ongoing monitoring to establish that exposure controls have been achieved or that contaminants are not migrating. This type of verification is specified in a post-remedial action operations and maintenance or post-closure plan and may include the following:

- Periodic site inspections
- Installing groundwater monitoring wells and periodic groundwater sampling
- Measuring airborne environmental radiation contaminant
- Installing vadose zone monitoring wells and periodic nonintrusive monitoring of contaminant migration and/or moisture content.

The site-specific verification strategy will be developed in the remedial design for each waste site based on the ROD.

6.2.5 Characterization Techniques and Emerging Technologies

Characterization methods at the Hanford Site combine intrusive and nonintrusive techniques. Characterization must consider proven methods and potentially applicable new technologies. Sections 6.2.5.1 through 6.2.5.5 discuss characterization methods successfully used in previous Hanford Site investigations. Section 6.2.5.6 presents information on promising new technologies.

6.2.5.1 Borehole Drilling. Borehole drilling is used to access the deeper vadose zone (9.1 m [30 ft] and beyond) to collect soil samples for direct analysis. Cable tool, air rotary and sonic, are commonly used drilling methods at the Hanford Site. The selection of these methods for a specific waste site is dependent on sampling objectives, contaminants of interest, soil properties of interest, contamination control issues, and cost.

Cable tool drill rigs use specialized tools to advance the boring to depth and collect representative samples of soils. A drive barrel attached to a steel cable is driven to the required depth with a percussion-type hammer. A sediment sample is collected using a split-spoon sampler. Casing is driven past the sample interval to prevent collapse of the hole. As the casing is advanced in the borehole, additional soil (i.e., slough) is pushed into the borehole from the area sampled. The slough is cleaned out of the borehole, and the process of advancing the boring and sample collection is repeated. Cable tool drilling with a split-spoon sampler typically provides samples more representative of the selected interval, and improved contamination control since the material is contained within the drive barrel or split spoon as it is removed from the borehole. Site-owned cable tool rigs are more appropriate for use in areas of higher radiological contamination because of the high cost of decontaminating and releasing contractor-owned drill rigs. This system has significant mobilization and demobilization costs, slow advancement of the borehole to depth, and captures only a very small cross-section of the waste site.

Air rotary systems use a drive hammer to drive drill string into the subsurface and compressed air to bring soil cuttings to the surface. Samples collected from the soil and air stream using this method are of poorer quality because air may strip off contaminants. However, air rotary systems can use a split-spoon sampler. When the sample interval of interest is reached, the drill bit is removed from the drill string and the split-spoon sampler installed. This process does slow down the advancement of the borehole, but overall the operation of the air rotary system provides better rates of penetration than cable tool drilling. It does require significant mobilization and demobilization costs, and contamination control requires additional high-efficiency particulate air (HEPA) filtration systems when contamination is present because air is used to circulate rotary samples to the surface.

The sonic drilling system uses a combination of mechanically generated vibrations and rotary power to drive the drill string through the soil. To advance the well to depth, soil is forced into the drill string through an open-face core-type drill bit and contained within an inner tube. When the inner tube is filled with soil, it is removed by a wireline retrieval system and provides a continuous core of the formation. The penetration rate of this system is excellent. However, recent concerns concerning sample integrity have limited it's use onsite. For example, sonic drilling may produce high temperatures at the bottom of the drill string that may volatilize organic compound of interest. Sonic core barrel samples in many cases also show evidence of having expanded during drilling (e.g., the amount of sample recovered during drilling may be greater than the length of the area drilled: 1.5 m [5 ft] is drilled; 3 m [10 ft] is recovered). This could impact the collection of representative samples for determination of soil physical properties. It is more rapid than cable tool drilling, but shares the higher mobilization and demobilization costs with the other drilling methods.

6.2.5.2 Test Pit Construction/Trenching. Test pits are shallow, concave-shaped excavations that can range from 7.6 to 9.1 m (25 to 30 ft) deep depending on the equipment used and the type of soil encountered. The pits are excavated using a back-hoe or track-hoe, depending on the required depth.

Samples are collected directly from the bucket and can be representative of as little as 152 mm (6 in.) layers of contaminated soil. With proper care to minimize sloughing of material from above, this sample collection method can be as good as borehole samples. These samples are excellent for pinpointing hot spots and assessing vertical extent of contamination at a waste site.

A related excavation technique is called trenching. Trenching is a test pit extended laterally across a waste site. Trenching provides the ability to locate suspected waste sites, determine their shape, and assess the lateral extent of contamination.

Either technique provides a direct visual confirmation of stratigraphy, allows optimum collection of samples, and is cost effective since it requires minimum site mobilization, and is designed to be completed within one day.

6.2.5.3 Cone Penetrometer/Geoprobe. The cone penetrometer system consists of special drill rods that are hydraulically pushed into the subsurface. The geoprobe system drives the same type of drill rods with a hydraulic vibratory hammer. Both methods differ from drilling in that soil is not excavated to advance the drill rods to depth. As the drill rod is driven into the ground, soil is forced aside to provide subsurface access. Both systems are very versatile. Depending on the type of rod selected, a wide range of data and/or samples can be collected. Capabilities include:

- Collection of soil gas samples
- Measurement of geophysical properties
- Collection of soil samples (limited volume)
- Measurement of gross gamma radiation
- Collection of perched groundwater samples.

In addition, because the cone penetrometer is basically a delivery system, it can accept new measurement techniques as they are developed. The geoprobe system is available onsite, while the cone penetrometer would need to be accessed through a subcontractor.

Either method can be a cost-effective tool for quickly defining the lateral and vertical extent of contamination at a waste site. Each has a limited depth of penetration. The small-diameter/small-volume cores that are collected are not representative of the grain size and are of insufficient volume for extensive laboratory analysis. At the Hanford Site, the maximum depth of penetration is about 36.6 m (120 ft) under ideal conditions (e.g., sand with some gravel). The maximum depth of penetration in a gravel unit is less than 12.2 m (40 ft). Based on field experience, over 50% the cone pushes do not reach their target depths due to obstructions (e.g., rocks or compacted zones). Groundwater samples are generally of poor quality, and data from these samples are used mainly to support the placement of permanent monitoring wells. The mobilization cost is low and the systems can accomplish multiple rod replacements within a single day.

6.2.5.4 Borehole Geophysics. The use of borehole geophysics to investigate soil properties can provide valuable information about the site. Borehole geophysics is commonly used at Hanford to assess the distribution of gamma-emitting radioactive contaminants and to determine the moisture content in soils. The Radionuclide Logging System (RLS) is used to determine the extent of radiological contamination in the soil column identifying specific gamma-emitting radionuclides and determining lithology based on a known distribution of naturally occurring radionuclides in specific formations. Moisture content is determined using a neutron logging probe. These tools are used in conjunction with existing characterization boreholes or wells and provide a continuous reading of soil characteristics. They are easily mobilized and can log multiple wells in a single day.

6.2.5.5 Surface Geophysical Methods. Surface geophysical methods are nonintrusive tools used to locate shallow 0-6.1 m (0-20 ft) subsurface features or determine surface levels of radioactive contaminants. Methods commonly used at Hanford to determine subsurface features include ground-penetrating radar (GPR), electromagnetic induction (EMI), and magnetics. These methods are commonly used to locate suspected disposal pits, buried materials, utilities, and pipelines. GPR is reliable in most situations and provides the most information of the nonintrusive methods. GPR can be time consuming if the site is very large and requires experienced personnel. EMI and magnetics are excellent reconnaissance tools that are easier to use than GPR.

Methods to measure radioactive contaminants include tractor-mounted beta-gamma detectors (that can be driven over large area sites and provide scale maps with radiation level contours), and portable systems carried by a single person that provide similar capabilities but are useful for small waste sites or where access is restricted. Either method provides a cost-effective alternative to soil sample collection and laboratory analysis.

6.2.5.6 Vadose Zone Monitoring. Techniques are available or under development that may be applicable to monitoring concentration changes or moisture movement at waste sites. These tools are considered appropriate for use after selection and installation of the chosen remedy, and would be implemented under an operations and maintenance plan or a post-closure monitoring plan. They are intended to show the adequacy of a remediation technology selected to prevent movement of contamination already in place. These techniques require a previously constructed installation, typically a single or multiple borehole network, to examine fluid movement potential factors, moisture content, soil gases, or to sample pore liquids. Stephens (1996) provides a good overview of vadose zone monitoring techniques and the data needs they can support.

Geophysical logging techniques are available to interrogate the soil volume around a borehole. As mentioned in Section 6.2.5.4, both gamma detection tools, such as the RLS, neutron probes, acoustic velocity logs, and neutron density logging tools can be used to track soil moisture or radionuclides in the soil column. Analyses of repeated measurements will detect changes in moisture content or radionuclide movement over time.

Cross-hole techniques such as gamma ray attenuation, and tomography tools such as electrical resistance, nuclear magnetic resonance, and X-ray computed devices, offer the potential to detect minor changes in soil moisture in three dimensions with an appropriate borehole array. At the Hanford Site, electrical resistance tomography has been examined and field-tested for application around tank farms (Narbutovskih et al. 1997). The system operates by passing an electrical current through the soil column, which is monitored for changes in resistivity resulting from changes in conductivity, induced by soil moisture fluctuations. Other tomography techniques are in the development stage but have not been widely tested.

Ground-based geophysical techniques are capable of measuring soil moisture using a combination of pre-installed subsurface sensors and surface-based interrogation or data collection systems. Electrical methods use electrodes to apply and receive a current through the soil and commonly measure resistivity changes. The method is best applied to delineate lateral extent over a target area or for depth profiling at a given point. Electromagnetic induction applies an electromagnetic pulse to the soil column and measures the response observed in soil depths from 3 to 60 m, depending upon the spacing of the transmitting and receiving coils. It can be used to measure apparent resistivity changes in the field at a site with uniform undisturbed features. GPR uses electromagnetic pulses in the radio frequency spectrum (10-1,000 Mhz) to detect reflecting soil units and conditions. Moisture content and certain contaminated liquids may be detected by this method. Most surface-based systems are best used as a reconnaissance tool to detect relative moisture conditions and are affected by soil column layering and soil material types.

Lysimetry techniques are also available to measure, in situ, the flow of liquids through a soil column and, potentially, the consequent movement of contaminants. The technique requires isolation of a representative disturbed or undisturbed soil mass from its surroundings. The isolated mass is then fitted to either collect liquids moving through the soil or monitor weight changes in the mass due to moisture additions and evaporation transpiration reductions. Lysimetry is a cumbersome, expensive process capable of providing accurate results at the expense of a considerable investment in time.

6.2.5.7 Characterization Technologies. The ongoing review and implementation of innovative characterization technologies is key to maintaining a cost-effective approach to the characterization of the hundreds of waste sites covered by this implementation plan. The following technologies represent promising examples of innovative characterization tools currently under development. Deployment of these tools is expected in the next 2 to 3 years and should be considered in the group-specific work plans.

- A laser-induced breakdown spectroscopy (LIBS) system, which can perform in situ measurements of metals including selected radionuclides in soils, is under development. The LIBS is delivered by a cone penetrometer to the required depth and performs the in situ measurement from the bottom of penetration to the surface as it is being removed. Although a recent onsite demonstration for the collection of in situ information on lead, barium, and uranium was not successful, LIBS has been shown in principle to be a potentially viable tool.

- A ground-penetrating holography (GPH) system enhances existing GPR technology by providing location and algorithm data that produce a volumetric image of objects beneath the ground surface. A single-channel system was successfully demonstrated at the 618-4 Burial Ground in the 300-FF-1 Operable Unit. The information gained from this demonstration will support the development of a multi-channel real-time system. The existing single-channel system is currently supporting cultural resource investigations at Hanford and can support other GPR activities.

- A pipe explorer system can transport characterization sensors into piping systems that are radiologically contaminated. The system deploys an air-tight membrane into the pipe being inspected. The characterization detector and its cabling enter the membrane and take measurements. Therefore, the potential for contamination of the equipment is minimized significantly. The system can be deployed through pipe constrictions, around 90° bends, vertically (up and down), and in wet conditions. Characterization tools that have been demonstrated with the system thus far include gamma detectors, beta detectors, and video cameras. Alpha measurement capability is also under development. The explorer system can be deployed in pipes as small as 50 mm (2 in.) in diameter and up to 76.2 m (250 ft) long.

- Soil gas sampling has been used to monitor changes in volatile and semivolatile organic compounds at selected waste sites, notably in the 200 West Area, as a means of measuring carbon tetrachloride in the vadose zone. A calibrated infrared photoacoustic spectrometer is being used either in a mobile laboratory or at boreholes to examine concentrations of volatile organic analytes. Sampling networks using existing boreholes and shallow soil probes can examine the volatile organic analyte concentration at desired depths in the soil column.

6.2.6 National Environmental Policy Act Values Associated with Characterization

In accordance with DOE policy and orders, CERCLA documents must, to the extent practicable, incorporate NEPA values. These values include ecological, offsite, socioeconomic, environmental justice, and cumulative impacts. These values are evaluated below with respect to characterization of the

200 Area waste sites. NEPA values related to remedial actions and residual contamination that might remain following remedial actions will be evaluated in group-specific feasibility studies.

Environmental impacts from characterization activities are expected to be minimal. Discharges to the environment would be limited to particulates (both contaminated and uncontaminated) that might be emitted during soil drilling activities. Dust-suppression measures will be used to control particulates. Wastes generated could include drilling fluids, contaminated soil and groundwater, and contaminated equipment and clothing. Contaminated drilling fluids will be either disposed at authorized liquid effluent disposal facilities or solidified and disposed at authorized solid waste management facilities. Other wastes generated during characterization will be designated, packaged, and disposed in accordance with site-specific waste control plans.

Reviews of 200 Area ecological and cultural resources are presented in Appendix F. No threatened and endangered species have been identified within the 200 Areas, and no impacts to ecological resources from general characterization activities are anticipated. Buildings in the 200 Areas have been identified for potential consideration as historic resources, but it is not anticipated that any buildings will be impacted by waste site characterization activities. Site-specific ecological and cultural resource surveys will be conducting before any ground-disturbing fieldwork begins.

Offsite impacts are also expected to be minimal. Air emissions from characterization activities are expected to be very low and located well away from site boundaries; therefore, offsite health impacts from the 200 Areas characterization are not expected. Most, if not all, characterization waste will be disposed at the Hanford Site (e.g., ERDF) rather than taken offsite.

No socioeconomic impacts are anticipated with respect to characterization. The existing Hanford Site work force and local resources would be used to perform characterization. Worker safety during characterization will be addressed in the overall health and safety plan (Appendix B) and activity-specific health and safety plans. Characterization activities are expected to use techniques for which protective measures for workers are readily available.

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, requires that federal agencies identify and address, as appropriate, disproportionately high and adverse human health or socioeconomic effects of their programs and activities on minority and low-income populations. Minority populations and low-income populations are present near the Hanford Site (Neitzel 1997). The analysis of the impacts identified in this Plan indicates that there would be only minimal impacts to the offsite population and onsite workers due to implementation of the proposed action because the characterization would take place in the center of the Hanford Site, the potential releases would be small, and the characterization would be performed by existing Hanford Site workers. Therefore, no disproportionately high and adverse human health or socioeconomic effect to any minority or low-income population is expected from this action.

Characterization activities are not expected to contribute significantly to cumulative impacts of activities in the 200 Areas or at the Hanford Site. Other activities occurring in the 200 Areas are the management of waste in underground storage tanks, management of liquid effluent and solid waste treatment/disposal facilities, and deactivation/decontamination/decommissioning of inactive facilities. The airborne emissions, waste generation, and infrastructure needs associated with characterization are minimal compared to these other programs.

7.0 PROJECT MANAGEMENT AND PROGRAMMATIC INTEGRATION

This section describes the activities necessary to support management and integration of the 200 Area's project to ensure that project objectives are achieved. The objectives of project management during the implementation of the RI/FS plans are to ensure the safety of the work force and the affected environment, direct and document project activities, ensure that data and evaluations meet the goals and objectives of the project, and to administer the project within budget and schedule. Sections 7.1 and 7.2 present a general discussion of the work breakdown structure (WBS) and areas of project management that will be common to all aspects of the 200 Area's project and subsequent group-specific work plans. As DQO workshops are conducted for each of the group-specific work plans as discussed in Section 6.1, the specific scope and schedule elements will be defined. These will result in the development of task-specific project management plans.

Within the 200 Areas there are other ongoing programs that may be affected by ER project activities. It is therefore necessary that the ER project interface with these other programs to ensure that an integrated and consistent approach is followed. This is currently done, for example, during review of excavation permits and site planning reports, and at meetings with other program personnel. Within the ER project, integration needs have been identified at various levels. Section 7.3 discusses the overall approach to integration of the Implementation Plan with other ER programs, Hanford Site programs such as the groundwater/vadose zone project, and other interested agencies or entities.

Section 7.4 provides a general discussion of the schedules for the 200 Area characterization and remedial action. The milestones that have been established for the first six group-specific work plans are presented, as well as a conceptual schedule that addresses the remaining 17 work plans and characterization activities to be accomplished over the next 10 years.

Involvement of the public is recognized as an important and necessary part of DOE activities on the Hanford Site. As group-specific work plans are developed and other ER-related activities occur in the 200 Areas, there will be opportunities for public involvement as discussed in Section 7.5. Additional details on the public involvement process have also been presented in Section 3.3.

7.1 WORK BREAKDOWN STRUCTURE

Work within the 200 Areas is structured to address the approach to remedial actions and assessment (or characterization) activities in a manner that is consistent with other ERC projects. Based on guidance from RL for establishment of a baseline document that establishes the scope, schedule, and budget for the ER project, the use of a detailed work plan (DWP) was adopted. The DWP is a 3-year plan, updated annually, which describes the specific details associated with each project that has been proposed. It is anticipated that for each group-specific work plan that is to be developed, a DWP will be prepared and approved that will define the scope, schedule, and budget to a level of detail that will be adequate for planning and management of that project. Inherent with this approach is the assumption that a DQO workshop will be held to define the specific scope associated with each waste group and this information will be used to define or refine the information presented in the DWP for that group. The DWP is a planning document for the ERC that rolls into and becomes a subset of the Long-Range Plan. The ERC Long-Range Plan provides an integrated technical, cost, and schedule lifecycle baseline for the various projects within the ERC. It is a tool that is used to forecast activities into the future so that appropriate staffing, funding, and schedule needs can be assessed.

Based on previous projects within the ERC project, a definition of the overall WBS associated with each of the group-specific work plans has been devised. This WBS represents a series of tasks that describe a specific scope of work for the investigation. This framework is consistent with the Hazardous, Toxic and Radiological Waste (HTRW) coding structure that provides a uniform structure for collecting and reporting of costs for the project and is used by all ERC projects. At a higher level these tasks may include the following:

- Preparation of plans
- Field investigations
- Direct project support
- Regulatory/other project interfaces
- Community relations/interfaces
- Document preparation.

Work may be planned, scheduled, estimated, and managed at lower levels or subtasks of the coding structure, depending on management needs. All lower level subtasks must be subparts or elements and roll up to the next level in a hierarchical manner. For example, within the field investigations task, the following subtasks may be included:

- Source characterization
- Vadose zone investigation and monitoring
- Geologic investigation
- Air investigation
- Ecological investigation
- Data evaluation.

7.2 PROJECT MANAGEMENT

This section addresses the basic concepts of project management that occur throughout the life of the project. Specific portions or tasks that will occur throughout the RI/FS process, including each of the group-specific work plans, are described in the following sections. Individuals that are associated with the project and interfaces with other organizations are also described.

Further detail on schedule control, cost control, meetings, and reporting can be found in the *Environmental Restoration Field Office Management Plan* (DOE-RL 1989) and the *Tri-Party Agreement Action Plan* (Ecology et al. 1996).

7.2.1 Project Organization and Responsibilities

The project organization for implementing characterization activities outlined in the 200 Area Implementation Plan is shown in Figure 7-1. The following sections describe the responsibilities of the individuals shown in Figure 7-1. The positions described here have overall management authority for the project. Additional support roles are described in further detail in the project management section of the Quality Assurance Project Plan (QAPjP) in Appendix A.

7.2.1.1 Regulatory Agencies and the U.S. Department of Energy.

Senior Project Managers. The EPA, the DOE, and Ecology have each designated an individual as senior project manager for characterization and remedial activities at the Hanford Site. These senior project managers will serve as the primary point of contact for all activities to be carried out under the Tri-Party Agreement. The responsibilities of the senior project managers are given in Section 4.1 of the Tri-Party Agreement.

Project Managers. As shown in Figure 7-1, the EPA, the DOE, and Ecology will each designate an individual to act as the project (or unit) manager for each of the 23 waste groups or operable units. The EPA and Ecology have decided on which organization will serve as the lead regulatory agency for each of the waste groups as reflected in Table G-1 of Appendix G. These decisions will be reflected in Appendix C of the Tri-Party Agreement.

The project manager from DOE will be responsible for maintaining and controlling the schedule and budget and keeping the EPA and Ecology project managers informed as to the status of the activities in the 200 Areas, particularly the status of agreements and commitments.

7.2.1.2 Contractor Support Staff.

Project Manager. On behalf of the DOE, the ERC Remedial Action and Waste Disposal (RAWD) Project also provides a project manager who has the overall responsibility for safe and successful execution of the project. The principles and responsibilities discussed in the *Remedial Action and Waste Disposal Project Manager's Implementing Instructions* (PMII) (BHI 1998) are used by all key personnel. All key personnel assigned to management roles within the RAWD Project must ensure compliance with these PMIIs and are responsible for implementing these principles with project staff.

200 Area Task Lead. The task lead shall be assigned by the RAWD Project and is responsible for management and identification of functional support needs of the project. The task lead works closely with project controls, quality assurance, health and safety, and the field engineer to ensure that work scope is being performed in accordance with each of these areas of responsibility. The responsibilities of the Bechtel Hanford, Inc. (BHI) 200 Area task lead will also be to plan, authorize, and control work so that it can be completed on schedule and within budget, and to ensure that all planning and work performance activities are technically sound. Other duties include coordination of communications with the DOE, the EPA, and Ecology. The task lead reports to the RAWD project manager and the DOE project manager.

Preselected Subcontractor Support. Staff from the preselected subcontractor will support the performance of assessment-related activities, including items such as generation of group-specific work plans, RI/FS documents, field activities, sample and data analysis, risk assessments and modeling that may be required, remedial alternatives assessment, and proposed plans. The preselected subcontractor will keep the 200 Area task lead informed as to the work status and any problems that may arise, and will participate in any long-range planning activities related to these areas. Preselected subcontractor staff will also support preparation of closure and post-closure plans for any TSD units that are to be addressed within a waste group, along with proposed permit modifications. This includes coordination of any field activities with planned RI/FS activities.

BHI Functional Support Groups. The project shall use the services of additional personnel as required to manage and control the project. These individuals may include a quality assurance representative, health and safety officer, project engineer, field superintendent, and an environmental lead. In addition, staff may be supplied from support organizations such as waste management, sample and data management, radiological controls, and planning/integration. The roles of some of these individuals are described further in Appendix A.

7.2.2 Work Control

The primary goals of the ER Project *Baseline and Funds Management System* (BFMS) (ER-PC-01) are to provide methods for planning, authorizing, and controlling work so that it can be completed on schedule and within budget. The BFMS is to ensure that all planning and work performance activities are technically sound and in conformance with management and quality requirements. BHI will have the overall responsibility for planning and controlling the investigation activities, and providing effective technical, cost, and schedule baseline management. If a subcontractor is used, BHI will maintain overall project management responsibilities. The management control system used for this project must meet the requirements of DOE Order 4700.1A, "Project Management System." The ER Project BFMS (ER-PC-01) was developed to meet these requirements.

7.2.2.1 Cost Control. Project costs, including labor, other direct costs, and subcontractor expenses (e.g., drilling and laboratory analyses), will be assessed monthly. The budget tracking activity is computerized and provides the basis for invoice preparation and review, and for preparation of cost performance reports. These reports assess the status of each project task against projected budgets, determine performance, and report any corrective actions that may be required. Any adjustments to budgets are controlled through a formal management process, which includes use of baseline change proposals to modify baseline budgets. The DOE project manager will update the EPA and Ecology project managers of their respective project costs to date (i.e., for their operable unit, waste site group, and/or TSD units) at monthly unit managers meetings.

7.2.2.2 Schedule Control. Scheduled milestones will be statused, at a minimum, on a monthly basis for each task on a given project. This will be done in conjunction with cost performance reports associated with cost tracking. Work plan milestones will also be statused monthly at unit managers meetings.

The lifecycle or total project schedule developed for the 200 Areas will be updated at least annually, to expand the new current fiscal year and the follow-on year. In addition, any approved schedule changes (see Section 12.0 of the Tri-Party Agreement for the formal change control system) would be incorporated at this time, if not previously incorporated. This update will be performed in the fourth quarter of the previous fiscal year (e.g., July to September) for the upcoming fiscal year in conjunction with preparation of the DWP. Individual group-specific work plan schedules are detailed in the DWP and are summarized at a higher level of WBS in the Long-Range Plan. In this manner the lifecycle schedule for the 200 Areas is considered in the long-range planning efforts for the ERC project.

7.2.3 Meetings

Project managers (DOE, EPA, and Ecology) will meet monthly at unit managers meetings to discuss progress and project costs, address issues, and review near-term plans pertaining to their respective operable units and/or TSD units. The meetings shall be technical in nature, with emphasis on technical issues and work progress. The assigned DOE project manager for the operable unit will be responsible for preparing revisions to the schedule prior to the meeting. The schedule shall address all ongoing activities associated with an active operable unit. This schedule will be provided to all parties and reviewed at the meeting. Any agreements and commitments (within the project manager's level of authority) resulting from the meeting will be prepared and signed by all parties as soon as possible after the meeting. Unit manager meeting minutes will be issued by the DOE project manager and will summarize the discussion at the meeting, with information copies given to the project managers.

Other meetings will be held, as necessary, with subcontractors and other appropriate entities (particularly those involved with other programs operating in the 200 Areas) to communicate information, assess project status, and resolve problems.

7.2.4 Records Management

The Tri-Party Agreement specifies documentation and records management requirements for remediation activities at the Hanford Site. The Tri-Party Agreement categorizes all supporting documents based on importance of documenting final data or use in decision making to support remediation. Under the Tri-Party Agreement, documents are categorized as either primary or secondary documents. Tables 8-1 and 8-2 of the Tri-Party Agreement provide a listing of primary and secondary documents, respectively.

The Tri-Party Agreement describes the process for review, comment, and revision of documents supporting cleanup of an operable unit. The Information Management Overview, Appendix C of this document, details ER and Hanford Site programs for records management. As noted in Subsection 7.2.2.2, the 200 Area project managers are responsible for implementing Tri-Party requirements for characterization and remediation of the 200 Areas. Revisions, should they become necessary after finalization of any document, will be in accordance with Section 9.3 of the Tri-Party Agreement. Changes in the work schedule, as well as minor field changes, can be made without having to process a formal revision. The process for making these changes will be as stated in Section 12.0 of the Tri-Party Agreement. The Administrative Record will be maintained to support 200 Area characterization activities in accordance with Section 9.4 of the Tri-Party Agreement.

The project file will be kept organized, secured, and accessible to the appropriate project personnel. All field reports, field logs, health and safety documents, QA/QC documents, laboratory data, memoranda, correspondence, and reports will be logged into the file upon receipt or transmittal.

7.2.5 Progress and Final Reports

Monthly progress will be documented at unit managers' meetings. Meeting minutes will be prepared, distributed to the appropriate personnel and entities (e.g., project managers, coordinators, contractors, subcontractors), and entered into the project file.

All RI/FS/closure plan reports and supporting documents will be categorized as either primary or secondary documents. The process for document review and comment and maintenance of administrative records is covered by the *Tri-Party Agreement Action Plan* (Ecology et al. 1996).

7.2.6 Quality Assurance

The specific planning documents required to support the RI/FS/closure plans have been developed within the overall QA program structure mandated by the DOE for all activities at the Hanford Site. Within that structure, the documents are designed to meet current EPA guidelines for format and content and are supported and implemented through the use of standard operating procedures drawn from the existing program or that have been developed specifically for environmental investigations. To ensure that the objectives of this project are met in a manner consistent with applicable DOE guidelines, all work conducted by BHI will be performed in compliance with the BHI *ERC Quality Program* (BHI-QA-1) that specifically describes the application of manual requirements to environmental investigations. The QAPjP provided in Appendix A supports the overall approach described in this chapter. The QAPjP defines the specific means that will be used to help ensure that the sampling and analytical data are defensible and will effectively support the purposes of the investigation. The QAPjP will be implemented by this subtask. Details that are specific to each waste group being investigated will be documented in a QAPjP section of the group-specific work plans that will be reviewed and approved by the lead regulatory agency for the group-specific work plan.

7.2.7 Health and Safety

The health and safety plan (HASP) (Appendix B) will be used to implement standard health and safety procedures for BHI employees and contractors engaged in RI/FS activities in the 200 Areas. More specific details on the management aspects of the HASP are found in the appendix. A site-specific HASP will be written for each work plan or field activity as necessary and as determined by the Health and Safety officer in charge of the project. Minor activities that do not require the level of detail found in the HASP will be covered by an Activities Hazard Analysis.

7.2.8 Community Relations

Community relations activities will be conducted in accordance with the *Community Relations Plan for the Hanford Federal Site Facility Agreement and Consent Order* (Ecology et al. 1997). All community relations activities associated with the 200 Areas will be conducted under this overall Hanford Site Community Relations Plan.

7.3 INTERFACE WITH OTHER PROGRAMS AND AGENCIES

Several ongoing Hanford Site programs may impact or be impacted by ER (EM-40) activities. These programs include waste management (EM-30), Tank Waste Remediation System (EM-30), Facility Transition and Management (EM-60), and Technology Development (EM-50) programs. Several projects also exist in the ER Project that are active in the 200 Areas and require integration. The following sections provide a brief discussion of each project and identify mechanisms that are currently in place to integrate the projects.

The parties managing and overseeing characterization of the 200 Areas (ERC, the DOE, and regulatory agencies) interface with other programs through their involvement in, or oversight of, other Hanford Site programs, projects, or work groups, such as the following:

- Groundwater/Vadose Zone Integration Project
- D&D Strategy Work Group
- Facility transition supporting Tri-Party Agreement Amendment
- Canyon Initiative Team
- B Plant Transition
- RCRA Closures and Permitting
- Groundwater Remediation
- Tank Waste Remediation System
- 100 and 300 Area Remediation Projects
- Environmental Restoration Disposal Facility
- Low-Level Burial Grounds.

7.3.1 Groundwater/Vadose Zone Integration Project

As shown in Figure 7-2, there are numerous Hanford Site major projects working to solve contamination issues on the Site. The recent formation of the Groundwater/Vadose Zone (GW/VZ) Integration Project will be a key driver for insuring integration of GW/VZ activities in the 200 Areas. In addition to the *Management and Integration of Hanford Site Groundwater and Vadose Zone Activities* (DOE-RL 1998a) the GW/VZ Project has several other key documents that define their project. The *Groundwater/Vadose Zone Integration Project Specification* (DOE-RL 1998b), defines and communicates the vision, mission, goals, objectives, and technical boundaries for the scope of work needed to achieve the GW/VZ project objectives. The Groundwater/Vadose Zone Integration Project - Project Management Plan will define the overall management of the technical scope, cost, and schedule baselines for the GW/VZ Project and also will define the authorities, organizational roles, and responsibilities of the GW/VZ Project participants. An GW/VZ Project Baseline report will also be prepared that will identify the processes, tools, and resources required to develop and maintain the GW/VZ Project cost, schedule, and technical scope of work. It will also include the prioritization logic, the long range plan, and the detailed work plan of activities. Integration of 200 Area remedial action project activities with this team, through the review and concurrence on ER project detailed work plans by the GW/VZ Project Team, will be necessary as development of the group-specific work plans proceed.

As stated in the *Groundwater/Vadose Zone Integration Project Specification* (DOE-RL 1998b), "Integration is the heart of the GW/VZ integration project." Furthermore the "Integration Project seeks to remedy the fragmentation inherent in past approaches to characterization and assessment of impacts regarding contamination at, or originating from, the Hanford Site. The general approach is to (a) identify organization overlaps and other inefficiencies; (b) identify deficiencies in knowledge and the work needed to fill those deficiencies; and (c) using information from (a) and (b) to expeditiously implement appropriate remedies."

The Groundwater/Vadose Zone Integration Project also has the lead for working with the authors of the *Screening Assessment and Requirements for a Comprehensive Assessment, Columbia River Comprehensive Impact Assessment* (CRCIA) (DOE-RL 1998c). The CRCIA report was prepared by stakeholders to delineate requirements believed to be critical and that should be considered for long term assessment of the impacts of Hanford operations on the environment and public health. The GW/VZ project is reviewing the CRCIA requirements and working with CRCIA team representatives to understand the requirements. It is anticipated that the *Groundwater/Vadose Zone Integration Project Specification,* Appendix E *(DOE-RL* 1998b) will contain the guidelines or project-specific translation of how the CRCIA requirements will be implemented.

7.3.2 Environmental Restoration Project

The ER Project must assess and remediate inactive hazardous and radioactive facilities and waste sites, including past practice and RCRA TSD units. The ER project consists of several projects, including Remedial Actions and Waste Disposal, Groundwater Remediation, N Area, and D&D Projects.

Integration needs have been identified at various levels within the ER project. Several operable units have completed various levels of assessment work and include the 200-BP-1, 200-UP-2, and 200-ZP-2 source operable units, and the 200-UP-1, 200-ZP-1, 200-BP-5, and 200-PO-1 groundwater operable units. To date, the 200 Area source work has been based on the geographic operable unit approach to organizing waste sites. Sites within these source operable units were included in the groups established in the *Waste Site Grouping for 200 Areas Soil Investigations* report (DOE-RL 1997).

Interim groundwater remediation efforts are currently under way in the 200-UP-1 and 200-ZP-1 groundwater operable units and are being managed by the Groundwater Remediation Project. Integrating source (i.e., waste sites and associated vadose zone contamination) and groundwater projects will primarily be required in the long term to implement final remedial decisions for the 200 Areas. However, a more immediate need for groundwater/source integration exists in the Z Plant area where extensive carbon tetrachloride contamination exists in the vadose zone and groundwater. The 200-ZP-2 vapor extraction expedited response action is currently limited to four cribs. However, an expanded treatment program may be needed to address other areas of carbon tetrachloride contamination in the vadose zone in the 200 West Area. As group-specific work plans are developed, integration with the groundwater project will facilitate development of contaminants of concern that may be impacting groundwater from source sites. For work plans that include TSD units, closure and post closure groundwater monitoring activities will be prepared by the ER groundwater project and coordinated with the 200 Area soil assessment project. This will then insure integration with the overall groundwater/vadose zone project. Integration at this level will also serve to enhance coordination of the 200 Area group-specific work plans with other Hanford Site projects.

Integration with D&D projects occurs at three levels. One level is provided by the Radiation Area Remedial Action (RARA) program, which performs surveillance and maintenance at selected waste sites and interim stabilization of select inactive waste sites, if required. An annual report supplies information on the past years' surveillance and maintenance activities. Interim stabilization that may be required at a particular waste site is planned to include project input to ensure that the activity is consistent with possible CERCLA remedial actions. The information in the annual report is used to update WIDS to ensure that current status on waste sites is available. The second level of integration occurs during the facility transition process where the 200 Area project manager is involved in the review and acceptance of waste sites associated with the facility. The third level occurs when the long-range plan is updated yearly and the planned CERCLA and D&D activities are reviewed for possible impacts. In addition, there has been cross-project participation in strategy workshops, such as the current/ongoing canyon facility initiative team that looked at alternatives for D&D of the canyon facilities.

7.3.3 Other Hanford Site Programs

The waste management program manages waste generated on the Hanford Site, including the storage, treatment, and processing of defense high-level radioactive waste, waste minimization efforts, and corrective actions at waste management facilities. Numerous subprograms within waste management exist on the Hanford Site, including Tank Waste Remediation System (DOE 1996b), Solid Waste Management, Liquid Effluent, Spent Nuclear Fuels, and Analytical Services. Meetings with other waste management programs will be facilitated through the Groundwater/Vadose Zone Integration Project to provide the level of integration that is required.

The Facility Transition and Management Program must ensure that shutdown facilities are brought to a deactivated state, maintained, and eventually decontaminated and/or decommissioned or released for other uses. The Landord Program is a Site Infrastructure Division Program that is responsible for management of systems such as water, sewer, electricity, and communications on the Hanford Site.

The DOE Office of Technology Development must develop technologies to meet DOE's ER goals and work closely with other ER projects to identify, develop, and implement innovative technologies. The DOE Office of Technology Development has established five focus areas to address DOE's most pressing technology development needs, including (1) contaminant plume containment and remediation; (2) mixed waste characterization, treatment, and disposal; (3) high-level waste tank remediation; (4) landfill stabilization; and (5) D&D. Because of the unique nature of waste contamination and the lack of proven and cost-effective technologies, the need to evaluate promising technologies is recognized as an essential step to remediate the 200 Areas. The ER Project continues to actively work with the DOE Office of Technology Development to identify promising technologies and acquire the necessary support to evaluate/implement those technologies.

The Hanford Site Integrated Schedule identifies Hanford Site programmatic interfaces and site critical paths providing a high-level integrated plan. The Hanford Site Integrated Schedule provides a forum for dissemination of high-level summary schedule information between the various site programs, the stakeholders, and regulatory bodies. It provides a mechanism to integrate, analyze, and monitor Hanford Site programs.

7.3.4 Other Organizations

In addition to these other programs operating at the Hanford Site, there are a number of organizations that participate in providing recommendations that can affect the path the ER project follows. These organizations include the Hanford Advisory Board, the Interagency Management Integration Team, the Washington State Department of Health, Native American Indian Tribes, and other interested stakeholders.

7.4 SCHEDULE

Figure 7-3 provides a conceptual schedule that shows the 200 Areas Implementation Plan, milestone dates for the first six group-specific work plans that were identified in the *Waste Site Grouping for 200 Areas Soil Investigations* (DOE-RL 1997), and the remaining 17 work plans. This is based on Tri-Party Agreement change packages M-13-97-01 and M-20-97-01 approved in March 1998 to support the approach for the 200 Areas and to redefine existing milestones.

The implementation of this approach for the 200 Areas is driven by the requirement to meet the year 2008 Tri-Party Agreement milestone for completion of characterization activities. The schedule indicates that this milestone can be met with this approach.

As the first six group-specific work plans are being developed, the responsible regulatory agencies will meet to define the specific waste site groups that will be worked next. Experience gained during the investigation process for the first six groups will be used to refine characterization needs, establish priorities within the remaining work plans, and re-evaluate existing milestones or assign new milestones as needed. As work plans are written and characterization activities are initiated, the process will follow the integrated approach shown earlier in Figure 2-2 of this report. These investigations will be sufficiently comprehensive to satisfy the technical requirements of both RCRA and CERCLA programs when both past practice sites and TSD units are found in a waste site group. Each of the group-specific work plans will also contain enforceable schedules and milestones, consistent with Figure 2-2.

The schedule (Figure 7-3) assumes that the implementation plan and 23 work plans will be prepared; however, the number of work plans ultimately required will be based on the waste site groups and experience and information that is obtained as the process is followed. For planning purposes, 23 characterization activities, remedial investigation reports, and feasibility studies are assumed, consistent with the number of work plans. However, based on past experience in the 100 and 300 Areas, it is expected that additional consolidation of documents will occur as opportunities for additional streamlining are realized. With this same reasoning it may not be necessary to complete 23 proposed plans and RODs. Rather, it is reasonable to assume that streamlining of the decision-making process will be achieved that will allow consolidation of proposed plans and RODs, along with the use of explanation of significant differences and focus packages.

7.5 PUBLIC INVOLVEMENT

Public involvement is an integral and necessary part of DOE activities on the Hanford Site to ensure that decisions are made with the benefit and consideration of important public perspectives. This creates a mechanism that brings a broad range of diverse viewpoints and values into the DOE decision-making process, which enables DOE to make more informed decisions, improve quality through collaborative efforts, and build mutual understanding and trust between the DOE and the public.

Public involvement includes open, ongoing, two-way communication, both formal and informal, between DOE and its stakeholders, the regulators, and Tribal governments. It is intended as a means of keeping the public informed of progress and/or to status ongoing activities and/or issues. Public involvement is a process designed to increase opportunities for the public and the DOE to obtain the best information possible upon which to make informed decisions.

Tribal governments have a unique legal relationship with the U.S. government as set forth in the Constitution of the United States, treaties, statutes, and court decisions. The United States has committed to a government-to-government relationship with Indian tribes. Rather that seeking tribal participation through public forums, the DOE consults directly with Tribal Governments prior to taking actions that may affect their rights and interests, as outlined in the DOE American Indian Policy. The goals, core values, and principles of this public involvement policy apply equally to stakeholders and affected Tribes alike.

Within the 200 Areas project, opportunities for public involvement will occur as the process of characterization and remediation continues. Specific areas of public involvement are discussed further in Section 2.3 and are shown in Figure 2-2. The general public will be initially involved via this Implementation Plan and several of the initial group-specific work plans. Following completion of these reviews, it will be determined if future work plans need to be provided for public review. Other documents where public comment opportunities exist include proposed plans, proposed permit modifications, and remedial design and remedial action work plans.

Public participation opportunities are available through a number of organizations such as those discussed in Section 7.3.3. In addition, the Community Relations Plan (Ecology et al. 1997) specifies how the public can be involved in the processes that are followed on the Hanford Site. This is discussed further in Section 10 of the *Tri-Party Agreement Action Plan* (Ecology et al. 1996).

Figure 7-1. Project Organization for the 200 Areas RI/FS and Closure Plan Activities.

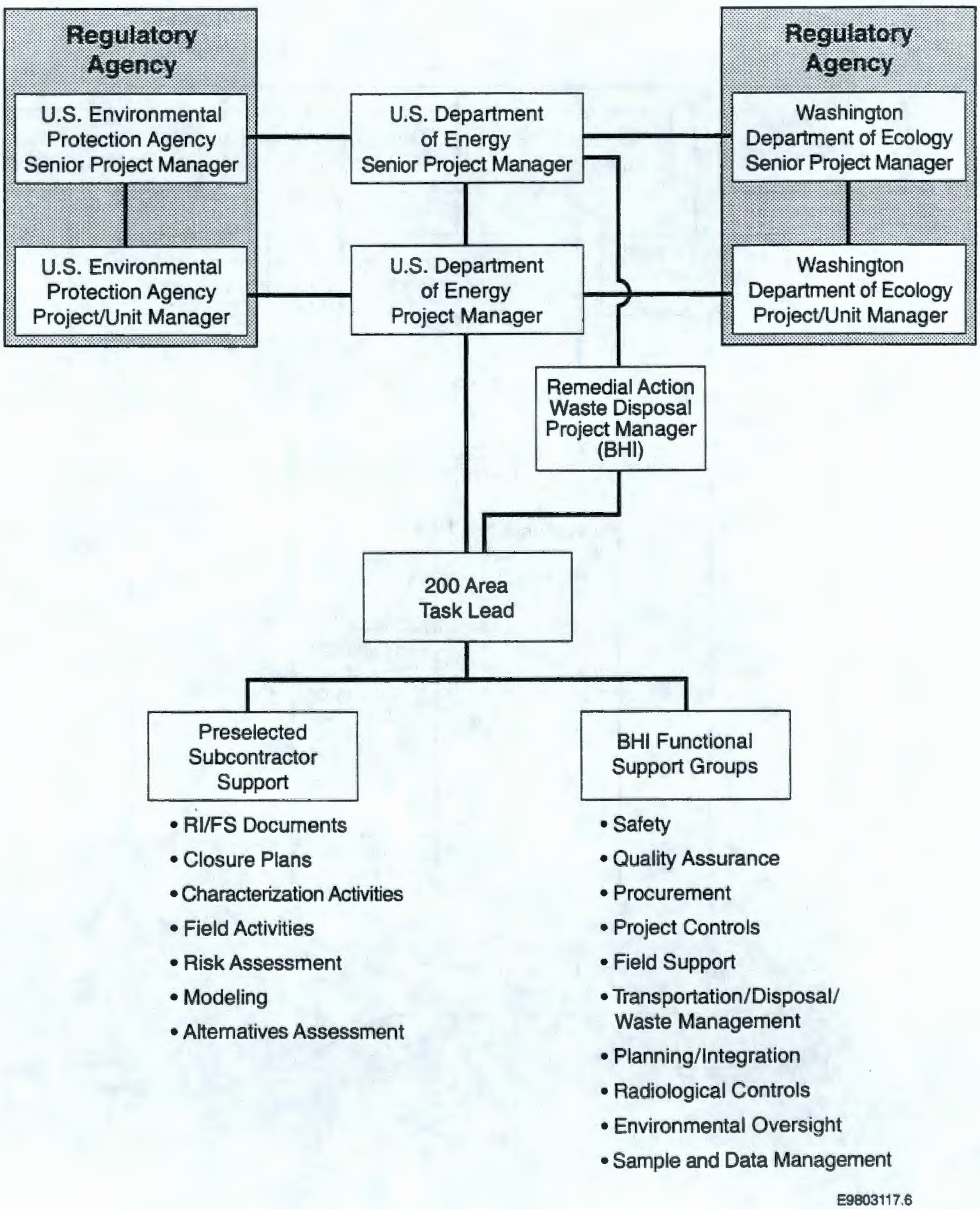
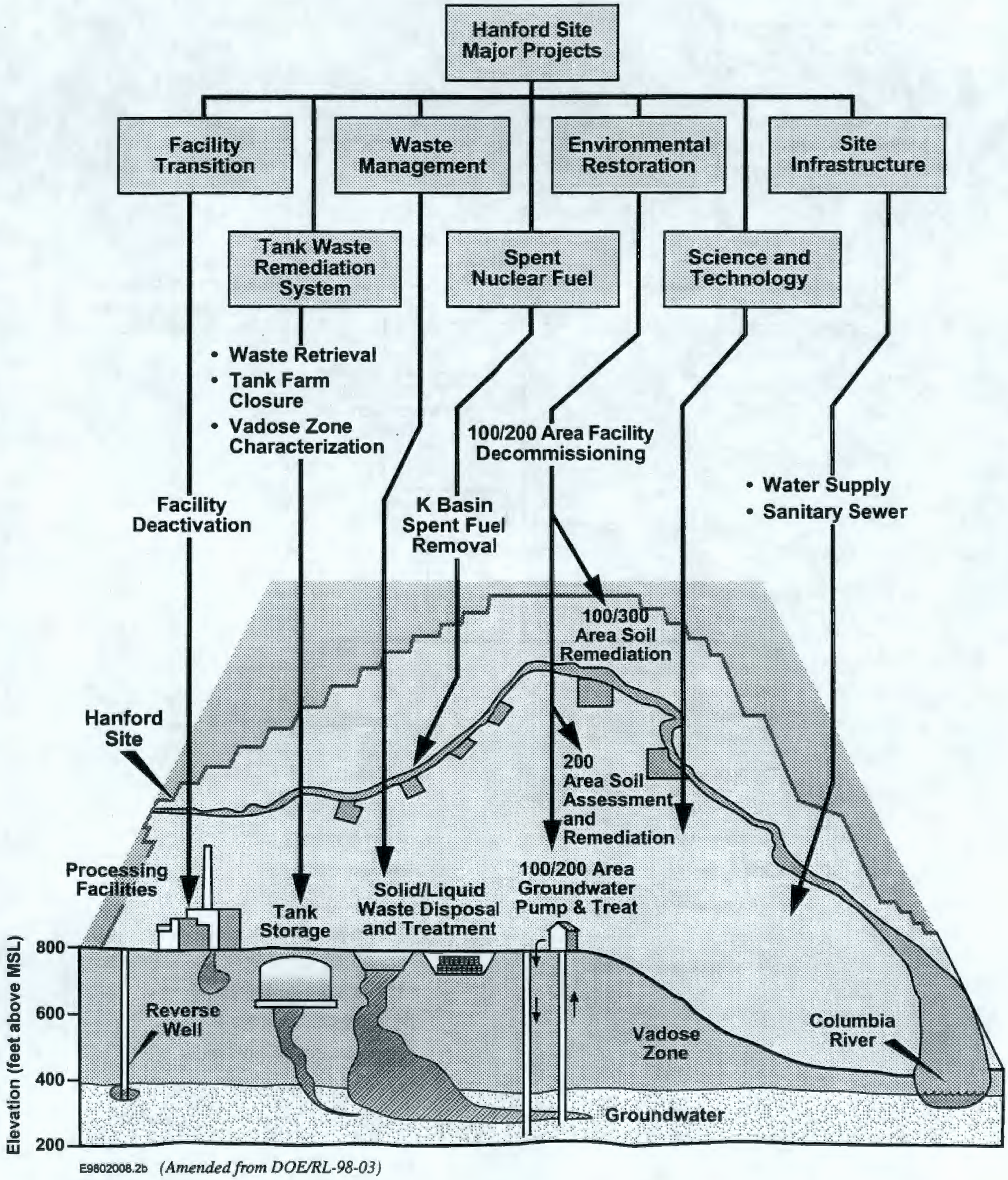


Figure 7-2. Current Groundwater/Vadose Zone Project-Related Activities.



(Amended from DOE/RL-98-03)

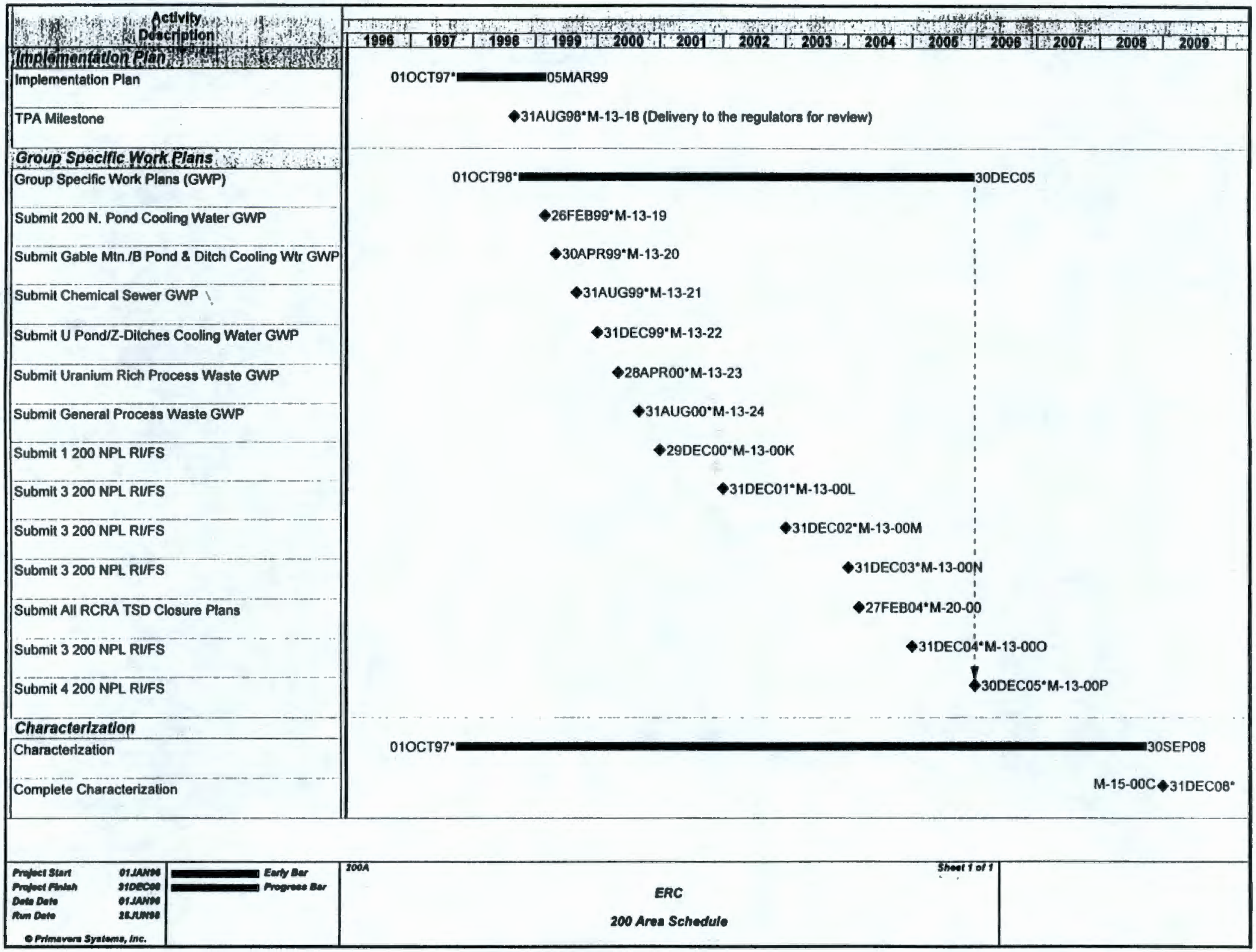


Figure 7-3. 200 Areas Soil Strategy Conceptual Schedule.

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APPENDIX A

QUALITY ASSURANCE PROJECT PLAN

A1.0 INTRODUCTION

This quality assurance project plan (QAPjP) establishes the quality requirements for sampling performed by Analytical Field Services. This plan complies with the requirements of U.S. Department of Energy (DOE) Order 5700.6C, *Quality Assurance*; 10 *Code of Federal Regulations* (CFR) 830.120, "Quality Assurance Requirements;" the *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA 1994); and the *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD), Volume 2, "Sampling Technical Requirements" (DOE-RL 1996). It is based on information contained in BHI-QA-03, *ERC Quality Assurance Program Plans*, Plan 5.1, "Field Sampling Quality Assurance Program Plan." The plan is supplemented by environmental investigation procedures (EIPs) in BHI-EE-01, *Environmental Investigations Procedures*, which document sampling practices.

The purpose of this appendix is to provide a framework of general requirements that apply to each of the 23 waste site groups covered in the *200 Areas RI/FS Implementation Plan*. The general requirements identified in this appendix shall be supplemented by specific waste site grouping requirements developed through the data quality objectives (DQO) process and documented in the associated group-specific work plans. Documentation may take the form of individual sampling and analysis instructions (SAIs), sampling and analysis plans (SAPs), and characterization plans (CPs).

A2.0 PROJECT MANAGEMENT

This section addresses the basic areas of project management and ensures that the project has a defined goal, that the participants understand the goal and the approach to be used, and that the planned outputs have been appropriately documented.

A2.1 PROJECT/TASK ORGANIZATION

The 200 Areas project shall be managed through the Environmental Restoration Contractor (ERC) Remedial Action and Waste Disposal (RAWD) Project on behalf of the DOE. The principles and responsibilities discussed in the *Remedial Action and Waste Disposal Project Manager's Implementing Instructions* (BHI 1998) are hereby incorporated into this document. All personnel assigned to the RAWD Project must comply with these Project Manager's Implementing Instructions. General positions and responsibilities for the project manager and task lead have been described in Section 7.2. Other support staff (functional group or preselected subcontractor) will be identified by the task lead to accommodate the needs of the project (i.e., RI/FS characterization or assessment activities require different staffing than do remedial action activities). Specific personnel assignments shall be documented in the group-specific work plan for each waste site grouping. Some of these staff may include the following:

- **Project Engineer**. The project engineer reports to the task lead and is responsible for the design engineering and for providing technical assistance to field support and health and safety programs. The project engineer provides ensures the technical adequacy of scope of work.

- **Field Superintendent**. The field superintendent reports to the task lead and has the ultimate responsibility for everything that occurs at the site. The field superintendent provides equipment resources and is responsible for direction of craft personnel for execution of the work scope. Other duties include maintenance of the field logbook.

- **Health and Safety**. The health and safety officer is matrixed to the task lead and provides health and safety planning and oversight to the project. The health and safety officer is responsible for reviewing the generic health and safety plan (Appendix B) and identifying/documenting any waste grouping-specific health and safety needs for the project. The health and safety officer routinely provides input to the field superintendent to ensure safe execution of the project operations. The health and safety officer is responsible for monitoring all potential health and safety hazards during field activities, including those associated with radioactive and hazardous materials. The health and safety officer has the responsibility and authority to halt field activities resulting from unacceptable health and safety hazards.

- **Waste Management**. The waste management representative is matrixed to the field superintendent and is responsible for preparation of site-specific waste management instructions in accordance with BHI-EE-10, *Waste Management Plan*. Other duties include waste profile evaluation, waste packaging, and waste shipment.

- **Environmental Lead**. The environmental lead is matrixed to the task lead and ensures that all environmental requirements are addressed in accordance with appropriate laws, regulations, policies, procedures, practices, environmental design criteria, permits, and DOE directives.

- **Sample and Data Management**. Sample and data management is responsible to provide functional support personnel as needed for sample collection, onsite measurements, sample tracking, and data management. Sample and data management is also responsible for management and coordination of communication with contract laboratories. Other duties include development and maintenance of any project-specific database applications that are needed by the project.

- **Radiological Controls**. The radiological control group is responsible for radiological control technician (RCT) coverage for the project. Other duties include preparing Radiological Work Permit (RWP) documentation and overseeing work performed in controlled areas under an RWP.

- **Quality Assurance Representative**. The quality assurance (QA) representative is matrixed to the task lead and is responsible for project QA issues, and coordination/performance of self-assessment, surveillance, and audit activities. Other duties include support to identification and implementation of corrective actions and communication of lessons learned information from other projects. This designated person shall have the necessary independence and authority to identify conditions adverse to quality and to systematically seek corrective action.

A2.2 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

Specific data quality requirements shall be developed for each waste site grouping through the DQO process as specified in BHI-EE-01, *Environmental Investigation Procedures*, Section 1.2, "Data Quality Objectives." The results of the DQO process shall be reflected within the document structure of the group-specific work plan as a summary table of data quality requirements. Suggested elements of the summary table include references to the measurement parameter (e.g., analyte), required action/cleanup/regulatory level, and required precision and accuracy criteria for each type of sample media (e.g., soil, water). Separate tables or references may be required to summarize the requirements for different types of data acquisition such as process monitoring and verification.

A.2.3 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

Training or certification requirements for ERC personnel are described in BHI-HR-02, *ERC Training Procedures*. Specific training requirements for personnel supporting the data acquisition process are identified in BHI-QA-03, *ERC Quality Assurance Program Plans*, as listed below.

- Plan 5.1, "Field Sampling Quality Assurance Plan"
- Plan 5.2, "Onsite Measurements Quality Assurance Program Plan"
- Plan 5.3, "Onsite Radiological Measurements Quality Assurance Program Plan."

Site workers shall have completed Occupational Safety and Health Administration 40-Hour Hazardous Waste Worker training and Hanford General Employee Training before starting work. Personnel transporting samples from the various 200 Area work sites to the designated Sample Storage Facility or to laboratories shall have completed U.S. Department of Transportation shippers training. Any waste site grouping-specific training requirements shall be specified in the appropriate group-specific work plan.

A2.4 DOCUMENTATION AND RECORDS

Sample collection and analysis activities shall be planned in accordance with BHI-EE-01, *Environmental Investigation Procedures*, Procedure 2.0, "Sample Event Coordination." The Sample Authorization Form/Field Sampling Requirements (SAF/FSR) information generated through the sample event coordination process shall document the following for onsite measurements and laboratory test methods:

- Test method/analyte and holding time
- Sample media
- Sample container type, size, and preservatives
- Turnaround times
- Data deliverable types.

Field documentation shall be maintained in accordance with BHI-EE-01, including the following procedures:

- Procedure 1.5, "Field Logbooks"
- Procedure 1.13, "Environmental Site Identification and Information Reporting"
- Procedure 3.0, "Chain of Custody."

Results of onsite measurement tests shall be managed in accordance with BHI-EE-05, *Field Screening Procedures*, Procedure 1.7, "Preparation, Review, and Control of Organic/Inorganic Data Packages." Data deliverables shall be managed in accordance with BHI-EE-01, Section 2.0, "Sample Management," through final disposition to Document and Information Services and the records holding area. Any waste site group-specific documentation requirements shall be specified in the appropriate group-specific work plan.

A3.0 MEASUREMENT/DATA ACQUISITION

The following section presents the general requirements for sampling methods, sample handling and custody, analytical methods, and field and laboratory quality control. The requirements for instrument calibration and maintenance, supply inspections, data acquisition, and data management are also discussed.

A3.1 SAMPLING METHODS

Samples for the various 200 Areas waste site groupings shall be collected in accordance with procedures found in BHI-EE-01, such as Procedure 4.0, "Soil and Sediment Sampling," and Procedure 4.4, "Container Sampling."

A3.2 SAMPLE HANDLING AND CUSTODY

Sample handling, shipping, and custody shall be performed in accordance with BHI-EE-01, Procedure 3.1, "Sample Packaging and Shipping," Procedure 3.0, "Chain of Custody," and Procedure 4.2, "Sample Storage and Shipping Facility."

A3.3 SAMPLE PRESERVATION, CONTAINERS, AND HOLDING TIME

The sample preservation, container, and holding time requirements for applicable test methods shall be specified in the SAF/FSR information as specified in Section A.2.4 of this appendix. The requirements for the specific test/laboratory methods of each waste site grouping shall be presented in a summary table within the applicable group-specific work plan.

A3.4 ANALYTICAL METHODS

Onsite measurement tests shall be performed in accordance with the procedures contained in BHI-EE-05 and/or the manufacturer test instructions (as written). Analysis by contract laboratories shall be performed using accepted methods in accordance with the technical requirements specified by the applicable purchase requisition. Hanford Site contractor-operated laboratories that are selected to provide support shall perform analysis in accordance with requirements specified by the work order and associated letter of instruction.

The specific waste site grouping analytical methods shall be presented in the group-specific work plan as a summary table. Suggested elements of the summary table include references to the analytical method, measurement parameter (e.g., analyte), detection/quantitation limit, and precision and accuracy criteria for each type of sample media (e.g., soil, water). Separate tables or references may be required to summarize the requirements for different types of data acquisition, such as process monitoring and verification.

A3.5 QUALITY CONTROL

Quality control (QC) measures shall be followed in the field and laboratory to ensure that reliable data are obtained. When performing this field sampling effort, precaution shall be taken to prevent the cross-contamination of sampling equipment, sample bottles, and other equipment that could compromise sample integrity. During the DQO process, specific waste site groups may require QC elements at a frequency other than those identified in this appendix. The applicable QC requirements shall be documented in the group-specific work plan.

A3.5.1 Field Quality Control

Several control samples are introduced into the collection system to monitor the adequacy of the sampling system and the integrity of samples during their journey from the field collection point through laboratory analysis. The frequency and type of QC samples to be collected are specified in SAI, SAP, or CP. These samples are defined, as mentioned in the following sections, with their mode of collection and purpose.

- **Trip Blanks.** Trip blanks are used to detect contamination during sample shipping and handling. A trip blank is an analyte sample container filled with distilled/deionized water, or clean silica sand (if specified), that is transported to the sampling site and then returned to the laboratory with the samples. Trip blanks are filled in the laboratory, or at the 3728 Sample Storage Facility, and are not to be opened in the field. The frequency of use of the trip blank should be specified in the site-specific SAP. Each trip blank should be stored at the laboratory with associated samples and analyzed with those samples.

  Trip blanks are primarily used when samples are to be analyzed for volatile organic compounds. However, trip blanks may be used for any parameter when there is concern that concentration of the parameter is biased by contamination. A trip blank will not only detect contamination during the shipping and handling of the containers, but will also serve to detect contamination from containers (i.e., function as a bottle blank), which is important if noncertified sample containers are being used.

- **Equipment Rinsate Blanks.** Equipment rinsates are samples of distilled/deionized water, or clean silica sand (if specified), passed through decontaminated sampling equipment before use of the equipment. Rinsates are used as a measure of the effectiveness of the equipment decontamination process. Equipment rinsates should be collected in the field and at the rate specified in the SAI, SAP, or CP. An equipment rinsate should be collected from each type of sampling equipment used to ensure that the decontamination procedures are applicable to all equipment types.

  Equipment rinsates are analyzed for the same analytes as samples collected using that equipment. All sample results should be evaluated to determine the possible effects of any contamination detected in the equipment rinsate blank.

- **Field Source Water Blanks.** Field source water blanks are samples of source water used for field decontamination and steam cleaning. The field source water blanks should be monitored throughout the project to detect any contamination that could be present in the decontamination water. The field source water blanks should be monitored for the same analytes as the samples being analyzed.

  If contamination is detected, a different source of water should be used. All sample results should be evaluated to determine the possible effects of any contamination detected in the field source water blank.

- **Field Duplicates.** Field duplicates are two samples produced from material collected in the same location that are submitted to the sample laboratory for analysis. Each sample will be numbered uniquely. Field duplicates provide information regarding the homogeneity of the matrix. A matrix constitutes soil, sediment, water, biota, or waste from a given site. A field duplicate may also provide an evaluation of the precision of the analysis process. Field duplicates for soil are collected and homogenized before being divided into two samples in the field. Field duplicates will normally be collected at a frequency of 5% to 10% of the samples collected per matrix. Soil samples submitted for volatile organic compound analyses are not to be homogenized or split; instead, it is necessary to collect these samples as collocated samples.

  Field duplicates should be sent to the laboratory in the same manner as the routine site samples; they may or may not be identified to the laboratory as field duplicates. The utility of information may be maximized when extra samples from the field splits are submitted for the laboratory to use as duplicates. This will help to distinguish between variability resulting from sample heterogeneity and variability resulting from laboratory manipulation. Field duplicate data should be reviewed for agreement. Data should meet the precision criteria established in the SAI, SAP, or CP.

- **Field Splits.** Field split samples are two uniquely numbered samples produced through homogenizing a field sample and separating the sample material into two separate aliquots. Field split samples are usually routed to separate laboratories for independent analysis, generally for the purposes of auditing the performance of the primary laboratory relative to a particular sample matrix and analytical method.

- **Collocated Samples.** Collocated samples are independent samples collected as close as possible to the same point in space and time and are intended to be identical. Because of the possible loss of volatile analytes when generating field duplicates, it is necessary to collect soil samples for volatile organic analysis as collocated samples. Collocated soil cores collected for volatile organic analysis should be sealed immediately and shipped to the laboratory. Collocated sample data are to be reviewed in the same manner as duplicate sample data.

- **Field Blanks.** Field blanks are samples of analyte-free media similar to the sample matrix transferred from one vessel to another at the sampling site. This blank is preserved and processed in the same manner as the associated samples and is used to document contamination in the sampling and analysis process.

A3.5.2 Onsite Measurements Quality Control

Minimum requirements for QC samples prepared and analyzed for onsite measurements (field screening) include duplicates, as described below. Further details can be found in BHI-EE-05.

- **Duplicates.** Duplicates are typically used as an indication of precision associated with the analytical process by calculating the relative percent difference between two results. At least one onsite measurements duplicate shall be prepared and analyzed each day of testing.

A3.5.3 Laboratory Quality Control

Method and/or protocol specific QC requirements shall be followed as outlined in the referenced procedures. Laboratory QC samples must be run as part of the delivery group or analytical batch as applicable. Types of laboratory QC samples are discussed below. Typical requirements for laboratory QC frequency and levels are provided, specific analytical techniques or protocols may have different requirements.

Laboratory Control Samples. Laboratory control samples (LCSs) contain known quantities of analytes and are carried through the sample analysis procedure. Recovery (determined as the percentage of "found" analyte relative to the known amount introduced) is used to assess the accuracy (bias) of the analytical technique.

LCSs shall, as much as possible, be of a similar matrix, and contain the same constituents of interest as the samples. Reference materials used to produce (e.g., spike) the LCS must be traceable to National Institute of Standards and Technology (NIST) (or equivalent) if possible and be of known quality. The LCS concentrations shall be at least 5 but not greater than 20 times the applicable required detection limits (RDLs). The LCSs shall be run at a minimum frequency of 1 in 20 samples, once per analytical batch, or once per delivery group, whichever is most frequent. LCS samples shall be prepared and analyzed in the same manner and have the same detection limit objectives as the samples.

Replicate Analyses. Replicate analyses consist of reanalysis of a sample, typically starting with the "raw" sample material. Replicate analyses are used to assess analysis precision. Some analytical techniques assess analytical precision via replicate measurement of "spiked" sample materials (see matrix spike).

Replicate analyses shall be run at a minimum frequency of 1 in 20 samples, once per analytical batch, or once per delivery group, whichever is most frequent. Replicate samples shall be prepared and analyzed in the same manner and have the detection limit objectives as the samples. If sufficient sample material has been provided, replicate samples shall use the same aliquot size as the original sample.

Preparation Blanks. Preparation banks are materials known to be free from contamination that are carried through the same analytical procedure as the samples. Preparation blanks are used to evaluate potential laboratory contamination of samples that could result in reporting of false positive results.

Preparation blanks shall be run at a minimum frequency of 1 on 20 samples, once per analytical batch, or once per delivery group, whichever is most frequent. Preparation blanks shall be prepared and analyzed the same manner which and meet the same detection limit objectives as the samples.

Matrix Spikes/Matrix Spike Duplicates. Matrix spikes consist of analysis of a replicate of an actual sample to which a known quantity of the analyte has been added. Recovery (determined as the percentage of "found" analyte relative to the known amount introduced) provides information on sample specific matrix effects that result in an analytical bias for a given analysis batch. Matrix spike duplicates are an additional matrix spike sample required by some analyses where analysis of a simple replicate sample is inappropriate.

The spiking materials must be traceable (NIST, if possible) and of known quality. If possible, spikes shall be the same component as the samples. The matrix spike should be added at a concentration of at least 5 but not greater than 20 times the applicable RDL. Matrix spikes shall be prepared and analyzed at a minimum frequency of one per analytical batch, delivery group, or 20 samples of like matrix, whichever is most frequent. The matrix spike shall be prepared and analyzed in the same manner and have the same detection requirements as the client samples.

Matrix spikes are not required for radiochemical analyses if an isotopic tracer or chemical carrier is used in the analysis to determine chemical recovery (yield) for the chemical separation and sample mounting procedures. Matrix spikes shall be run on a separate sample aliquot using the same element as that being analyzed whenever possible. Matrix spikes are not required for gross alpha, gross beta, or gamma energy analysis.

Isotopic Tracers and Chemical Carriers. Isotopic tracers are typically radioactive materials (e.g., plutonium-242, strontium-85), while carriers are typically nonradioactive (e.g., natural strontium). They are added to samples to determine the overall chemical yield for the analytical preparation steps. It is expected that when tracers or carriers are used, each sample is "spiked" separately and that individual sample yields will be determined.

Isotopic tracer materials must be traceable (NIST, if possible) and of known quality. Chemical carrier shall be of known quality and of minimum "ACS Reagent Grade." Quantities of material added to the samples must be sufficient to ensure that uncertainty values associated with the tracer/carrier account for less than 20% of total uncertainty of the final sample result. Isotopic tracers and chemical carries are not required for gross alpha, gross beta or gamma spectroscopy.

A3.6 INSTRUMENT CALIBRATION AND MAINTENANCE

Onsite measurement test instruments shall be calibrated and maintained in accordance BHI-QA-03, Procedure 5.2, "Onsite Measurements Quality Assurance Program Plan," Procedure 5.3, "Onsite Radiological Measurements Quality Assurance Program Plan," and the manufacturer test instructions. The results from all instrument calibration and maintenance activities shall be recorded in a bound logbook in accordance with procedures outlined in BHI-EE-01, Procedure 1.5, "Field Logbooks." Contract laboratory instruments shall be calibrated and maintained in accordance with the requirements specified by the applicable purchase requisition.

A3.7 FIELD DOCUMENTATION

Field documentation shall be managed as specified in Section A.2.4.

A3.8 DATA MANAGEMENT

Data resulting from the implementation of this sampling and analysis plan shall be managed and stored by the ERC Sample and Data Management organization in accordance with BHI-EE-01, Section 2.0, "Sample Management." At the direction of the task lead, all analytical data packages shall be subject to final technical review by qualified personnel before their submittal to regulatory agencies or inclusion in reports. Electronic data access, when appropriate, shall be via a database (e.g., Hanford Environmental Information System or a project-specific database). Where electronic data are not available, hard copies shall be provided in accordance with Section 9.6 of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1994).

A4.0 ASSESSMENT/OVERSIGHT

The Compliance and Quality Programs group may conduct random surveillance and assessments in accordance with BHI-MA-02, Procedure 2.9, "Surveillances," to verify compliance with the requirements outlined in this appendix, project work packages, the BHI Quality Management Plan, and BHI procedures and regulatory requirements. Deficiencies identified by assessments shall be reported in accordance with BHI-MA-02, Procedure 5.3, "Self-Assessments." When appropriate, corrective actions shall be taken by the task lead in accordance with *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD), Volume 1, Section 4.0 (DOE–RL 1996) to minimize recurrence.

A5.0 DATA VALIDATION AND USABILITY

Sample data shall be reviewed to ensure that analyses were performed and reported as requested. Sample results that require validation shall be validated in accordance with the requirements specified by BHI-EE-01, Procedure 2.5, "Data Package Validation Process." A variety of validation levels are available through the referenced procedure to meet the specific project needs. Specific validation requirements for each waste site grouping, including the validation frequency and level, shall be developed through the DQO process and documented in appropriate group-specific work plans.

A6.0 REFERENCES

BHI-EE-01, *Environmental Investigations Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-05, *Field Screening Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-10, *Waste Management Plan,* Bechtel Hanford, Inc., Richland, Washington.

BHI-HR-02, *ERC Training* Procedures, Bechtel Hanford, Inc., Richland, Washington.

BHI-MA-02, *ERC Project Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-QA-03, *ERC Quality Assurance Program Plans*, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1998, *Remedial Action and Waste Disposal Project Manager's Implementing Instructions,* BHI-00901, Rev. 1, Bechtel Hanford, Inc., Richland, Washington.

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DOE-RL, 1996, *Hanford Analytical Services Quality Assurance Requirements Documents*, DOE/RL-96-68, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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

APPENDIX B

GENERAL HEALTH AND SAFETY PLAN

B1.0 GENERAL CONSIDERATIONS AND REQUIREMENTS

B1.1 INTRODUCTION

The purpose of this appendix is to outline standard health and safety requirements for Bechtel Hanford, Inc. (BHI) employees and contractors engaged in remedial investigation activities in the 200 Areas waste groups. These activities will include surface investigation, drilling groundwater wells, groundwater sampling, characterization boreholes and test pits, and environmental sampling in areas of known chemical and radiological contamination. Appropriate site-specific safety documents (e.g., site-specific health and safety plan [SS HASP], activity hazard analysis [AHA]) will be written for each task or group of tasks. Specific safety procedures are documented in the BHI *Safety and Health Procedure Manuals* (BHI-SH-01 and BHI-SH-02). The *Radiological Control Work Instructions* manual (BHI-SH-04) and the *Hanford Site Radiological Control Manual* (HSRCM) (HSRCM-1) provide specific procedures relative to radiological concerns.

All employees of BHI or any other contractors who are participating in onsite remedial investigations activities in the 200 Areas waste groups shall read the site-specific safety documentation and attend pre-job safety or tailgate meetings to review and understand any hazards associated with the work scope.

B1.2 DESIGNATED SAFETY PERSONNEL

The field team leader and site safety officer are responsible for site safety and health. Specific individuals will be assigned on a task-by-task basis by project management. Their names will be properly recorded before the task is initiated. All onsite activities must be cleared through the field team leader. The field team leader has responsibility for the following:

- Allocating and administering resources to successfully comply with all technical and health and safety requirements
- Verifying that all permits, supporting documentation, and clearances are in place (e.g., electrical outage requests, welding permits, excavation permits, SS HASP or AHA, sampling plan, and radiological work permits [RWP])
- Providing technical advice during routine operations and emergencies
- Informing the appropriate site management and safety personnel of the activities to be performed each day
- Coordinating resolution of any conflicts that may arise between RWPs and the implementation of the SS HASP or AHA
- Handling emergency response situations as may be required
- Conducting pre-job and daily tailgate safety meetings
- Interacting with adjacent building occupants and/or inquisitive public.

The site safety officer is responsible for implementing the SS HASP at the site. The site safety officer shall do the following:

- Monitor chemical, physical, and (in conjunction with the radiological control technician [RCT]) radiation hazards to assess the degree of hazard present; monitoring shall specifically include organic vapor detection, radiation screening, and confined space evaluation where appropriate.
- Determine protection levels, clothing, and equipment needed to ensure the safety of personnel in conjunction with the Radiological Control organization.
- Monitor the performance of all personnel to ensure that the required safety procedures are followed.
- Halt operations immediately, if necessary, due to safety or health concerns.
- Conduct safety briefings, as necessary.
- Assist the field team leader in conducting safety briefings, as necessary.

The field team leader is responsible for site safety and health. The field team leader will use the Environmental Restoration Contractor (ERC) Radiological Control organization for ensuring that all radiological monitoring and protection procedures are being followed as specified in the HSRCM (HSRCM-1) and in the appropriate RWP. BHI Safety and Health personnel will provide safety overview during work site activities consistent with U.S. Department of Energy (DOE) and BHI policy and will provide technical advice, as requested. Personnel monitoring and downwind air monitoring for hazardous materials and radiological or other contaminants may be requested from appropriate project or contractor personnel as required.

The ultimate responsibility and authority for employee's health and safety lies with the employee and the employee's colleagues. Each employee is responsible for exercising the utmost care and good judgment in protecting his or her personal health and safety and that of fellow employees. Should any employee observe a potentially unsafe condition or situation, it is the responsibility of that employee to immediately bring the observed condition to the attention of the appropriate health and safety personnel, as designated previously. In the event of an immediately dangerous or life-threatening situation, the employee has "stop work" authority and the responsibility to immediately notify the field team leader or site safety officer. When work is temporarily halted because of a safety or health concern, personnel will exit the exclusion zone and meet at a predetermined place in the support zone. The field team leader, site safety officer, and RCT will determine the next course of action.

B1.3 MEDICAL SURVEILLANCE

All field team members engaged in hazardous waste site activities at sites governed by a SS HASP must have baseline physical examinations and participate in the BHI (or an equivalent) hazardous waste worker medical surveillance program.

Medical examinations will be designed to identify any pre-existing conditions that may place an employee at high risk, and will verify that each worker is physically able to perform the work required by this plan without undue risk to personal health. The physician shall determine the existence of conditions that may reduce the effectiveness or prevent the employee's use of respiratory protection. The physician shall also determine the presence of conditions that may pose undue risk to the employee while performing the physical tasks of this work plan using personal protection equipment including level B. This would include any condition that increases the employee's susceptibility to heat stress.

B1.4 TRAINING

As described in BHI-SH-02, Volume 1, all employees entering the work site must have the necessary qualifications and training to perform the assigned task in a safe manner. Prior to performing work on the site, each employee will attend training as specified in the Work Site Safety and Health Orientation. The initial training includes Hanford Site Orientation and/or Hanford General Employee Training. The topics covered in these training sessions include company and employee rights and responsibilities, alcohol and drug abuse policies, accident and incident reporting, emergency warning systems, and basic fire protection. Performing tasks in a radiation area or an exclusion zone will require the employee to have completed a variety of training requirements as described in the RWP and the SS HASP.

Each member of the team involved in a hazardous waste site operation is required by *Code of Federal Regulations* (CFR) 1910.120 to have received 40 hours of specific hazardous waste site training (and annual 8-hour refresher course). The field team leader and the site safety officer will also have an additional 8 hours of special training related to the operation of a hazardous waste site. Employees not directly involved with hazardous waste handling will have a minimum of 24 hours of training and be supervised by the field team leader.

B1.5 TRAINING FOR VISITORS

For the purposes of this plan, a visitor is defined as any person visiting the Hanford Site, who is not a Hanford Site contractor employee directly involved in the *Resource Conservation and Recovery Act/Comprehensive Environmental Response, Compensation, and Liability Act* facility investigation activities, including but not limited to those engaged in surveillance, inspection, or observation activities.

Visitors who must enter a controlled (either contamination reduction or exclusion) zone are subject to all of the applicable training, respirator fit testing, and medical surveillance requirements previously discussed. Escorts will inform all visitors of potential hazards and emergency procedures.

B1.6 CONTINGENCY AND EMERGENCY RESPONSE PLANS

In the event of an unanticipated, potentially hazardous situation indicated by instrument readings, visible contamination, unusual or excessive odors, or other indications, team members shall temporarily cease operations and move upwind to a pre-designated safe area as specified in the site-specific safety documentation. The SS HASP will designate specific emergency response procedures for reasonably anticipated site-specific emergency situations/scenarios.

B1.7 RADIATION DOSIMETRY

All personnel engaged in onsite activities will be assigned dosimeters according to the requirements applicable to the activity. All visitors will be assigned dosimeters if required.

B1.8 REQUIREMENTS FOR THE USE OF RESPIRATORY PROTECTION

All employees of BHI and subcontractors who may be required to use air-purifying or air-supplied respirators must be included in the medical surveillance program and be approved for the use of respiratory protection by the Hanford Environmental Health Foundation or other licensed physician. Each team member must be trained in the selection, limitations, and proper use and maintenance of respiratory protection (existing respiratory protection training may be applicable towards the 40-hour training requirement).

Before using a negative pressure respirator, each employee must have been fit-tested (within the previous year) for the specific make, model, and size according to fit-testing procedures in use by the ERC through the Hanford Environmental Health Foundation. Beards (including a few days' growth), large sideburns, or moustaches that may interfere with a proper respirator seal are not permitted.

Subcontractors must provide evidence to BHI that personnel are participants in a medical surveillance and respiratory protection program that complies with 29 CFR 1910.120 and 29 CFR 1910.134, respectively.

B1.9 AIRBORNE RADIOACTIVE AND RADIATION MONITORING

Appropriate respiratory protection will be required when conditions are such that the airborne radiological contamination levels may exceed administrative control levels for respiratory protection. Such conditions may result because of the presence of high levels of uncontained, loose contamination on exposed surfaces or from operations that may raise excessive levels of dust contaminated with airborne radioactive materials, such as excavation or drilling under extremely dry conditions.

Specific conditions requiring the use of respiratory protection because of radioactive materials in air will be incorporated into the RWP. If, in the judgement of the RCT, any of these conditions arise, work shall cease until appropriate respiratory protection is provided.

B2.0 GENERAL PROCEDURES

A hazardous waste site presents numerous health and safety concerns. The following guidelines represent the minimum requirements for reducing potential risks associated with 200 Areas waste group work scope activities.

B2.1 GENERAL WORK SAFETY PRACTICES

B2.1.1 Work Practices

The following work practices must be observed.

- Eating, drinking, smoking, taking medications, chewing gum, and similar actions are prohibited within the exclusion zone. Allowances for water may be authorized by the RWP during heat stress conditions. All sanitation facilities shall be located outside the exclusion zone; decontamination is required before using such facilities.

- Personnel shall avoid direct contact with contaminated materials unless necessary for sample collecting or required observation. Remote handling of such things as casings and auger flights will be practiced whenever practical.

- While operating in the controlled zone, personnel shall use the "buddy system" where appropriate, or be in visual contact with someone outside of the controlled zone.

- The buddy system will be used where appropriate for manual lifting. Mechanical lifting devices are to be used in lieu of manual lifting even with the buddy system for excessively heavy items.

- Radiological Control procedures will be followed for all work involving radioactive materials or conducted within a radiologically controlled area.

- Onsite work operations shall be carried out only during daylight hours, unless the entire control zone is adequately illuminated with artificial lighting. A new tour (shift) will operate the drilling rig after completion of each shift.

- Do not handle soil, waste samples, or any other potentially contaminated items unless wearing the protective equipment specified in the SS HASP, AHA, or RWP.

- Whenever possible, stand upwind of excavations, boreholes, well casings, drilling spoils, and the like, as indicated by an onsite windsock.

- Stand clear of trenches during excavation. Always approach an excavation from upwind.

- Be alert to potentially changing exposure conditions as evidenced by such indications as perceptible odors, unusual appearance of excavated soils, or oily sheen on water.

- Do not enter any test pit or trench deeper than 1.2 m (4 ft) unless in accordance with procedures specified in the SS HASP.

- Do not <u>under any circumstances</u> enter or ride in or on any backhoe bucket, materials hoist, or any other similar device not specifically designed for carrying passengers.

- All drilling team members must make a conscientious effort to remain aware of their own and others' positions in regards to rotating equipment, cat heads, or u-joints. Drilling operations members must be extremely careful when assembling, lifting, and carrying flights or pipe to avoid pinch-point injuries and collisions.

- Tools and equipment will be kept off the ground whenever possible to avoid tripping hazards and the spread of contamination.

- Personnel not involved in operation of the drill rig or monitoring activities shall remain a safe distance from the rig as indicated by the field team leader.

- Follow all provisions of each site-specific hazardous work permit as addressed in the SS HASP, including cutting and welding, confined space entry, and excavation.

- Catalytic converters on the underside of vehicles are sufficiently hot to ignite dry prairie grass. Team members should not drive over dry grass that is higher than the ground clearance of the vehicle and should be aware of the potential fire hazard posed by catalytic converters at all times. Never allow a running or hot vehicle to sit in a stationary location over dry grass or other combustible materials. Vehicles should be equipped with a fire extinguisher.

- Team members will attempt to minimize truck tire disturbance of all stabilized sites.

B2.1.2 Personal Protective Equipment

- Personal protective equipment will be selected specifically for the hazards identified in the SS HASP. The site safety officer in conjunction with BHI Radiological Control and Quality, Safety, and Health organization will choose the appropriate type and level of protection required for different activities at the job site.

- Levels of protection shall be appropriate to the hazard to avoid either excessive exposure or additional hazards imposed by excessive levels of protection. The SS HASP will contain provisions for adjusting the level of protection as necessary. These personal protective equipment specifications must be followed at all times, as directed by the field team leader, RCT, and site safety officer.

- Each employee must have a hard hat, safety glasses, and substantial protective footwear available to wear as specified in the SS HASP or AHA.

- The exclusion zone around noisy drilling or other noisy operations will be posted "Hearing Protection Required" and team members will have had noise control training.

- Personnel should maintain a high level of awareness of the limitations in mobility, dexterity, and visual impairment inherent in the use of level B and level C personal protective equipment.

- Personnel should be alert to the symptoms of fatigue, heat stress, and cold stress and their effects on the normal caution and judgment of personnel.

- Rescue equipment as required by Occupational Safety and Health Administration (OSHA), Washington Industrial Safety and Health Act, or standards for working over water will be available and used when applicable.

B2.1.3 Personal Decontamination

- The SS HASP will describe in detail methods of personnel decontamination, including the use of contamination control corridors and step-off pads when appropriate.

- Thoroughly wash hands and face before eating or putting anything in the mouth to avoid hand-to-mouth contamination.

- At the end of each workday or each job, disposable clothing shall be removed and placed in (chemical contamination) drums, plastic-lined boxes, or other containers as appropriate. Clothing that can be cleaned may be sent to the Hanford Site laundry.

- Individuals are expected to thoroughly shower before leaving the work site or Hanford Site if directed to do so by the RCT, site safety officer, or field team leader.

B2.1.4 Emergency Preparation

- A certified first aid provider and equipment shall be at all construction sites and work locations where emergency medical service is longer than 3 minutes away.

- A multipurpose dry chemical fire extinguisher, a fire shovel, a complete field first-aid kit, and a portable pressurized spray wash unit shall be available at every site where there is potential for personnel contamination.

- Prearranged hand signals or other means of emergency communication will be established when respiratory protection equipment is to be worn, because this equipment seriously impairs speech.

- The Hanford Fire Department shall be initially notified before the start of the site investigation project. This notification shall include the location and nature of the various types of field work activities as described in the work plan and potential hazardous and radioactive materials that may be present and handled. A site location map shall be included in this notification.

B2.1.5 Confined Space/Test Pit Entry

- The field investigation activities in the 200 waste group project, as a rule, should not require confined space entry. However, the hazards associated with confined spaces are of such severity that all employees should be aware of safe work practices related to such conditions. Requirements for confined space entry will be included in the job-specific AHA or SS HASP where confined space entry is required.

- Before entering any confined space, <u>including any test pit</u>, the atmosphere will be tested for flammable gases, oxygen deficiency, and organic vapors. If other specific contamination, such as radioactive materials or other gases and vapors, may be present, additional testing for those substances shall be conducted. Depending on the situation, the space may require ventilation and retesting before entry. All "permit required confined spaces" as defined by OSHA in 29 CFR 1910.146 require, at a minimum, continuous ventilation prior to and during entry. In every case, specific entry procedures shall be set forth in the SS HASP.

- No employee shall enter any test pit or trench deeper than 1.2 m (4 ft) unless the sides are shored or laid back to a stable slope as specified in OSHA 29 CFR 1926.652 or equivalent state occupational health and safety regulations. If an employee is required to enter a pit or trench 1.2 m (4 ft) deep or more, an adequate means of access and egress, such as a slope of at least 2:1 to the bottom of the pit or a secure ladder or steps shall be provided.

B3.0 POTENTIAL HAZARDS

While the information presented in Section 3.1 of the 200 Areas Implementation Plan is believed to be representative of the constituents and quantities of wastes at the time of discharge, the present chemical nature, location, extent, and ultimate fate of these wastes in and around the liquid disposal facilities are largely unknown. Onsite tasks will involve noninvasive surface sampling procedures and invasive techniques. Hanford Site waste sites have the potential to contain hazardous chemical substances, toxic metals, and radioactive materials.

Nonintrusive investigative techniques, such as surface radiological surveillance, surface sampling, geophysical surveys, and mapping activities have a potential concern of fugitive dust and radiological contamination. Invasive investigative techniques could encounter hazardous substances that may include radionuclides, heavy metals, and corrosives. In addition, volatile organics may also be associated with certain facilities such as solvent storage buildings or underground storage tanks and piping.

Potential hazards include the following:

- External radiation (beta-gamma) from radioactive materials in the soil
- Internal radiation resulting from ingestion, inhalation, or absorption through open cuts and scratches
- Inhalation of toxic vapors or gases such as volatile organics or ammonia
- Inhalation or ingestion of particulate (dust) contaminated with inorganic or organic chemicals, and toxic metals
- Dermal exposure to soil or groundwater contaminated with radionuclides
- Dermal exposure to soil or groundwater contaminated with inorganic or organic chemicals, and toxic metals
- Physical hazards such as noise, heat stress, and cold stress
- Slips, trips, falls, pinch points, overhead hazards, crushing injuries, and other hazards typical of a construction-related job site
- Penetrating unknown or unexpected underground utilities
- Biological hazards; snakes, spiders, etc.

The general safe work practices previously described were designed to reduce as many hazardous situations as possible.

B4.0 SITE CONTROL

The field team leader, site safety officer, and RCT are responsible for coordinating access control and security at the work site. Special control measures may be necessary to restrict public access. If the controlled zone is also a radiological area, all members of the team must also heed the criteria of the RWP.

Controlled areas will be clearly marked with rope and/or appropriate signs. Controlled zone boundary size and shape may increase or decrease based on field monitoring results, climatic changes, or revisions in operational technique. The site command post and staging area will be established upwind of the control zone, as determined by an onsite windsock. Vehicle access and accessibility to utilities and sampling locations may also be a consideration in the location of the command post.

B5.0 REFERENCES

29 CFR 1910, "Occupational Safety and Health Standards," *Code of Federal Regulations*, as amended.

29 CFR 1926, "Safety and Health Regulations for Construction," *Code of Federal Regulations*, as amended.

ACGIH, *Threshold Limit Values and Biological Exposure Indices*, American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio.

BHI-SH-01, *ERC Environmental Safety and Health Program*, Bechtel Hanford, Inc., Richland, Washington.

BHI-SH-02, *Safety and Health Procedures*, Volumes 1-4, Bechtel Hanford, Inc., Richland, Washington.

BHI-SH-04, *Radiological Control Work Instructions*, Bechtel Hanford, Inc., Richland, Washington.

HSRCM-1, *Hanford Site Radiological Control Manual*, HSRCM-1, Revision 2, Richland, Washington.

NIOSH, 1994, *Pocket Guide to Chemical Hazards, National Institute for Occupational Safety and Health*, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, Washington, D.C.

APPENDIX C

INFORMATION MANAGEMENT OVERVIEW

DEFINITIONS OF TERMS

Action Plan. Action plan for implementation of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1994). The Action Plan defines the methods and processes by which hazardous waste permits will be obtained, and by which closure and post-closure actions under *the Resource Conservation and Recovery Act of 1976* (RCRA) and by which remedial actions under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) will be conducted on the Hanford Site.

Administrative Record. The administrative record is the body of documents and information that is considered or relied upon in arriving at a final decision for a remedial action, removal action, corrective measure, interim measure, RCRA permit, or approved RCRA closure plan.

Data Management. The planning and control of activities affecting information (including data, records, documents, etc.).

Data Validation. The process whereby data are reviewed based on a set of criteria. This aspect of quality assurance involves establishing specified criteria for data validation. The quality assurance project plan (QAPjP) must indicate the specified criteria that will be used for data validation.

Document and Information Services. The central facility and services that provide a files management system for processing information.

Hanford Environmental Information System. A computer-based information system used as a resource for the storage, statistical analysis, and display of investigative data collected for use in site characterization and remediation activities. Subject areas include geophysics/soil gas, vadose zone soil (geologic), groundwater, atmospherics, and biota.

Lead Agency. The regulatory agency (U.S. Environmental Protection Agency [EPA] or Washington State Department of Ecology [Ecology]) that is assigned the primary administrative and technical responsibility with respect to actions at a particular operable unit.

Operable Unit. An operable unit at the Hanford Site is a group of land disposal and groundwater sites placed together for the purposes of site cleanup and remediation. The primary criteria for placement of a site into an operable unit are geographic proximity, similarity of waste characteristics and site types, and the possibility for economies of scale.

Primary Document. A document that contains information, documentation, data, and proposals upon which key decisions will be made with respect to the remedial action or permitting process. Primary documents are subject to dispute resolution and are part of the administrative record.

Project Manager. The individual responsible for implementing the terms and conditions of the Action Plan on behalf of his/her respective party. The U.S. Department of Energy (DOE), EPA, and Ecology will each designate one project manager.

Record of Decision. The CERCLA document used to select the method of remedial action to be implemented at a site after the feasibility study/proposed plan process has been completed.

<u>Secondary Document.</u> As distinguished from a Primary Document, a secondary document is considered to be a supporting document providing information or data and does not, in itself, reflect key decisions. A secondary document is subject to review by the regulatory agencies and is part of the administrative record. It is not subject to dispute resolution.

C1.0 INTRODUCTION AND OBJECTIVES

C1.1 INTRODUCTION

An extensive amount of data will be generated over the next several years in connection with the activities planned for the 200 Areas. Data quality is extremely important to the remediation of the operable unit as agreed on by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology (Ecology), and interested parties.

This Information Management Overview (IMO) provides an overview of the data management activities at the operable unit level and identifies procedures and plans that control the collection and handling of these data. The IMO provides information for the project manager, unit managers, task lead, remedial investigation/feasibility study coordinators, and other involved personnel and reviewers in order to fulfill their respective roles. All data collected will be in accordance with the Bechtel Hanford, Inc. (BHI) Environmental Investigations Procedures (EIP) contained in the BHI *Environmental Investigations Procedures* manual (BHI-EE-01).

Data Management Plans for Hanford Site Business Functions (DOE-RL 1995) and *ERC Project Procedures* (BHI-MA-02) are plans and procedures for the management of environmental data and documents generated for the Environmental Restoration Contractor (ERC) program. The purpose of these documents is to identify and fulfill the document and data control requirements of the U.S. Department of Energy, Richland Operations Office, the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement [Ecology et al. 1994]), BHI, and the DOE Environmental Restoration (ER) Program.

C1.2 OBJECTIVES

This IMO describes the process for the collection and control procedures for data, records, documents, correspondence, and other information associated with this operable unit. This IMO addresses the following:

- Types of data to be collected
- Plans for managing data
- Organizations controlling data
- Databases used to store the data.

C2.0 TYPES OF DATA

C2.1 TYPES OF DATA

The general types of technical data that may be collected in the 200 Areas are listed in Table C-1. BHI-EE-01 provides the procedures for the collection and management of environmental and site characterizations. Documents controlling activities outlined in the group-specific work plans are also included in Table C-1.

All such data are submitted to BHI Document and Information Services (DIS) for retention and are transmitted to the Administrative Record (AR), if appropriate.

C2.2 DATA COLLECTION

Data collection activities are described in each of the group-specific work plans. Additional direction and detail will be provided in sampling and analysis plans. All data collection will be conducted in accordance with the Quality Assurance Project Plan (QAPjP). Section C2.1 listed the controlling procedures for data collection and handling before turnover to the organization responsible for data storage. All procedures for data collection shall be approved in compliance with BHI-EE-01.

C2.3 DATA STORAGE AND ACCESS

Data will be handled and stored according to procedures approved in compliance with the *ERC Quality Program* (BHI-QA-01). The BHI DIS is the central files management and process facility. Data entering the DIS will be indexed and stored. Data designated for placement into the AR will be copied and placed into the Hanford Site AR file, if appropriate. Retrieval of information may be accomplished through hard copy or electronic data.

Public access to applicable documents is through the Administrative Record Public Access Room located in the 2440 Stevens Center facility in Richland, Washington. This facility includes AR file documents (including identified guidance documents and technical literature).

Administrative record documents consist of the documents and information considered or relied upon in order to arrive at a final decision for site cleanup. Requirements governing the AR for CERCLA actions are specified in Section 113(k) of CERCLA. Tri-Party Agreement unit managers determine what additional documents, including sampling and analysis results, sample validation, technical studies, inspection and other studies that may be appropriate for inclusion as part of the AR. The Tri-Party Agreement defines a number of these documents as primary and secondary documents. Definition as primary or secondary determines administrative requirements applicable to the document.

Unit managers may access data that are not in the AR by requesting it at the monthly unit managers' meeting for the waste site group of concern or by contacting the group specific task lead. As the project moves towards the Record of Decision, all of the relevant data will be contained in the AR and the need to access data by requesting it at the unit managers' meetings will be minimal.

In addition to the AR, the following types of data will be accessed from and reside in locations other than the BHI DIS:

- Quality assurance/quality control laboratory data
- Sample status
- Training records
- Meteorological data
- Radiological exposure.

C2.4 DATA QUANTITY

Data quantities for the investigative activities will be estimated based on the sampling and analysis plans developed for investigation of representative sites within each waste site group. Section 6.2 of the 200 Areas Implementation Plan describes the general field investigation activities that will take place.

C3.0 DATA MANAGEMENT

C3.1 OBJECTIVE

A considerable amount of data will be generated through the implementation of the group-specific sampling and analysis plans. This section identifies responsible organizations, databases available, and BHI DIS programs (including documents and records) used to manage data in support of characterization and remediation activities in the 200 Areas. The QAPjP will provide the specific procedural direction and control for obtaining and analyzing samples in conformance with requirements to ensure quality data results. For sampling activities, the work plan and sampling and analysis plans will provide the basis for selecting the location, depth, and frequency of collection of media to be sampled and methods to be employed to obtain samples of selected media for cataloging, shipment, and analysis. Figure C-1 displays the general sample and data management process for data generated through work plan activities.

C3.2 ORGANIZATIONS CONTROLLING DATA

This section addresses the organizations that are involved in the management of data generated from group-specific work plan activities.

C3.2.1 200 Areas Project Team

The 200 Areas Project Team provides the group-specific task lead. The task lead is responsible for interfacing with personnel who maintain and transmit data to DIS. The 200 Areas Project Team is responsible for transmitting the laboratory analytical data to Ecology and EPA per Section 9.6 of the Tri-Party Agreement.

C3.2.2 Tri-Party Agreement Unit Managers

Tri-Party Agreement Unit Managers are responsible for identifying administrative record documents and requesting that copies of these documents are provided to BHI DIS for inclusion in the applicable AR.

C3.2.3 Sample and Data Management

The Sample and Data Management Process consists of 10 integrated steps as shown in Figure C-1. Steps 1 and 2 are planning steps. Steps 3 through 10 are production steps and are integrated electronically. The detailed plans, procedures, and systems used day-to-day by the Sample and Data Management Process users are found in BHI-EE-01 and BHI-EE-09.

Step 1 - Data Quality Objectives. The data quality objectives (DQO) process establishes the mechanism for collecting the right information with the right people. A streamlined approach can then be used for planning environmental data acquisition. By following the DQO process, a collective review of the project, available data, regulatory concerns, sampling and analytical approaches (ERC Analytical Toolbox), and technical issues can be performed. Once the process is completed, the agreements reached are documented in a DQO Summary Report. This report forms the basis for all project sampling documents.

Step 2 – Sampling Documents. Sampling Documents are designed to provide the performance details for the collection and analysis of appropriate quality and quantity of data. A graded approach is used to determine the types of Sampling Documents needed to implement sampling and analysis activities. The most formal Sampling Documents are Sampling and Analysis Plans, which implement the DQOs.

Step 3 – Sample Event Coordination. Sample Event Coordination takes the sampling and analytical information generated in Step 1 and Step 2 and coordinates the sampling event with the sampling organization and the analytical service provider. Projects initiate services by using the Request for Analytical Services Form. The information on the form is then used to generate an approved Sample Authorization Form (SAF). The SAF is electronically generated by the Sample Data Tracking System. The information loaded into the system is used by the samplers to initiate sample collection and by the projects to track and manage samples through the remaining process steps. Analytical service providers are selected with the aid of the ERC Analytical Toolbox.

Step 4- Sample Collection. Sample Collection is conducted after approval of the Sampling Document and SAF. All sampling activities are conducted to approved procedures and to an approved Quality Assurance Program Plan.

Step 5 – Sample Shipment. Offsite Sample Shipments are transported from the field to a central receiving and shipment facility. Samples for onsite analysis are transported directly from the field to the identified laboratory. The Project Hanford Management Contractor (PHMC) approves all hazardous or radioactive sample shipments.

Step 6 – Sample Analysis. Sample Analysis can be provided at the job site using onsite measurements. Analyses of this type are conducted in accordance with approved procedures and an approved Quality Assurance Program Plan. Analyses of this type generally have higher detection limits and are less accurate; however, turnaround time is within minutes or hours.

Sample Analysis may also be conducted at PHMC, Pacific Northwest National Laboratory (PNNL), or commercial laboratories. Turnaround times for these analyses can be as short as 24 hours, or more typically, several days. Analyses of this type generally have lower detection limits. These laboratories are audited annually by the ERC to ensure the projects that appropriate procedures and Quality Assurance Programs are in place to meet customer needs.

Appropriate Sample Analysis providers are selected during Sample Event Coordination to ensure services are ready to accept samples and turnaround analyses to customer requirements. The ERC Analytical Toolbox contains the approved list of analytical methods and providers currently used by the ERC.

Step 7 – Data Receipt. During the Data Receipt step, the analytical results (hard copy and/or electronic) are received from the onsite measurements or laboratory providers. Hard copies of the data are stored for up to 6 months for the convenience of project customers and to aid in resolving any questions regarding the analytical results.

Step 8 – Verification/Validation. Verification is done on selected data packages to ensure copy quality and completeness prior to transmittal to Document and Information Services. Verification is not a required process step and is normally conducted on selected data packages based on the following conditions:

1. Use of a new analytical resource that a performance history has not been established.

2. Observation during the Data Receipt process of poor quality and/or poor completeness performance trend with an established analytical provider.

Validation is the process where the data package provided by the analytical provider is subjected to a rigorous review to ensure the total data package is suitable for its intended purpose. Data that is subjected to validation is usually a subset of the total number of data packages used to make closure decisions. The Validation process is currently implemented through subcontracts. Validation requirements are identified in the Project's Sampling Document.

Step 9 – Data Management. Data Management furnishes electronic copies of environmental data reports to ERC customers using Project-Specific Databases or the Hanford Environmental Information System (HEIS). Reports are generated from the HEIS with the current analytical data for soils, biota, and groundwater. Project-Specific Databases may be developed to assist ERC Projects with DQOs, site close-out, and customized data reports.

In addition to analytical reports, Data Management also provides the Hanford Site with geographic and waste information summaries and maps. The Waste Information Data System (WIDS) is the official summary of the history and status of the Hanford waste sites. The Hanford Geographic Information System (HGIS) contains detailed, accurate maps of the site.

Step 10 – Data Quality Assessment. Data Quality Assessment is used to determine whether the type, quantity, and quality of data needed to support decisions has been achieved. This step presumes that the appropriate DQO has been established and planning for sampling (Sampling Documents) has been achieved using a scientifically based information collection strategy. Data Quality Assessment steps include:

1. Review of the DQO.
2. Conduct preliminary data review.
3. Select statistical test.
4. Verify the assumptions.
5. Draw conclusions from the data.

This approach is not intended to be a definitive analysis of a project or problem, but provide an initial assessment of the "reasonableness" of the data that have been generated. Detailed guidance on conducting Data Quality Assessment is found in the *Guidance for Data Quality Assessment, Practical Methods for Data Analysis* (EPA 1996).

C3.2.4 BHI Document and Information Services

BHI DIS provides consistent processing and retrieval of Environmental Restoration Program information (data, documents, and records) utilizing management systems for document control and records management. DIS will utilize the AR information repository system to meet Tri-Party Agreement records requirements and information access. It is the responsibility of all ERC personnel to submit documents/records to DIS for appropriate processing per applicable procedures.

C3.2.5 Hanford Environmental Health Foundation

The Hanford Environmental Health Foundation (HEHF) performs the analyses on the nonradiological health and exposure data (Section C3.3.2) and forwards summary reports to the Fire and Protection group and the Safety and Health group within BHI. Nonradiological and health exposure data are maintained also for other Hanford Site contractors (PNNL and ICF Kaiser Engineers Hanford [ICF KH]) associated with other waste group-specific activities. The HEHF provides summary data to the appropriate site contractor.

C3.2.6 BHI Quality, Safety, and Health Organization

The BHI Quality, Safety, and Health (QS&H) organization maintains personal protective equipment fitting records and maintains nonradiological health field exposure and exposure summary reports provided by HEHF for BHI and subcontractor personnel. They are also responsible for QA interface with analytical resources on quality issues and for monitoring ERC data management activities to ensure compliance with designated requirements.

C3.2.7 ERC Functional Organizations

Training records and scheduling of BHI employees for recertifications are currently maintained by secretarial staff in the organization to which the employee is functionally assigned. More information on training records in provided in Section C3.3.4.

C3.2.8 Pacific Northwest National Laboratory

The PNNL operates the Hanford Meteorological Station (HMS) and collects and maintains meteorological data (Section C3.3.1). Data management is discussed in Andrews (1988).

PNNL collects and maintains radiation exposure data (Section C3.3.3).

C3.3 DATABASES

This section addresses databases that will receive data generated from the group-specific work plan activities. All of these databases exist independently of the 200 Areas activities and serve other site functions. Additional databases that are also available are identified in DOE-RL (1995).

C3.3.1 Meteorological Data

The HMS collects and maintains meteorological data. The HMS database contains meteorological data from 1943 to the present, and the document Andrews (1988) contains meteorological data management information.

C3.3.2 Nonradiological Exposure and Medical Records

The HEHF collects and maintains data for all nonradiological exposure records and medical records.

C3.3.3 Radiological Exposure Records

PNNL collects and maintains data on occupational radiation exposure.

C3.3.4 Training Records

Training records for BHI and subcontractor personnel are managed in accordance with Section 8.0, "Environmental, Safety, and Health Training" of *Hanford ERC Environmental, Safety, and Health Program* (BHI-SH-01). Training records for non-BHI personnel are entered into the BHI database to document compliance with BHI-SH-01.

Training records in the database include the following:

- Initial 40-hour hazardous waste worker training
- Annual 8-hour hazardous waste worker training update
- Hazardous waste generator training
- Hazardous waste site specific training
- Radiation safety training
- Cardiopulmonary resuscitation
- Scott air pack
- Fire extinguisher
- Noise control
- Mask fit.

C3.3.5 Environmental Restoration Document and Records Tracking System

DIS will develop, establish, and maintain a database in support of the ER Program. The database will provide an index of key information on all data submitted to DIS. This database will be used to assist in data retrieval and to produce index lists as required. The ER database will be managed by BHI personnel.

C3.3.6 Sample and Data Tracking

Sample Management is responsible for operation of a tracking database that integrates the sample and data management process. Information relating to process activities from event coordination through sample collection and analysis, receipt of data deliverables, verification and validation, data transmittal to DIS, and sample return/disposal is entered and stored in the database. The database system is a tool that can be used to provide status reports and monitor performance.

C3.3.7 Hanford Environmental Information System

The HEIS is the primary Tri-Party Agreement resource for computerized storage, retrieval, and analysis of quality-assured technical data associated with ER programs for cleanup activities being undertaken at the Hanford Site. The HEIS provides interactive access to data sets extracted from other databases relevant to implementation of the Tri-Party Agreement (Ecology et al. 1994). HEIS ensures that data consistency, quality, traceability, and security are achieved through incorporation of all environmental data within a single controlled database.

The following is a list of data subjects available in HEIS:

- Soils (sample)
- Geologic (particle)
- Atmospheric
- Biota
- Groundwater
- Surface water

- Waste site information
- Miscellaneous materials
- Field QC
- Wells.

The HEIS data is currently available to Hanford Site users via the Hanford Local Area Network (HLAN) or Bechtel Local Area Network.

C3.3.8 Hanford Geographic Information System

The HGIS can display detailed maps for the Hanford restoration sites including data from HEIS and the WIDS database. Such spatially related data can be used to support analysis of waste site technical issues and restoration options. The combination of the WIDS for summary waste site information, the HEIS for sample analytical data, and the HGIS spatial displays offers some powerful tools for many users to analyze and collectively evaluate the environmental data from the ER and sitewide monitoring programs.

C3.3.9 Waste Information Data System

Pursuant to the Tri-Party Agreement, the WIDS is the official Hanford source for the validated summary information and status of suspect waste site investigation/classification, remediation, and closure activities. The WIDS is accessible to Hanford Site users via the Hanford Local Area Network or the Bechtel Local Area Network.

C4.0 REFERENCES

Andrews, G. L., 1988, *The Hanford Meteorological Data Collection System and Data Base*, PNL-6509, Pacific Northwest Laboratory, Richland, Washington.

BHI-EE-01, *Environmental Investigations Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-09, Environmental Data Management Procedures, Bechtel Hanford, Inc., Richland, Washington.

BHI-MA-02, *ERC Project Procedures*, Bechtel Hanford, Inc., Richland, Washington.

BHI-QA-01, *ERC Quality Program*, Bechtel Hanford, Inc., Richland, Washington.

BHI-SH-01, *Hanford ERC Environmental, Safety, and Health Program*, Bechtel Hanford, Inc., Richland, Washington.

BHI-SH-02, *Safety and Health Procedures*, Volumes 1-4, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1995, *Data Management Plans for Hanford Site Business Functions*, DOE/RL-94-94, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, Fourth Amendment, 89-10, Washington Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA, 1996, *Guidance for Data Quality Assessment, Practical Methods for Data Analysis*, EPA QA/G-9, U.S. Environmental Protection Agency, Washington, D.C.

Figure C-1. Data and Sample Management Process.

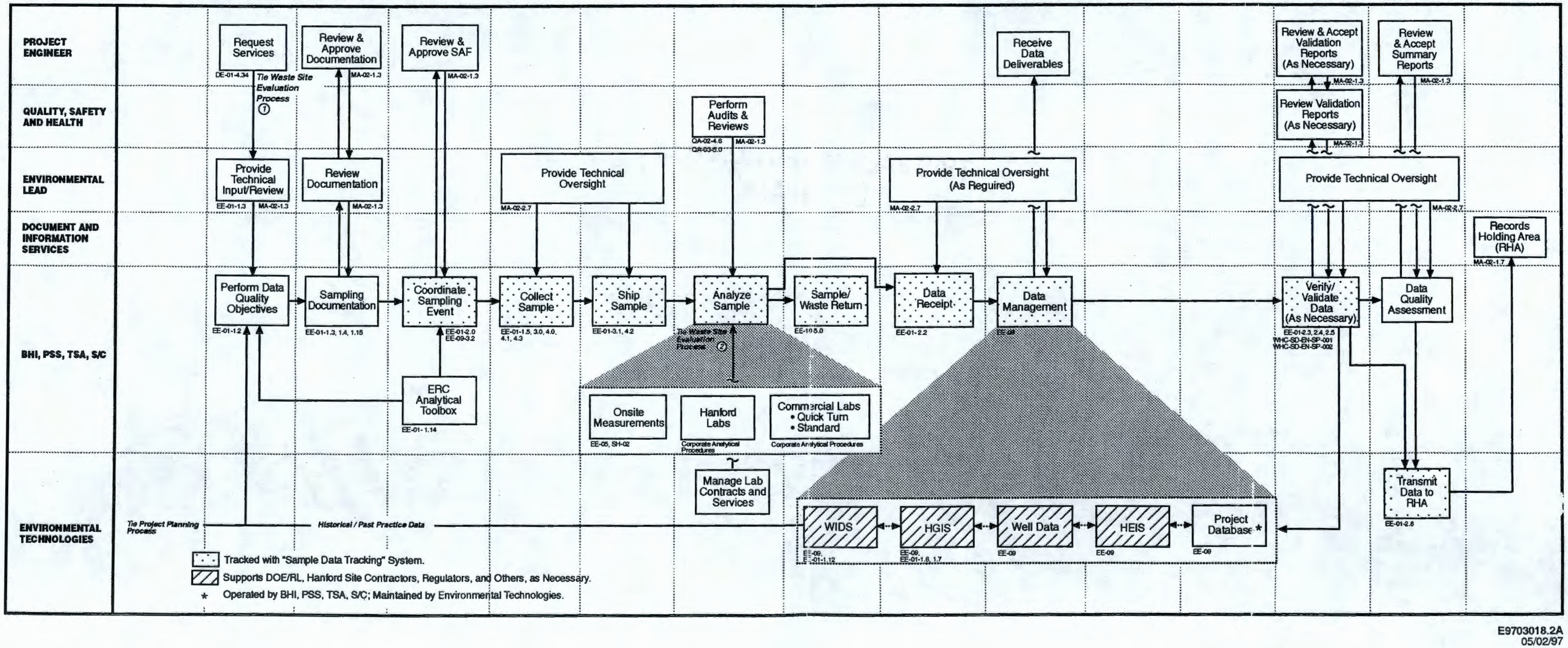

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Table C-1. Technical Data Types and Controlling Documents.

Work Plan Task – Type of Data	Controlling Document
Surface Radiological Surveys	BHI-SH-02[a]
Surface Geophysics Surveys	EIP 7.2[b]
Soil Sampling	EIP 2.0 - 2.7, 3.0, 4.0, 6.1, 6.2
Test Pit Excavation	EIP 5.2
Cone Penetrometer	EIP 5.0
Well Installation	EIP 6.0
Groundwater Sampling and Water Level Measurement	EIP 2.0 - 2.7, 4.1, 7.1
Air Monitoring	BHI-SH-02
Ecological Monitoring	EIP 2.0 - 2.7
Soil Removal and Confirmatory Sampling	EIP 2.0 - 2.7, 4.0

[a] *Safety and Health Procedures*, Vol. 2 (BHI-SH-02).
[b] *Environmental Investigations Procedures* (BHI-EE-01).

APPENDIX D

PRELIMINARY REMEDIAL ACTION TECHNOLOGIES

D1.0 INTRODUCTION

The purpose of conducting a feasibility study (FS) is to identify and evaluate alternatives for the remediation of waste sites under *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). Remediation alternatives are developed by assembling combinations of viable technologies or associated process options for specific media of concern. The initial process of identifying viable remedial action alternatives consists of the following steps:

1. Define remedial action objectives (RAOs) (preliminary RAOs have been developed in Section 5.0)
2. Identify general response actions (GRAs) to satisfy RAOs
3. Identify potential technologies and process options associated with each general response action (GRA)
4. Screen process options to select a representative process for each type of technology based on their effectiveness, implementability, and cost
5. Assemble viable technologies or process options retained in step 4 into alternatives representing a range of removal, treatment, and containment options plus no action.

After a range of suitable alternatives is developed, a detailed analysis is performed as the final step in the FS process. The detailed analysis phase consists of refining and analyzing in detail each alternative, generally on a waste site-specific basis. The results of the final FS are used to select a preferred alternative.

The overall objective of this appendix is to perform steps 1-5 to identify viable remedial action alternatives for contaminated soil and buried solid waste in the 200 Areas (i.e., source waste sites assigned to the Environmental Restoration Program). The alternatives identified will form the basis for subsequent detailed 200 Areas FS on a waste group-specific basis. Only a limited amount of source remedial investigation (RI) has been completed in the 200 Areas and, to a large extent, waste site-specific characterization data are limited. As a result, recommendations for remedial alternatives are general and cover a range of potential actions to reflect the broad range of potential contamination conditions in the 200 Areas. Alternatives are expected to require refinements or modifications based on site characterization data collected during the RI. These refinements will be made in the detailed (final) FS.

A secondary objective of this appendix is to identify additional technology-specific (rather than waste site-specific) information needed to complete the detailed analysis. This information can be satisfied by conducting treatability tests of selected technologies. The intent is to conduct treatability studies for promising technologies that may have broad application in the 200 Areas early in the RI/FS process. Conclusions regarding the feasibility of some individual technologies may change after new data become available.

D2.0 PRELIMINARY REMEDIAL ACTION OBJECTIVES

Preliminary RAOs identified in Section 5.0 are used to develop preliminary remedial action alternatives consistent with reducing the potential hazards of contamination and satisfying potential applicable or relevant and appropriate requirements (ARARs). The preliminary RAOs for the 200 Areas are as follows:

- Prevent or mitigate risk to human and ecological receptors associated with ingestion of, dermal contact with, inhalation of, and external exposure to contaminants at levels that exceed ARARs or a risk of 10^{-4} to 10^{-6}.
- Prevent or mitigate the migration of contaminants to groundwater such that no further groundwater degradation occurs.
- Prevent or mitigate the migration of contaminants to groundwater and through groundwater so that contaminants do not reach the Columbia River at levels that exceed ARARs or a risk of 10^{-4} to 10^{-6}.
- Prevent plants and animals from creating a migration pathway for the contaminants.
- Prevent or mitigate risk to workers performing remedial action.
- Provide conditions suitable for proposed future land use.
- Prevent destruction of significant cultural resources and sensitive wildlife habitat. Minimize the disruption of cultural resources and wildlife habitat in general, and prevent adverse impacts to cultural resources and threatened or endangered species.

The primary media of concern, which are the basis for this analysis, are radionuclide-contaminated and chemically contaminated soils and solid waste.

D3.0 PRELIMINARY GENERAL RESPONSE ACTIONS

GRAs represent broad classes of remedial measures that are intended to satisfy RAOs (Figure D-1). The following are the GRAs:

- No action
- Institutional control
- Containment
- Removal and disposal
- Ex situ treatment
- In situ treatment.

These general response actions are intended to cover the range of options from no action to complete remediation, and are briefly defined below:

No action is included for evaluations as required by the *National Environmental Policy Act* (NEPA) and National Contingency Plan (40 *Code of Federal Regulations* [CFR] 300.68 (f)(l)(v)) to provide a baseline for comparison with other response actions. The no action alternative may be appropriate for some sources of contamination if risks are acceptable to natural resources or humans and no exceedances of contaminant-specific ARARs occur.

Institutional controls involve the use of physical barriers (fences) and access restrictions (deed restrictions) to reduce or eliminate exposure to contamination. Institutional controls can also include groundwater, vadose, surface soil, biotic, and/or air monitoring. Many access and land-use restrictions are currently in place at the Hanford Site and will remain in place during implementation of remedial actions. Because the 200 Areas are already committed to waste management for the long term, institutional controls may be important as a final remedial alternative.

Containment includes physical measures to restrict accessibility to in-place waste or the migration of contaminants from in-place wastes. Containment technologies include the use of engineered surface barriers (caps) and vertical barriers as physical and hydraulic barriers to control the downward or lateral migration of contaminants, and biotic intrusion (including humans). Containment also serves as a barrier to direct radiological exposure and may also be useful in controlling gases. Barriers provide long-term stability with relatively low maintenance requirements. The U.S. Environmental Protection Agency (EPA) has identified containment as a presumptive remedy for CERCLA municipal landfills (EPA 1993a).

Removal and disposal involves the excavation of contaminated material for disposal typically in a landfill. Depending on the nature (e.g. radioactivity levels, hazardous waste classification) of the waste removed, ex situ treatment of the waste may be performed prior to disposal.

Treatment of contaminated material can be performed in situ or ex situ and involves the use of biological, thermal, physical, or chemical technologies. There are three primary treatment strategies including:

- Destruction or alteration of contaminants
- Extraction or separation of contaminants
- Immobilization of contaminants.

Contaminant destruction technologies are generally applicable only to organics. Metals and radionuclides cannot be destroyed or degraded, and as a result, active treatment is limited to separation or immobilization technologies.

Ex situ treatment involves the aboveground treatment of soil after it has been excavated. Typical treatment options include biological land farming, thermal processing, soil washing, and solidification/stabilization.

In situ treatment technologies is distinguishable from ex situ treatment in its ability to attain RAOs without removing the wastes. The final waste form generally remains in place. This feature is advantageous when exposure or worker safety during excavation would be significant or when excavation is technically impractical (e.g., deep contamination). Examples of in situ waste treatment process options include in situ vitrification, in situ stabilization, soil vapor extraction, and in situ biotreatment. Treatment technologies, in general, must often be pilot tested before they can be implemented.

Although **natural attenuation** is not an actual technology, it is addressed as an in situ treatment process for the purpose of this appendix. Natural attenuation encompasses natural subsurface processes or contaminant characteristics that can effectively reduce contaminant toxicity, mobility or volume. Natural attenuation processes include radioactive decay, biodegradation, biological stabilization, volatilization, dispersion, dilution, chemical or biological stabilization, transformation or destruction, and sorption.

The following section discusses the identification of technology types and process options associated with each GRA.

D4.0 IDENTIFICATION OF REMEDIAL TECHNOLOGIES

Several sources of information are available that identify, review, and provide general performance information on technologies applicable to various media. These sources were used to identify technologies that are technically implementable for soil and solid waste, in general, and for conditions that are representative of the 200 Areas, including the presence of a wide variety of contaminant types (organics, metals, radionuclides): coarse-grained, low organic soil; a deep vadose zone; and an arid climate. The primary sources of information used to identify potentially applicable technologies included the following:

- DOE Preferred Alternatives Matrices Remediation/Waste Processing (DOE 1997)
- Federal Remediation Technologies Roundtable, Remediation Technologies Screening Matrix and Reference Guide, Third Edition (AEC 1997)

Other sources of information used in this evaluation included the following:

- *Technological Approaches to Cleanup of Radiologically Contaminated Superfund Sites* (EPA 1988)
- 200 Areas Aggregate Area Management Studies
- Hanford-specific engineering studies and evaluations (e.g., DOE-RL 1996)
- EPA policy on the use of monitored natural attenuation (EPA 1997).

Technology types and process options that satisfied the GRAs are identified in Table D-1.

D5.0 TECHNOLOGY SCREENING

Potentially applicable technology types and process options identified in Section D4.0 can be screened using effectiveness, implementability, and relative cost as criteria to eliminate those process options that are least feasible and retain those process options that are considered most viable. These criteria are only applied to the technology and do not consider waste site-specific characteristics. Site-specific considerations will be made following the RI and during the detailed analysis in the final feasibility study. The remaining process options can then be grouped into remedial alternatives (Section D6.0).

The effectiveness criterion focuses on (1) the potential effectiveness of process options in handling the areas or volumes of media and meeting the RAOs (including associated ARARs), (2) the potential impacts to human health and the environment during the construction and implementation phase, and (3) how proven and reliable the process is with respect to contaminants. This criterion also concentrates on the ability of a process option to treat a contaminant type (organics, inorganics, metals, radionuclides, etc.) rather than a specific contaminant (nitrate, cyanide, chromium, plutonium, etc.).

The implementability criterion places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits for offsite actions; the availability of treatment, storage, and disposal services; and the availability of necessary equipment and skilled workers to implement the technology. The criterion also focuses on the process option's developmental status, whether it is an experimental or established technology.

The relative cost criterion is an estimate of the overall cost of a process, including capital and operating costs. The cost analysis is based on the Remediation Technologies Screening Matrix and Reference Guide, Third Edition (AEC 1997), and engineering judgment. Each process is evaluated as to whether costs are high, medium, or low relative to other process options.

A process option is rated effective if it can handle the amount of area or volume of media required, if it does not impact human health or the environment during the construction and implementation phases, and if it is a proven or reliable process with respect to the contaminants and conditions representative of the 200 Areas. Also a process option is considered more effective if it treats a wide range of contaminants rather than a specific contaminant. An example of an effective process option would be vitrification because it treats inorganics, metals, and radionuclides. However, chemical reduction may only treat chromium (VI), making it a less useful option.

An easily implemented process option is one that is an established technology; uses readily available equipment and skilled workers; uses treatment, storage, and disposal services that are readily available; and has few regulatory constraints. Preference is given to technologies that are easily implemented.

Preference is given to lower cost options, but cost is not an exclusionary criterion. A process option is not eliminated based on cost alone.

Results of the screening process are shown in Table D-2. Brief descriptions are given of the process options, followed by comments regarding the evaluation criteria. The last column of the table indicates whether the process option is rejected or carried forward for possible alternative formation. The following sections discuss the technologies retained after screening.

D5.1 NO ACTION

The National Contingency Plan (40 CFR 300) requires that a No Action Alternative be evaluated as a baseline for comparison with other alternatives. The No Action Alternative represents a situation where no restrictions, controls, or active remedial measures are applied to the site. No action implies a scenario of walking away from the site, taking no measures to monitor or control contamination. The No-Action Alternative requires that a site pose no unacceptable threat to human health and the environment. Current information indicates that some remedial action is required for most waste sites in the 200 Areas.

D5.2 INSTITUTIONAL CONTROLS

Institutional controls consist of physical and legal barriers to prevent access to contaminants, and monitoring of the groundwater and/or the vadose zone. Institutional controls are usually required when waste is left in place above cleanup levels.

Physical methods of controlling access to waste sites are access controls, which include signs, entry control, artificial or natural barriers, and active surveillance. Physical restrictions are effective in protecting human health by reducing the potential for contact with contaminated media and avoiding adverse environmental, worker safety, and community safety impacts that arise from the potential release of contaminants associated with other remedial technologies (e.g., removal). If used alone, however, physical restrictions are not effective in achieving containment, removal, or treatment of contaminants. They also require ongoing monitoring and maintenance.

Legal restrictions include both administrative and real property actions intended to reduce or prevent future human exposure to contaminants remaining on site by restricting the use of the land, including groundwater use. Land-use restrictions and controls on real property development are effective in providing a degree of human-health protection by minimizing the potential for contact with contaminated media. Restrictions can be imposed through land covenants, which would be enforceable through lawsuits by the United States, and, under Washington State law, the Washington State Department of Ecology. They also avoid adverse environmental, worker safety, and community safety issues that arise from the potential release of contaminants associated with other remedial technologies (e.g., removal). Land-use restrictions are somewhat more effective than access controls if control of a site transfers from the DOE to another party, because they use legal and administrative mechanisms that are already available to the community and the State.

The disadvantages of land-use restrictions are similar to those for access control: they do not contain, remove, or treat contaminants. Also, land-use restrictions are not self-enforcing. They can only be triggered by an effective system for monitoring land use to ensure compliance with the imposed restrictions.

D5.3 CONTAINMENT TECHNOLOGIES

Containment technologies are effective in isolating and preventing the horizontal or vertical spread of contamination by the use of physical measures. The EPA has recognized this by their adoption of containment as the presumptive remedy for CERCLA municipal landfill sites (EPA 1993a). The containment process options retained in this evaluation include surface barriers engineered for arid climates, and slurry wall or grouting process options as vertical barriers.

Surface barriers control the amount of water infiltrating into contaminated media and thus reduce or eliminate potential leaching of contamination to groundwater. Vertical barriers control the horizontal movement of subsurface contaminants. In addition to their hydraulic performance, barriers also function as physical barriers to limit direct human and animal interaction with the contamination, are engineered to limit wind and water erosion, can control the release of organic vapors and radon, and attenuate radiation.

Three **multi-layered surface barrier** designs have been specifically developed for various categories of 200 Area waste sites (Table D-4) and provide a range of protection levels (i.e., graded approach). The barrier designs are described in the *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas* (DOE-RL 1996) and include:

- Hanford Barrier
- Modified RCRA C Barrier
- Modified RCRA D Barrier.

Slurry walls are formed by vertically excavating a trench that is filled with a slurry, typically a mix of soil, bentonite and water, that forms a continuous low-permeability barrier. Slurry walls are often used to contain contaminated groundwater but have application in the vadose zone to limit the horizontal movement of moisture into contaminated materials or control gases.

Grout walls are formed by injecting grout, under pressure, directly into the soil matrix (permeation grouting) or in conjunction with drilling (jet grouting) at regularly spaced intervals to form a continuous low permeability wall. Through the use of directional drilling techniques, angled grout walls can be formed beneath a waste site. This type of vertical barrier is limited (more so than slurry walls) by difficulties in verifying barrier continuity, and materials used. New innovative materials actually can assist with limiting radionuclide mobility through chemical reactions.

Engineered barriers are well-developed and demonstrated technologies effective in containing waste for the duration of their designed functional life and are applicable to all types of contaminants, and both soil and solid media. Alternative surface barrier technologies that are less costly than barrier designs provided in earlier EPA guidance have now been approved by EPA. Surface barriers are most effective for conditions where contamination is relatively shallow (e.g., less than 15m [50 ft]). Surface barriers are generally not effective for deep contamination (e.g., more than 30m [100 ft]), although vertical barriers can be used as a supplemental element in the design to effectively improve containment performance in deeper zones. Surface and vertical barriers are easily implemented and are designed to blend with natural site conditions. However, land use will be impacted. Worker exposure concerns are generally minimal because the waste zone is not exposed as in excavation. Constructability and performance has been demonstrated onsite for the Hanford Barrier, which is the most complex of the three barrier designs.

D5.4 REMOVAL AND DISPOSAL TECHNOLOGIES

Removal and disposal options were retained for further evaluation including excavation of contaminated soils or buried solid waste debris with transportation and disposal to a landfill, either onsite or offsite. Excavation of materials is accomplished using standard earthmoving equipment, such as backhoes and front-end loaders. Selection of construction equipment is based on worker safety, production rates, and potential for additional release of contamination. The removal process starts with excavation of clean overburden, which is set aside for later use as backfill. The contaminated soils are excavated in lifts and surveyed for contamination. Contaminated soils are removed to a depth designated to achieve the remedial goals.

After removal, the soil and/or debris may require ex situ treatment to meet disposal requirements or reduce waste volumes. Materials may be roughly characterized (e.g., combustible, metallic, inorganic, and radioactive) and segregated for different treatment and disposal options.

Both onsite and offsite land disposal options are retained, depending on the volume of soil and the nature of the contaminants. Currently available disposal options for soils and solids include the following:

- Disposal of low-level radioactive waste at the low-level burial grounds located in the 200 Areas.
- Disposal of low-level radioactive waste and/or hazardous waste at the Environmental Restoration Disposal Facility (ERDF) located in the 200 Areas.
- Disposal of hazardous waste offsite at an existing RCRA-approved landfill.
- Disposal of transuranic (TRU) waste offsite in a geologic repository.

Soil that is designated as "mixed waste" with both low-level radionuclides and hazardous chemical contaminants would have to be disposed of at the ERDF. The Central Waste Complex can serve as a storage location for mixed waste that cannot be disposed to the ERDF.

Removal and disposal is effective because contaminated materials are physically removed, there are no long-term requirements for monitoring and maintenance of the site, and there is greater flexibility in future land use. This technology is easily implemented at sites with shallow contamination, as it is a standard construction practice, and methods are available to handle most expected construction-related problems. Requirements for safety, monitoring, and sampling are generally well understood. Radioactive waste will require special handing protocols and may require remotely controlled equipment if levels are high enough to preclude the use of standard construction equipment.

Removal technologies do not require that the extent of contamination be precisely known before excavation. Rather, characterization occurs as the excavation proceeds, and the extent of contamination is determined using the observational approach.

There are several drawbacks to the implementation of this GRA:

- Removal of contaminated material can be hazardous to workers since it requires handling, transporting, and treating or disposing of contaminated materials. Removal can result in a high degree of disturbance to existing natural and cultural resources.
- Control of fugitive dust and vapor emissions may be of particular concern at some sites.
- Extensive safety procedures and monitoring plans may be required to ensure the protection of the workers and the environment. Safety and environmental concerns must be balanced against the benefits of removal.
- Limited to sites with relatively shallow contamination.

Contaminated soil and solids removal with disposal at the ERDF has been the preferred alternative for waste sites in the 100 and 300 Areas, and has been demonstrated to be effective on the Hanford Site. Given the same type of contamination, the suitability of this alternative is enhanced for the 200 Areas because haul distances would be substantially reduced.

D5.5 EX SITU TREATMENT TECHNOLOGIES

Retained ex situ treatment processes include thermal desorption, vapor extraction, vitrification, soil washing, mechanical separation, and solidification/stabilization. Collectively, these processes address a range of contaminants including volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), inorganics, and metals.

Mechanical separation involves segregation of materials to allow for proper treatment and/or disposal. The primary separation technique for solid media is sieving to segregate material according to size, but other physical properties may also be used as a basis for segregation (e.g., local discoloration of soil). The general advantage of mechanical separation is the reduction of contaminant volume and segregation of waste for proper disposal or recycling. The main disadvantages of this technology are that increased waste handling carries the potential for increased worker risk and the production of fugitive dust. This process has been used as a component of removal and disposal actions on the Hanford Site. Experience in the 300 Area burial grounds has shown that certain problems with sieving solid debris may be encountered, specifically clogging of the sieving device.

Soil washing uses a wash solution (e.g., water) to remove soil contaminants by dissolving or suspending them in solution or by concentrating them through particle size separation, gravity separation, and attrition scrubbing. The washing agent and soil fines are residuals that require further treatment. This process is applicable to coarse-grained soils contaminated with a wide variety of metal, radionuclide, and organic contaminants, particularly those that tend to bind to the fine soil fraction. Soil washing has been pilot-scale tested for 100 and 300 Area soil and has been shown to be effective for select contaminants.

Thermal desorption has been identified as a presumptive remedy by EPA (1993b) for the removal of VOCs from soil. This technology uses heat to volatilize organic contaminants from soil. A carrier gas or vacuum is used to collect and transport the volatilized organics to a gas treatment system. Concentrated contaminants can be removed (e.g., by carbon adsorption) from the process stream or destroyed using a secondary combustion chamber or catalytic oxidizer. Residual liquids and spent activated carbon require further treatment. With low-temperature thermal desorption, the decontaminated soil retains its physical properties and ability to support biological growth.

Ex situ vapor extraction uses excavated soil to place over a network of aboveground perforated piping to which vacuum is applied to facilitate the movement of air through the soil and volatilize contaminants. The off-gas is then treated, commonly by activated carbon. Residual liquids and spent activated carbon require secondary treatment. An advantage of ex situ vapor extraction over in situ is that treatment is more uniform and better monitored. Soil vapor extraction is a conventional process for remediating soils contaminated with VOCs and has been identified by the EPA as a presumptive remedy (EPA 1993b).

Ex situ vitrification is applicable to a wide variety of contaminant types, but is mainly applied to metals, radionuclides and other inorganics. The process uses electricity to melt contaminated soil. As the molten material cools the contaminants are encapsulated in a vitrified mass that is high in strength and highly resistant to leaching. Because of the high temperature involved in the melting process, organic contaminants present in the soil are often destroyed. This process can be used as a standalone technology or as a secondary treatment process for concentrated solid residuals from other processes (e.g., contaminated soil fines from mechanical separation).

Solidification/stabilization uses admixtures of stabilizing agents to encapsulate and render inert various hazardous substances. This process is mainly targeted at metal, radionuclides, and other inorganics. Stabilizing agents include cement, asphalt, and polymeric materials. The EPA has identified polymer macroencapsulation as the Best Demonstrated Available Technology for radioactive lead solids and mixed waste debris. The advantage of this technology is that it can satisfy the treatment option for land disposal restricted LDR wastes; wastes treated in this manner could be landfilled.

Ex situ treatment generally requires that material be first excavated and transported to a treatment area. The use of excavation limits the application of ex situ treatment to sites with shallow contamination. Cleaned soil, particularly the coarser fraction, is often returned to the site of excavation. For mixed waste conditions such as those encountered in the 200 Areas, it is unlikely that a single process exists to treat all constituents and as a result several technologies may be required to form a treatment train.

Ex situ treatment can be effective in destroying organics and reducing the toxicity, mobility, and/or volume of contaminants, and requires no site monitoring or maintenance at the end of remediation because contaminants are removed or stabilized. Metals and radionuclides are not destroyed by ex situ treatment and require eventual disposal as residuals. Soil washing and mechanical separation concentrate radionuclides, which may change the classification of the waste and impact disposal requirements. The advantages of ex situ treatment are often shorter cleanup times than in situ treatment, and a more uniform, controlled and monitored process. A general disadvantage is the increased handling of waste beyond that of the excavation process and the potential increased health and safety risk to site workers through skin contact and air emissions.

Ex situ treatment is generally more effective for matrix materials with low amounts of natural organics that is typical of 200 Areas soils.

D5.6 IN SITU TREATMENT TECHNOLOGIES

Retained in situ treatment processes include vitrification, vapor extraction, grout injection, and soil mixing, dynamic compaction, and natural attenuation. Collectively, these processes address a range of contaminants including VOCs, SVOCs, inorganics, and metals.

In situ soil vapor extraction is a conventional process for remediating soils contaminated with VOCs and has been identified by the EPA as a presumptive remedy (EPA 1993b). This process involves inducing airflow through the soil matrix with an applied vacuum that facilitates the mass transfer of adsorbed, dissolved or free phases to the vapor phase. Vapors are pumped from the subsurface using vertical extraction wells or horizontal piping to the surface for treatment. In situ soil vapor extraction has been commonly used for VOC contamination at Superfund sites and has a history of effectively treating waste in place at a relatively low cost. This process has been successfully implemented in the 200 Areas for removal of carbon tetrachloride and chloroform from the vadose zone in combination with ex situ activated carbon treatment.

In situ vitrification applies an electrical current to melt contaminated soil and forms a stable vitrified mass when cooled that encapsulates contaminants. The process combines thermal treatment with stabilization. The melting process often destroys or removes organic contaminants present in the soil. Off-gases are collected using a vacuum hood and treated. Process depths are limited to less than 6 m (20 ft) in homogeneous soils and are generally applicable to smaller volumes of highly contaminated soil.

Grout injection for soil remediation is an adaptation of a well-developed construction technique of injecting grout into the soil matrix. The injection process encapsulates the material and produces a monolithic solid block that can be left in place or excavated for disposal elsewhere.

Deep soil mixing uses large augers (mixer) and injector head systems to inject and mix solidifying agents (cement- or pozzolanic-based) into contaminated soil in place. The process reduces the mobility of contaminants. The process can be used to inject microorganisms for in-situ bioremediation of sites.

Dynamic compaction is used to densify soil, compact buried solid waste, and/or reduce void spaces by dropping a heavy weight onto the ground surface. Dust control is required, and worker exposure can be a concern because the compaction process can expel contaminated particulates to the surface. The compaction process can reduce the hydraulic conductivity of subsurface soils and correspondingly the mobility of contaminants. Because the compactive energy attenuates with depth, dynamic compaction is limited to shallow applications.

Natural attenuation relies on natural processes to lower contaminant concentrations through physical, chemical, and/or biological processes until cleanup levels are met, including the following:

- Biodegradation, which is effective for most organic compounds given proper conditions
- Sorption, which can immobilize most kind of contaminants

- Oxidation reduction reactions, which can transform contaminants into less mobile or less toxic forms
- Radioactive decay, which significantly reduces the activity of radionuclides with short half-lives (i.e., on the order of several to tens of years).

Radioactive decay is the only process to eliminate nuclear particle emissions, as no available treatment process exists to eliminate radioactivity. Radioactive decay does not affect the mobility of radioelements and as a potential remediation process is considered to be mainly applicable to radioelements with short half-lives and lower mobilities in soil. Examples of 200 Area waste sites where natural attenuation processes are acting to reduce or immobilize contaminants include (1) the Solid Waste Landfill where VOCs found in groundwater have been diminishing with time; (2) the 216-B-5 Reverse Well where plutonium, cesium, and strontium are either strongly sorbed to aquifer soils or are sufficiently immobile such that they are expected to decay to negligible levels before they migrate from the 200 Areas; and (3) The Z-Plant area where "barometric pumping" has been found to be effective in removing carbon tetrachloride vapors from subsurface soils. As discussed in Section 3.0, most of the short-lived isotopes associated with 200 Area processes and disposed of to the ground have decayed to stable isotopes.

EPA (1997) acknowledges that natural attenuation can be an appropriate remedial option for contaminated soil. Because of uncertainties in the science of natural attenuation processes, EPA considers source control and performance monitoring fundamental components of the option. From a technical standpoint, monitored natural attenuation is readily implemented because it requires little or no significant action (e.g., construction activity).

In situ treatment has a significant advantage because waste is treated in place without the need for excavation and transportation, which can have a significant cost savings and minimize worker exposure. In addition, in situ techniques are often the only effective treatment technology type for sites with deep contamination. Disadvantages include generally longer cleanup times, and the process can be difficult to control and to verify its effectiveness. Thermal treatment provides faster cleanup times, but are capital and operations and maintenance (O & M) intensive and can be costly. Generally, technology availability for in situ treatment of inorganics and radionuclides is limited, not well developed, and/or not cost effective, and in many cases natural attenuation and/or removal are the only viable options. Vitrification, grout injection and soil mixing processes are generally not applicable for solid/debris matrices (i.e., landfill waste). For vadose zone with organic contamination, particularly VOCs, effective in situ technologies are available. In situ treatment is generally more effective for matrix materials with low amounts of natural organics (i.e., 200 Areas soils).

D6.0 PRELIMINARY REMEDIAL ACTION ALTERNATIVES

Several remedial alternatives are considered applicable to disposal sites that contain hazardous chemicals, metals, radionuclides, VOCs and/or SVOCs based on the process options retained in Section D5.0. These remedial alternatives are developed and described generically for application in the 200 Areas. The intent is to provide a range of the alternatives that can address the range of contamination conditions expected in the vadose zone 200 Areas. Alternatives that are relevant to a particular waste group will form the basis for the group's final (i.e., detailed) FS. The detailed evaluation of the alternatives will be performed once site-specific conditions are understood and reported in the final FS to be completed on a waste group-specific basis.

D6.1 DEVELOPMENT OF REMEDIAL ALTERNATIVES

Potentially feasible remedial technologies were described and evaluated in Section D5.0. Some of those technologies have been proven to be effective and implementable at industrial waste sites and the Hanford Site, while other technologies are less proven or developed. The EPA guidance (EPA 1989a) on FSs for

uncontrolled waste management units recommends that a limited number of candidate technologies be grouped into "Remedial Alternatives."

D6.1.1 General Response Actions

For this study, technologies were combined to provide at least one alternative for each of the following general strategies (i.e., general response actions):

- No action
- Institutional controls
- Containment
- Removal and disposal combined with ex situ treatment, as needed
- In situ treatment.

Figure D-1 shows the relationship of GRAs, technologies, and alternative development.

The alternatives are intended to treat a major component of the 200 Area waste. Alternatives were developed based on treating classes of compounds (radionuclides, heavy metals, inorganics, and organics) rather than specific contaminants. At a minimum, the alternative must be a complete package. For example, disposal of radionuclide-contaminated soil must be combined with excavation and backfilling of the excavated site. One important factor in the development of the preliminary remedial action alternatives is that radionuclides, heavy metals, and some inorganic compounds cannot be destroyed. Rather, these compounds must be physically immobilized, contained, isolated, or chemically converted to less mobile or less toxic forms to satisfy RAOs. Organic compounds can be destroyed, but may represent a smaller portion of the overall soil contamination in the 200 Areas.

No action and institutional control options are required to be considered as part of the CERCLA RI/FS guidance. The purpose of including both of these alternatives is to provide decision makers with information on the entire range of available remedial actions.

For the containment strategy, engineered surface barriers, with or without vertical barriers (depending on the specifics of the remediation) were selected. Two alternatives were selected to represent the removal and disposal strategy. One of these deals with disposal of TRU contaminated soils. Three in situ alternatives were identified; one deals with vapor extraction for VOCs, one with stabilization of soils and the other with vitrification of soils. Finally, monitored natural attenuation is identified as an alternative.

This process does not result in an exhaustive list of all applicable alternatives for each GRA, but does provide a reasonable range of remedial actions that are likely to be evaluated in future detailed feasibility studies.

D6.1.2 Remedial Action Alternatives

The remedial action alternatives are summarized as follows:

- No action.
- Institutional controls.
- Engineered surface barriers with or without vertical barriers. Three conceptual surface barrier designs from DOE-RL (1996) provide a range of protective levels. Feasible vertical barriers include slurry walls and grout curtains. Dynamic compaction is also provided as a foundation improvement technique for surface barriers when needed.
- Excavation and disposal with or without ex situ treatment. Feasible technologies for organic compounds include thermal processing, vapor extraction, and stabilization. Feasible technologies for radionuclides include soil washing, mechanical separation, vitrification, and stabilization. Options for both onsite and offsite disposal are provided.
- Excavation, ex situ treatment, and geologic disposal of soil with TRU radionuclides.
- In situ grouting or stabilization of soil.
- In situ vitrification of soil.
- In situ soil vapor extraction of VOCs.
- Monitored natural attenuation.

These alternatives, except for no action and institutional controls, were developed to satisfy a number of RAOs simultaneously and use technologies that are appropriate for a wide range of contaminant types. For example, constructing an engineered multimedia cover may effectively contain radionuclides, heavy metals, inorganic compounds, and organic compounds simultaneously. It satisfies the RAO of protecting human health and the environment from direct exposures from contaminated soil, biomobilization, and airborne contaminants. In situ soil vapor extraction is more contaminant-specific than the other alternatives, but it addresses a contaminant class (VOCs) that is not readily treated using the other options, such as in situ stabilization. It is possible that some waste sites may require a combination of the identified alternatives to completely address all contaminants.

In all alternatives except the no-action alternative, it is assumed that monitoring and institutional controls may be required, although they may be temporary. These features are not explicitly mentioned, and details are purposely omitted until a more detailed evaluation may be performed in subsequent studies. Also, treatability studies may accompany many of the alternatives during implementation.

In the following sections, the preliminary remedial action alternatives are described in more detail, with the exception of the no-action and institutional control options.

D6.2 ALTERNATIVE 1 - ENGINEERED SURFACE BARRIERS WITH OR WITHOUT VERTICAL BARRIERS

Alternative 1 consists of engineered surface barriers based on three conceptual designs developed in DOE-RL (1996) for various categories of waste types (Table D-3). Vertical barriers such as grout curtains or slurry walls may be used in conjunction with the cover should additional horizontal containment measures be required. The surface barrier designs presented in DOE-RL (1996) are as follows:

Hanford Barrier. This barrier is for sites with Greater-Than-Class C (GTCC) low-level waste (LLW) and/or GTCC mixed waste, and/or significant inventories of TRU constituents. This barrier is designed to remain functional for a performance period of 1,000 years and to provide the maximum practicable degree of containment and hydrologic protection of the three designs. The Hanford Barrier is composed of nine layers of durable material with a combined thickness of 4.5 m (14.7 ft). The barrier layers are designed to maximize moisture retention and evapotranspiration capabilities, and to minimize moisture infiltration and biointrusion, considering long-term variations in Hanford Site climate.

The primary structural differences between the Hanford Barrier and other barriers discussed in this report are the increased thickness of individual layers and the inclusion of a coarse-fractured basalt layer to control biointrusion and to limit inadvertent human intrusion. A full-scale treatability test of the Hanford Barrier has been performed in the 200 Areas. Testing has demonstrated that the barrier performs effectively under ambient and extreme climatic conditions (three times the normal rainfall and 1000-year storms).

Modified RCRA Subtitle C Barrier. This barrier is for sites containing dangerous waste, Category 3 LLW and/or Category 3 mixed LLW, and Category 1 mixed LLW. This barrier is designed to provide long-term containment and hydrologic protection for a performance period of 500 years. The performance period is based on radionuclide concentration and activity limits for Category 3 LLW. The Modified RCRA Subtitle C Barrier is composed of eight layers of durable material with a combined minimum thickness of 1.7 m (5.5 ft). This design incorporates *Resource Conservation and Recovery Act of 1976* (RCRA) "minimum technology guidance" (MTG) (EPA 1989b), with modifications for extended performance. One major change is the elimination of the clay layer, which may desiccate and crack over time in an arid environment. The geomembrane component has also been eliminated because of its uncertain long-term durability.

The Modified RCRA Subtitle C Barrier is similar in structure to the Hanford Barrier, but layer thickness is reduced and there is no fractured basalt layer. The design incorporates provisions for biointrusion and human intrusion control. However, the provisions are modest relative to the corresponding features in the Hanford Barrier design, reflecting the reduced activity of the subject waste and the reduced design-life criterion.

Modified RCRA Subtitle D Barrier. This barrier is the baseline design for nonradiological and nonhazardous solid waste sites as well as Category 1 LLW sites where hazardous constituents are not present. The Modified RCRA Subtitle D Barrier is composed of four layers of durable material with a combined minimum thickness of 0.90 m (2.9 ft). It is designed to provide limited biointrusion and limited hydrologic protection (relative to the other two barrier designs) for a performance period of 100 years. The performance period is consistent with the radionuclide concentrations and activity limits specified for Category 1 LLW. The 100-year design life is also consistent with the minimum expected duration of active institutional control.

Figure D-2 through Figure D-4 provides profiles for each of the three generic conceptual designs. Figure D-5 represents the logic for determining the barrier to be evaluated in the site-specific evaluation and for implementation of the "graded approach" to surface barriers for the 200 Areas. Applying the logic requires that sufficient information is available regarding contaminant constituents and concentrations to classify the radiological component of the waste, and to determine whether dangerous constituents are present at levels of regulatory concern.

Alternative 1 would provide a permanent cover over the affected area. The cover would accomplish the following: minimize the migration of precipitation into the affected soil and contaminant leaching; minimize the potential for biotic intrusion; reduce the migration of windblown dust that originated from contaminated surface soils; reduce the potential for direct exposure to contamination; and reduce the volatilization of VOCs to the atmosphere. If vertical barriers were included, they would limit the amount of lateral migration of contaminants and limit the horizontal movement of moisture beneath the surface barrier. An option for dynamic compaction is also included in this alternative for application at solid waste landfills prior to surface barrier construction to reduce settlements and subsidence that may impact the integrity of a surface barrier. This alternative would not reduce the volume or toxicity of the contaminants, and periodic inspections, maintenance, and monitoring would be required for an indefinite period.

D6.3 ALTERNATIVE 2 - EXCAVATION AND DISPOSAL WITH OR WITHOUT EX SITU TREATMENT

Under Alternative 2, radioactive and hazardous soil or solid debris would be excavated using conventional techniques, with special precautions to minimize fugitive dust generation. Depending on the configuration of the area to be excavated, shoring might be required to comply with safety requirements and to reduce the quantity of excavated soil. If needed, several treatment options could be selected from the physical, chemical, and thermal ex situ treatment process options screened in Section D5.0. For example, thermal desorption with off gas treatment could be used if organic compounds are present; soil washing or mechanical separation could be used to separate contaminated fine-grained soil particles; and stabilization/solidification could be used to immobilize radionuclides and heavy metals or to satisfy the treatment option for land disposal restricted wastes. The specific treatment method would depend on site-specific conditions. Treatability tests would be performed to determine the specific soil treatment protocols and methodology. The treated soil would be backfilled into the original excavation or landfilled. Soil treatment by-products may require additional processing or treatment.

Both onsite and offsite landfill disposal options are included in the alternative depending on the nature of the waste. Section D5.4 identifies currently available disposal options; however, the ERDF located adjacent to the 200 Areas is preferred because it has been specifically constructed to handle low level radioactive and/or hazardous waste from environmental remediation activities on the Hanford Site. The offsite disposal option is identified as a contingency for waste forms or contaminants prohibited at the ERDF.

Alternative 2 would be effective in treating a full range of contamination, depending on the type of treatment processes selected. Attainment of RAOs would depend on the depth to which the material was excavated. If near surface soil or buried waste was treated, airborne contamination, direct exposure to contaminated soil, and bio-mobilization of contamination would be minimized. Because of practical limits on deep excavation, deep contamination may not be removed and would be subject to migration into groundwater. If further degradation of the groundwater were a concern, additional treatment of deep contamination would be needed. For example, Alternative 2 could be used in conjunction with Alternative 4 (in situ grouting or stabilization of soil) to stabilize deep contaminants.

A combination of laboratory treatability tests and pilot-scale field tests might be required to develop the optimum methods for above ground treatment of the excavated soil. The specification of the required treatability tests would depend on the nature of the contaminants at each of the remediation sites and the development status of the process.

D6.4 ALTERNATIVE 3 - EXCAVATION, EX SITU TREATMENT, AND GEOLOGIC DISPOSAL OF MATERIAL WITH TRANSURANIC RADIONUCLIDES

Certain waste sites in the 200 Areas may contain isolated zones where the concentration of TRU radionuclides exceeds 100 nCi/g. For Alternative 3, the soil or solids from those isolated zones would be excavated, stabilized or treated, and shipped to an offsite geologic disposal site. Such a disposal facility has not yet been licensed, so interim storage of the stabilized waste may be required until a final geologic repository is constructed.

Depending on the configuration of the affected area, shoring may be required during excavation to comply with worker safety regulations and to minimize the amount of excavated soil. Special excavation procedures would have to be used to minimize fugitive dust. The excavated waste would be sorted according to TRU concentration. Material with TRU radionuclides exceeding 100 nCi/g would be either vitrified (soil only) or stabilized using an ex situ treatment process, then stored until a geologic disposal facility was available.

Some of the excavated waste could contain TRU radionuclides at concentrations less than 100 nCi/g, and could be treated using a combination of the technologies described in Section D5.0. After the non-TRU waste was treated to achieve appropriate cleanup standards, it could be backfilled into the original excavation or disposed of at an onsite landfill. Imported fill material would be used to restore the site to its original grade. If the residual unexcavated soil or the treated soil used for backfill contained contaminants at concentrations exceeding the RAOs, then an engineered surface barrier (Alternative 1) might have to be installed at the site to prevent direct exposure or groundwater impacts.

This alternative would use many excavation and treatment technologies that have been only partly demonstrated at industrial sites. Extensive treatability testing would be required for the TRU-containing soil to develop optimum methods for treating or stabilizing the TRU radionuclides. Additional treatability studies might be required to support the aboveground treatment of the non-TRU soil. The use of remotely controlled excavation and material handling equipment may be needed.

D6.5 ALTERNATIVE 4 - IN SITU GROUTING OR STABILIZATION OF SOIL

Radioactive and hazardous soil would be grouted in this alternative using in situ injection methods. The end product is monolithic block of contaminated material encapsulated in grout which would significantly reduce the leachability of hazardous contaminants, radionuclides, and/or SVOCs from the affected soil. Grouting may also be used to fill voids, such as in timbered cribs, thereby reducing subsidence. Another variation of this alternative would be to stabilize the soil using in situ mixing of soil with stabilizing compounds such as fly ash.

There are two common methods of in situ grout injection that have been used at industrial sites. In the first method, grout injection wells are installed at prescribed lateral spacing (based on pilot tests) and through the affected vertical zones. Specially formulated grout is then injected at high pressure to provide overlapping zones of influence and allowed to cure. This first method can theoretically be used to stabilize soil deep below the ground surface. In the second method, a patented large-diameter auger/mixer is used to mechanically agitate and blend grout mixtures that are injected into the soil through ports in the auger. This method has commonly been used to grout large areas of soil down to significant depths. One other technology, jet mixing, uses a jetting process to inject and mix in solidification agents. The jetting process is initiated at the bottom of a small-diameter boring and forms a column of treated soil as the jets are backpulled.

Alternative 4 would provide a combination of immobilization and containment of heavy metal, radionuclide, inorganic, and SVOC contamination. Thus, this alternative would reduce migration of precipitation into the affected soil, reduce the migration of windblown dust that originated from contaminated surface soils, reduce the potential for direct exposure to contaminated soils, and possibly reduce the volatilization of VOCs. Because this alternative would not remove the contaminants from the soil, it is likely that institutional controls would be required.

D6.6 ALTERNATIVE 5 - IN SITU VITRIFICATION OF SOIL

In this alternative, the contaminated soil in a subject site would be immobilized by in situ vitrification. Treatability tests would be performed initially to determine site-specific operating conditions. Import fill would initially be placed over the affected area to reduce exposures to the remediation workers from surface contamination. High-power electrodes would be used to vitrify the contaminated soil under the site to a depth below where contamination is present. A large fume hood would be constructed over the site before the start of the vitrification process to collect and treat emissions. Fences and warning signs may be placed around the vitrified monolith to minimize disturbance and potential exposure.

In situ vitrification would be effective in treating radionuclides, heavy metals, and inorganic contamination, and can also destroy organic contaminants. This would reduce the potential for exposures by leaching to groundwater, windblown dust, and direct dermal contact. However, this alternative would not reduce the mass or toxicity of the radionuclides present onsite. Also, in situ vitrification may be limited to depths of less than about 6 m (20 ft), which may not be adequate to immobilize deep contamination.

D6.7 ALTERNATIVE 6 - IN SITU SOIL VAPOR EXTRACTION FOR VOLATILE ORGANIC COMPOUNDS

Soil vapor is drawn from wells that are screened in permeable soil zones that contain high organic vapor concentrations. The vented air would be treated to remove water vapor, the organic vapor of concern, particulate radionuclides that might be entrained in the air stream, and volatile radionuclides. Water vapor must be removed (usually by condensation) to protect the vacuum pumps. If the condensed water contains organic contamination or radionuclides, then it would have to be treated and/or disposal of in an appropriate manner. Particulate radionuclides that were entrained in the air stream can be effectively removed using banks of conventional high-efficiency particulate air (HEPA) filters. The organic vapors would be treated with activated carbon. The required removal efficiency will be determined based on applicable ARARs.

Alternative 6 utilizes proven technologies to remove the volatilized vapors from the vadose zone soil. No additional treatability testing is expected to be needed for this process because it has been successfully implemented in the 200 Areas near Z Plant. Soil vapor extraction would reduce downward and lateral migration of the VOC vapors through the vadose zone, and thereby reduce potential cross-media migration into the groundwater. Soil vapor extraction would reduce upward migration of VOC through the soil column into the atmosphere, and thereby minimize inhalation exposures to the contaminants. In some cases where radionuclides were discharged to the disposal sites with VOCs (e.g., carbon tetrachloride), the removal of VOCs could reduce the mobility of the radionuclides, and thereby reduce the potential for downward migration of the radionuclides. Finally, soil vapor extraction would enhance partitioning of the VOC off of the soil and into the vented air stream, resulting in the permanent removal of the VOC. Alternative 6 may be used in conjunction with other alternatives if contaminants other than VOCs are present.

D6.8 ALTERNATIVE 7 - MONITORED NATURAL ATTENUATION

This alternative includes a variety of contaminant-specific physical, chemical, or biological processes to reduce the mass, activity, toxicity, mobility, volume, or concentration of contaminants in soil or solid debris. The alternative would include sampling and environmental monitoring, consistent with EPA guidance (EPA 1997), to verify that contaminants are attenuating as expected and to ensure that contaminants remain isolated (i.e., will not lead to further degradation of groundwater). As part of the site-specific detailed analysis of this alternative, the hazards and mobility of the possible transformation or daughter products must be addressed.

Sampling activities would include:

- Sampling contaminated materials and the soils below the sites to verify the nature and extent of contamination,
- Verify the hydrogeologic, geochemical and/or biological properties of the vadose zone important to the attenuating processes
- Serve as a monitoring baseline
- Support predictive modeling, if needed.

Environmental monitoring (e.g., vadose zone and/or groundwater) would be conducted to ensure waste containment is achieved and no further degradation of groundwater occurs. The existing network of groundwater monitoring wells in the 200 Areas should be adequate for monitoring most sites. Vadose zone monitoring may be appropriate to verify the effectiveness of attenuating processes and as an indicator of potential future groundwater impacts. For example, if the contaminant of concern is a gamma emitter or a radionuclide that emits gamma-radiation can be used as an indicator parameter of other contaminants, than gamma-ray logging of boreholes can be used to track contaminant movement or changes in activity levels. Soil gas probes can be used to track changes in VOC contamination.

Monitored natural attenuation may be used as a complete remedial alternative, in conjunction with other remedial alternatives, or as a follow-up activity to remedial measures already completed. As a standalone option, monitored natural attenuation is considered most applicable to low-mobility contaminants with limited persistence, where the source is controlled, contaminant plumes that are stable or shrinking, and where potential surface exposure is minimal. If the ability of natural attenuation to meet site-specific RAOs is uncertain, contingency measures (e.g., defaulting to another alternative) should be identified. In any case, institutional controls will likely be necessary to ensure long-term protectiveness.

D7.0 PRELIMINARY REMEDIAL ACTION ALTERNATIVES FOR SPECIFIC WASTE GROUPS

The preliminary remedial action alternatives identified previously for use in the 200 Areas comprise the complete list of alternatives. However, not all alternatives are applicable to all waste groups. For example, in situ vapor extraction would not be applicable for waste groups that do not have volatile organic soil contamination. Criteria used to evaluate the applicability of alternatives to specific waste groups include:

- Installing engineered surface barriers with or without vertical barriers (Alternative 1) could be used on sites where contaminants may be leached or mobilized by the infiltration of precipitation or if surface/near-surface contamination exists. Surface barriers would not be effective at sites with deep contamination.

- Excavation and disposal with or without soil treatment (Alternative 2) could be used at most waste sites that contain shallow contamination including; radionuclides, heavy metals, other inorganics compounds, SVOCs, and VOCs.
- Excavation, treatment, and geologic disposal of TRU-containing soils (Alternative 3) could be used only on those sites that contain TRU radionuclides. Since a geologic repository is likely to accept only TRU radioactive soils or TRU/mixed waste, the non-TRU radioactive soils will not be remediated using this alternative.

- In situ grouting or stabilization (Alternative 4) could be used on waste sites that contains heavy metals, radionuclides, and/or other inorganic compounds. In situ grouting could also be effective in filling voids for subsidence control.

- In situ vitrification (Alternative 5) could be used at most waste sites although this alternative is considered to be most applicable to sites that contain high concentrations of contamination in a small area. Vapor extraction may be needed when VOCs are present. In situ vitrification would not be effective at sites where deep contamination or combustible solid debris is present.

- In situ soil vapor extraction (Alternative 6) could be used on any sites that contains VOCs.

- Natural attenuation (Alternative 7) is applicable at any waste site.

Using these criteria, Table D-5 shows preliminary remedial action alternatives that could be used to remediate specific waste groups. Note that a single alternative may not be sufficient to remediate all contamination within a single group. For example, it may be more feasible to place engineered surface barriers at certain waste sites within a group while at other sites excavation and disposal may be more appropriate. Furthermore, some waste sites may require a combination of alternatives. For example, soil vapor extraction to remove organic contaminants could precede in situ vitrification. Also, there may be instances where additional technologies are possible besides those presented in these preliminary alternatives. More specific waste treatment alternatives could be identified and evaluated as more information is obtained. Detailed FSs will be required to refine and more fully evaluate alternatives as they relate to the specific waste sites.

D8.0 TECHNOLOGY NEEDS

Treatability testing may be needed to support the detailed analysis of remedial alternatives identified in Section D6.0 or to support the remedial design and implementation phase. The purpose of this section is to identify potential technology testing needs that should be considered when establishing group-specific needs in work plans or remedial design/remedial action work plans. In most cases, the process options that make up the alternatives are fully developed remedial technologies that have a history of use at Hanford or other sites. With some exceptions, sufficient information exists on each of the process options to support a detailed analyses of the alternatives in the final FS without the need for additional treatability testing. However, site-specific testing may be required to support the remedial design phase and to define operating parameters.

Table D-6 summarizes general testing needs for each of the process options selected in the development of remedial alternatives for the 200 Areas. Testing needs are identified as either technology-specific or site-specific. Technology-specific testing (i.e., nonsite-specific) needs address issues that apply to the process option in general, the results of which would have broad application to 200 Area waste sites. Criteria used to assess testing needs include:

- Have treatability tests been performed on the Hanford Site? Process options that have been tested would generally not require additional technology-specific testing. However, site-specific testing may be needed.
- Has the technology been used to remediate Hanford waste sites? Process options that are well proven for conditions that are representative of the 200 Areas would generally not require additional testing.
- Is the technology sensitive to site-specific conditions, specific matrix conditions, or waste constituents that would require site-specific testing?

A summary of the development status and potential treatability testing needs for each of the alternatives is discussed below.

Engineered surface barriers with or without vertical barriers. Three conceptual designs have been developed for potential application at waste sites in the 200 Areas that provide a range of protective levels depending on site-specific needs (DOE-RL 1996). A full-scale prototype of the Hanford Barrier has been constructed over the 216-B-57 Crib located in the 200 Areas, and 3-years of treatability testing have been completed. Treatability testing has demonstrated that the barrier is constructable , stable and effective at preventing drainage into the waste layer under ambient and extreme precipitation (three times normal rainfall and 1,000-year storms) (Ward et al. 1997). Potential barrier performance testing that remain include the following:

- Assessment of the long-term (500 to 1,000 years) durability of the asphalt layer.
- Assessment of the impacts from potential settlements or subsidence on barrier integrity.
- Material availability for the various barrier layers particularly the silt layer. If materials specified in the three conceptual design are not readily available, alternative materials may be needed that require additional performance testing.

- Full-scale performance testing of the Modified RCRA C and D Barrier designs.

Excavation and disposal, with or without ex situ treatment. Testing would not be required for the excavation and disposal process options because of the significant amount of experience and success gained in implementing this alternative in the 100 and 300 Areas. If needed, ex situ treatment processes will generally require testing before implementation with the possible exception of soil washing and mechanical separation. Pilot-scale soil washing treatability tests completed for 100 and 300 Area waste sites are applicable to the 200 Areas for select contaminants. Treatability testing of thermal desorption, ex situ vapor extraction, ex situ vitrification, and solidification/stabilization processes would generally be needed. It is anticipated that most of the treatability information required could be obtained by a combination of literature research, laboratory screening, and bench-scale studies. However, pilot-scale testing may be required for certain treatment processes.

Excavation, ex situ treatment and geologic disposal of transuranic soil. Treatability testing needs for this alternative is similar to the above alternative. However, the application of excavation and treatment process options at TRU-contaminated soil sites has only been partly demonstrated and will require additional testing. Special handling technologies have been developed (e.g., remotely controlled excavation and handling equipment), but will likely require pilot-scale or demonstration testing. Laboratory- and/or bench-scale tests are expected to be needed to develop optimum methods for ex situ treatment of TRU contaminated soil. Other Hanford Site programs are expected share similar TRU technology needs, and any testing should be integrated, accordingly. In addition, the DOE Office of Technology Development has established the Buried Waste Integrated Demonstration (BWID) at INEL to help resolve some of the issues surrounding retrieval and treatment of TRU-contaminated soil.

In situ grouting or stabilization. The process options that make up this alternative represent mature geotechnical construction-type methods that have been adapted to remediate contaminated soil sites. Operating parameters are controlled by site-specific conditions (e.g., soil type, moisture content) that may require field tests to optimize grout well spacing, grout injection methods or grout properties. Laboratory-, bench-, and/or pilot-scale tests may be required to assess the compatibility of the admixture and waste, and to demonstrate the overall effectiveness in stabilizing the waste (e.g., leachability).

In situ vitrification. In situ vitrification has been tested and field demonstrated on soil sites contaminated with radionuclides, heavy metals, and organic wastes, but is not considered a fully mature technology due to a limited experience base. Pilot-scale testing should be performed to evaluate operating parameters, and reduce cost and performance uncertainties to acceptable levels to support a detailed analysis. The following issues should be considered:

- Subsurface migration of contaminants into clean areas
- Transient gas release events and volatilization of contaminants
- Containment and treatment of offgases
- Secondary waste generation
- Control of melt geometry and measurement of effectiveness
- Operating parameters and costs.

In situ soil vapor extraction. In situ soil vapor extraction is the conventional method for remediating VOC contaminated soil and has been used in the 200 West Area to effectively remediate carbon tetrachloride contaminated soil. No additional testing needs are expected to be needed.

D9.0 REFERENCES

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Figure D-1. Development of Primary Candidate Remedial Alternatives for the 200 Areas.

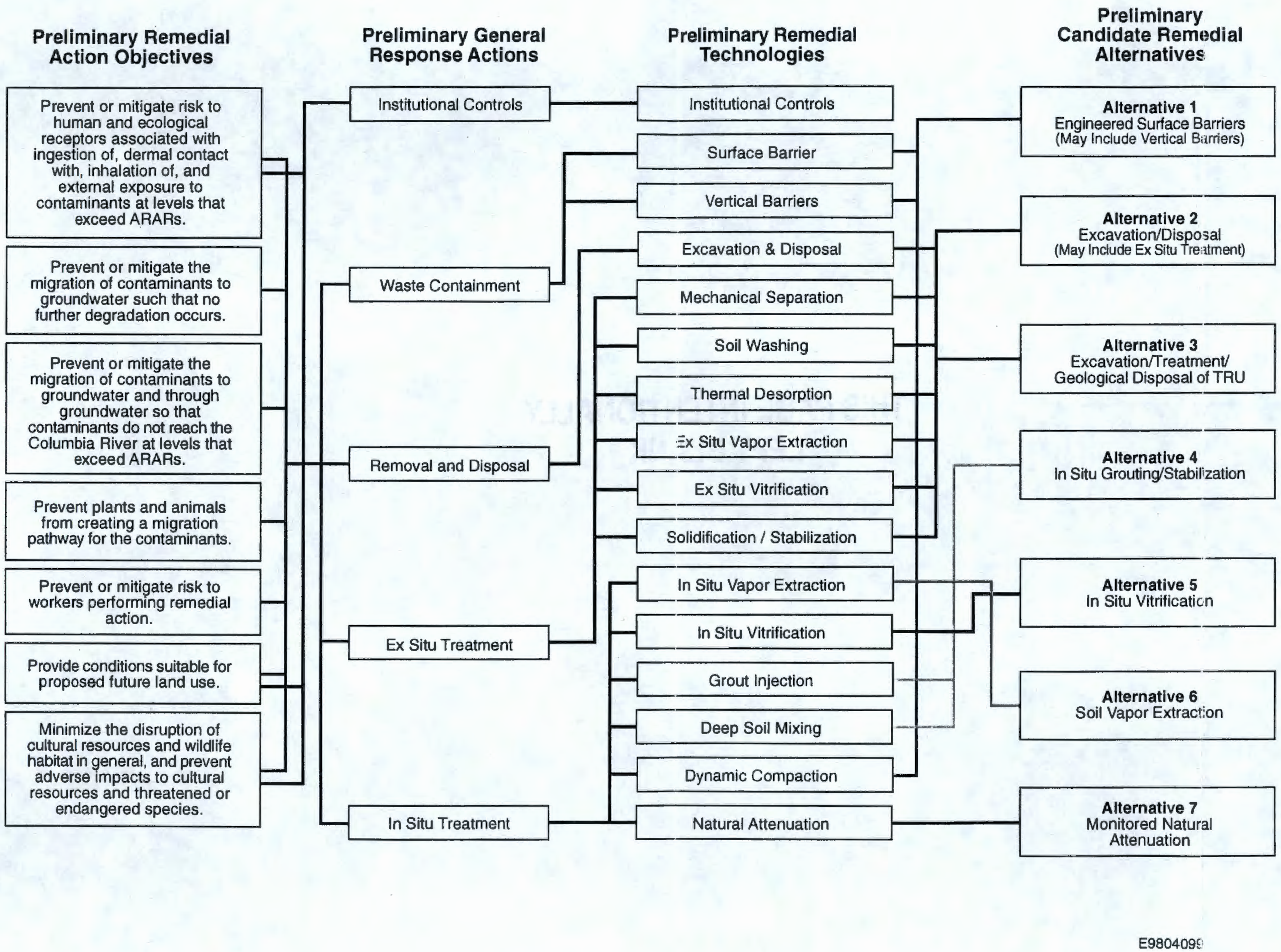

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Figure D-2. Hanford Barrier Profile from DOE-RL (1996).

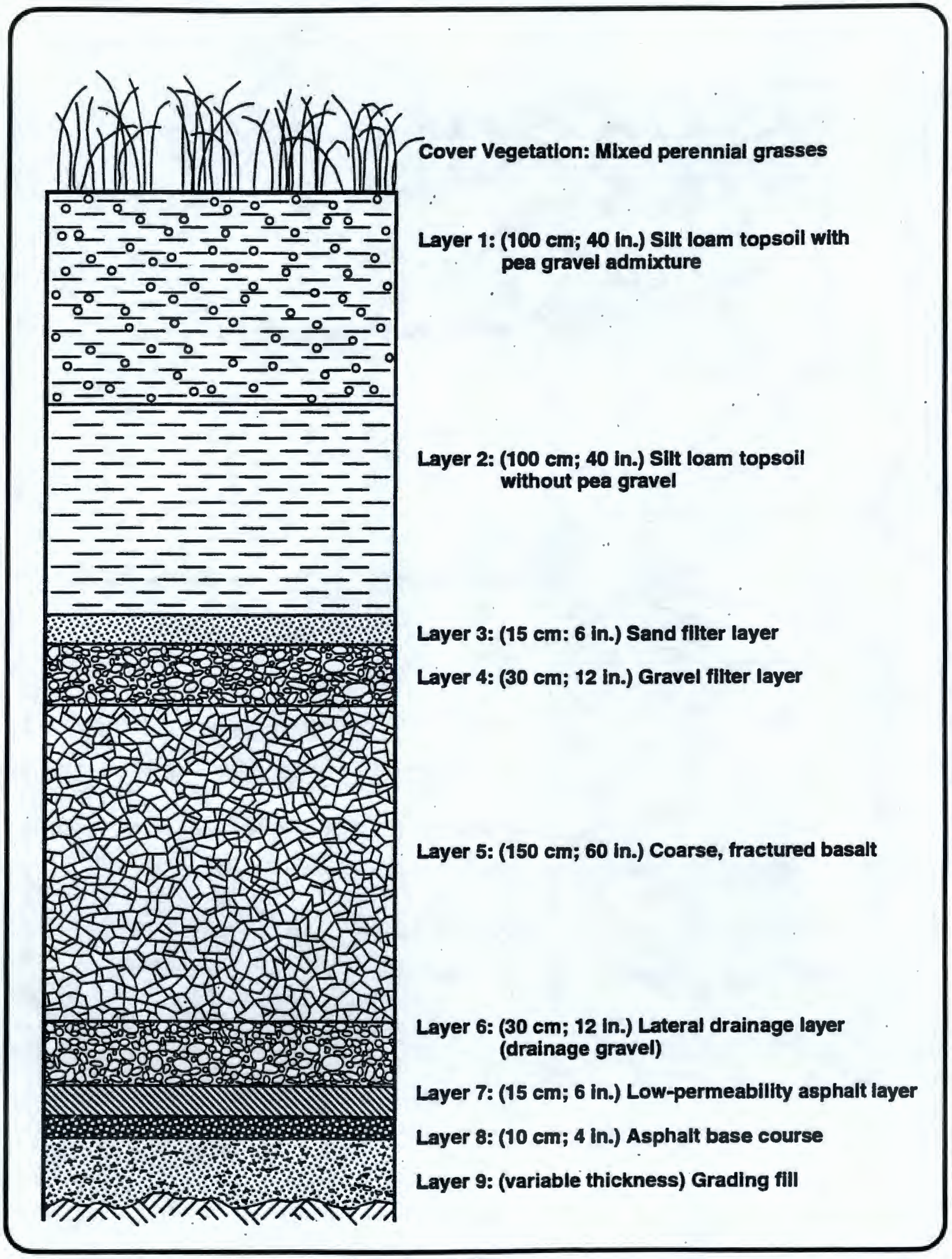


Figure D-3. Modified RCRA Subtitle C Barrier Profile from DOE-RL (1996).

Figure 2. Modified RCRA Subtitle C Barrier Profile.

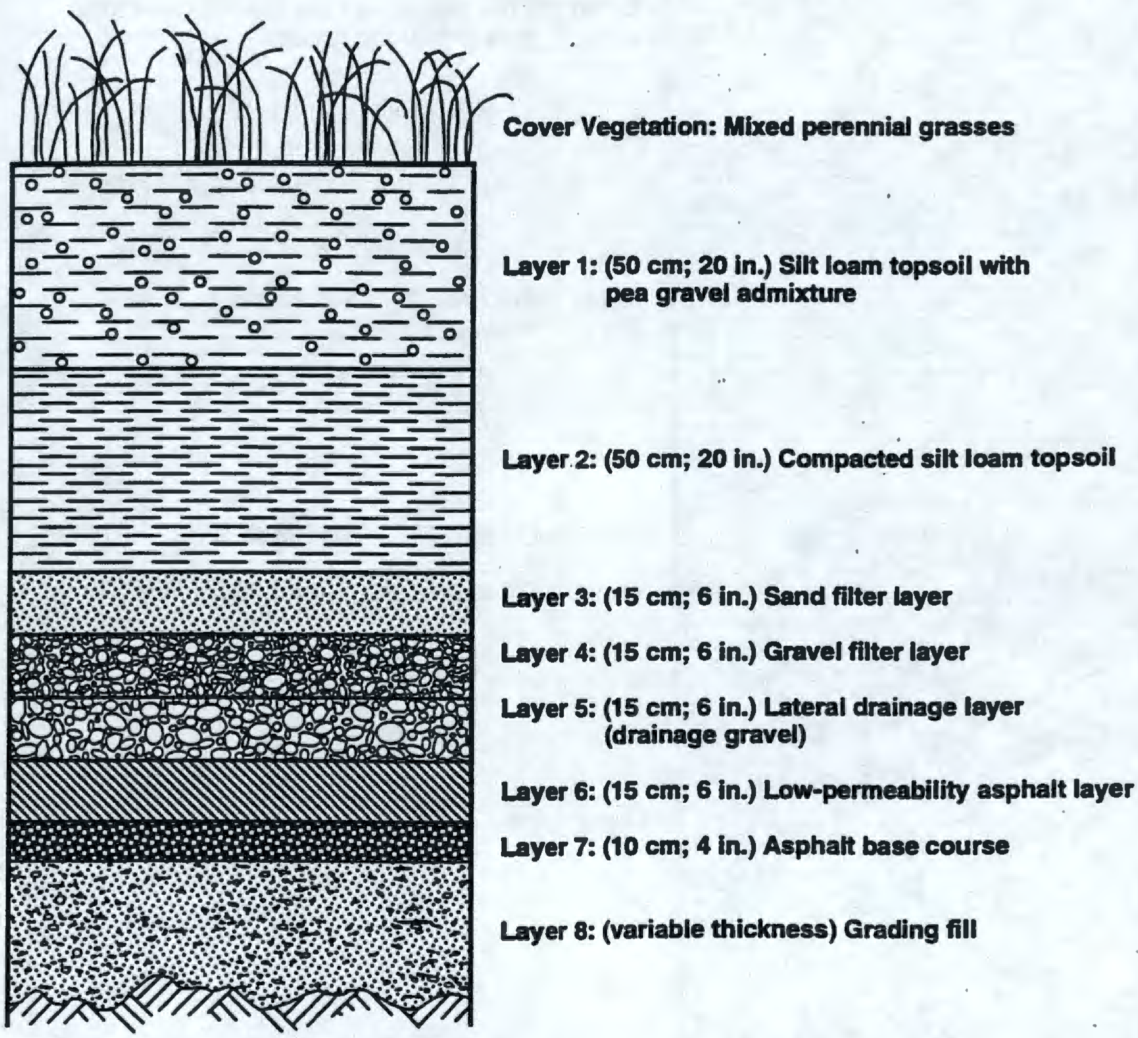


Figure D-4. Modified RCRA Subtitle D Barrier Profile from DOE-RL (1996).

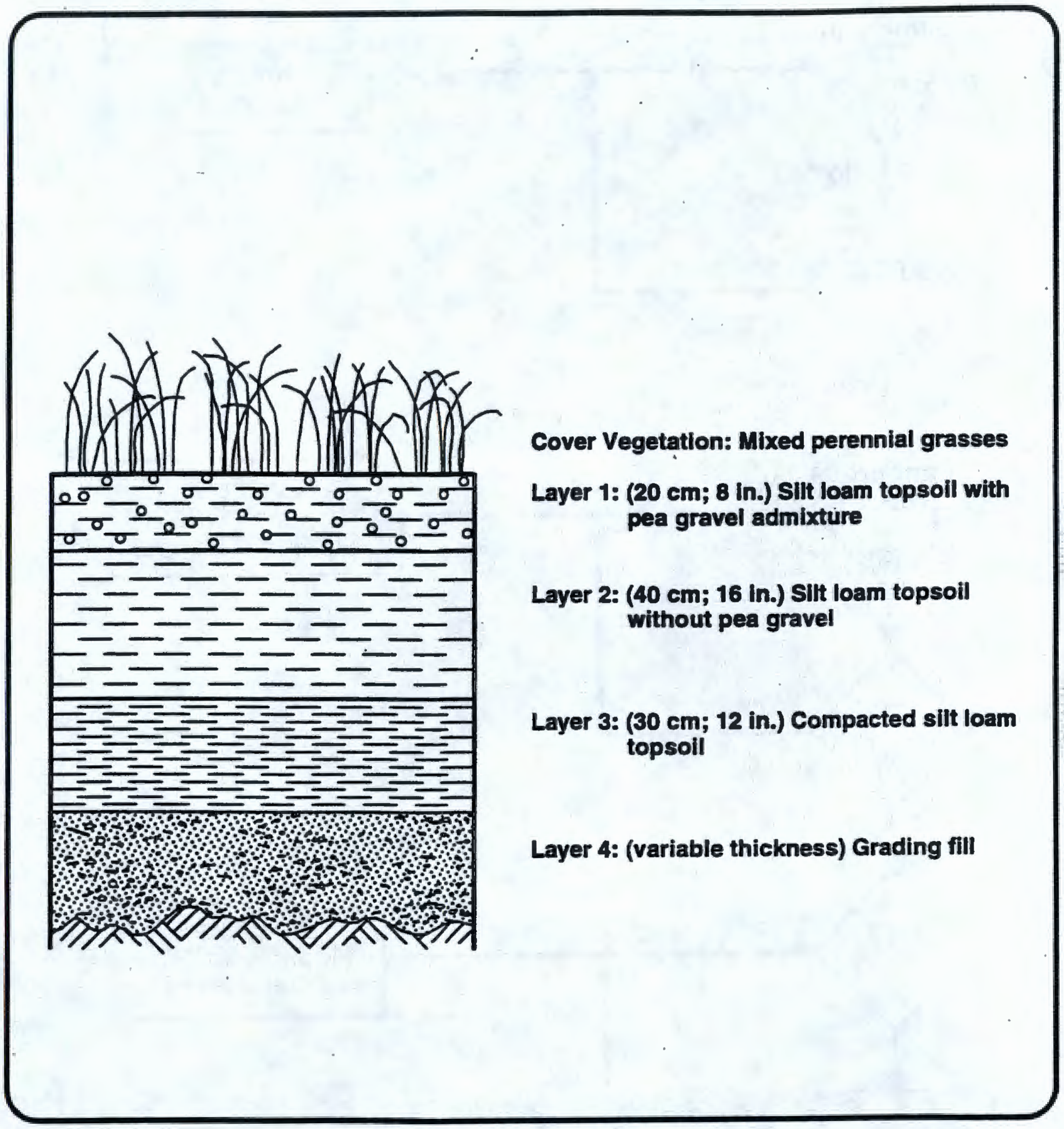
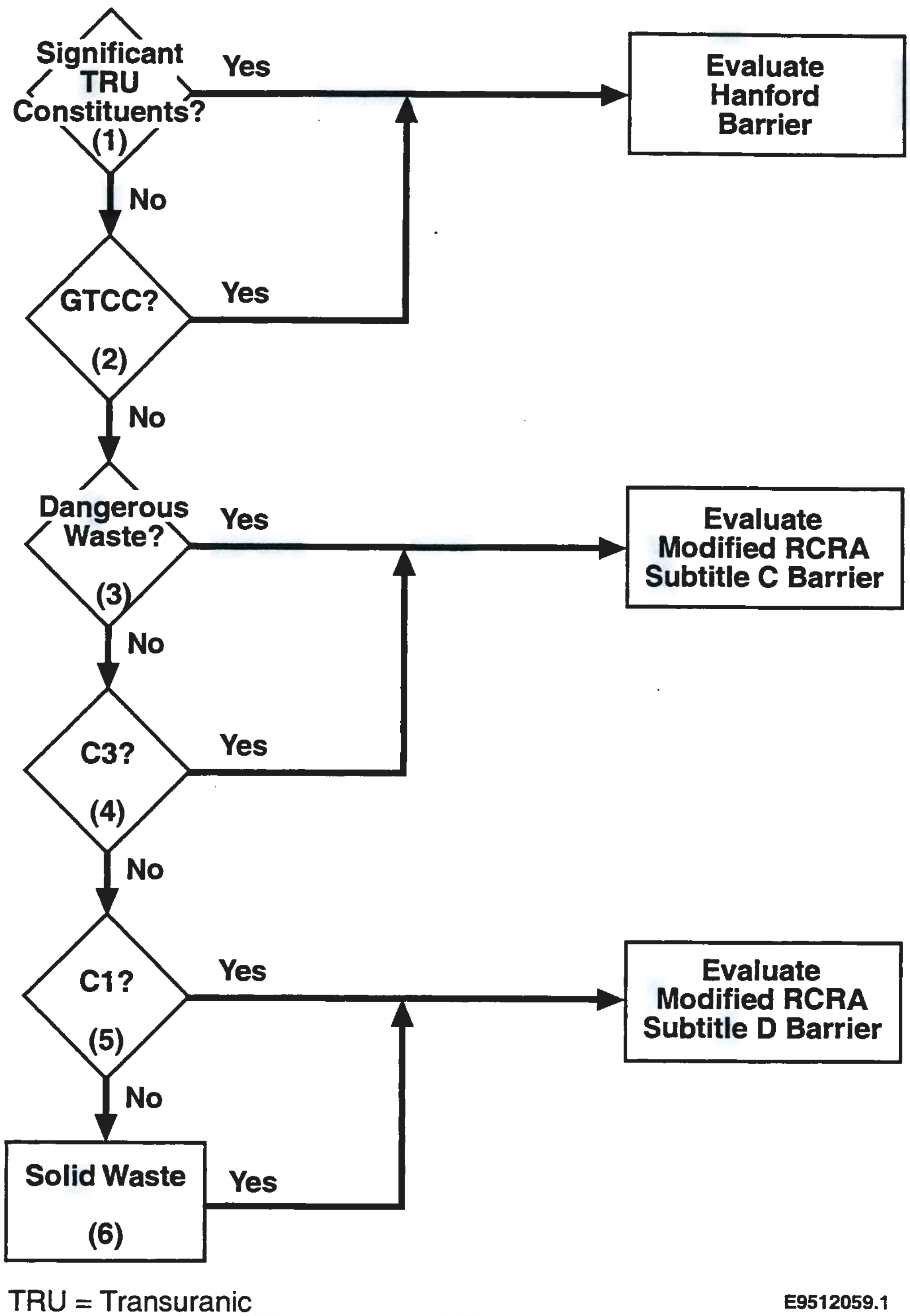


Figure D-5. Implementation Logic for the Graded Barrier Approach from DOE-RL (1996).



TRU = Transuranic
GTCC = Greater-Than-Class C Low Level Waste (LLW)
C3 = Category 3 LLW
C1 = Category 1 LLW

Table D-1. Technology Types and Process Options for Soil and Solid Media. (2 pages)

General Response Action	Technology Type	Process Option	Contaminants Treated
No Action	No Action	No Action	NA
Institutional Controls	Land Use Restrictions	Deed Restrictions	NA
	Access Controls	Signs/Fences	NA
		Entry Control	NA
	Monitoring	Monitoring	NA
Containment	Surface Barriers	Arid Climate Engineered Cap	I,M,R,O
		Asphalt, Concrete, Cement-Type Cap	I,M,R,O
		RCRA Cap	I,M,R,O
	Vertical Barriers	Slurry Walls	I,M,R,O
		Grout Curtains	I,M,R,O
		Cryogenic Walls	I,M,R,O
	Soil Stabilization	Membranes/Sealants/Wind Breaks/Wetting Agents	I,M,R,O
Removal	Excavation	Conventional	I,M,R,O
Disposal	Landfill Disposal	Onsite Landfill	I,M,R,O
		Offsite Landfill/Repository	I,M,O, T (Non-T radionuclides if mixed with T)
Ex Situ Treatment (Ex situ assumes excavation)	Thermal Treatment	Calcination	I, O
		Thermal Desorption	O
		Incineration	O
		Pyrolysis	O
		Steam Reforming	O
		Vitrification	I, M, R, O
	Physical/Chemical Treatment	Chemical Leaching	I,M,R,O
		Dehalonization	O
		Vapor Extraction	O
		Soil Washing	I, M, R, O
		Mechanical Separation	I,M,R,O
		Solvent Extraction	O
		Chemical Reduction/Oxidation	I, M
		Solidification/ Stabilization	I,M,R,O

Table D-1. Technology Types and Process Options for Soil and Solid Media. (2 pages)

General Response Action	Technology Type	Process Option	Contaminants Treated
	Biological Treatment	Composting	O
		Biological Treatment	O
		Landfarming	O
		Slurry Phase Bio Treatment	O
In Situ Treatment	Thermal Treatment	Vitrification	I,M,R,O
		Thermally Enhanced SVE	O
	Chemical/Physical Treatment	Soil Flushing	I,M,R,O
		Vapor Extraction	O
		Grout Injection	I, M, R
		Soil Mixing	I,M,R
		Dynamic Compaction	NA
	Biological Treatment	Biodegradation	O
		Bioventing	O
	Natural Attenuation	Natural Attenuation	I, M, R, O

I = Other Inorganics contaminants applicability
M = Heavy Metals contaminants applicability
NA = Not Applicable
O = Organic contaminants applicability
R = Radionuclide contaminants applicability
T = Transuranic Radionuclides applicability.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
No Action	No Action	Do nothing to clean up the contamination or reduce the exposure pathways.	Not effective in reducing the contamination or exposure pathways.	Easily implemented, but might not be acceptable to regulatory agencies, local governments, and the public.	Low	Retained as a "baseline" case.
Land Use Restrictions	Deed Restrictions	Identify contaminated areas and prohibit certain land uses such as farming.	Depends on continued implementation. Does not reduce contamination.	Administrative decision is easily implemented.	Low	Retained to be used in conjunction with other process options.
Access Controls	Signs/Fences	Install a fence and signs around areas of soil contamination.	Effective if the fence and signs are maintained.	Easily implemented. Restrictions on future land use.	Low	Retained to be used in conjunction with other process options.
	Entry Control	Install a guard/monitoring system to prevent people from becoming exposed.	Very effective in keeping people out of the contaminated areas.	Equipment and personnel easily implemented and readily available.	Low	Retained to be used in conjunction with other process options.
Monitoring	Monitoring	Analyze soil and soil gas samples for contaminants and scan with radiation detectors.	Does not reduce the contamination, but is very effective in tracking the contaminant levels.	Easily implemented. Standard technology.	Low	Retained to be used in conjunction with other process options.
Surface Barriers	Arid Climate Engineered Cap	Multi-layer design utilizing natural materials; designed for arid climates (DOE 1996); applied over contaminated areas.	Effective on all types of contaminants, use of natural materials enhances design life.	Easily implemented. Restrictions on future land use will be necessary.	Medium	Retained because of long-term effectiveness, implementability, and demonstrated performance.
	Asphalt, Concrete, Cement-Type Cap	Single-layer cover system of asphalt or cement materials.	Effective on all types of contaminants. Temporary and susceptible to weathering settling and cracking.	Easy and relatively fast to implement. Restrictions on future land use will be necessary.	low	Rejected because of limited duration of integrity and protection
	RCRA Cap	Multi-component cap with synthetic membrane over low-permeability soil. Developed for wetter climates.	Effective on many contaminants. Use of synthetics limits design life that may be inadequate for the radioactive waste categories. Low-permeability soil may crack in arid climate.	Easily implemented. Restrictions on future land use will be necessary.	Medium	Rejected because of limited design life considerations.
Vertical Barriers	Slurry Walls	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry.	Effective in blocking lateral movement of all types of soil contamination. May not be effective for deep contamination.	Commonly used practice and easily implemented with standard earth-moving equipment. May not be possible for deep contamination.	Medium	Retained for shallow contamination.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Grout Curtains	Pressure injection of grout in a regular pattern of drilled holes.	Effective in blocking lateral movement of all types of soil contamination.	Commonly used practice and easily implementable, but depends on soil type. May be difficult to ensure continuous wall.	Medium	Retained because of potential effectiveness and implementability.
	Cryogenic Walls	Circulate refrigerant in pipes surrounding the contaminated site to create a frozen curtain with the pond water.	Effective in blocking lateral movement of all types of soil contamination.	Specialized engineering design required. Requires ongoing freezing/ maintenance.	Medium	Rejected because it is difficult to implement.
Soil stabilization	Membranes/ Sealants/Wind Breaks/Wetting Agents	Using membranes, sealants, windbreaks, or wetting agents on top of the contaminated soil to keep the contaminants from becoming airborne.	Effective in blocking the airborne pathways of all soil contaminants, but may require regular upkeep.	Commonly used practice and very easy to implement, but land restrictions will be necessary.	Low	Rejected because of limited duration of integrity and protection.
Excavation	Conventional	Contaminated soil is removed and transported to a disposal site.	Well-proven and effective in removing contamination. Dust generation must be controlled.	Readily implemented.	Low	Retained because of potential effectiveness and implementability.
Landfill Disposal	On-Site Landfill Disposal	Place contaminated soil in an existing on-site landfill or off-site RCRA landfill.	Does not reduce the soil contamination but moves all forms of contamination to a more secure place.	Easily implemented with existing facilities for radiological, dangerous, and mixed waste.	Low	Retained because of potential effectiveness and implementability. Construction of a geologic repository onsite is preferred for transuranics disposal.
	Off-Site Landfill/ Repository	Place contaminated soil in an existing off-site RCRA landfill or geologic repository (TRU waste).	Does not reduce the soil contamination but moves all forms of contamination to a more secure place.	Available for dangerous and TRU waste but difficult to implement because of limited availability, and permits for transporting. Requires pretreatment of TRU-contaminated soil.	High	Retained because of effectiveness on transuranic wastes. May be required for other waste restrictions.
Ex Situ Thermal Treatment	Calcination	Use of high temperatures to purify solids by driving off or consuming the volatile or combustible constituents.	Effective in the decomposition of inorganics such as hydroxides, carbonates, nitrates, sulfates, and sulfites. Removes organic components but does not combust them because of the absence of air. Ineffective for radionuclides and heavy metals. Crushing may be required for gravelly soil.	Commercially available. High-volume high throughput. Off-gas treatment is required. Treatability testing would likely be required.	High	Rejected because of limited effectiveness.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Thermal Desorption	Waste heated to 90 to 560°C (200 to 1000°F) to volatilize water and organic contaminants followed by off gas treatment. Liquid residual produced.	Technology targeted at VOC and SVOCs. Effectively destroys the organic soil contaminants. Volatile metals may be removed. Radionuclides will not be treated.	Implementable. Treatability testing would likely be required.	Medium	Retained because of potential effectiveness and implementability. EPA presumptive remedy for VOCs.
	Incineration	High temperatures (870 to 1200°C) used to volatilize and combust organics in a fluidized bed, kiln, etc. Off-gas treatment required. Liquid and solid residuals produced.	Effectively destroys the organic soil contaminants. Heavy metals can produce a bottom ash that requires stabilization. Some heavy metals will volatilize. Radionuclides will not be treated.	Implementable. Technology is well developed. Mobile units are available for relatively small soil quantities. Off-site treatment is available. Air emissions and wastewater generation should be addressed.	High	Rejected because of potential air emissions and wastewater generation and low organic content of soils. EPA presumptive remedy for VOCs.
	Pyrolysis	Transforms organic material into gas components, solid residue (coke) by heating (430°C) waste in the absence of oxygen followed by off-gas treatment. Liquid and solid residuals produced.	Technology targeted at SVOCs. May be effective in halogenated hydrocarbons. Treated media containing heavy metals may require stabilization. Radionuclides will not be treated. May be applicable to mixed waste.	Limited availability. Technology targeted at treatability testing would likely be required.	High	Rejected because of implementation problems.
	Steam reforming	Uses superheated steam to gasify organics followed by a high-temperature reaction chambers/thermal oxidizer to destroy gasified organics. Liquid and solid residuals.	Effectively destroys organic soil contaminants. Metals, radionuclides, and other inorganics are partitioned and isolated for disposal. Mainly applicable to waste high in organics. Applicable to low-level, TRU, and high-level mixed waste forms.	Limited commercial availability. Treatability testing would likely be required.	High	Rejected because of limited effectiveness and difficult implementation.
	Vitrification	Convert soil to glassy materials by application of electric current.	Technology targeted at inorganics. Effective in destroying organics and immobilizing the inorganics and radionuclides. Off-gas treatment for volatile metals and gaseous radionuclides required.	Implementable. Commercial units are available. Laboratory testing required to determine additives, operating conditions, and off-gas treatment. Must pre-treat soil to reduce size of large materials.	High	Retained because of potential ability to immobilize radionuclides and destroy organics.
Ex Situ Physical/ Chemical Treatment	Chemical Leaching		Targets organics.			

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Dehalonization	Destroys contaminants by dehalonization process.	Technology targets SVOCs and pesticides. Can be used to treat halogenated VOCs.	Limited availability. Low reliability and high maintenance. Treatability testing would be required.	High	Rejected because of limited effectiveness and difficult implementation.
	Vapor Extraction	Excavated soil is placed over a network of aboveground piping to which vacuum is applied to volatilized gases for additional treatment. Liquid residual.	Technology targeted at VOCs. Treatment is more uniform and easily monitored than its in situ counterpart, although the excavation process posses potential health and safety risk to site workers. Inorganics and radionuclides not treated.	Readily implemented.	Low	Retained because of potential effectiveness and implementability. EPA presumptive remedy for VOCs.
	Soil Washing	Removal of contaminants by dissolving, suspending, or concentrating contaminants from contaminated soil using a washing solution. Liquid and solid residuals.	Applicable to a wide variety of heavy metals, radionuclides, and organics in coarse-grained soils. Generally more effective on contaminants than partition to the fine soil fraction.	Implementable.Treatability tests are necessary. Well-developed technology and commercially available. Requires treatment of the rejected water and contaminated soil fines.	Medium	Retained because of potential effectiveness and implementability.
	Mechanical Separation	Sorts soil into size fractions to physically separate the contaminant matrix.	Effective as a concentration process for all contaminants that partition to a specific soil size fraction.	Implementable.Most often used as a pretreatment to be combined with another technology. Equipment is readily available.	Low	Retained because of potential effectiveness and implementability.
	Solvent Extraction	Separates contaminants by application of a solvent to preferentially dissolve contaminants. Liquid residual.	Technology targeted at SVOCs and VOCs. The selected solvent is often just as hazardous as the contaminants presented in the waste. Solvent can remain in the treated soil matrix and lead to further contamination. Inorganics and radionuclides not treated.	Implementable. Laboratory testing necessary to determine appropriate solvent and operating conditions.	High	Rejected because the solvent may lead to further contamination.
	Chemical Reduction/ Oxidation	Reduction/oxidation reactions are used to chemically convert hazardous contaminants to a less toxic and more stable form. Solid residual.	Technology targeted at Inorganics. May be effective in treating heavy metal soil contaminants. Radioactivity will not be reduced.	Difficult to implement for large soil volumes or high contaminant levels. Treatability tests are necessary. Competing reactions may reduce efficiency.	Medium	Rejected because of limited applicability and implementation problems.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Solidification/ Stabilization	Mixing of soil with a stabilizing agent to physically bind or enclose contaminants within a stabilized mass or induce a chemical reaction to reduce mobility. Admixtures include cement, asphalt, or polymeric materials.	Target contaminants are inorganics and radionuclides. Generally not effective for organics.	Implementable and reliable. Treatability studies may be needed. Volume of waste is increased.	Medium	Retained because of potential effectiveness and implementability.
Ex Situ Biological Treatment	Composting	Aerobic microbial degradation of contaminants. Excavated soils are mixed with bulking agents and organic amendments. Moisture, temperature, carbon/nitrogen ratio, oxygen, and pH are controlled.	Target contaminants are VOCs, explosives, and fuels. Demonstrated effectiveness on organics is limited. Not effective on inorganics or radionuclides. Addition of water may leach contaminants.	Implementable and all materials and equipment are commercially available. Volume of waste is increased. High contaminant concentrations may be toxic to microorganisms. Treatability tests are required.	Medium	Rejected because of limited effectiveness and difficult implementation.
	Biological Treatment	Aerobic microbial degradation of contaminants. Excavated soils are placed on a treatment area with leachate collection system and aerated. Moisture, heat, nutrients, oxygen, and pH are controlled.	Target contaminants are VOCs, explosives, and fuels. Treatment has been demonstrated on a variety of organic compounds. Not effective on inorganics or radionuclides and questionable effectiveness for halogenated compounds.	Potentially implementable and all materials and equipment are commercially available. Applicable to large soil volumes. High contaminant concentrations may be toxic to microorganisms. Treatability tests are required.	Medium	Rejected because of limited effectiveness and difficult implementation.
	Landfarming	Aerobic microbial degradation of soil contaminants relying on natural organisms. Moisture, nutrients, oxygen level, soil bulking, and pH are controlled.	Target contaminants are VOCs and fuels. Demonstrated effectiveness on organics is limited. Not effective on inorganics or radionuclides. Addition of water may leach contaminants.	Implementable and all materials and equipment are commercially available. High contaminant concentrations may be toxic to microorganisms. Excavation may not be needed. Treatability tests are required.	Low	Rejected because of limited effectiveness and difficult implementation.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Slurry Phase Biotreatment	Aerobic microbial degradation of contaminants. Excavated soil is treated in a bioreactor vessel as a slurry with microorganism, nutrient, and oxygen additions.	Target contaminants are VOCs, explosives, and fuels. Effectiveness is very contaminant- and concentration-specific. Treatment has been demonstrated on a variety of organic compounds. Not effective on inorganics or radionuclides and questionable effectiveness for halogenated compounds.	Potentially implementable and commercially available. Soil must be processed to remove large soil fraction. Applicable to smaller volumes of soil. High contaminant concentrations may be toxic to microorganisms. Treatability tests are required. Dewatering of fines required.	Medium	Rejected because of limited effectiveness and difficult implementation.
In Situ Thermal Treatment	Vitrification	Electrodes are inserted into the soil and a carbon/glass frit is placed between the electrodes to act as a starter path for initial melt to take place.	Effective in immobilizing radionuclides and most inorganics. Effectively destroys some organics through pyrolysis. Some volatilization of organics and inorganics may occur.	Potentially implementable. Implementability depends on site configuration, e.g., lateral and vertical extent of contamination. Treatability studies required.	High	Retained because of potential ability to immobilize radionuclides and destroy organics.
	Thermally Enhanced Vapor Extraction	Uses steam/hot-air injection or electric/radio frequency to mobilize and facilitate extraction of contaminants. Liquid residuals.	Primary target is SVOCs. Not effective on inorganics or radionuclides. Contaminants are transferred from soil to air.	Implementable. Emissions treatment and treatability studies required.	Medium	Rejected because of limited applicability.
In Situ Chemical/ Physical Treatment	Soil Flushing	Solutions are injected through injection system to flush and extract contaminants.	Potentially effective for all contaminants. Effectiveness depends on chemical additives and hydrogeology. Flushing solutions posing environmental threat likely to be needed. Difficult recovery of flushing solution.	Difficult to implement. Not implementable for complex mixtures of contaminants. Flushing solution difficult to recover. Chemical additives likely to pose environmental threat.	Medium	Rejected because of implementation problems.
	Vapor Extraction	Vacuum is applied by use of wells inducing a pressure gradient that causes volatiles to flow through air spaces between soil particles to the extraction wells.	Effective for volatile organics. Ineffective for semivolatile organics, inorganics, and radionuclides. Emission treatment required.	Easily implementable for proper site conditions. Requires emission treatment for organics and capture system for radionuclides and volatilized metals.	Medium	Retained for potential application to volatile organics. EPA presumptive remedy for VOCs.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Grout Injection	Involves drilling and injection of grout to form barrier, encapsulate contaminated material, or fill voids. Applicable for both soil and buried solid waste	Effective for containing inorganics and radionuclides in soil or solid debris matrices. Effective in filling voids or as structural fill. Difficult to maintain integrity as a barrier. Most effective on uniform coarse soil.	Grouting services or equipment and materials are readily available. Implementable but dependent on site conditions.	Medium	Retained because of ability to limit contaminant migration and potential use for filling void spaces.
	Soil Mixing	Solidification agent is applied to soil by mixing in place. Mobility is reduced by physical and chemical means.	Effective for reducing mobility of inorganics and radionuclides. Effectiveness depends on site conditions and additives used.	Implementable and well demonstrated. Services are available from a number of vendors. Treatability studies required to select proper additives. Thorough characterization of subsurface conditions and continuous monitoring required. Waste volumes are increased.	Medium	Retained because of potential effectiveness and implementability.
	Dynamic Compaction	A heavy weight is dropped onto the ground surface to consolidate soil and solid waste burial sites.	Effective for reduces waste void spaces, increasing material stability, and decreasing the hydraulic conductivity of soil	Implementable, readily available and a common construction technique.	Low	Retained for stabilizing buried solid waste because of potential effectiveness and implementability
In Situ Biological Treatment	Biodegradation	Microbial growth utilizing organic contaminants as substrate is enhanced by injection of or percolation water mixed with nutrients and saturated with dissolved oxygen.	Effective for most organics under proper conditions. Ineffective for inorganics and radionuclides. High concentration of heavy metal or radionuclides, highly chlorinated organics, or inorganic salts are likely toxic to microorganisms. Risk of leaching contaminants.	Difficult to implement. Treatability studies and thorough subsurface characterization required.	Medium	Rejected because of limited applicability and difficult implementation.
	Bioventing	Microbial growth utilizing organic contaminants as substrate is stimulated by injection of oxygen.	Effective for organics in coarse grained soils with natural hydrocarbon-degrading microorganisms. Low soil moisture limits biodegradation. Ineffective for inorganics and radionuclides.	Implementable, but a relatively new technology. Pilot-scale tests and thorough subsurface characterization necessary.	Low	Rejected because of limited applicability.

Table D-2. Screening of Process Options for Contaminated Soils and Solid Contaminated Media. (8 Pages)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Natural Attenuation	Natural subsurface processes (e.g., biodegradation, dilution, and radioactive decay) that reduce contaminant concentrations without active treatment.	Target contaminants are VOCs, SVOCs, radionuclides, and metals. Effective for short-lived radionuclides.	Easily implemented. Requires demonstration of effectiveness through modeling, evaluation of degradation rates and pathways and monitoring.	Low	Retained for short-lived radionuclides.

Table D-3. Relationships Between Waste Categories and Cover Designs from DOE-RL 1996.

Cover type	Waste site characterization
Hanford Barrier	Sites with significant inventories of TRU constituents, GTCC LLW, and GTCC Mixed LLW
Modified RCRA Subtitle C Barrier	RCRA Subtitle C (Dangerous) Waste Category 3 LLW and Category 3 Mixed LLW Category 1 Mixed LLW
Standard RCRA Subtitle C Barrier	Dangerous Waste
Modified RCRA Subtitle D Barrier	RCRA Subtitle D (Nondangerous and Nonradiological) Waste Category 1 LLW

TRU = Transuranic
GTCC = Greater-Than-Class C
LLW = Low-Level Waste
NOTE: Classification system for LLW at the Hanford Site is described in WHC (1993).

Table D-4. Preliminary Remedial Action Alternatives Applicable to Representative 200 Area Waste Sites.

Waste Group	Alt. 1 Engineered Multimedia Surface Barrier	Alt. 2 Excavation and Disposal	Alt. 3 Excavation Ex Situ Treatment, and Geologic Disposal of Transuranic Soil	Alt. 4 In Situ Grouting or Stabilization	Alt. 5 In Situ Vitrification of Soil	Alt. 6 In Situ Soil Vapor Extraction	Alt. 7 Monitored Natural Attenuation
200-PW-1, Plutonium/ Organic-Rich Process Waste Group	✓	✓	✓	✓	✓	✓	✓
200-PW-2, Uranium-Rich Process Waste Group	✓	✓		✓	✓		✓
200-PW-3, Organic-Rich Process Waste Group	✓	✓		✓	✓	✓	✓
200-PW-4, General Process Waste Group	✓	✓		✓	✓		✓
200-PW-5, Fission Product-Rich Process Waste Group	✓	✓		✓	✓		✓
200-PW-6, Plutonium Process Waste Group	✓	✓	✓	✓	✓		✓
200-CW-1, Gable Mountain/B-Ponds and Ditches Cooling Water Group	✓	✓					✓
200-CW-2, S-Pond and Ditches Cooling Water Group	✓	✓					✓
200-CW-3, 200 North Cooling Water Group	✓	✓					✓
200-CW-4, T-Pond and Ditches Cooling Water Group	✓	✓					✓
200-CW-5, U-Pond/Z-Ditches Cooling Water Group	✓	✓	✓	✓	✓		✓
200-SC-1, Steam Condensate Group	✓	✓		✓			✓
200-CS-1, Chemical Sewer Group	✓	✓		✓	✓		✓
200-LW-1, 300 Area Laboratory Waste Group	✓	✓		✓	✓	✓	✓
200-LW-2, 200 Areas Chemical Laboratory Waste Group	✓	✓	✓	✓	✓	✓	✓
200-MW-1, Miscellaneous Waste Group	✓	✓		✓	✓		✓
200-TW-1, Scavenged Waste Group	✓	✓		✓	✓		✓
200-TW-2, Tank Waste Group	✓	✓	✓	✓	✓		✓
200-IS-1, Tanks/Lines/ Pits/Boxes Group		✓	✓	✓	✓		✓
200-UR-1, Unplanned Releases Group	✓	✓	✓	✓	✓		✓
200-ST-1, Septic Tank and Drain Fields Group		✓					✓
200-SW-1, Non-Radioactive Landfills and Dumps Group	✓	✓					✓
200-SW-2, Radioactive Landfills and Dumps Group	✓	✓	✓	✓			✓

Table D-5. Technology Status and General Treatability Testing Needs. (2 Sheets)

Alternative	Process Option	Process Option Development Status	Technology-Specific Treatability Testing Needed?	Site-Specific Treatability Testing Needed?	Potential Testing Needs
Engineered Surface Barriers with or without Vertical Barriers	Engineered Surface Barriers	Full	Yes	No	Assess long-term asphalt durability. Assess availability of barrier materials. Assess field performance at Mod. RCRA C and D barrier designs.
	Slurry Walls	Full	No	Yes	Assess compatibility of admix and waste. Assess admix specifications based on site-specific conditions (soil conditions). Verify barrier constructability and integrity.
	Grout Walls	Full	No	Yes	Assess compatibility of admix and waste. Assess admix specifications based on site-specific conditions (soil conditions). Verify barrier constructability and integrity.
	Dynamic Compaction	Full	No	No	
Excavation and Disposal with or without Ex Situ Treatment or Excavation, Ex Situ Treatment and Geologic Disposal of Transuranic Soil	Conventional Excavation	NA	No	No	Assess special handling and treatment needs for TRU-contaminated soil.
	Thermal Desorption	Full	No	Yes	Assess effectiveness and reaction time requirements for matrix and contaminant specific conditions. Assess secondary waste treatment requirements.
	Vitrification	Full	No	Yes	Assess effectiveness for matrix and contaminant specific conditions. Assess process requirements for generating melt based on matrix conditions. Assess secondary waste treatment requirements. Assess potential for use in treating soil residuals from other process options.
	Vapor Extraction	Full	No	Yes	Assess secondary waste treatment requirements.

Table D-5. Technology Status and General Treatability Testing Needs. (2 Sheets)

Alternative	Process Option	Process Option Development Status	Technology-Specific Treatability Testing Needed?	Site-Specific Treatability Testing Needed?	Potential Testing Needs
Excavation and Disposal with or without Ex Situ Treatment or Excavation, Ex Situ Treatment and Geologic Disposal of Transuranic Soil (continued)	Soil Washing	Full	No	Yes	Assess effectiveness based on site-specific conditions (soil conditions) and target contaminants. Formulate washing agent specifications. Assess secondary waste treatment requirements.
	Mechanical Separation	Full	No	No	
	Solidification/ Stabilization	Full	No	Yes	Assess compatibility of admix and waste. Assess admix specifications based on matrix conditions and volumetric changes. Verify effectiveness against leaching and waste form stability.
In Situ Grouting or Stabilization	Solidification/ Stabilization	Full	No	Yes	Assess compatibility of admix and waste. Assess admix specifications based on site-specific conditions (soil conditions). Verify constructability and effectiveness against leaching.
In Situ Vitrification of Soil	In Situ Vitrification	Full	Yes	Yes	Assess costs. Assess effectiveness and process requirements for generating melt based on site-specific (soil conditions) and target contaminants. Assess secondary waste generation and treatment requirements.
In Situ Soil Vapor Extraction	In Situ Vapor Extraction	Full	No	No	
Monitored Natural Attenuation	Natural Attenuation	NA	No	No	

APPENDIX E

WASTE MANAGEMENT FOR THE 200 AREAS IMPLEMENTATION PLAN

E1.0 PURPOSE

The purpose of this appendix is to establish a flexible approach to the management of investigation-derived waste (IDW) while ensuring protection of human health and the environment during the implementation of the 200 Areas strategy. Storage and disposal of IDW will meet the applicable requirements established in the Washington State Dangerous Waste Regulations (*Washington Administrative Code* [WAC] Chapter 173-303) for *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) and *Resource Conservation and Recovery Act* (RCRA) sites at Hanford. Hanford Site IDW that meets the Environmental Restoration Disposal Facility (ERDF) waste acceptance criteria (BHI 1996) and approval authorization will be disposed of in the ERDF.

This appendix is meant to provide an overview of the strategy agreed to in *Strategy for Management of Investigation-Derived Waste* (Ecology et. al. 1995) and other pertinent waste management policies as they apply to the 200 Areas Implementation Plan. Lessons learned from other projects will be incorporated into 200 Areas project documentation. This document is intended to be utilized in conjunction with the "Environmental Protection Policy" (BHI-MA-01, *ERC Policies, Organization, and Responsibilities*, Section 3.2), "Waste Management Program" (BHI-MA-02, *ERC Project Procedures*, Section 9.1), "Control of CERCLA and Other Past Practice Investigation Derived Waste" (BHI-FS-01, *Field Support Administration,* Procedure No. 4.14), and the BHI *"Waste Management Plan"* (BHI-EE-10).

E2.0 APPLICABILITY

This document applies primarily to IDW generated from site characterization and environmental investigations of past-practice units regulated under CERCLA and RCRA. Project managers shall strive to minimize the generation of IDW through proper planning of activities to reduce the need for special storage or disposal requirements. IDW is defined as any waste generated as a result of conducting a CERCLA or RCRA past-practice investigation, treatability study or well construction, maintenance, or abandonment activity. IDW may include, but is not limited to, the following:

- Drilling mud
- Cuttings from test pit and well installation
- Materials from well maintenance, remediation, and abandonment
- Purgewater, soil, and other materials from collection of samples
- Residues (e.g., ash, spent carbon) from testing of treatment technologies
- Contaminated personal protective equipment
- Solutions (aqueous or otherwise) used to decontaminate nondisposable protective clothing and equipment.

Groundwater and free liquids contained in groundwater slurries will be managed according to the Hanford Site purgewater agreement, *Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington* (Izatt 1990).

E3.0 REGULATORY BACKGROUND

Administrative requirements such as obtaining permits, documentation, reporting, and record keeping are not applicable to actions undertaken at CERCLA units; however, IDW will be managed in accordance with the substantive requirements of RCRA and WAC 173-303. The substantive requirements associated with management of dangerous waste in containers will be complied with to the extent practicable.

IDW may be placed in the ERDF provided regulatory approval is gained and the waste acceptance criteria are met. A variety of wastes are produced as a result of activities associated with the Hanford Site cleanup effort that are authorized for disposal at ERDF. Since IDW generated during investigations of the operable units is similar in nature and contamination to remedial action waste, the U.S. Environmental Protection Agency (EPA) has authorized disposal of IDW at ERDF. The ERDF provides for safe and environmentally protective disposal of this material.

E4.0 COLLECTION OF WASTE

When an IDW-generating activity is conducted within a waste site or suspect waste site, the resulting waste may be managed at the site or transferred to a designated central storage area. Waste collection and storage will be performed pending receipt of analytical results to enable proper disposition of the waste. Only clean water will be used for dust control or equipment decontamination within the waste site boundary. The use of water shall be minimized.

IDW generated outside a known or suspected waste site will not normally require collection, storage, or sampling unless visual evidence or field screening indicates the potential presence of contamination or the project managers identify a need to do so. If collection is required for IDW outside the waste site boundaries, samples will be analyzed only for the constituents of concern identified by the project. Slurry pits and liquid discharged to the soil outside the waste unit boundary will normally be allowed unless the area is suspected to contain contamination.

Waste requiring sampling will have well defined boundaries (e.g., soil piles). Should the analyses indicate contamination, waste stored on the soil surface will be excavated to a depth to ensure all contaminated material is removed. Contaminated waste, liquid, semi-liquid, and miscellaneous wastes from suspect areas will be contained and stored onsite or at a centralized location until it is dispositioned.

E5.0 WASTE CHARACTERIZATION

In most cases, samples will be routinely collected as part of the investigation process. These samples will be submitted for analysis and will provide the basis for characterization. The results from these analyses, or other documentation as agreed upon by the unit managers, will be used to characterize IDW materials. If additional data are needed to characterize IDW, samples will be collected and analyzed for the constituents of concern as identified in the associated work plan or equivalent document. Process knowledge and/or waste characterization information will be used in conjunction with field screening to identify those wastes that would be designated as characteristic or listed dangerous waste per WAC 173-303. Where process knowledge is used, "worst case" constituent concentration data will be used as input in the preparation of ERDF waste profiles.

For solid material generated within the boundaries of a waste site, the toxicity characteristic of the waste may be determined if necessary. If a totals analysis of the IDW demonstrates that individual analytes are present in concentrations that could not exceed the toxicity criteria, the IDW in question will not be analyzed using the Toxicity Characteristic Leaching Procedure (TCLP) nor be assigned the toxicity characteristic waste code. If the total analysis indicates concentrations sufficiently high enough to possibly fail the TCLP, the test will be performed on the material and waste codes will be assigned accordingly (WAC 173-340).

In addition to required chemical analysis, samples will be collected and screened for radiological constituents. Screening for radiological contamination will be performed as indicated in the work plan or equivalent document. Waste analysis to identify radiological constituents will be performed when necessary. The above actions, along with the use of existing process knowledge, will serve to identify major risks and to protect human health and the environment during these specific types of activities.

In accordance with the Purgewater Agreement (Izatt 1990), IDW consisting of purgewater from the 200 West Area groundwater plume will be collected and stored. IDW consisting of soil from the unsaturated zone in the 200 West Area will require collection when carbon tetrachloride levels exceed the characteristic dangerous waste designation limit of 500 ppb, regardless of co-contaminates present. Soil IDW containing less than 500 ppb carbon tetrachloride will not require collection under this strategy, nor will such media be considered to "contain" a listed dangerous waste, provided co-contaminants are not present above regulated levels.

E6.0 WASTE MANAGEMENT

When site characterization and environmental investigation operations are conducted within a known or suspected waste site, all IDW will be collected and appropriately managed. When site characterization and environmental investigation operations are conducted outside of or near the boundaries of a known waste site, discussion will be conducted between the U.S. Department of Energy, Richland Operations Office (RL) and the lead regulatory agency to determine the need for IDW collection.

Waste site boundaries within an operable unit shall be determined in concurrence with the lead regulatory agency. This determination will be initially based on existing process knowledge and environmental monitoring data and then substantiated in the field with the use of field screening instrumentation, if necessary. The actual waste site boundary, container storage location, and the need for soil piles and/or slurry pits, if any will be agreed to and documented.

IDW management for sites within a given waste site grouping will be identified in a group-specific waste control plan (WCP) or a site-specific waste management instruction (SSWMI) developed for each waste management activity. These documents shall specifically identify the waste site boundaries, activity-specific waste handling, inspection, storage requirements, and disposal points, if any, and requirements for IDW sampling. These documents shall be developed in accordance with the requirements identified in the BHI *Waste Management Plan* manual (BHI-EE-10). Waste management procedures are mandated by *Control of CERCLA and Other Past Practice Investigation Derived Waste* (BHI-FS-01, *Field Support Administration,* Procedure No. 4.14), and additional requirements for radioactive waste will be implemented in accordance with HSRCM, *Hanford Site Radiological Control Manual*. Items such as (1) the proper labeling of containers, (2) maintenance of those labels, (3) requirements (or exceptions) for container lids or covers, (4) the process and schedule for routine inspections of waste storage areas, (5) the process for documenting and resolving problems that are identified during inspections, and (6) the use and identification of appropriate sample data for generation of waste profiles are addressed in these procedures and/or manuals. Additional requirements for purgewater will be implemented in accordance with *Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington* (Izatt 1990).

The following sections describe management of IDW prior to final disposition (e.g., disposal at ERDF).

E6.1 SOILS

Soils will be characterized as described in the appropriate SSWMI or WCP and Section E5.0 of this appendix. Process knowledge may be used to manage soils as clean material such as when drilling boreholes or digging test pits outside of a waste site. In these cases, soil will be collected in stockpiles at the point of generation provided that evidence does not justify otherwise. Soils may be placed back into the test pit upon completion of the activity.

Contaminated or suspect contaminated soils shall be managed to mitigate the spread of contaminants to the environment (e.g., placed on a tarp, containerized). Upon completion of sampling, test pit soils may be returned to the excavation. Clean soils are placed on the top of the excavation. Containers of soil above dangerous waste designation limits, whether generated inside or outside a waste site boundary, will be managed in accordance with the appropriate SSWMI or WCP and Section E7.0 of this appendix.

E6.2 SLURRY WASTE

Slurry waste includes groundwater slurries and drilling fluids, but excludes groundwater and free liquids separated from groundwater slurries. Slurry waste generated within a waste site boundary, including slurry waste that cannot be chemically/radiologically released, will be containerized and sampled as described in the SSWMI or WCP. Containerized slurry waste will be appropriately managed onsite or in a designated storage area pending analytical results.

Slurry waste generated outside a waste site boundary may be disposed in a pre-excavated, lined (porous membrane liner) slurry pit located adjacent to the drill rig if the area under investigation is not within an area requiring purgewater management as described in the Hanford Site purgewater agreement, *Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington* (Izatt et al. 1990). Slurry pit locations must be outside the exclusion zone and will be documented in the project logbook.

E6.3 WELL WASTE

Waste generated as a result of well drilling, sampling, maintenance, remediation, decommissioning, abandonment, or other related activities that are part of a CERCLA or RCRA past-practice shall be managed as IDW. Waste will be managed as described above for onsite or offsite activities, contaminants present, and specific waste form (i.e., solid or liquid). Purgewater will be managed in accordance with Section E6.4.

E6.4 PURGEWATER

Purgewater is considered all waste water generated from a well during development, aquifer testing, routine groundwater sampling, well maintenance, well remediation, and well abandonment activities. Before generating purgewater, an assessment will be completed to determine if the water generated must be stored at a storage facility or can be disposed to the soil column. Management of purgewater will be in compliance with the *Strategy for Handling and Disposal of Purgewater at the Hanford Site, Washington* (Izatt 1990).

Depending on the well status as described in the "Purgewater Strategy Implementation List[1]," purgewater will be directly discharged to the ground at the well head, diverted away from the well head via a diversion system, temporarily stored at sites or pumped directly into trucks designed to contain purgewater and transported to the appropriate treatment, storage, and disposal (TSD) unit.

E6.5 DECONTAMINATION FLUIDS AND OTHER LIQUID MATERIALS

Decontamination fluids (water and/or nonhazardous cleaning solutions) and other liquid materials (groundwater and free liquids separated from groundwater slurries) generated from operations conducted within the boundaries of a waste site or suspect waste site will be collected and managed in accordance with Section E7.0 of this strategy or the Hanford Site purgewater strategy as appropriate.

Decontamination fluids and other liquid materials generated from operations conducted outside the boundaries of a waste site or suspect waste site will be managed as noncontaminated unless the area under investigation is suspect as described in Section E4.0. If not a suspect area, these wastes may be disposed to the ground at or near the point of generation. These waste disposal locations will be documented in the project logbook.

E6.6 MISCELLANEOUS SOLID WASTE

All miscellaneous solid waste (MSW) that is generated as a result of site characterization and environmental investigation efforts (e.g., rags, personnel protective equipment) and that has contacted potentially contaminated materials (contact MSW) will be segregated from soils, slurries, and liquids to the extent practicable. Contact MSW will be collected upon generation and managed in accordance with Section E7.0.

Waste management determinations for contact MSW will be based on results obtained from characterization activities. Where analytical data indicate that the dangerous and radioactive constituents are below levels of concern, contact MSW will be disposed of at an appropriate facility. If analyses indicate that contaminant limits are exceeded, the contact MSW will be disposed of as IDW at ERDF or other appropriate facility.

All MSW generated that has not contacted waste material (non-contact MSW) will be segregated from all other material generated at the unit and disposed in an appropriate facility.

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[1] List is available from Document Information Services, Pacific Northwest National Laboratory

E7.0 WASTE STORAGE AND CONTAINER MANAGEMENT

E7.1 STORAGE LOCATION

The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994) has divided the Hanford Site into operable units based on the type of disposal units and characteristics of the waste disposed in a given area. Therefore, for the purposes of this project, the area of contamination will be defined as 200 Areas operable units as delineated in the Tri-Party Agreement. The location of a waste accumulation area will be negotiated and agreed upon during preparation of the group-specific work plans.

Most of the generated IDW will be managed in accordance with the applicable WCP or SSWMI for the waste group from which the waste was generated. Waste will be stored at the waste site or at a centralized storage area(s) until analytical data are evaluated for proper waste designation. Most contaminated IDW will be disposed at the ERDF if it meets the waste acceptance criteria. However, based on field screening instrumentation and/or analytical data, it may be determined that it is appropriate to manage certain types of IDW at another approved facility, rather than at the ERDF.

E7.2 SUBSTANTIVE CONTAINER MANAGEMENT REQUIREMENTS

The federal and state regulatory requirements for management of containers are established in 40 *Code of Federal Regulations* (CFR) 264 Subpart I, WAC 173-303-630, and WAC 173-303-160. All containers of IDW that have been determined to pose a potential threat to human health and the environment will be managed in accordance with the applicable federal and/or state requirement(s), *Control of CERCLA and Other Past Practice Investigation Derived Waste* (BHI-FS-01, *Field Support Administration,* Procedure No. 4.14), and other ERC procedures, as applicable (e.g., HSRCM and/or the Hanford Site purgewater strategy).

Waste will be stored at the waste site or at a centralized storage area(s) until analytical data are evaluated for proper waste designation and subsequent disposal or transport to the appropriate TSD unit. Radiologically contaminated waste will be segregated from nonradiologically contaminated waste. All containers will be legibly labeled, including HAZARDOUS WASTE or DANGEROUS WASTE labels, waste codes, *Solid Waste Management Tracking Systems* (SWITS) numbers, and identification of major risks, as required. All containers will remain closed and sealed except when it is necessary to add or remove waste. Routine inspections will occur.

E7.3 UNKNOWN WASTE

While being stored, each container of unknown waste must be labeled with the date of sampling and the words "WASTE PENDING ANALYSIS". The following information must be kept in the log for each unknown waste: the container tracking number; the date of discovery; the date samples were shipped to a testing facility; and the name, address, and phone number of the testing facility.

E7.4 LISTED WASTE

The major risk (corrosive, reactive, ignitable, toxic), for listed waste not otherwise designated, shall be labeled on the container (not marked) as an "F-listed" waste. Major risks for other waste shall be consistent with either the waste designation or the U.S. Department of Transportation hazard class. Use descriptive labels (i.e., do not use Class 9 labels as major risk labels).

E7.5 RELEASE REPORTING

WAC 173-303-145 establishes the requirements for reporting releases of hazardous substances. Adherence to all other applicable or relevant and appropriate requirements for notification of releases of hazardous substances in excess of a specified reportable quantity is required.

E8.0 WASTE DETERMINATION

This section provides the basis upon which IDW management determination will be made. IDW will be radiologically released when the waste meets applicable release levels. Waste that is above established release levels and meets the waste acceptance criteria will be transported to the ERDF for disposal. Nonradioactive IDW containing hazardous constituents below dangerous waste designation limits and Model Toxics Control Act (MTCA), Method B soil cleanup standards will be disposed to the ground at or near the point of generation. Waste that exceeds dangerous waste release or MTCA Method B limits and meets the ERDF waste acceptance criteria will be disposed at the ERDF. IDW that does not meet the ERDF waste acceptance criteria will remain on the waste site or in a centralized storage area pending disposal at an appropriate facility or storage at Hanford's Central Waste Complex.

E9.0 DISPOSAL OF INVESTIGATION-DERIVED WASTE

The IDW will be stored within a designated area until the appropriate waste management decision has been made. Upon receiving the analytical results and profiling the waste, waste resulting from that action will be treated, stored, and/or disposed, as appropriate. Contaminated IDW that meets that ERDF waste acceptance criteria will be disposed at the ERDF. Liquids will be managed as described above. Miscellaneous material that does not require disposal in the ERDF will be disposed in an appropriate solid waste disposal facility.

A case-by-case disposal determination shall be made in instances where IDW exceeds the ERDF waste acceptance criteria. In these instances, the IDW of concern shall be appropriately managed to minimize impacts to human health and the environment.

E10.0 SPECIAL CIRCUMSTANCES

The RCRA and CERCLA project managers designated by the respective Tri-Party participants (RL, the Washington State Department of Ecology, and the EPA) shall have authority to negotiate IDW criteria not specified in this document or other regulatory agreements. Any negotiations conducted outside of the scope of this document will only be conducted for unique situations where application of the existing scope of this document is impractical or otherwise inappropriate. Prior to implementation of any special IDW management action negotiated by project managers, they will document the technical and regulatory justifications for their actions. If management of IDW is not conducted in accordance with this document and existing regulatory agreements, and agreement on special management actions cannot be reached by the project managers, the IDW will be managed in accordance with WAC 173-303 until the issue is resolved.

Concurrence with language in RL or contractor IDW procedures that are not addressed in this document and existing regulatory agreements will be the responsibility of the individual project managers during development of each group-specific work plan to control waste and will be based on site-specific conditions.

The provisions of this strategy shall be periodically reviewed by the Tri-Parties or their designees for purpose of amending the document, if it is deemed necessary. If there is a significant need by any of the Tri-Parties for revision at any time, the document may be revised and approved by them.

E11.0 REFERENCES

BHI, 1996, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, BHI-00139, Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-10, *Waste Management Plan*, Bechtel Hanford, Inc., Richland, Washington.

BHI-FS-01, *Field Support Administration*, Bechtel Hanford, Inc., Richland, Washington.

BHI-MA-01, *ERC Policies, Organization, and Responsibilities,* Bechtel Hanford, Inc., Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601, et seq., as amended.

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

Ecology, EPA, and DOE, 1995, *Strategy for Management of Investigation-Derived Waste*, letter from R. Stanley, Washington State Department of Ecology, D. R. Sherwood, U.S. Environmental Protection Agency, and K. M. Thompson, U.S. Department of Energy, dated July 26, 1995.

HSRCM-1, 1996, *Hanford Site Radiological Control Manual*, Hanford site Contractors, Richland, Washington.

Izatt, R. D., 1990, *Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington*, letter 90-ERB-075, to P.T. Day and T. L. Nord, MacTech Services, August 20, U.S. Department of Energy, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq., as amended.

WAC 173-303, "Dangerous Waste Regulations, "*Washington Administrative Code*, as amended.

WAC 173-340, "Model Toxics Control Act-Cleanup," *Washington Administrative Code*, as amended

APPENDIX F

PHYSICAL SETTING

F1.0 INTRODUCTION

Data on the physical characteristics of the contaminated sites and surrounding areas are needed to define potential contaminant transport pathways in the subsurface from the disposal sites toward groundwater and toward potential receptors. These data (which are summarized in Section 3.1) describe the physical setting for the conceptual models of contaminant distribution (presented in Section 3.3) and exposure (presented in Section 5.0). Data on the physical characteristics are also needed to provide sufficient engineering data for development and screening of remedial action alternatives.

Appendix F contains the description of the physical setting for the 200 Areas. This information is included as an appendix to the 200 Areas Implementation Plan so that it can be referenced, rather than repeated, in the individual group-specific work plans. As a result, each work plan will build on a consistent base of information with a minimum of redundancy.

Descriptions of the physical setting of the 200 Areas are included in each of the ten AAMS reports prepared for the geographically-based operable units (Table 3-1). This information is also summarized in the Hanford Site National Environmental Policy Act Characterization report prepared and updated by Pacific Northwest National Laboratory (Neitzel 1997). The descriptions of the 200 Area physical setting included in this appendix are taken largely from these sources. As each group-specific work plan is prepared, the most recent environmental reports will be consulted to ensure that this description of the physical setting is still correct and complete; any significant modifications to the information presented here will be incorporated into these future work plans.

F2.0 TOPOGRAPHY OF THE 200 AREAS

The land surface of the Hanford Site is dominated by low-relief plains and basaltic ridges (Gable Mountain-Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills) in the western portion of the site that rise above these plains (Figure F-1). This general topography of the Hanford Site has been modified by two natural processes, Pleistocene cataclysmic flooding and Holocene eolian activity, and by Hanford Site construction activity.

Cataclysmic flooding occurred when ice dams in western Montana and northern Idaho were breached, allowing large volumes of water to spill across eastern and central Washington. The last major flood occurred about 13,000 years ago, during the late Pleistocene epoch. Flood channels, giant current ripples, and giant flood bars are among the landforms created by the floods. One of these flood bars (Cold Creek Bar) forms a prominent terrace, roughly defined by the 215-m (700-ft) contour line, that is commonly referred to as the "200 Area Plateau" because the surface of the flood bar is a broad, flat area that constitutes a local topographic high (Figure F-1). This terrace drops off to the north and northwest with elevation changes between 15 and 30 m (50 and 100 ft) (DOE-RL 1993b).

Cold Creek bar trends generally east-west. The northern boundary of the flood bar is defined by an erosional channel that runs east-southeast before turning south just east of the 200 East Area. This erosional channel formed during waning stages of flooding as floodwaters drained from the basin (Bjornstad et al. 1987). The northern half of the 200 East Area and the entire 200 North Area lie within this ancient flood channel (Figure F-1). The southern half of the 200 East Area and most of the 200 West Area are situated on the flood bar. A secondary flood channel running southward off the main channel bisects the 200 West Area (Last et al. 1989). Buried former river and flood channels may provide preferential pathways for groundwater and contaminant movement.

Since the end of the Pleistocene epoch, winds have locally reworked the flood sediments, depositing primarily sand on the low-relief plains and loess (windblown silt) around the margins of the Pasco Basin. In the 200 West Area and southern part of the 200 East Area, these deposits consist dominantly of laterally discontinuous sheets of wind-blown silt and fine-grained sand (Hartman and Dresel 1998). Anchoring vegetation has stabilized much of the dune sand. However, stabilized dunes are easily reactivated in areas where vegetation is disturbed by fire or man. Stabilized sand dunes are present along the southern boundary of the 200 East Area (Last et al. 1989).

Construction and operation of waste management facilities for liquid and solid waste disposal resulted in local modifications to the topography.

The topography of the 200 West Area is generally flat. The elevation ranges from approximately 221 m (725 ft) above mean sea level (msl) along the northern half of the eastern perimeter, situated on the flood bar, to approximately 197 m (647 ft) above msl in the southwestern corner (DOE-RL 1993b).

The topography of the 200 East Area is generally flat. The elevation ranges from approximately 225 m (740 ft) above msl in the southwestern part, situated on the flood bar, to approximately 180 m (590 ft) above msl in the northeastern part, situated within the flood channel (DOE-RL 1993a).

The topography of the 200 North Area slopes gently to the south and east. The elevation in the vicinity of the 200 North Area ranges from approximately 181 m (593 ft) in the northeastern corner to approximately 170 m (560 ft) in the southeastern corner (DOE-RL 1993c).

F3.0 METEOROLOGY OF THE 200 AREAS

The Hanford Site lies east of the Cascade Mountains and has a semi-arid climate because of the rainshadow effect of the mountains. Climatological data are monitored at the Hanford Meteorological Station (HMS), located between the 200 East and 200 West Areas, and at other locations throughout the Hanford Site. Meteorological data from the HMS are available for 1945 through 1996 in a report (Hoitink and Burk 1997) and for 1997 through the present on the HMS internet site (Hoitink and Burk 1998). Historical data tables of temperature and precipitation are also available through the HMS internet site (Hoitink and Burk 1998). Data from the HMS are representative of the general climatic conditions for the region and describe the specific climate of the 200 Area Plateau (Neitzel 1997).

F3.1 WIND

The Cascade Mountains have considerable effect on the wind regime at the Hanford Site by serving as a source of cold air drainage. Because of this gravity drainage, prevailing wind directions on the 200 Areas Plateau are from the northwest in all months of the year (Figure F-2). Secondary maxima occur for winds from the southwest. Winds from the northwest quadrant occur most often during the winter and summer. During the spring and fall, the frequency of winds from the southwest increases with a corresponding decrease in northwest flow. Winds blowing from other directions (e.g., northeast) display minimal variation from month to month (Neitzel 1997).

Monthly average wind speeds are lowest during the winter months, averaging 10 to 11 km/h (6 to 7 mi/h), and highest during the summer, averaging 13 to 15 km/h (8 to 9 mi/h) (Hoitink and Burk 1997). Wind speeds that are well above average are usually associated with southwesterly winds.

However, the summertime drainage winds are generally northwesterly and frequently reach 50 km/h (30 mi/h) (Neitzel 1997).

Winds are a potential agent of contaminant transport for particles at the ground surface. For example, former liquid waste disposal sites at ground surface (e.g., ponds and trenches) that dry out may expose contaminated soils that could be mobilized by wind.

F3.2 BAROMETRIC PRESSURE

The average barometric pressure at the HMS is 98.9 kPa (29.2 in. Hg). In general, the barometric pressure is higher in the winter than in the summer, although both the highest and lowest recorded pressures at the Hanford Site occurred during the winter (DOE 1988). Fluctuations in barometric pressure also tend to be greater in winter than in summer (Figure F-3). Fluctuations in barometric pressure affect the movement of volatile contaminants within the vadose zone by inducing natural subsurface pressure gradients. This naturally-occurring "barometric pumping" phenomenon can also cause release of volatile contaminants to the atmosphere. In general, falling barometric pressure causes subsurface vapor to move to the atmosphere through soil pores or wells, which provide preferential pathways. Barometric pressure fluctuations also produce fluctuations in the elevation of the semi-confined and confined water tables.

F3.3 TEMPERATURE AND HUMIDITY

The mean surface air temperature averages approximately 12°C (53°F) at the HMS (DOE 1988). During the 53 years between 1945 and 1997, the average monthly temperature was coldest in January at -1°C (31°F) and hottest in July at 25°C (76°F) (Hoitink and Burk 1998). The maximum and minimum monthly average temperatures during any single year are listed for each season in Table F-1. The maximum temperature recorded at the HMS was 45°C (113°F) in August 1961; the minimum temperature recorded at the HMS was –31°C (-23°F) in February 1950 (Hoitink and Burk 1998). An average of 174 d/yr at the HMS are free of freezing temperatures, with the recorded range lying between 142 and 215 d/yr (DOE 1988).

The annual average relative humidity at the HMS is 54%. It is highest during the winter months, averaging about 75%, and lowest during the summer, averaging about 35% (Neitzel 1997).

Temperature affects the evapotranspiration of precipitation and thus is one factor determining the amount of recharge to the unconfined aquifer. Precipitation that infiltrates through the vadose zone can mobilize contaminants.

F3.4 PRECIPITATION

Average annual precipitation at the HMS during the 51 years between 1947 and 1997 was 17.3 cm (6.8 in.) (Hoitink and Burk 1998). In the wettest year on record, 1995, 31.2 cm (12.3 in.) of precipitation was measured; in the driest year, 1976, only 7.6 cm (3.0 in.) was measured. On average, winter is the wettest season; approximately 38% of the annual precipitation falls during December, January, and February. Only 14% of the annual precipitation falls during June, July, and August. Even though precipitation is less frequent during the summer months, summer rainfall, when it does occur, is on average twice as intense as winter precipitation (DOE 1988). The maximum monthly average precipitation during any single year is listed for each season in Table F-2.

During the 51 winters between 1946 and 1997, the average monthly snowfall was highest in December at 13.7 cm (5.0 in.) and lowest in March at 1.3 cm (0.5 in.) (Hoitink and Burk 1998). The record monthly snowfall of 59.4 cm (23.4 in.) occurred in January 1950; the second highest monthly snowfall of 57.4 cm (22.6 in.) occurred in December 1996. The seasonal record snowfall of 142.5 cm (56.1 in.) occurred during the winter of 1992-1993. Snowfall accounts for about 38% of all precipitation from December through February (Neitzel 1997). On average, the depth of snow on the ground will exceed 150 mm (5.9 in) in about only one winter out of eight (DOE 1988).

Days with greater than 1.3 cm (0.50 in.) of precipitation occur on average less than one time each year. Rainfall intensities of 1.3 cm/hr (0.5 in/hr) persisting for 1 hour are expected once every 10 years. Rainfall intensities of 2.5 cm/hr (1 in./hr) for 1 hour are expected only once every 500 years (Neitzel 1997).

The average occurrence of thunderstorms is 10 per year. They are most frequent during the summer; however, they have occurred in every month (Neitzel 1997). Lightning strikes in the summer have occasionally ignited grass fires that have burned thousands of acres in the Hanford Site region (DOE 1988).

The frequency and intensity of precipitation at the Hanford Site are of specific interest because of their influence on moisture infiltration to soil and potential recharge to groundwater. The rate and degree of infiltration of snow will also depend on the rate at which it melts. Large amounts of precipitation can enter the ground over relatively small areas as the result of a downpour from a thunderstorm or rapid snow melt. Potential surface run-off and run-on at individual waste sites will depend on the local topography and permeability of ground surface cover. Building and road run-off of relatively low rates of rainfall can lead to precipitation being focused on small areas and ponding in low areas, both of which would increase the infiltration rate. Another cause of increased infiltration is associated with leaks or spills from utility water lines, such as those in the fire hydrant systems.

F3.5 RECHARGE

Recharge to the unconfined aquifer within the 200 Areas may be from natural and artificial sources. If natural recharge occurs, it originates from precipitation because no natural surface waters exist within the 200 Areas. Artificial recharge in the 200 Areas resulted from large volumes of liquid waste disposed to the ground from plant operations that began in 1943. In the 1950's through 1980's the annual volume of effluent discharged to the soil column in the 200 Areas typically ranged from 10 to 25 billion Liters (Hartman and Dresel 1998). Zimmerman et al. (1986) report that between 1943 and 1980, 6.33×10^{11} L (1.67×10^{11} gal) of liquid wastes was discharged to the soil column in the 200 Areas. Currently, most sources of artificial recharge have ceased in the 200 Areas and are largely limited to liquid discharges to sanitary sewers, the two State-Approved Land Disposal Structures, and over 140 small volume, uncontaminated, miscellaneous waste streams (DOE-RL 1997a).

The primary factors affecting the magnitude of precipitation recharge are climate, soils, vegetation/land use, and topography (Fayer and Walters 1995). Evapotranspiration of precipitation is considered to significantly reduce the amount of precipitation that reaches the groundwater (Gee 1987). In general, infiltration to soils is higher in the winter when precipitation is more frequent and evapotranspiration is low (DOE-RL 1997b).

A number of field studies have been conducted on the Hanford Site to assess precipitation, infiltration, water storage changes, and evaporation to evaluate the natural water balance during the recharge process. Precipitation recharge values ranging from 0 to 100 mm/yr (0 to 4 in./yr) have been estimated from these studies and depend largely on soil texture and the type and density of vegetation. A natural recharge map based on distributions of soil and vegetation types is shown in Figure F-4. Recharge from precipitation is higher in the coarse-textured soils with little or no vegetation, as are found in the 200 Areas (Hartman and Dresel 1998). Historically, the volume of natural recharge was expected to be significantly lower than the volume of recharge contributed by artificial sources throughout the 200 Areas. Graham et al. (1981) estimate that historical artificial recharge from liquid waste disposal in the 200 Areas exceeded all natural recharge on the Hanford Site by a factor of 10 (DOE-RL 1997b).

With the cessation of artificial recharge in the 200 Areas, the downward flux of moisture in the vadose zone to groundwater has decreased underlying liquid disposal sites and is expected to continue to decrease with time. The maximum flux of moisture occurred when plant operations were active, creating many localized areas of saturation/near saturation in the soil column beneath liquid disposal waste sites. When waste sites cease operating, the moisture flux continues to be significant for a period of time because of gravity drainage of the saturated/near-saturated soil column. When unsaturated conditions are reached, moisture flux becomes increasingly less significant because unsaturated hydraulic conductivity decreases with decreasing moisture content. The decrease in artificial recharge in the 200 Areas is reflected in the water table, which continues to decrease in elevation throughout the 200 Areas. In the absence of artificial recharge, the potential for recharge from precipitation becomes more important as a downward driving force for remaining vadose zone contamination (DOE-RL 1997b).

The unconfined aquifer underlying the 200 Areas may also receive natural recharge from two additional sources. Rainfall and run-off from the higher bordering elevations to the west of the site recharge the unconfined aquifer upgradient of the 200 Areas. Also, in areas of upward gradients, the unconfined aquifer may be recharged with water from the underlying confined aquifer system. The direction of the vertical gradients may change as waste water disposal practices change (DOE-RL 1993b).

Water that infiltrates the vadose zone may leach contaminants from both liquid and solid waste disposal sites and transport them to groundwater. Recharge thus represents a potential long-term mechanism for contaminant migration.

F4.0 VADOSE ZONE HYDROGEOLOGY

The vadose zone beneath the 200 Areas ranges in thickness from approximately 55 m (180 ft) beneath the former U Pond in the 200 West Area to approximately 104 m (341 ft) in the southern portion of the 200 East Area to 49 m (160 ft) along the western part of the 200 North Area. The vadose zone thins from the 200 Areas north to 0.3 m (1 ft) near West Lake. Sediments in the vadose zone consist primarily of the Hanford formation, Plio-Pleistocene unit/early Palouse soil, and Ringold Formation, as illustrated in a generalized east-west cross-section through the Hanford Site (Figure F-5). Variable surface topography and the variable elevation of the water table in the underlying uppermost aquifer causes this observed variation in vadose zone thickness. Other important features of the vadose zone include basalt of the Columbia River Basalt Group projecting above the water table north of the 200 East Area, clastic dikes occurring in the Hanford formation, and wind-blown sand and silt deposits at the surface.

Both the Ringold and Hanford formations have been subdivided into different units and facies based on rock type and depositional environment. Detailed stratigraphic sections for the 200 West and 200 East Areas are presented in Figure F-6. Location-specific cross-sections that provide examples of the variability in thickness and continuity of different sedimentary units and facies are presented in Figures F-7 through F-10. Structure and isopach maps of the principal geologic units that make up the vadose zone are included in Connelly et al. (1992a, 1992b).

Although sediments of the Hanford and Ringold formations are present beneath the 200 West, 200 East, and 200 North Areas, the vadose zones at these three locations differ significantly. The Plio-Pleistocene unit/early Palouse soil, which has a relatively low permeability that impacts the migration of liquid and vapor, is found only underlying the 200 West Area. The groundwater table occurs within the less conductive Ringold Formation in the 200 West Area and primarily within the Hanford formation in the 200 East and 200 North Areas (Figure F-11).

Calcium carbontate ($CaC0_3$) content is typically less than 1% in the Ringold Formation Unit E, less than 1% in the upper Ringold Unit, as much as 10% in the Plio-Pleistocene Unit/early Palouse soil and less than 2% in the Hanford formation.

The following subsections provide a brief description of the units, in descending order, that make up the vadose zone in the 200 Areas.

F4.1 SURFICIAL DEPOSITS

Holocene-aged deposits in the 200 Areas are dominated by eolian sheets of sand that form a thin veneer across the 200 Areas except in localized areas where they have been removed by human activity. Surficial deposits consist of very fine- to medium-grained sand to occasionally silty sand and are generally less than 3 m thick. Silty deposits (<1 m thick) have also been documented at waste management facilities (e.g., ponds and ditches) where fine-grained windblown material has settled out through standing water over many years.

F4.2 HANFORD FORMATION

The Hanford formation (informal designation) consists of uncemented gravels, sands, and silts deposited by Pleistocene cataclysmic flood waters. As discussed by Lindsey et al. (1991), these cataclysmic flood deposits are divided into three facies: gravel-dominated, sand-dominated, and silt-dominated. Based on the distribution of these facies, the Hanford formation is divided locally into three informal stratigraphic sequences. These sequences are designated as the upper gravel, sand, and lower gravel sequences. However, because of the variability of the Hanford formation sediments, contacts between these sequences are sometimes difficult to distinguish, especially where the sand sequence is missing and the upper gravel directly overlies the lower gravel. Although the Hanford formation as a whole is continuous throughout the vadose zone in the 200 Areas, none of these individual stratigraphic sequences is continuous across the 200 Areas: all three sequences display marked changes in thickness and continuity and are lithologically heterogenous (Figures F-8 though F-10).

F4.2.1 Upper Gravel Sequence of the Hanford Formation

The upper gravel sequence consists of interstratified gravel, sand, and lesser silt. Gravel-dominated deposits generally dominate the sequence. This coarse-grained upper gravel sequence is distinguished by a coarse-grained sand to a boulder gravel that displays massive bedding, plane to low angle bedding, and large-scale cross bedding in outcrop. The matrix is commonly lacking in the gravels, giving them an open-framework texture. The thickness of this coarse-grained sequence is 70 m (230 ft) at the northeast corner of the 200 North Area and thins to zero near the southern border of the 200 East Area. Within the 200 West Area, the thickness of the upper coarse unit ranges from 0 to 45 m (0 to 148 ft). The contact between the coarse-grained sequence and underlying strata is generally sharp.

F4.2.2 Sand Sequence of the Hanford Formation

The sand sequence of the Hanford formation in the 200 Areas is thick, but locally discontinuous. The sequence is 0 to 90 m (0 to 295 ft) thick in the central portion of the 200 East Area and 0 to 32 m (0 to 105 ft) thick in the 200 West Area. To the north, the sand sequence occurs only in the ancient flood channel along the eastern border of the 200 North Area, where it is up to 15 m (50 ft) thick. It is absent elsewhere in the 200 North Area. The sand sequence generally thickens to the south. The sequence is missing in the central part of the 200 West Area as a result of erosional scouring during the cataclysmic flooding events. This erosional scour is elongated in a north-south direction (Connelly et al. 1992b). The sand sequence consists predominantly of silt, silty sand, and sand with interbedded coarser sands.

F4.2.3 Lower Gravel Sequence of the Hanford Formation

The lower gravel sequence is dominated by deposits typical of the gravel-dominated facies. Local intercalated sandy beds typical of the sand-dominated facies are also found. In the 200 West Area this sequence is missing. It is found throughout most of the 200 East Area at a thickness ranging from 0 to 44 m (0 to 135 ft). However, it is absent in the east-central portion of the 200 East Area. In the 200 North area, the lower gravel sequence is up to 23 m (75 ft) thick in the ancient flood channel along the eastern border. Where this unit is overlain directly by the upper gravel sequence, it is not possible to distinguish between the two. Where it is overlain by the sand sequence, the contact between the sand and lower gravel sequences is interpreted to be at the top of the first thick gravelly interval (6 m [20 ft] or greater in thickness) encountered below the sand-dominated strata of the sand sequence.

F4.3 PLIO-PLEISTOCENE/EARLY PALOUSE SOILS

The Plio-Pleistocene/early Palouse soils are missing from the 200 East and North Areas. The early Palouse soil is largely restricted to the vicinity of the 200 West Area. The unit is differentiated from the overlying Hanford slackwater deposits by (1) greater calcium carbonate content, (2) cohesive structure in core samples, (3) uniform fine-grained texture, and (4) high natural-gamma response. It is distinguished from the underlying Plio-Pleistocene unit by the high natural-gamma response and lower calcium carbonate content. The loess-like sediments of the early Palouse are uncemented. The unit pinches out near the southern, eastern, and northern boundaries of the 200 West Area. Boreholes located west of the 200 West Area, however, do encounter the unit. Due to the fine-grained nature of the soil, this unit is also an impediment to downward migration of water and contaminants.

Like the early Palouse soil, the Plio-Pleistocene unit is restricted to the vicinity of the 200 West Area, pinching out to the northern, eastern, and southern boundaries of the area. It represents a highly weathered surface that developed on the surface of the Ringold Formation. In the 200 West Area, the calcrete facies dominates and is locally referred to as the "caliche layer." The differentiating features of this unit are (1) high degree of cementation, (2) presence of roots and animal bores in cores, and (3) white color. This unit is an impediment to vertical migration of water and vapor due to the high degree of cementation. The thickness is very irregular, and there may be erosional windows through the unit.

F4.4 RINGOLD FORMATION

The Ringold Formation is an interstratified sequence of unconsolidated clay, silt, sand, and gravel-to-cobble gravel deposited by the ancestral Columbia River. The Ringold Formation forms the lower part of the vadose zone throughout the 200 West Area and south of the 200 East Area. The Ringold Formation generally occurs completely in the saturated zone in and north of the 200 East Area, although relatively small isolated pockets of Ringold occur within the 200 East Area vadose zone. In the 200 Areas, these clastic sediments, from youngest to oldest, consist of four major facies: overbank-dominated deposits of the Upper Ringold; fluvial gravels of Unit E; paleosol and lacustrine muds of the lower mud sequence; and fluvial gravels of Unit A. Ringold Units B, C, and D are not present in the 200 Areas with the exception of localized occurrences of fluvial gravel of Unit C in the 200 East Area.

F4.4.1 Upper Ringold Unit

The upper Ringold unit is missing in the 200 East and 200 North Areas and is discontinuous across the 200 West Area because of post-Ringold erosion. The upper unit in the 200 West Area consists of silty overbank deposits and fluvial sands. This unit is recognized by (1) abundance of well-sorted sand, (2) light color, and (3) variable natural-gamma response. It is found only in the west, north, and central portions of the 200 West Area. It dips to the south-southwest.

F4.4.2 Unit E of the Ringold Formation

Unit E is the uppermost unit of the Ringold Formation in the 200 East and North Areas. It is dominantly composed of fluvial gravel, but strata typical of the fluvial sand and overbank facies may be encountered locally. The unit is recognized by (1) coarse texture, (2) high proportion of quartzite and granitic clasts, (3) relatively low calcium carbonate content, (4) partial consolidation, and (5) relatively low natural gamma response. In the 200 West Area, the gravels of Unit E generally thin from north-northwest to east-southeast while the surface dips toward the east-southeast (Figure F-5). Gravels of Unit E occur in the southwest corner of the 200 North Area, at a thickness up to 5 m (16 ft), and in the southwest corner of the 200 East Area, at a thickness up to 35 m (115 ft). From the 200 North and East Areas, Unit E thickens to the south-southwest. Unit E is the only part of the Ringold Formation identified within the 200 North Area.

F4.4.3 Lower Mud Sequence of the Ringold Formation

The overbank and lacustrine deposits of the lower mud sequence occur beneath the gravels of Unit E. The lower mud sequence generally thickens and dips to the west and to the southeast away from the 200 East Area (Figure F-5). The unit appears in the vadose zone as small isolated pockets in the center of the 200 East Area, underneath B Pond and between B Pond and Gable Mountain (Figure F-11). In the 200 West Area, it forms the aquitard at the base of the unconfined aquifer and is not a part of the vadose zone.

F4.4.4 Unit A of the Ringold Formation

In the 200 East Area, the fluvial gravels and sands of Unit A generally thicken and dip to the south (Connelly et al. 1992a). This unit rises above the water table in a small isolated pockets near the western and eastern boundaries of the 200 East Area and south of Gable Mountain (Figure F-11). Unit A is below the unconfined aquifer and therefore is not part of the vadose zone in the 200 West Area.

F4.5 COLUMBIA RIVER BASALT GROUP

The Elephant Mountain Member is the uppermost basalt unit (i.e., bedrock) in the 200 Areas. Except for a small area north of the 200 East Area boundary where it has been eroded away, the Elephant Mountain Member is laterally continuous throughout the 200 Areas. The Elephant Mountain Member is 21 to 30 m thick and thins to the north. Where the Elephant Mountain Member is absent, the Pomona Member forms the uppermost basalt unit. Areas of basalt project above the water table north of the 200 East Area (Figure F-11).

F4.6 CLASTIC DIKES

Clastic dikes are common structures that occur in many of the geologic units in the Pasco Basin and vicinity. One subset, clastic injection dikes, are fissures filled with sand, silt, clay, and minor coarser debris. Many dikes occur as near-vertical tabular bodies filled with multiple layers of unconsolidated sediments. The margins of most dikes and internal layers within dikes are separated by thin clay/silt linings (Fecht et al. 1998).

Clastic dikes range in continuous vertical extent from less than 30 cm to more than 55 m (Fecht et al. 1998). The deepest known occurrence of a clastic dike below ground surface is greater than 75 m (246 ft) in the 200 West Area; the total vertical extent of this clastic injection dike is not known (Fecht et al. 1998). In cross section, clastic dikes range in width from less than 1 mm to over 2 m (Fecht et al. 1998). Attitudes of the dikes range from vertical to horizontal, with near-vertical dikes being more common. Material filling the dikes is locally derived and ranges in size from mud to gravel. Distribution and hydraulic properties of the dikes are not well known. Clastic dikes occur in the Hanford formation in both the 200 West and East Areas. They are most common in the finer grained sand sequence and are rare in the open-framework gravel. Clastic dikes do occur in the Ringold Formation sediments elsewhere, but their occurrences are rare. Clastic dikes can be both preferential pathways for water and vapor and a barrier to water and vapor flow.

F4.7 WATER AND VAPOR FLOW THROUGH THE VADOSE ZONE

The flow of water, vapor, or other fluids through the vadose zone to the water table depends in complex ways on properties of both the soil and the migrating fluid. The flux is a function of the hydraulic conductivity and the hydraulic gradient. If the migrating fluid includes dissolved contaminants, the contaminants will also be transported through the vadose zone unless they are retained as a result of interaction with the soil.

The hydraulic conductivity has dimensions of velocity (e.g., m/day or ft/day) and describes the capability of sediments to transmit water, vapor, or other fluids through the soil. It generally has high values for coarser grained sediments such as sand and gravel and lower values for finer grained sediments such as silt and clay. In addition to hydraulic conductivity, subsurface flow is controlled by:

- Thickness, lateral distribution, and dip of the sediments
- Moisture retention capacity of the sediments
- Fluid density
- Porosity, grain size, and orientation of the sediments
- Permeability of the sediments to water, air, or other fluids
- Amount of natural and artificial recharge
- Degree of saturation of the vadose zone pore spaces.

The hydraulic gradient can be defined as the difference in hydraulic head (pressure and elevation head) between two locations in the subsurface divided by the distance between the two locations. Because both the head and the distance have units of length (e.g., m or ft), the hydraulic gradient is usually dimensionless.

The distribution of contaminants within the vadose zone is a function of the concentration of the contaminants at the source and the physical and chemical interactions of the contaminants with the sediments through which they migrate. The degree to which contaminants interact with sediments depends on the properties of the particular contaminant (e.g., volatility, solubility), the geochemical properties of the sediments (e.g., calcium carbonate content, organic content, clay content), and the physical properties described above. The distribution coefficient (K_d) for a particular contaminant describes the likelihood that the contaminant will partition to the soil matrix rather than to the migrating liquid. A high K_d indicates that the contaminant will tend to be retained on the soil particles, whereas a low K_d indicates that the contaminant will tend to remain dissolved in the water. The retardation factor for a particular contaminant describes how much its travel time is lengthened, compared to that of water, as a result of its retention on soil particles.

The mobility of each contaminant is determined by its K_d, and each contaminant will have a specific K_d for a particular sediment type. In general, the K_d is dependent on the amount of fine-grained material in the sediment. The more fine-grained the material, the higher the K_d and the greater the capacity of the soil to retain moisture and contaminants. In the 200 West Area, the Plio-Pleistocene/early Palouse soils will have higher K_d values than the Hanford or Ringold sands, which will have higher K_d values than the Hanford or Ringold gravels. Further discussions on the mobility of contaminants are provided in Section 3.3.

Perched water zones form when moisture moving downward through the vadose zone accumulates on top of low-permeability soil lenses, highly cemented horizons, or above the contact between a fine-grained horizon and an underlying coarse-grained horizon as a result of the capillary barrier effect. The Plio-Pleistocene/early Palouse soil unit is the most significant aquitard in the 200 West Area above the water table and is a major component controlling the accumulation of perched water where effluent was discharged. The Ringold lower mud sequence also represents a potential perching layer. Up to 2.1 m (7 ft) of perched water has been found above the lower mud sequence in the vicinity of the 216-B-3C Pond lobe in the 200 East Area.

Wastewater discharges since 1943 have contributed to the rise in the water table elevation underlying the 200 Areas and have created local groundwater mounds, most notably under U Pond in the 200 West Area and under B Pond in the 200 East Area. In the 200 West Area, water levels have declined over 6 m (20 ft) since 1984 because of reduced discharges to the cribs and unlined trenches; in the 200 East Area, the water table elevation has been declining since 1988 because wastewater discharges to disposal facilities in the 200 East Area and B Pond were reduced (Hartman and Dresel 1998). A continued decrease in the water table elevations and concomitant increase in the thickness of the vadoze zones underlying the 200 Areas is expected.

The thickness, lateral distribution, and dip of the sediments in the vadose zone in the 200 Areas were discussed in the previous sections. Structure and isopach maps of those sediments are provided in Connelly et al. (1992a, 1992b). The lateral continuity and structural orientation of the sediments determine the spatial distribution of hydraulic properties.

The major driving force to move contaminants from the vadose zone to the water table is both artificial and natural recharge. Artificial recharge in the 200 Areas varied widely from small intermittent volumes applied to cribs to thousands of gallons per day at the ditches and ponds. Since 1995, most artificial recharge in the 200 Areas has ceased, and the principal driving force today is natural recharge, which averages approximately 100 mm/yr (4 in./yr) in the 200 Areas.

In the vadose zone, the pressure head is negative under unsaturated conditions. This reflects the fact that water in the unsaturated zone is held in the soil pores under negative pressure by surface-tension forces. If the volume of water in the vadose zone equals the volume that can be retained by surface tension forces (defined as the field capacity of the soil), no water will be available to migrate. However, as additional water is added to the vadose zone, for example by recharge, it will continue to migrate vertically under the force of gravity. Analyzing water flow in the vadose zone is complicated because both water content and hydraulic conductivity are nonlinear functions of pressure head. As the water content increases, the surface tension holding the water in the pore space decreases, and the water flux increases. Therefore, to analyze flow in the vadose zone, the moisture-retention capacity of the soil must be evaluated by measuring water content as a function of pressure head. The relationship between water content and pressure head is typically displayed graphically on a moisture retention curve. If either the saturated hydraulic conductivity or the unsaturated hydraulic conductivity at a specified water content is known, the moisture-retention curve can be used to generate the unsaturated hydraulic conductivity as a function of moisture content (typically displayed graphically as a curve). Khaleel and Freeman (1995) and Connelly et al. (1992a, 1992b) have cataloged the moisture retention curves as well as the saturated hydraulic conductivity collected for the 200 Areas soils. Knowing the unsaturated hydraulic conductivity allows the travel time for water in the vadose zone to be calculated for various conditions.

Unsaturated hydraulic conductivities may vary by several orders of magnitude depending on moisture content. Moisture content measurements in the 200 Area vadose zone have historically ranged widely from 1% to saturation (perched water) from liquid disposal activities, but typically range from 2% to 10% under ambient conditions. Connelly et al. (1992a, 1992b) summarized hydraulic conductivity measurements made for 200 Area soils under various moisture contents. For Hanford formation samples taken in the 200 East Area, vadose zone hydraulic conductivity values at saturation range from about 10^{-6} to 10 cm/s, with many of the values falling in the 10^{-5} to 10^{-3} cm/s range. However, under unsaturated conditions at a 10% moisture content, hydraulic conductivity values range from about 10^{-16} to 10^{-5} cm/s, with many of the values falling in the 10^{-10} to 10^{-5} m/s range. Unsaturated hydraulic conductivity values for Ringold Unit A gravel samples ranged from less than 10^{-18} to 10^{-10} cm/s at moisture contents near 10% and from 10^{-7} to 10^{-5} cm/s at saturation moisture contents of 39% and 57%, respectively. Ringold lower mud samples had unsaturated hydraulic conductivities ranging from less than 10^{-18} at a 10% moisture content to approximately 10^{-9} at saturation (57%) (DOE-RL 1997b).

A detailed description for using moisture-retention and hydraulic conductivity curves to calculate travel times through the vadose zone for steady-state natural recharge conditions is provided by DOE-RL (1996a in Appendix C). The following steps can be used to calculate the time for dissolved contaminants to travel from a liquid waste site to groundwater (this does not include the reverse well sites or liquids other than water):

1. Use existing geologic maps to determine the lithology at the waste site and establish the thickness of each geologic unit.

2. Use the estimated natural recharge rate and the existing moisture retention curves appropriate for the geologic unit to calculate a steady state moisture content.

3. Use the moisture content to calculate travel time for water through the geologic unit.

4. Sum the travel times through the different geologic units encountered.

5. Apply a contaminant-specific retardation factor for each contaminant based on its distribution coefficient and the density of the soils to obtain the travel time for each contaminant at the waste site to reach groundwater.

6. For a radionuclide, apply the specific half-life to estimate the percentage of concentration remaining by the time the radionuclide arrives at groundwater.

Using this methodology, the travel time for dissolved contaminants to reach the groundwater can be estimated and the potential impact to the groundwater can be evaluated.

F5.0 SURFACE WATER HYDROLOGY OF THE 200 AREAS

Primary surface water features associated with the Hanford Site are the Columbia and Yakima Rivers. The 200 Areas are not on a designated flood plain of the Columbia River based on probable maximum flood data presented by Skaggs and Walters (1981). Calculations indicate that the probable maximum flood of the Columbia River would result in a flood wave crest to an elevation of 125 m (410 ft) above msl. A flood to this elevation would inundate portions of the 100 and 300 Areas along the Columbia River, but would not be expected to affect more central portions of the Hanford Site including the 200 Areas (DOE-RL 1993b, 1993c).

Cold Creek and its tributary, Dry Creek, are ephemeral streams on the Hanford Site that are within the Yakima River drainage system. A probable maximum flood (storm frequency of 500 to 1,000 years) associated with the Cold Creek and Dry Creek drainages southwest of the 200 West Area would inundate approximately the southwestern quarter of the 200 West Area, but not the 200 East or 200 North Areas. Based on this result, Skaggs and Walters (1981) stated that flood protection would be required to an elevation of about 197 m (645 ft) above msl through the part of the Cold Creek Valley in the vicinity of the 200 West Area (DOE-RL 1993b, 1993c).

The 216-N-8 Pond (West Lake), 0.8 km (0.5 mi) east of 200 North Area, is the only natural lake within the Hanford Site and the only naturally occurring surface water body within the vicinity of the 200 Areas. Artificial surface water bodies such as wastewater ponds, cribs, and ditches associated with nuclear fuel reprocessing and waste disposal activities have also been present in the 200 Areas during the last 50 years; and a few are still active.

Before waste water disposal began at the Hanford Site, West Lake was an intermittent seasonal pond located in a natural basin at the base of Gable Mountain. After the introduction of large quantities of water to the 216-A-25 Pond (Gable Mountain Pond) 1.2 km to the southwest in 1957, the water table in the area was elevated sufficiently to provide year-round water to the West Lake (DOE-RL 1993a, 1993c). West Lake is less than 1 m (3 ft) deep and extends over approximately 40,000 m^2 (10 acres) (DOE 1988).

Bodies of standing water such as ponds are accessible to migratory waterfowl, creating a potential pathway for the dispersion of contaminants (Neitzel 1997). As the ponds dry up, exposed contaminated soil can be transported by wind. West Lake is vegetated with riparian plant species.

F6.0 GROUNDWATER

Groundwater underlying the Hanford Site flows within a multi-aquifer system. The uppermost aquifer currently is within the sediments of the Ringold and Hanford formations overlying the Columbia River Basalt. In general, the uppermost aquifer system is unconfined and is interconnected on a sitewide scale (Neitzel 1997). Locally, however, within the 200 Areas the uppermost aquifer may be confined or semi-confined. The aquifers within the Columbia River Basalt are usually confined. North of the 200 East Area, the unconfined system is in communication with the confined system (DOE-RL 1993b).

Before wastewater disposal operations began at the Hanford Site, the uppermost aquifer was mainly within the Ringold Formation, and the water table extended into the Hanford formation at only a few locations (Newcomb et al. 1972). However, wastewater discharges and upgradient irrigation have elevated the water table across the Hanford Site. Because of the general increase in groundwater elevation, the uppermost aquifer now extends upward into the Hanford formation across most of the eastern half of the Hanford Site (Figure F-11). This change has resulted in an increase in groundwater transmissivity, not only because of the greater volume of groundwater, but also because the newly saturated Hanford sediments are approximately 10 to 100 times more permeable than the Ringold sediments, which are more consolidated and partially cemented (Neitzel 1997).

Since the beginning of Hanford operations in 1943, the water table has risen about 27 m (89 ft) under at least one disposal area in the 200 West Area and about 9 m (30 ft) under disposal ponds near the 200 East Area. The volume of water that has been discharged to the ground at the 200 West Area is actually less than that discharged at the 200 East Area. However, the lower conductivity of the aquifer near the 200 West Area has inhibited groundwater movement in this area and resulted in a higher groundwater mound. Groundwater flow conditions vary between the 200 West and 200 East Areas in part because the water table occurs in different units with different hydraulic properties. In the 200 West Area, the water table occurs primarily in Ringold gravels, while in the 200 East Area, it occurs primarily in the Hanford sands and gravels. In general, the Ringold gravels have a lower hydraulic conductivity than the Hanford sediments (Neitzel 1997).

Prior to the initiation of waste disposal activities at the Hanford Site, the general groundwater flow appears to have been from west to east across the site to the Columbia River with an average horizontal hydraulic gradient of 0.001 (Graham et al. 1981). Wastewater discharges since 1943 have created local groundwater mounds under the primary wastewater disposal areas in the 200 Areas; the locations and heights of the mounds have changed as wastewater discharge locations and rates have changed. Although the general groundwater flow direction has remained from west to east toward the Columbia River, the presence of the groundwater mounds has locally affected the direction of groundwater movement, causing radial flow from the discharge areas. Hydraulic gradients significantly increased as the groundwater elevations increased. In recent years, discharges of water to the ground have been greatly reduced. As a result, the elevation of both the water table and the local groundwater mounds have been declining. As the mounds continue to dissipate, horizontal hydraulic gradients are also expected to decrease and to return to the natural regional easterly direction (DOE-RL 1993b).

Groundwater elevations within the upper Cold Creek Valley rose 15 m between 1944 and 1955 in response to artificial recharge from agricultural irrigation. The continued influence of irrigation recharge within the upper Cold Creek Valley is still evident, and may be responsible for maintaining elevated water levels north and west of the 200 West Area (DOE-RL 1993b).

The groundwater underlying the Hanford Site contains plumes of chemical and radiological contaminants as a result of wastewater discharge since 1943. The sources of these contaminants during Hanford operations, and the waste management practices that introduced them to the environment, are described in Section 3.2. The physical and chemical interactions between the contaminated liquid discharges and the sediments resulted in mobile contaminants migrating to groundwater and less mobile contaminants being retained within the vadose zone, as described in Section 3.3.

F7.0 NATURAL BACKGROUND CONCENTRATIONS OF CHEMICAL AND RADIOLOGICAL ANALYTES

The range of background concentrations in soil at the Hanford Site and associated environments has been documented for both nonradioactive analytes (DOE-RL 1995a) and radionuclides (DOE-RL 1996a). A thorough discussion of the sitewide conceptual model that guided the collection and interpretation of background data is included in these reports.

The characterization of background in soil and groundwater is an important component in environmental restoration activities because it can be used to identify contamination, establish cleanup goals, evaluate restoration alternatives, and assess risk and cleanup levels. Background conditions are also useful for establishing pre-operational conditions for new and existing facilities. The sitewide approach has been determined to be a technically viable and cost-effective method for evaluating background conditions at the Hanford Site, as opposed to establishing background concentrations at each individual waste unit.

To establish nonradioactive background, 104 samples were collected randomly from a variety of locations on or near the Hanford Site. A variety of judgment samples were also collected to include minor soil types that were potentially missed during random sampling. Only the random samples were used to compute the statistics used to define background. A subset of the nonradioactive random background sample set was selected to characterize radionuclide background; some surface samples associated with monitoring activities were also used to establish levels for anthropogenic background (i.e., man-made, from global fallout).

A summary of the background data for nonradioactive and radioactive analytes is presented in Tables F-3 and F-4, respectively. Ecology mandates the use of the 90th percentile of the appropriate distribution for purposes of comparing background to cleanup levels (Ecology 1992). Other statistical approaches may also be used when background is used as a cleanup standard. Ecology has accepted alternate statistical tests for use at Hanford (DOE-RL 1994).

F8.0 ENVIRONMENTAL RESOURCES

Environmental resources for the 200 Areas refers to the wildlife and plants found within the vicinity of these areas. Biological and ecological information aids in evaluating impacts to the environment, including potential effects of implementing remedial actions, and identification of sensitive environments and species.

F8.1 VEGETATION

The vegetation of the 200 Areas Plateau is characterized by native shrub-steppe, interspersed with large areas of disturbed ground dominated by annual grasses and forbs. In the native shrub-steppe, the dominant shrub is big sagebrush (*Artemisia tridentata*) and the understory is dominated by the native perennial, Sandberg's bluegrass (*Poa sandbergii*) and the introduced annual, cheatgrass (*Bromus tectorum*). Other shrubs typically present include rabbitbrush (*Chrysothamnus* spp.), spiny hopsage (*Grayia spinosa*), and antelope bitterbrush (*Purshia tridentata*). Other native bunchgrasses that are also present include Indian ricegrass (*Oryzopsis hymenoides*) and needle-and-thread grass (*Stipa comata*). Common herbaceous species include turpentine cymopteris (*Cymopteris terebinthinus*), globemallow (*Sphaeralcea munroana*), balsamroot (*Balsamorhiza careyana*), milkvetch (*Astragalus* spp.), yarrow (*Achillea millifolium*), and daisy (*Erigeron* spp.).

Disturbed habitat communities are primarily the result of either range fires or mechanical disturbance (e.g., from road clearing or facility construction). Mechanical disturbance typically entails a loss of soil structure and disruption of nutrient cycling, which have a significant effect on the plant species that will re-colonize a site. The principal colonizers of disturbed sites are annual weeds, such as Russian thistle (*Salsola kali*), Jim Hill mustard (*Sisymbrium altissimum*), bur-ragweed (*Ambrosia acanthicarpa*), and cheatgrass. Once disturbed, native stands of vegetation may take decades (or centuries if the soil has been removed) in the mid-Columbia climate to return to a state near to the original condition. Disturbed areas with sandy soils that lack vegetation typically have higher recharge rates than sites with a plant cover (Fayer and Walters 1995).

The vegetation that was present in and around the former waste ponds and ditches on the 200 Areas plateau includes cottonwood (*Populus trichocarpa*), willows (Salix spp.), sedges (*Carex* spp.), and cattails (*Typha latifolia*). However, most of this vegetation has died with the cessation of liquid effluents flowing to the ponds and ditches. The only pond that remains in the 200 Areas is the naturally occurring West Lake. It exists because of a naturally shallow water table, and is vegetated with riparian species such as bulrush (*Scirpus* spp.).

F8.2 WILDLIFE

The largest mammal frequenting the 200 Areas plateau is the mule deer (*Odocoileus hemionus*). While mule deer are much more common along the Columbia River, the few that forage throughout the 200 Areas make up a distinct group called the Central Population (Dirkes and Hanf 1997). A large elk herd (*Cervus canadensis*) currently resides on the Fitzner-Eberhardt Arid Lands Ecology Reserve (ALE). Occasionally a few animals have been seen just south of the 200 Areas, and their presence may increase as the herd on ALE continues to grow. Other mammals common to the 200 Areas are badgers (*Taxidea taxus*), coyotes (*Canis latrans*), Great Basin pocket mice (*Perognathus parvus*), northern pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging ability and have been suspected of excavating contaminated soil at 200 Area radioactive waste sites (O'Farrell et al. 1973). The majority of badger diggings are a result of searches for food, especially other burrowing mammals such as pocket gophers and mice. Pocket gophers and mice (especially Great Basin pocket mice and deer mice) are abundant in the 200 Areas, consume predominantly vegetation, and can excavate large amounts of soil as they construct their burrows (e.g., Hakonson et al. 1982). Mammals associated with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and various bat species.

Common bird species in the 200 Areas include starlings (*Sturnus vulgaris*), horned larks (*Eremophila alpestris*), meadowlarks (*Sturnella neglecta*), western kingbirds (*Tyranus verticalis*), rock doves

(*Columba livia*), black-billed magpies (*Pica pica*), and ravens (*Corvus corax*). Burrowing owls (*Athene cunicularia*) commonly nest in the 200 Areas in abandoned badger or coyote holes. Loggerhead shrikes (*Lanius ludovicianus*) and sage sparrows (*Amphispiza belli*) are common nesting species in habitats dominated by sagebrush. Long-billed curlews (*Numenius americanus*) have been observed nesting on inactive 200 Areas waste sites.

Common reptiles at the 200 Areas include gopher snakes (*Pituophis melanoleucus*) and sideblotched lizards (*Uta stansburiana*). Three of the most common groups of insects include darkling beetles, grasshoppers, and ants.

F8.3 SPECIES OF CONCERN

The Hanford Site is home to a variety of species of concern, but many of these are restricted to the Columbia River and associated shoreline. No plants on the federal list of threatened and endangered species are known to occur on the Hanford Site. Two animal species that do occur at Hanford, bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*), depend on the river corridor and are rarely observed at the 200 Areas. Several state-threatened, endangered, and candidate species are found in and near the 200 Areas, such as ferruginous hawks (*Buteo regalis*), burrowing owls, loggerhead shrike, long-billed curlew, and sage sparrow. Migratory bird species are also protected by the *Migratory Bird Treaty Act*. Plant species of concern (which includes those listed as state endangered, threatened, sensitive, and monitored) that may occur at the 200 Areas include Dwarf evening primrose (*Camissonia pygmaea*) and Piper's daisy (*Erigeron piperianus*) (Washington Natural Heritage Program 1998).

Both plant and animal species of concern, their designations, and places of occurrence can change over time. At this time none are suspected of having the potential to significantly affect the characterization or remediation of any waste site, but incorporating the needs of these species into project planning will help to mitigate any potential effects. Especially important is avoiding, where possible, undisturbed shrub-steppe habitat, as this is important to many species of concern. The undisturbed shrub steppe in and near the 200 Areas is Level 3 habitat, which requires mitigation of any disturbance, for example through avoidance and minimization, and possibly rectification and compensation (DOE-RL 1996b). More detailed direction on protecting Level 3 habitats and species of concern is provided in the *Hanford Site Biological Resources Management Plan* (DOE-RL 1996b). In addition, site-specific environmental surveys, required before ground disturbance can occur, serve as a final check to ensure ecological resources are adequately protected.

F8.4 SIGNIFICANCE OF ECOLOGICAL RESOURCES TO CONTAMINANT FATE AND TRANSPORT

Wildlife and plants in the 200 Areas have a history of taking up contaminants from waste sites through burrowing and root penetration (e.g., Johnson et al. 1991, 1994). Plant roots can take up radionuclides to varying extents, depending on the radionuclide, plant species, depth of contamination, and soil chemistry. Plants such as Russian thistle that have both deep roots and grow preferentially on disturbed, poor soils are especially known for taking up certain radionuclides and then releasing them to the environment as the plant dies back in the fall or as animals eat the contaminated parts of the plant. Animals that burrow, such as harvester ants, mice, pocket gophers, and badgers, have all been found to distribute contaminants from buried waste sites at Hanford. For example, O'Farrell et al. (1973) documented the spread of radionuclides by black-tailed jackrabbits (*Lepus californicus*) licking contaminated salts in the BC Cribs and leaving contaminated fecal pellets and urine over an area of several square miles. Animals digging into waste sites can distribute contaminants or be affected by contaminants by many pathways, including

(1) wind dispersal of excavated soil, causing spread of contamination; (2) animal consumption of the soil (e.g., if it contains a salt and is consumed on purpose, or is lodged on the pelt of a prey species consumed by a predator); (3) a dose to burrowing animals from radionuclides in the soil; and (4) excavated contaminated materials exposing other animals to an external dose. The probable maximum depths of burrowing and root penetration for the more significant wildlife and plant species are shown in Table F-5.

As radionuclides and other hazardous materials enter the food web, the degree to which they bioaccumulate depends on the specific contaminant, the species of plant or animal it transfers into, and the part of the biota it enters (e.g., bones or seeds may accumulate more or less of a material than muscle or leaf material).

F9.0 CULTURAL RESOURCES

In 1996, the U.S. Department of Energy, Richland Operations Office (RL), the Washington State Historic Preservation Office, and the Advisory Council on Historic Preservation signed a Programmatic Agreement (PA) (DOE-RL 1996c) that modified compliance with Section 106 of the *National Historic Preservation Act* with respect to Hanford's historic buildings. Through the PA, RL created the Hanford Site Manhattan Project and Cold War Era Historic District as a means to replace individual building-by-building documentation and mitigation with the systematic treatment of a representative sample of buildings. As required by the PA, all 200 Area buildings were evaluated for their eligibility for listing in the National Register of Historic Places as contributing or noncontributing properties within the Historic District. Of the 139 buildings determined to be contributing properties, 62 were selected to represent the events and activities that took place within the 200 Areas. Buildings selected included the 202-A PUREX Plant; 212-N Lag Storage Facility; 221-T Plant; 222-S REDOX Plant; 225-B Encapsulation Building; 231-Z Plutonium Metallurgical Laboratory; 232-Z Waste Incinerator Facility; 233-S Plutonium Concentration Building; 234-5Z Plutonium Finishing Plant; 236-Z Plutonium Reclamation Facility; 242-Z Water Treatment Facility; 282-E Pump House and Reservoir Building; 283-E Water Filtration Plant; and 284-E Power House and Stream Plant. If alteration or destruction is planned for buildings in the 200 Areas as a result of this project, mitigation of the impacts will be undertaken in accordance with the conditions of the Hanford Site Manhattan Project and Cold War Era Historic District Treatment Plan (DOE-RL 1998).

The Hanford Cultural Resources Laboratory conducted a comprehensive archaeological resources review for the fenced portions of the 200 Areas in 1987-1988. This review incorporated both an examination of the existing literature as well as "an intensive pedestrian survey of all undisturbed portions of the 200 East Area and a stratified random survey [of the undisturbed portions] of the 200 West Area" (Chatters and Cadoret 1990). Two historic-archaeological sites (i.e., can and glass scatters), four isolated historic artifacts, one isolated cryptocrystalline flake, and an extensive linear feature (i.e., the White Bluffs Road) were the only materials greater than 50 years old discovered during the field survey. Only the White Bluff Road, in its entirety, was determined eligible for listing in the National Register. This road, which passes diagonally southwest to northeast through the 200 West Area, originated as a Native American trail. It has been in continuous use since antiquity and continued to play a role in Euroamerican immigration, development, agriculture, and Hanford Site operations. Within the 200 West Area, two intact segments of the road are considered contributing elements: (1) the southwest segment from the perimeter fence to approximately 19th Street at Dayton Avenue, and (2) the extreme northeast segment above T Plant to the perimeter fence. A 100-m (328-ft) easement has been created to protect these segments of the road from uncontrolled disturbance. The remaining portions of the road within the 200 West Area have been disturbed or destroyed by previous construction-related activities and are classified as noncontributing.

In general, archaeological sites have been recorded primarily in areas of high topographic relief and near water sources on the Hanford Site. Because of the lack of nearby water supplies, a terrain of low relief, and large open inland flats, the 200 Areas maintain only limited archaeological potential, with the exception of trail-associated isolated finds. Previous construction-related activities for the 200 Areas facilities, such as buildings and waste sites, further reduce the likelihood of archeological resources being located in these areas of high disturbance. Historic-archaeological sites and isolated finds are similarly limited in their distribution. However, site-specific cultural resource surveys will be required before ground disturbance can occur to ensure that archaeological resources are adequately identified and protected. This is particularly important for remedial actions that will take place outside the fenced portions of the 200 Areas.

With the exception of project-specific information provided for undertakings that have, or might have, impacted the sacred sites of Gable Mountain and Gable Butte, no comprehensive consultations have been conducted with Tribal representatives to identify other locations within the vicinity of the 200 Areas that might be of concern to the Native American community. Archaeological surveys of nearby areas in 1968 and in the late 1980's identified numerous sites believed to represent religious and hunting activities (Rice 1968, 1987). In addition to these sites marked by rock cairns, rock alignments, and/or artifacts, other sites relating to subsistence and ceremonial activities, which are not marked by physical remains, may be present but unrecognized within the project area. For example, subsistence, medicinal, and ceremonial plants were all gathered on the Hanford Site; however, the existence and significance of such locations often can be ascertained only through interviews with knowledgeable users of the area. Plants, and the areas from which they are gathered, qualify as Traditional Cultural Properties, and could merit inclusion in the National Register of Historic Places because of their "association with the cultural practices and beliefs of a living community" (Parker and King 1990). This is also true for sites of spiritual significance to the Tribes. The identification of sacred, ceremonial, and traditional use areas cannot be accomplished without the use of traditional elders and spiritual leaders. Their involvement is needed to identify those areas for which no on-the-ground evidence exists. Therefore, consultations with representatives of the Native American communities with ancestral ties to the Hanford Site will be required before ground disturbance can occur to ensure that traditional cultural resources are adequately identified and protected.

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Figure F-1. Topography of the Hanford Site.

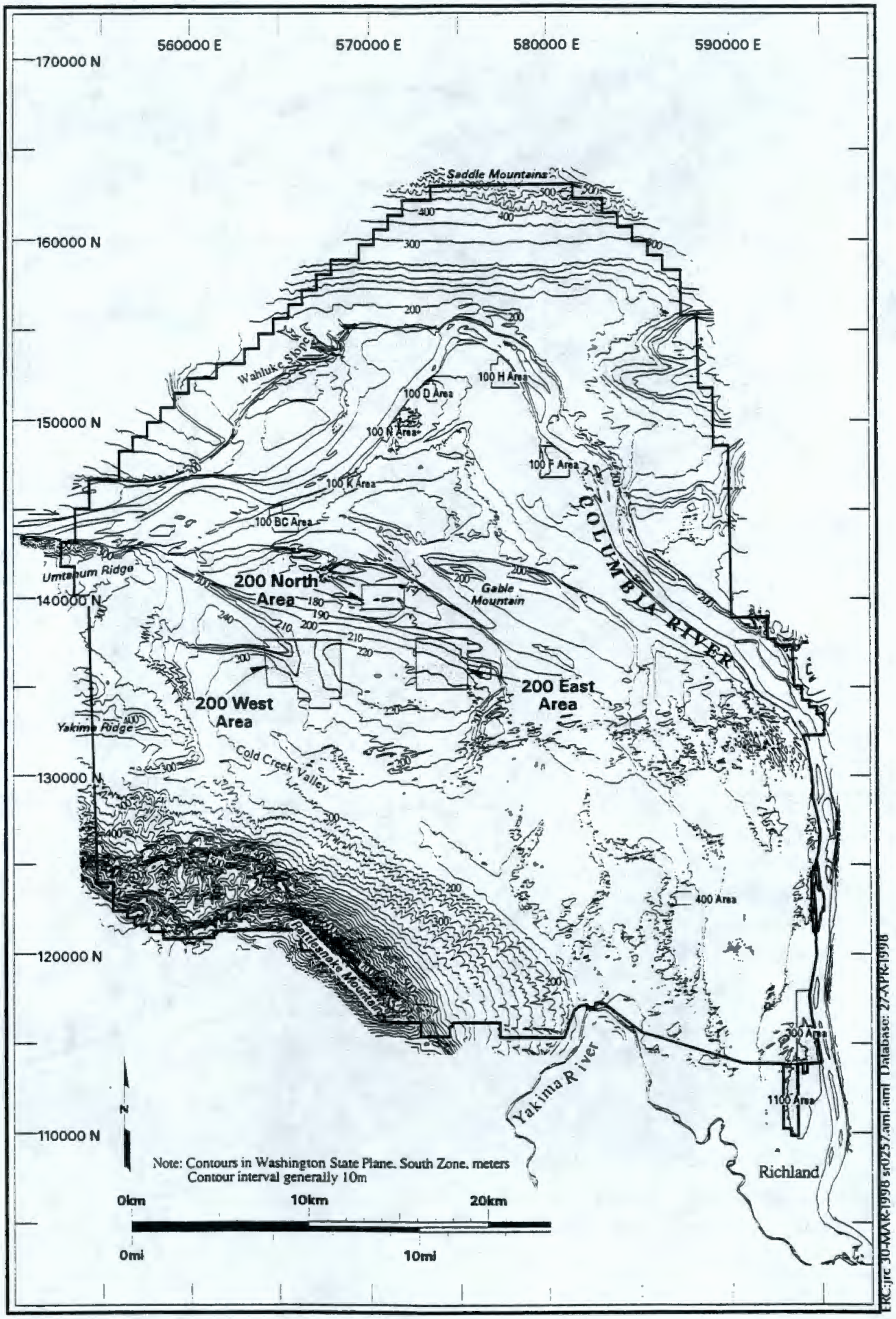


Figure F-2. Wind Roses at the 10-m (30-ft) Level of the Hanford Meteorological Monitoring Network, 1982-1996 (from Neitzel 1997).

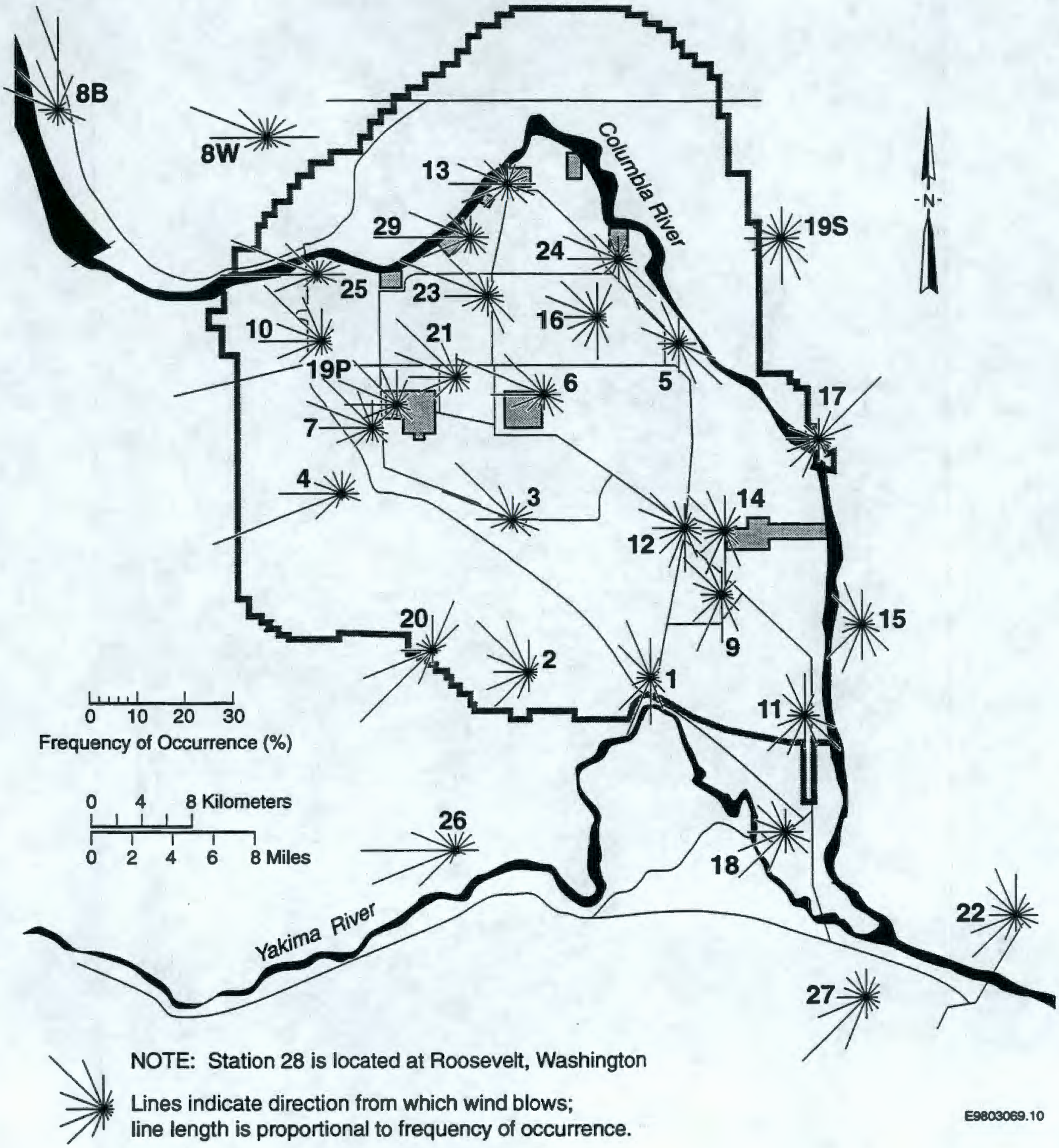


Figure F-3. Average Daily Barometric Pressure at the Hanford Meteorological Station, 1997 (averaged from hourly observations provided by HMS).

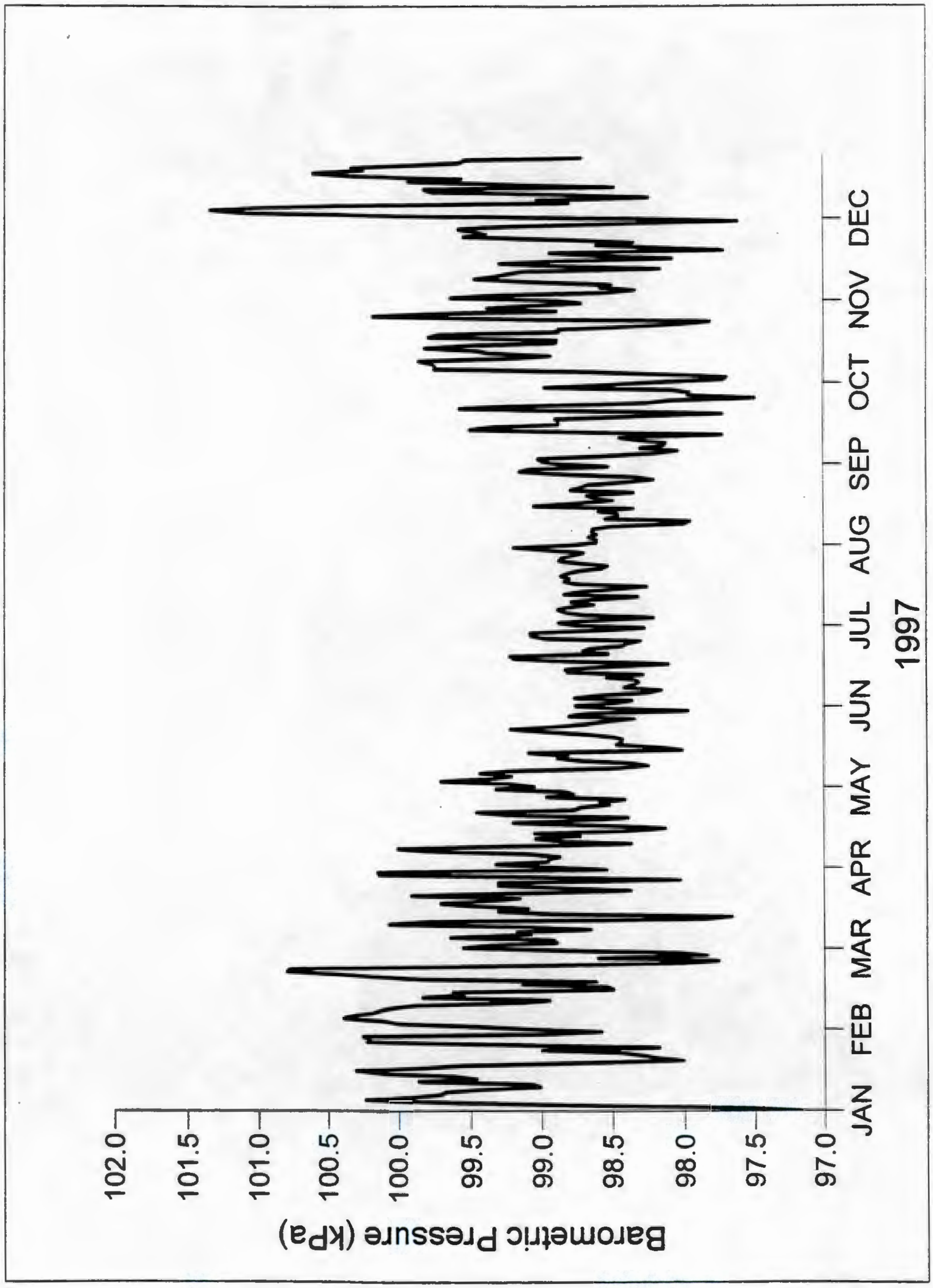
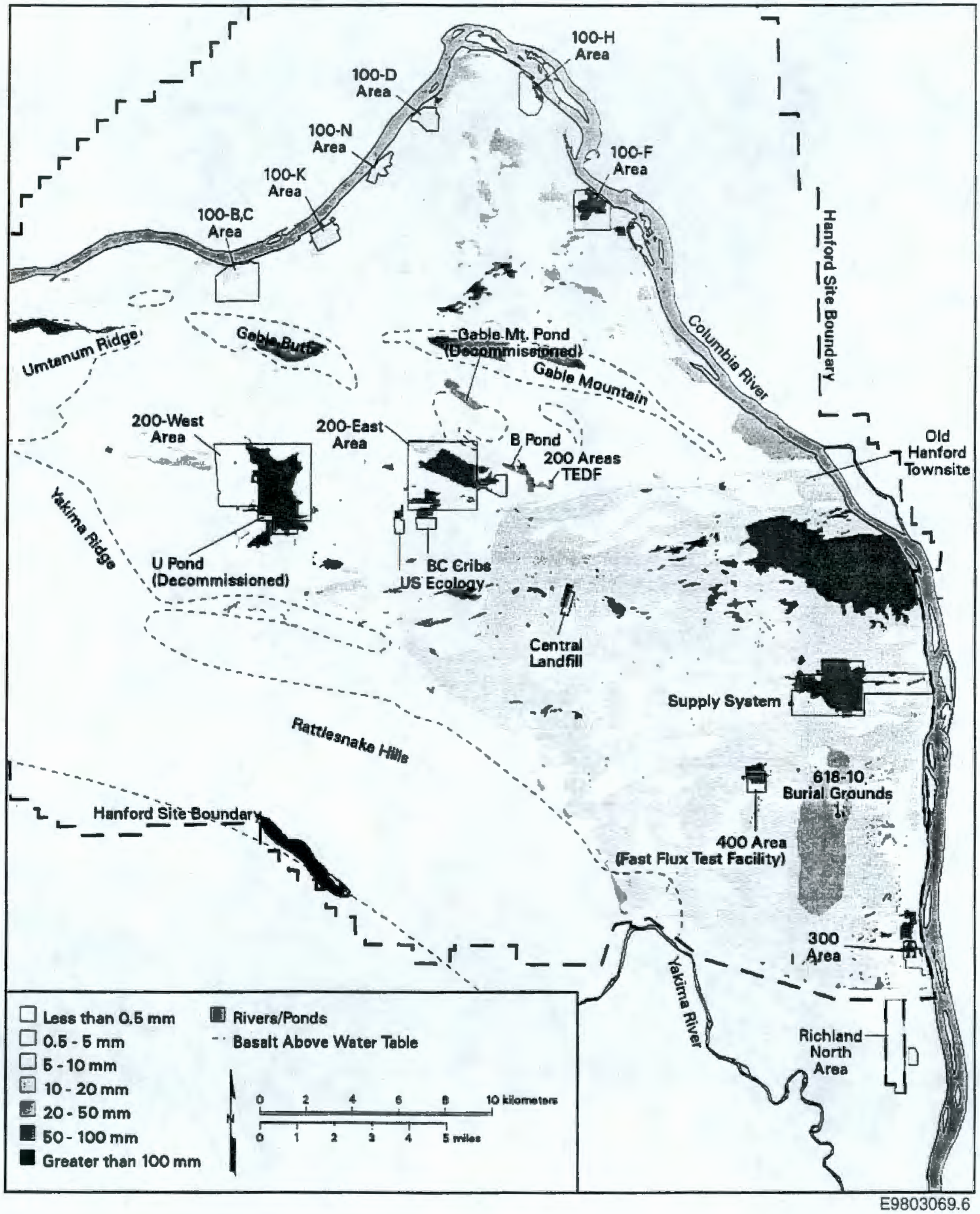


Figure F-4. Estimated Recharge at the Hanford Site from Infiltration of Precipitation and Irrigation (from Fayer and Walters 1995).



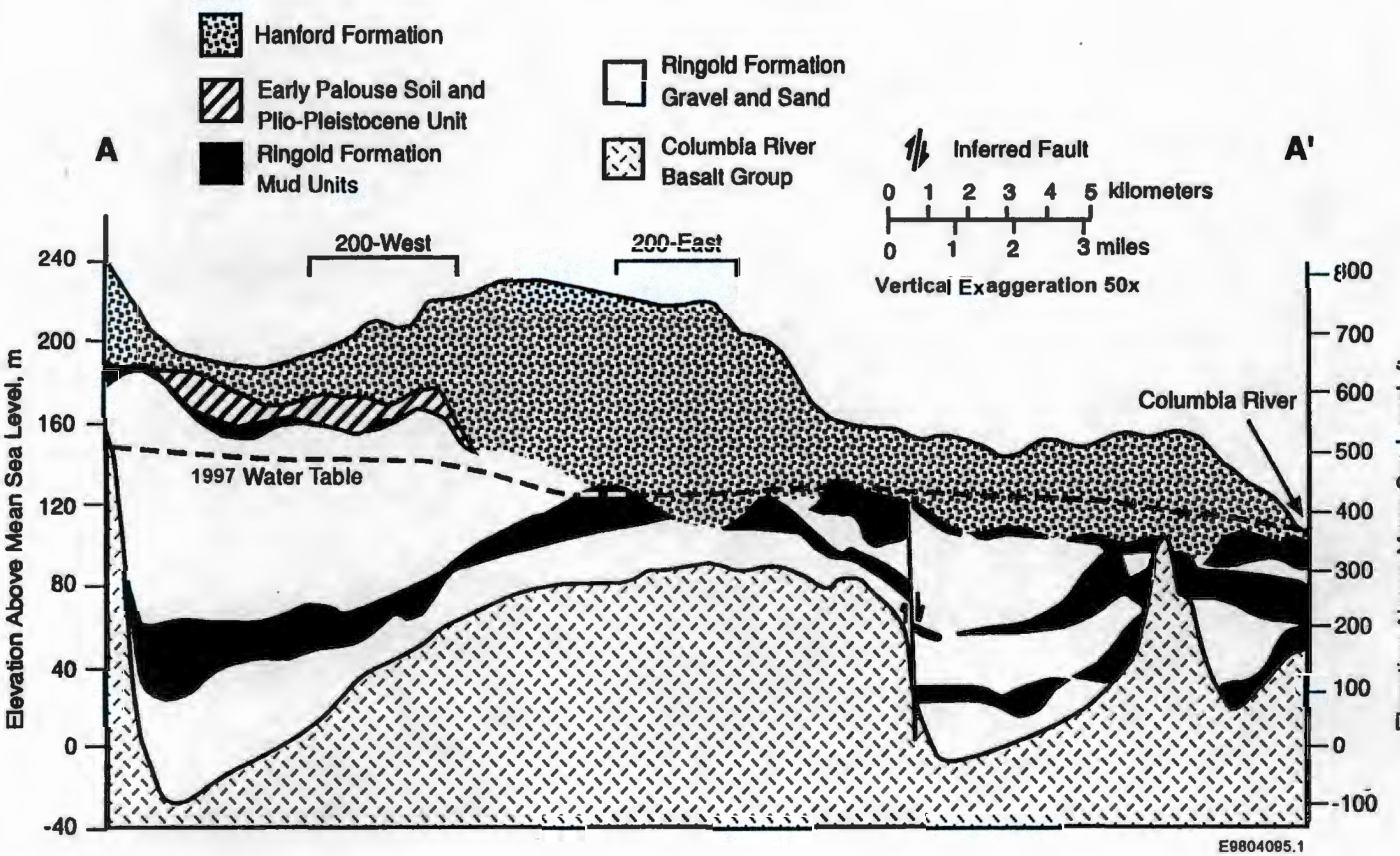
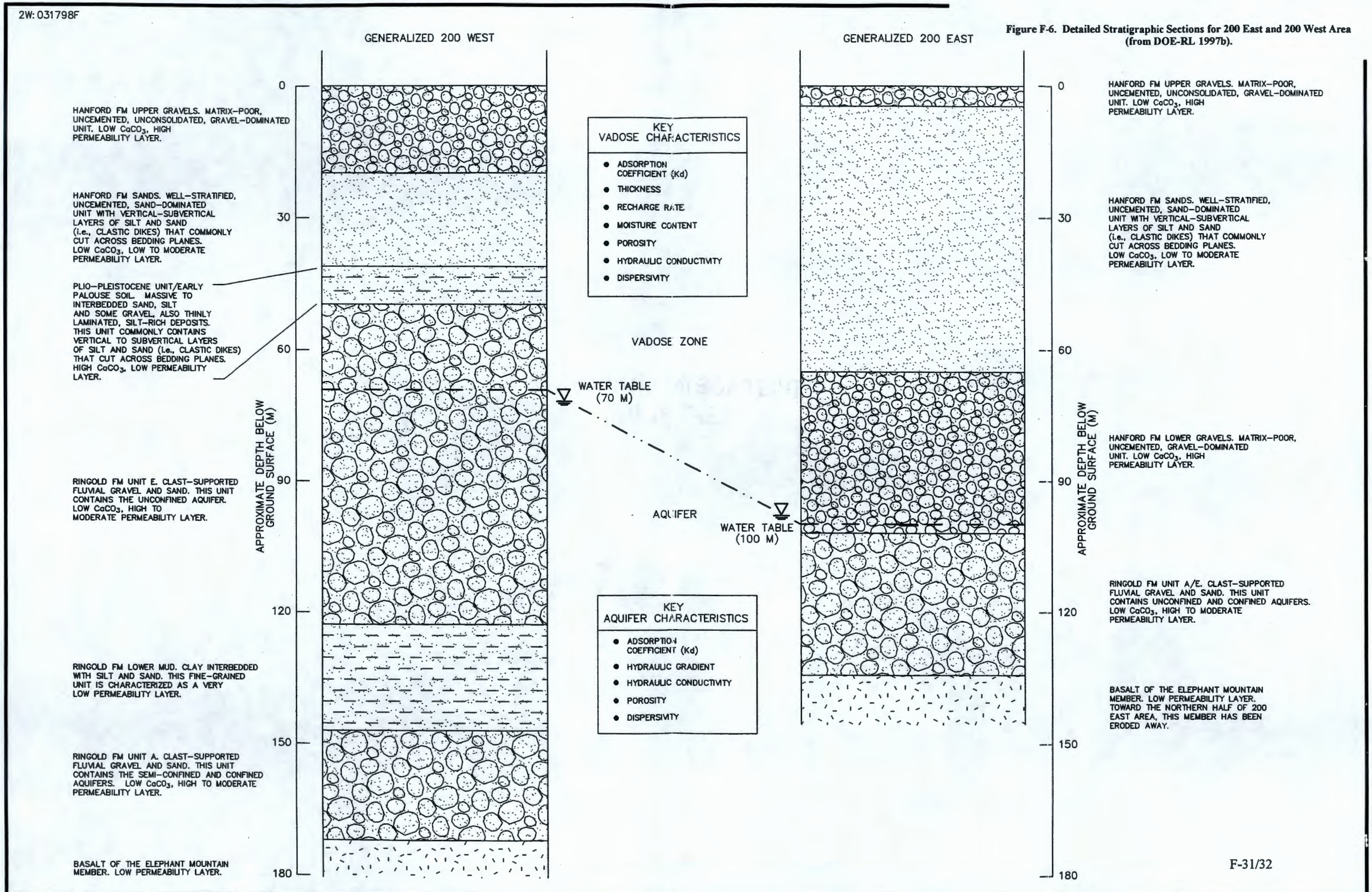


Figure F-5. Generalized Hanford Site Geologic Cross-Section (from Hartman and Dresel 1998). Location of Cross-Section Shown in Figure F-11.

Figure F-6. Detailed Stratigraphic Sections for 200 East and 200 West Area (from DOE-RL 1997b).



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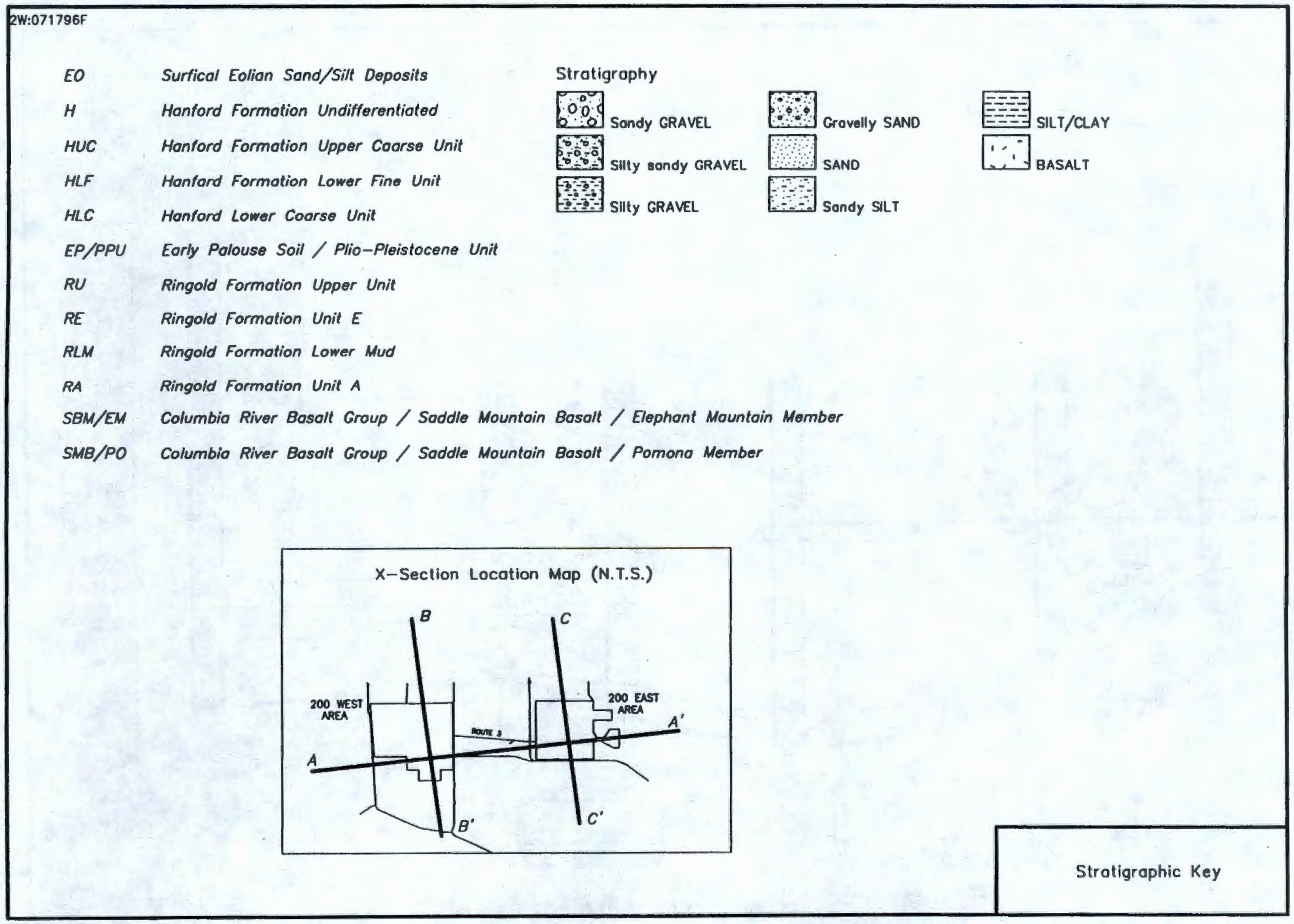

Figure F-7. Stratigraphic Key for Figures F-8 Through F-10 (from DOE-RL 1997b).

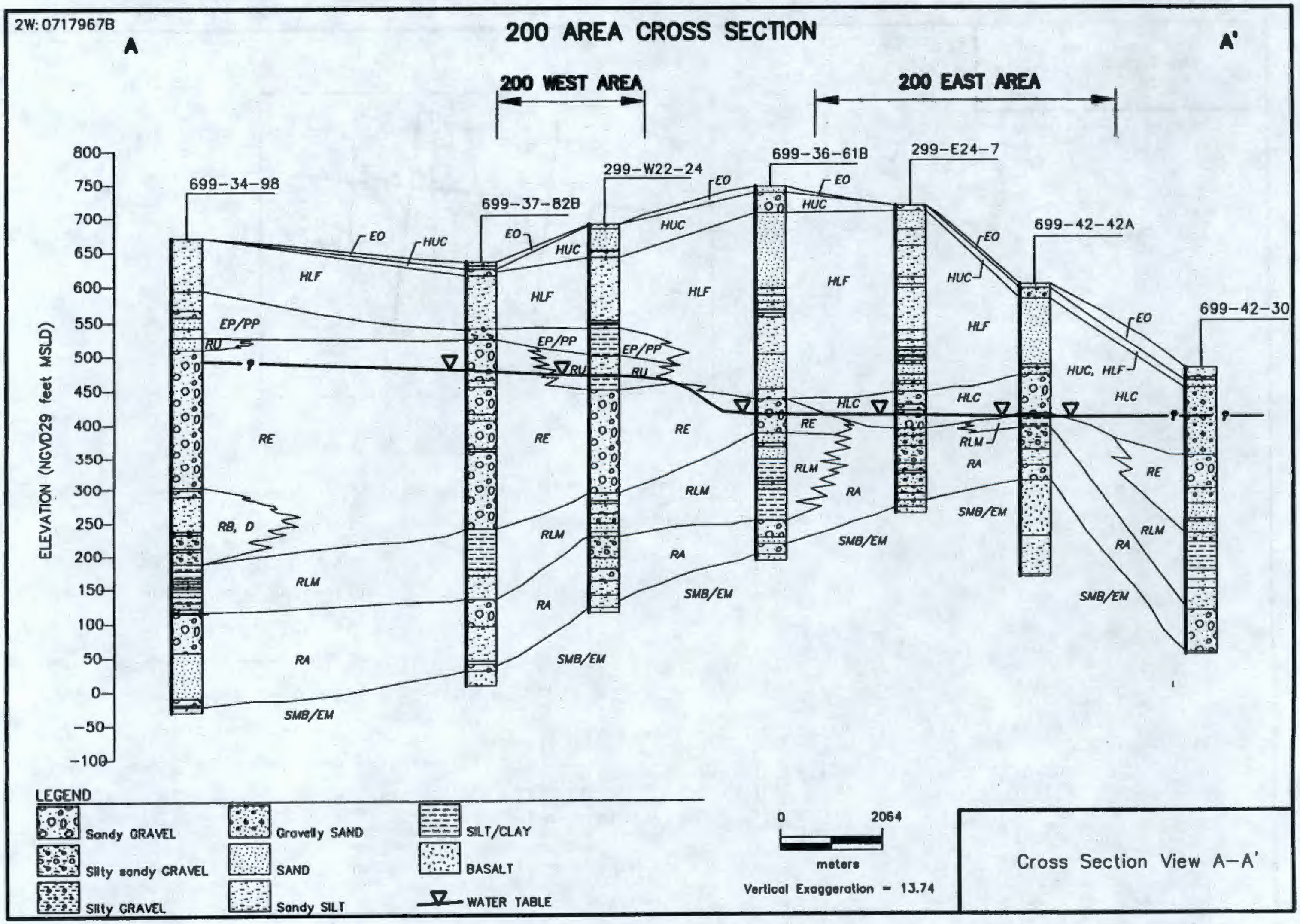

Figure F-8. East-West Cross Section Through the 200 Areas (View A-A') (from DOE-RL 1997b).

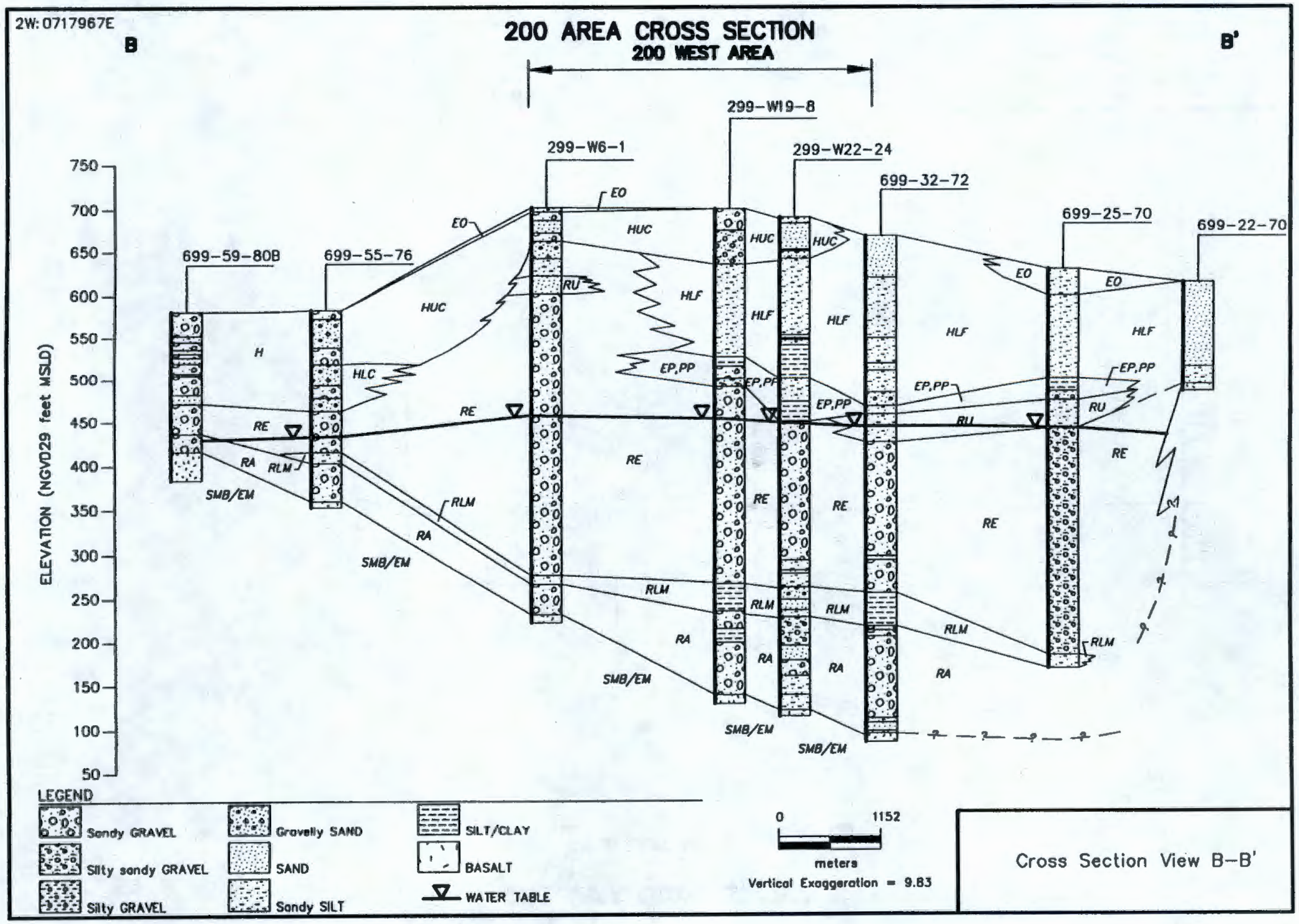

Figure F-9. North-South Cross Section Through the 200 West Area (View B-B') (from DOE-RL 1997b).

Figure F-10. North-South Cross Section Through the 200 East Area (View C-C') (from DOE-RL 1997b).

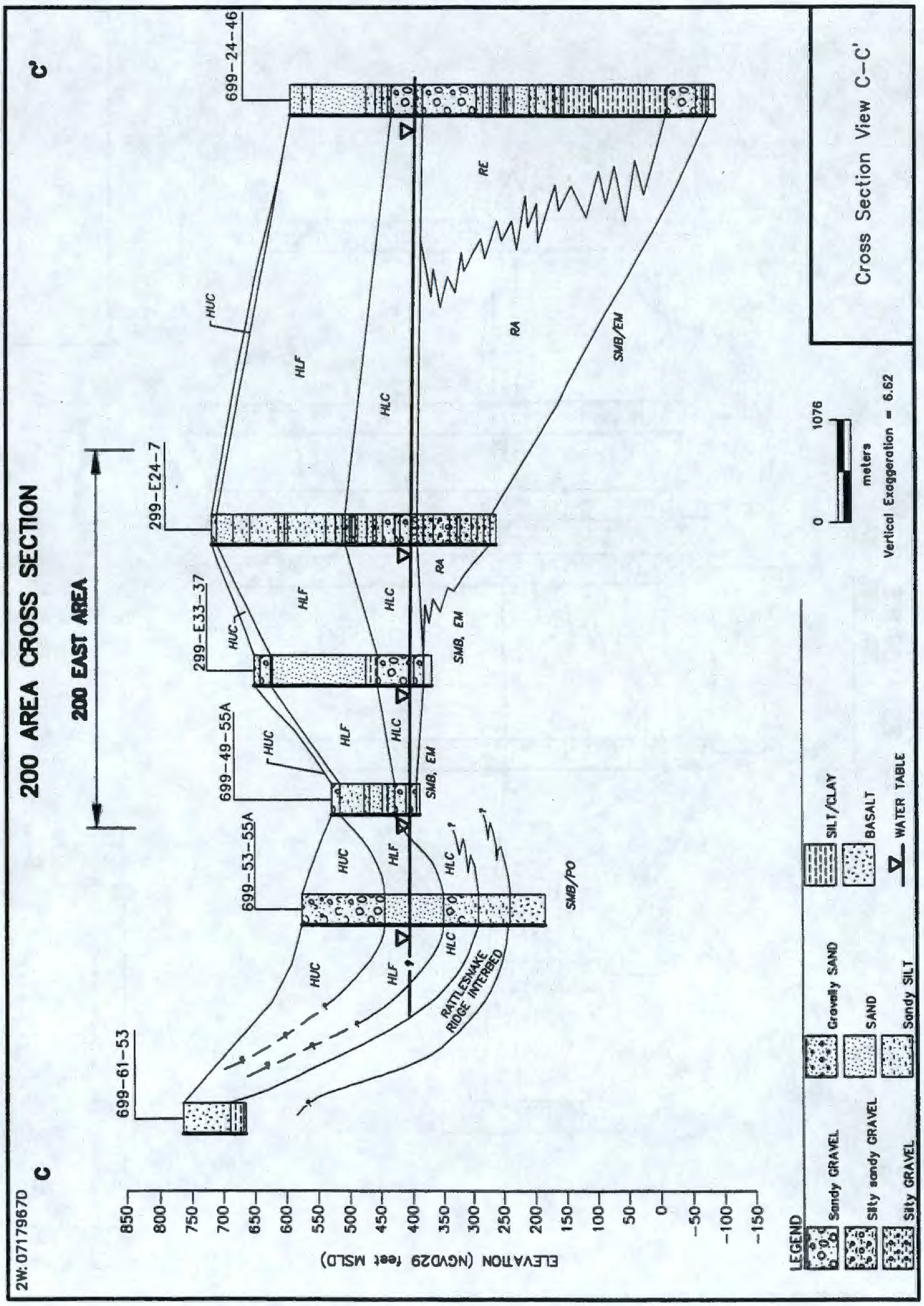

Figure F-11. Geologic Units Present at the Water Table (from Hartman and Dresel 1998).

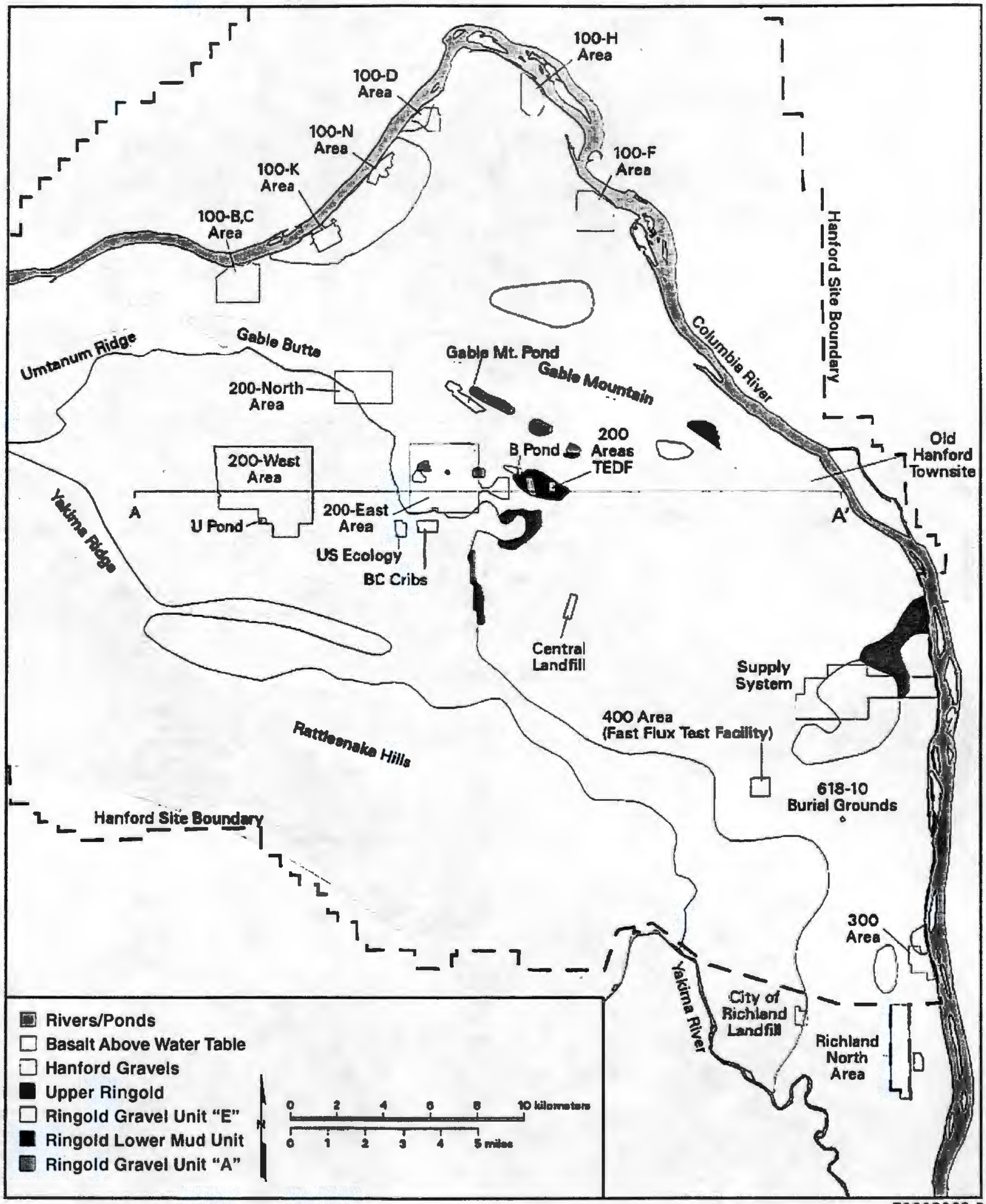

Table F-1. Average Monthly Temperatures by Season (compiled from Hoitink and Burk 1998).

Season	Winter		Spring		Summer		Autumn	
Months	Dec – Feb		Mar – May		Jun – Aug		Sep – Nov	
Maximum	45°F	Feb 1958	69°F	May 1947	82°F	Jul 1985	72°F	Sep 1990
	7°C		20°C		28°C		22°C	
Minimum	12°F	Jan 1950	39°F	Mar 1955	63°F	Jun 1953	25°F	Nov 1985
	-11°C		4°C		17°C		-2°C	

Table F-2. Monthly Average Precipitation by Season (compiled from Hoitink and Burk 1998).

Season	Winter		Spring		Summer		Autumn	
Months	Dec – Feb		Mar – May		Jun – Aug		Sep - Nov	
Maximum	3.7 in.	Dec 1996	2.0 in.	May 1972	2.9 in.	Jun 1950	2.7 in.	Oct 1957
	9.4 cm		5.2 cm		7.4 cm		6.9 cm	

Table F-3. Statistical Characteristics of the Sitewide Background Data for Nonradioactive Analytes (from DOE-RL 1995a). (2 Pages)

Analyte	Systematic random samples, concentration (mg/kg)		Overall maximum concentration of all samples (mg/kg)	90th Percentile of the Lognormal Distribution
	Minimum	Maximum		
Aluminum	3,940	18,100	28,800	11800
Antimony	15.7	15.7	31	~
Arsenic	3	11.4	27.7	6.47
Barium	45.2	221	480	132
Beryllium	0.6	2.1	10	1.51
Cadmium	0.66	0.66	11	~
Calcium	3,820	86,600	105,000	17200
Chromium	2.9	30.6	320	18.5
Cobalt	5.7	16.9	110	15.7
Copper	8.1	36.1	61	22
Iron	13,200	35,100	68,100	32600
Lead	1.1	26.6	74.1	10.2
Lithium	34	38.2	38.2	33.5
Magnesium	2,900	10,100	32,300	7060
Manganese	196	704	1,110	512
Mercury	0.16	3.8	3.8	0.33
Molybdenum	2	2	6	~
Nickel	7.2	28.2	200	19.1
Potassium	851	3,280	7,900	2150
Selenium	5	6	6	~
Silicon	5.2	583	1,203	44
Silver	1.4	14.6	14.6	0.73
Sodium	101	5620	6,060	690
Thallium	3.7	3.7	3.7	~
Titanium	524	2940	3,180	2570
Vanadium	24.3	97.9	140	85.1
Zinc	30.9	119	366	67.8
Zirconium	11	84.8	84.8	39.8
Alkalinity	31	37,600	150,000	7710
Ammonia	0.6	26.4	26.4	9.23

Table F-3. Statistical Characteristics of the Sitewide Background Data for Nonradioactive Analytes (from DOE-RL 1995a). (2 Pages)

Analyte	Systematic random samples, concentration (mg/kg)		Overall maximum concentration of all samples (mg/kg)	90th Percentile of the Lognormal Distribution
	Minimum	Maximum		
Chloride	1	1,480	1,480	100
Fluoride	1	73.3	73.3	2.81
Nitrate	0.6	538	906	52
Nitrite	21	21	36.5	~
O-Phosphate	2	225	225	0.785
Sulfate	1	4,340	12,600	237

Table F-4. Selected Values for the Sitewide Background Radionuclide Data Set (pCi/g) (from DOE-RL 1996a).

Analyte	Minimum	Maximum	Arithmetic Mean	Standard Deviation	90th percentile
K-40	9.29	19.7	13.1	2.71	16.6
Co-60[a]	-0.0111	0.0387	0.00132	0.00591	0.00842
Sr-90	0.00661	0.366	0.0806	0.0688	0.178
Cs-137	-0.00156	1.64	0.417	0.338	1.05
Eu-154[a]	-0.0732	0.0790	0.000826	0.0250	0.0334
Eu-155[a]	-0.0187	0.0984	0.0234	0.0184	0.0539
Ra-226	0.298	1.16	0.561	0.202	0.815
Th-232	0.468	1.58	0.945	0.260	1.32
U-234	0.399	1.51	0.793	0.233	1.10
U-235[b]	0.00462	0.386	0.0515	0.0373	0.109
U-238	0.354	1.21	0.763	0.216	1.06
Pu-238[a]	-0.000489	0.0193	0.00158	0.00332	0.00378
Pu-239/240	-0.0050	0.0331	0.00935	0.00782	0.0248
Gross Beta	13.6	25	19.78	2.40	22.96

[a] Majority of the data are below detection; included here for completeness.
[b] Uranium-235 statistics were computed using 47 samples: 17 above and 30 below detection limits. Two data were suspended owing to negative values.
Percentiles are based on the lognormal distribution.

Table F-5. Root Penetration and Burrowing Depths of Selected 200 Area Wildlife and Plant Species (adapted from DOE-RL 1995b).

Species	Root Penetration or Burrowing Depth		
	Average Maximum Depth (meters)	Maximum Depth (meters)	Reference
PLANTS			
Cheatgrass	0.7	1.2	Foxx et al. 1984
Gray rabbitbrush	1.83	2.5	Klepper et al. 1985
Green rabbitbrush	1.53	1.6	Klepper et al. 1985
Tumblemustard (Jim Hill mustard)	1.0	2.0	Estimated (DOE-RL 1995b)
Big sagebrush	2.0	2.5	Klepper et al. 1985 (at Hanford)
Antelope bitterbrush	2.96	3.0	Klepper et al. 1985
Russian thistle	1.72	3.0	Klepper et al. 1985
Sandberg's bluegrass	-	0.35	Link et al. 1990
Needle and thread grass	1.39	1.6 1.83	Klepper et al. 1985; Schaffer et al. 1979
ANIMALS			
Deer mice	0.4	-	Estimated (DOE-RL 1995b)
Great Basin pocket mouse	0.9	2.0	O'Farrell et al. 1975; McKenzie et al. 1982
Northern pocket gopher	0.3	2	OSU 1998; UC 1998
Badger	2.5	-	McKenzie et al. 1982
Harvester ant colony	2.3	2.7	Rogers et al. 1988

APPENDIX G

WASTE SITE LISTING

G1.0 WASTE SITE LISTING

Appendix G expands upon the discussion of waste site groupings presented in Section 3.3 by describing the waste category characteristics in more detail. Appendix G also presents a tabulation of all 200 Area Waste Information Data System (WIDS) liquid and solid waste sites, unplanned releases and outside-the-fence tank farm-related facilities considered by this Implementation Plan. In addition, this appendix discusses the evolution of waste sites, design characteristics of the respective waste site types and potential impacts of plant operations. This information, along with data presented in Appendix H, Process Descriptions and Flow Diagrams, is important to developing a logical conceptual contaminant transport model for each group to show how contaminants may be distributed within and below a waste site. Data in these two appendices will serve as the basis for developing both group-specific DQOs and work planning documents and will help to direct additional waste site historical research, if needed.

Table G-1 is a revised list of the waste sites and grouping information that updates a list presented in Appendix A of the *Waste Site Groupings for 200 Area Soil Investigations* document (DOE-RL 1997d). The Appendix A list was collected from a database compiled from the eight source Aggregate Area Management Study reports. At the time the report was being compiled, the Appendix A list was checked against the current WIDS to insure that all appropriate 200 Area sites were included. The waste sites were grouped by waste type categories, subdivided as appropriate into 23 waste groups, and representative sites selected. The Appendix G tabulation in this document transitions from the old AAMS database to WIDS, which by *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994) requirements, is now the official tracking mechanism for all Hanford waste sites.

Revisions to the list from the earlier version in DOE-RL (1997a) are based on the current waste site list in WIDS. Some of the changes that have occurred include the following:

- Some sites may have been deleted from the 200 Areas Waste Site Groupings document (DOE-RL 1997a), based on a Tri-Party Agreement-approved WIDS determination that the site is already covered by another designation. With regulator approval, duplicate information was combined, although the deleted number is retained as an "alias." An example of these is the deletion of the 216-T-30 waste site, a site that is listed in WIDS as an unplanned released (UPR-200-W-38).

- A decision has been made to delete the sites from the 200 Areas Waste Site Groupings document (DOE-RL 1997) for specific reasons. For example, the three pipelines listed originally in the 200 North Ponds Cooling Water group and the 216-C-9 Pond Diversion Box have been deleted. A unified approach to address all waste site pipelines and associated structures has not yet been generated. A specific future task for the WIDS program is to track all pipelines and associated structures in the 200 Areas. Until this task has been completed, these sites will not be addressed.

- Some sites were split to allow for two or more DOE programs to be responsible for a specific part of a waste site (e.g., the 216-A-36A and 216-A-36B Cribs). This resulted in the addition of several waste site (site code) numbers. The previous waste site number is retained as an alias or as an associated waste site. The final result of this effort was a Memorandum of Agreement (MOA), which was approved and signed by all the DOE program representatives (DOE-RL 1997b, 1997c, 1997d).

- In other instances, such as UPR-200-E-124 (200 Areas Laboratory Chemical Wastes group), no WIDS references exist to substantiate the site's existence other than a reference in the AAMS report. Efforts to confirm the sites existence have not been successful for UPR-200-E-124, therefore, the site has been rejected by the WIDS. The sanitary crib designation has been replaced with the designation 216-SX-2. Both names apply to the same structure, but the latter has been accepted to better suit the waste stream sent to the ground.

- In many cases, waste sites have been moved between waste site groups. For example, UPR-200-E-95 has been moved from the General Unplanned Release group into the Gable Pond/B-Ponds and Ditches Cooling Water group, based on better definition of the nature and location of the site. Conversely, UPR-200-W-63 has been moved from the Radioactive Landfills group to the General Unplanned Releases category since it has been determined that the site of the release was primarily outside of the boundaries of the 218-W-3/4 Burial Grounds. Also, a large number of Unplanned Release group sites have been linked to releases from outside-the-fenceline tank waste sites and have been transferred to the Tanks/Lines/Pits/Boxes group.

- Several sites that were "discovery" sites at the time the 200 Areas Waste Site Grouping document (DOE-RL 1997a) was compiled have now been changed to "accepted" waste sites by WIDS and are now included in the appropriate group in this appendix. As a result, several new sites have been added to the Nonradioactive Landfills group.

The procedure of evaluating new sites that are identified will follow the *Maintenance of the Waste Information Data System (WIDS)* (TPA-MP-14). A large number of discovery waste sites have been reported and are undergoing review for inclusion in the database. This is anticipated to be an ongoing occurrence, and 200 Areas Project personnel will review and group new sites on a regular basis.

During the DQO process that will occur as part of the development of the group-specific work plans, all ER sites will be evaluated to determine whether there are any candidates that may be reclassified as "rejected," "closed out," "deleted from NPL," or "no action" sites. Tri-Party Agreement Handbook Guideline TPA-MP-14 will be utilized for this purpose to reclassify sites. Reclassified sites will be kept in a separate list for tracking purposes. Candidates for reclassification may include instances where (1) waste disposal facilities were constructed but not used, (2) duplicate labeling (as discussed earlier) exists for a waste site produced by an unplanned release, (3) sites have been cleaned up, (4) the contamination has decayed to background levels, (5) sites were miss-classified as a waste site, or (6) a voluntary action such as a housekeeping activity may be used to remediate a site. All reclassifications are expected to be based on data packages provided to the Tri-Party Agreement reclassification team and will require reclassification approval from the team.

G1.1 WASTE STREAM TYPES AND GROUPINGS

An examination of the 250 + waste disposal sites used by the 200 Areas process and waste management facilities suggests that there are many variables in waste stream chemistry, volume, and other factors which interfere with a logical and meaningful grouping of sites. A review of plant designs and operations, processing chemistries used, process upsets, and facility clean-out campaigns would seem to confound any grouping strategy. Also, due to the fact that radionuclides were the primary waste stream contaminants of concern during plant operations, little attention was given to inorganic and organic chemical constituents released in the waste stream. While there is general understanding of radionuclide inventories and radionuclide migration in the soil column, the impact of the nonradioactive waste components on radionuclide movement is not as well understood. Further, waste site inventory data is largely calculated from effluent samples taken as part of the plant operations. Some waste streams were routinely sampled and provided representative results, but many waste stream sampling routines are not well known and may have been sampled in less representative ways, thus casting some doubt on the inventory reports.

Despite these uncertainties, an effective characterization approach can be developed using appropriate caution. Much of the uncertainty inherent in waste stream chemistry must be accepted and allowances must be built-in to the characterization plans to cover the exceptions. One good approach to assessing impacts of uncertainties is the development of conceptual models, which depict the current level of knowledge of both the waste stream and the site's physical setting. Models can be used to identify data gaps, test the effects of data uncertainties and to indicate suitable sampling and characterization responses to those uncertainties. Conceptual models must be applied to a reasonably uniform set of site and waste stream contaminant conditions. A conceptual model for an organic-rich waste stream cannot be reasonably expected to explain contaminant distributions in the soil column for a waste stream with a significant inorganics content.

Previous waste site groupings were based on geographic relationships. There was a need to more thoroughly characterize operable units where low- and high-volume waste streams were mixed in with more and less highly contaminated waste streams. Thus, to insure adequate characterization, a greater number of sites in each of the geographically defined operable units were required to be characterized. A very few groups were both geographically isolated and unified by a single waste stream type to suggest a waste stream-based approach which could be used to reduce characterization efforts.

The general approach in planning characterization activities is to study a limited number of sites that cover a reasonable number of variables without sampling for every possible permutation. Grouping sites according to similar characteristics is the primary mechanism by which characterization activities are optimized. Application of the analogous waste site concept directs characterization activities at a few sites, which have been selected to represent average and worst-case waste site conditions. These are based primarily on inventory, waste volumes discharged, and similar waste site types.

This report relies on an understanding of how plants generate wastes as a means of grouping the sites. This has led to the recognition that there are a relatively limited number of actual waste stream types coming from any process plant. In general terms, most plants emitted waste streams as one or more of the following types - gas/vapor, liquid or solid phase streams. Gas/vapor phase wastes, discussed in G1.1.1, are not considered in detail in this report, other than as contributors in unplanned releases. Solid wastes are quite variable in characteristics, inventory and form but have been traditionally segregated within large burial grounds. In addition, solid wastes are not noted for their impact to the vadose zone and groundwater.

Liquid wastes, by their nature, past disposal practices, and contaminant inventory, have had the greatest impact on the 200 Areas. There are two general types of liquid wastes, those derived from intimate contact with process liquids and those where a barrier separated the process liquids from water used for heating or cooling in a process step. For waste streams where barriers were present, typically cooling or heating coil pipe walls, contamination of the stream required either small- or large-scale failures of pipe material. For these waste streams, surface disposal sites were used due to the low contaminant concentrations and the generally low potential for pipe failures.

For waste streams derived from intimate contact with process chemicals, contamination concentrations were determined by the volatility, chemical constituents and temperatures of the process solutions. The radiological and chemical content of contact process liquid could be of a highly- or mildly concentrated nature. In all cases, the material driven off in the vapor phases of the process were condensed offline and then disposed of according to the radionuclide content. Tank farm wastes were derived from vapors released from boiling acidic solutions used to digest fuels rods. Later process steps requiring heating or boiling generated less contaminated vapors, and the condensates were usually disposed to the ground.

G1.1.1 Vapor/Gaseous Streams

Gaseous or vapor releases from the 200 Area plants are not considered in this document, except where the process discharged liquid wastes to the ground, or as a number of unplanned releases associated largely with plant ventilation or stack upsets. However, the ventilation system was a key part in overall plant operation and was the subject of elaborate designs or administrative controls to prevent or mitigate releases of contaminants.

Two major streams dominated the flow of air through the plants-building ventilation and process vacuum streams. Stacks were the primary exhaust point for both streams and were equipped with alarms plus monitoring and sampling equipment to ensure proper operation. Ventilation stacks were typically constructed to heights of 61 m (200 ft) to ensure good dilution of the gaseous components that bypassed or escaped the filter/treatment systems. Some condensed liquids were typically associated with the various ventilation plenums, fans, stack gas sampling facilities, and the stacks themselves.

A multi-source ventilation system provided large volumes of fresh air to all parts of the canyon buildings and attached support buildings. Flow configuration and forced exhaust established an airflow pattern from noncontaminated to contaminated areas, to cells, and then to the exhaust ductwork. Particulate, vapor, and fume-based contaminants in cells and galleries were passed through sand- or paper-filter systems prior to discharge into the stack. Large electric fans maintained a vacuum on the ventilation system, but steam turbine-driven exhaust fans were also provided as an emergency backup. The ventilation liquids disposed to the ground in the 200 Areas were generated either from stack or fan and plenum ventilation operations and were sent to waste sites such as french drains, reverse wells, and small cribs. This waste stream is categorized in the Miscellaneous Waste group.

Process vacuum systems were largely responsible for collecting and transferring vessel fumes, vapors, condensates, and particulate matter away from the decladding, dissolver, and process vessels' headspace. This system drew process gases to the condenser/treatment system or release point using vacuum steam jets. At all fuel processing plants, the decladding/dissolving step generated a significant vapor phase. Dissolver fumes, gases, particulates, and vapors were either released at the bottom of the stack (at the $BiPO_4$ processes in 221-B and T Plants) or through a silver reactor system (at the 202-S REDOX and 202-A PUREX Plants). The remaining vapor phase was released either directly at the bottom of the stack or between the exhaust fan units and the stack. Some short-lived ($t^{1/2}$ = minutes to days) fuel fission product fractions such as iodine-131 (I-131), xenon-133 (Xe-133), and ruthenium-103 (Ru-103) were very mobile and vaporized significantly or completely in the dissolver vessels.

Initial $BiPO_4$ dissolver operations were occasionally limited by poor atmospheric circulation associated with weather inversions. In these cases, dispersion tended to keep contamination close to the ground and required temporary cessation of fuel rod processing. This limitation was overcome with improved ventilation systems and longer aging of the fuel rods, either at the 200 North facilities or in the reactor storage pools. Later, PUREX and REDOX used silver reactors to remove the I-131 from the gases. Typical pre-reactor treatment steps included condensing, de-entraining, drying and reheating the gases and fumes before entering the silver reactor, and a filtration step after the reactor. Liquids condensed from the decladding/dissolver operations were recovered and sent to the tank farms as a small volume, highly contaminated stream. Other processing ventilation systems did not require silver reactor systems, but did rely on sand or paper filter banks to contain particulate contaminants borne out of process vessels or hoods as fumes, gases, or vapors.

Decladding and dissolver vessels were not required steps at the 221-U (URP), Waste Fractionization (221-B), or the Plutonium Finishing Plants (PFP). The URP process at 221-U Plant used the existing sand filter for certain process vessel and general plant ventilation requirements. Cloth and/or fiberglass filters were used for vault and selected roof-based, process vessel ventilation systems. The Waste Fractionization program at 221-B relied on the existing B Plant building filter and ventilation system for operational areas. For process vessels, two systems consisting of heaters, vacuum transport jets, high efficiency particulate air (HEPA) filters, condensers, and receiver tanks were added to treat ammonia-rich and nonammonia vapor streams. Fractionization process condensates from these systems were discharged to the 216-B-12 and 216-B-62 Cribs.

Process upsets associated with ventilation system releases were mostly the result of solids building up in the ventilation system which were then blown out the high stacks. This occurred for the first several years following startup of the REDOX facility, and sporadically at PUREX. Contamination releases were also reported for the 221-B and –T Plants in 1947-1948.

G1.1.2 Solid Waste Steams

Solid wastes typically consist of radiologically contaminated equipment, tools, clothing, paper, or other forms. Contact or potential contact with process solutions, materials or wastes resulted in the classification of solid material as contaminated. "Potential contact" wastes dominate the volume of solids sent to the burial grounds. Free release of these materials has always been difficult due to the risk of making a "not-contaminated" decision based on inefficient portable detectors. This dilemma and the inability to standardize release levels have consistently blocked free release to offsite sources.

Beyond the day-to-day solids generated from routine operations, large volumes of nonroutine solid wastes were commonly generated when a process revision or equipment repair or replacement produced excess contaminated parts and materials. If decontamination was not able to remove or reduce the contamination to acceptable levels, the equipment or material was disposed of in solid waste burial grounds. Small volume radioactive laboratory samples were frequently disposed to nearby vaults.

In addition to the radiological waste, large quantities of nonhazardous and hazardous wastes have been generated over the years, much of which was not considered hazardous at the time. Certain laboratory wastes, particularly unused chemicals, fell into this category. Large pits for the powerplant ash were placed close to the respective facilities. Debris piles from the demolition of old buildings are another typical, although usually smaller, waste site type found in and around the 200 Areas. With the advent of environmental regulations in the 1960s and 1970s, some attempt at segregating hazardous and dangerous wastes was made, independent of actual legal application to the Hanford Site. This resulted in the construction/operation of the Nonradioactive Dangerous Waste Landfill (NRDWL) and the adjacent Solid Waste Landfill.

G1.1.3 Liquid Waste Stream Types

Low-level liquid waste stream disposal sites constitute a significant concern for the Implementation Plan's characterization and follow-up remediation activities. Virtually all liquid waste sites are presently inactive. As discussed below, a wide variety of liquid wastes were generated through a number of individual process steps at each plant or facility.

G1.1.3.1 Process Condensate/Process Waste Category. This family of waste streams originates from direct contact with the process chemistry or from direct contact with a process side stream, such as acid or solvent recovery processes. Process condensates, as the name implies, were derived from plutonium-, uranium-, fission product-, or chemical-rich process streams, which had been heated to boiling or near-boiling conditions, or which were evolving a vapor, gas, or fume phase. Process wastes are defined as nonirradiated wastes resulting from the cold start-up testing of a process, a step that typically included decladding and dissolving fuel rods. Process condensates differ from process wastes in that the latter has no or negligible quantities of fission products or plutonium. Individual groupings have been developed based on the relative quantities of specific constituents such as uranium, plutonium, organic-plutonium, organic, fission product, and general waste constituents. This waste category is the most diverse in contaminant content and concentrations of all major liquid discharges in the 200 Areas.

Process Condensates. Process condensates consisted mostly of water but contained varying, albeit minor, concentrations of chemical and radiological constituents. Contamination of the condensate resulted from two primary pathways, entrainment and volatilization. Entrainment is carryover of normally minute droplets of liquid from the heated vessel (pot) to the condenser. Entrainment would thus carry even nonvolatile salts into the condensate stream. Good design minimized entrainment, but even the best Hanford units typically operated with an approximately 1 ppm carryover (e.g., nonvolatile concentrations in the condensate one-one millionth of the pot concentration). Entrainment in the uranium concentrator condensates from U Plant resulted in the highest quantities of uranium discharged to the soil column, over 45,000 kg (99,000 lb). Entrainment in the evaporator process condensates (from treating neutralized tank farm wastes high in fission products) accounts for the bulk of the radionuclides in these streams.

Any volatile component that had a finite vapor pressure at the concentrator pot temperature was carried to the condenser to a greater or lesser degree, depending on the component's boiling point. If sufficiently volatile, some, or essentially all, of a given component would remain in the vapor phase and leave via the ventilation system (e.g., iodine venting during fuel dissolution). Acid recovery processes at PUREX, REDOX, and URP produced and discharged condensates with generally low pH, although neutralization of acidic wastes is reported for a few of the known acidic process wastes. Organic recovery processes produced condensates that contained quantities of hexone, tributyl phosphate/NPH, or carbon tetrachloride, depending on the plant from which they originated.

Since chemical reactions were commonly driven to faster rates by elevating process chemistry to boiling or near boiling temperatures, condensates from these operations became a major component of the 200 Areas waste disposal process. They were generally associated with the fuel dissolution or waste concentration steps at the separations and radionuclide recovery programs such as REDOX, PUREX, URP, and B Plant Waste Fractionization processes. The $BiPO_4$ process plants did not generate separate process condensate waste streams as piping was not provided to allow off-line treatment of vapors.

Concentration steps/vessels were another high volume source of contaminated condensate liquids in the 200 Areas. The 202-S REDOX, 202-A PUREX, Z Plant, and 221-B Waste Fractionation/WESF processes relied on concentrators to reduce the volume of purified product (e.g., plutonium, uranium) and waste streams. URP used concentrators in the 221-U to reduce the volume of the sluiced tank wastes prior to processing as well as for concentrating the uranium-bearing solutions recovered by the solvent extraction process. In addition, concentrators were at the core of volume reduction steps at the 242-A, -B, -S, -T, and –Z evaporator facilities. Condenser units were used at the boiling waste tank farms (241-A and 241-SX) to liquefy the vapors and return them to either the tanks or a waste site. Process condensates were also generated during the regeneration of process chemicals, such as acids and solvents, at the REDOX, PUREX, URP, and Waste Fractionization/WESF plants.

Although most process condensates were considered to be low-salt (not chemically neutralized) and neutral-basic, a few contained one or more compounds that are suspected or known to have increased the mobility of otherwise rather immobile contaminants. Acidic waste streams are known at most of the major process plants, except for the $BiPO_4$ streams. Organic agents were routinely discharged in one or more waste streams from the URP, PUREX, REDOX, and PFP facilities. Detergents and cleaning compounds were used for plant vessel and piping decontamination washes at the conclusions of REDOX, B Plant, and T Plant operations and were often discharged to the soil column. In virtually all cases, these waste streams were discharged to cribs.

Process Wastes. Process wastes comprise a small volume of this category and are almost completely composed of cold startup wastes. Prior to startup of every major process, a charge of feed material was introduced to the plant and run through some (e.g., decladding/dissolving) or all of the individual steps. This step was used for process scale-up evaluations, troubleshooting and training purposes. Unirradiated fuel rods were decladded and dissolved for the REDOX and PUREX processes while URP processing used an unirradiated uranium solution to test its system. The full chemical nature of these wastes is not well documented. Commonly, these waste streams were reported to consist of depleted or unirradiated uranium along with small quantities of nitrates (Stenner et al. 1988). One REDOX waste site was also reported to have received contaminated hexone from initial test runs. The cold startup waste sites are generally notable for their significant quantities of uranium. Process wastes were almost exclusively discharged to trench waste sites.

G1.1.3.2 Steam Condensates/Cooling Water/Chemical Sewer Category. Cooling water, steam condensates, and chemical sewers were common to all separations process facilities in the 200 Areas. Most other facilities were generators of at least steam condensate and cooling water wastes. For the $BiPO_4$ processes, these three stream types were all dealt with as one discharge stream and sent to the respective pond systems. For the solvent extraction process, radionuclide recovery programs and waste volume reduction programs, these streams were often isolated and sent to separate waste sites. This was made necessary by the significant volumes of each stream produced by continuous operations. Discharges of this type were targeted for elimination in the late 1980s and early 1990s, and were effectively terminated by 1995.

These waste streams are grouped together because they may be regarded as largely non-contact waste streams with very low concentrations of radionuclides and/or chemicals. Typically, a physical barrier (e.g., the wall thickness of a heating or cooling pipe coil) separated the steam condensate and cooling water streams from the process liquids. In the case of chemical sewers, the wastes were not routinely exposed to radiologically contaminated solutions or vessels. At PUREX, chemical sewer sources also included floor drain discharges from the cold shops area. All three streams were apparently regarded to have such low quantities of contaminants that operational sampling only looked for key radionuclides.

Ideally, these waste stream groups should not have become radiologically contaminated. However, minute quantities of radiological contamination were routinely present. This is especially true for steam condensates and cooling water streams, where the combined steam heating and cooling water coil systems were placed directly into the chemical process solutions. When operating in highly corrosive environments or when subject to significant thermal gradients, chemical attack or mechanical pipe wear resulted in the formation of pinholes or hairline cracks. Usually, this was not a problem as the pressures of steam or cooling water in the pipe coils were greater than the process or condenser vessel pressure and any leaks would flow into the process vessel. However, at times when coils were not under pressure, minor leakage through the flaws occurred and contamination exited the tank. The presence of such flaws was detectable by indirectly measuring process parameters, such as the process liquid's specific gravity. Failing equipment could often be detected and repaired or replaced before major process upsets occurred.

In the corrosive operating environment both internal and external to the pipe coil, flaws would occasionally go to complete failure. Radiological monitoring of waste streams was performed at certain points, often for combined waste lines exiting a plant, rather than for an individual waste generator. Coil failures in the REDOX dissolver and concentrators and PUREX process vessels were reported as unplanned releases and were responsible for some of the serious unplanned releases in the 200 Areas.

Steam Condensates. As noted in the process waste discussion, chemical reactions were frequently conducted at temperatures significantly above ambient. This was done to accelerate a process, to prevent precipitation and settling of material, or to ensure that a reaction went to completion. Temperature adjustments to process steps were made with steam, which either was directly injected into the chemical solution (sparging) or was circulated through heating coils inside a process vessel. The rate of steam entering the coil or sparger determined how much heat was brought into the system. In the case of heating coils, the spent steam was collected in an off-line condenser or reheated in a closed-loop system. At a condenser, spent steam would come into contact with a pipe coil carrying cooling water, which would chill and condense the steam to a liquid. The condensed steam was then discharged to a plant sewer or piping system that, in turn, discharged to a ditch/pond system or crib. Generally, if a single stream, this water was still hot when it reached a crib.

The waste site types to which steam condensate was discharged varied over time. As noted above, the $BiPO_4$ process used steam heating extensively. The condensate was routed directly into the plant sewer line and sent to the 216-B and –T ponds and ditches, along with the cooling water and chemical sewer streams. Similarly, operations at the URP also combined the three waste streams. The 242-T evaporator discharged steam condensate to the 216-T-4-1 ditch and pond system, while the 242-A evaporator first routed its steam condensate to the 207-A North retention basins for sampling and holding, prior to release to the 216-B-3 pond and ditch system.

Steam condensate generated by the REDOX, PUREX, and Waste Fractionization program, along with steam condensate from the 242-S and 242-B Evaporators, was discharged to cribs. The change in waste disposal site types versus steam condensate disposal to ponds appears to correlate with a series of coil failures in REDOX that contaminated the original waste site, the 216-S-17 Pond. PUREX and Waste Fractionization activities continued this trend, with the probable explanation that concentrator and dissolver coil failures carried greater potential for contamination release and should therefore be disposed of to underground sites.

Under normal operating conditions, the steam condensates were not expected to be acidic or otherwise rich in chemical constituents. However, some chemical additions to inhibit corrosion or scale buildup are reported at the powerhouses. The wastes were released as warm or hot water and vapors tended to carry some contamination to the surface through crib vent systems. Plastic or paper barriers installed in cribs at the top of gravel layers did not always sufficiently prevent vapor, or radionuclide, migration to the ground surface.

Steam was generated at the 284 East and West powerhouses and piped to each major plant from the inception of 200 Areas operations until 1997. Steam was also provided to the major separations plants for emergency plant ventilation needs in event of electrical grid power loss. This source alone contributed a significant fraction of steam liquids to a plant's total steam condensate consumption.

Cooling Water. Cooling water was used in virtually every separations, waste recovery, waste storage, and waste volume reduction facility in the 200 Areas. It followed plant steam heating requirements for most processes in a near-synchronous relationship. However, noncontact cooling is a relatively inefficient method of cooling process vessels. Based on pounds needed per degree change in temperature, a much larger quantity of heat can be added to a process using steam than is removed using cooling water. Consequently, in every plant, cooling water was volumetrically the greatest source of waste liquids any facility produced. Cooling water was derived from the 200 Area raw water supply, which was pumped directly from the Columbia River. With little or no treatment beyond filtration, this water was sent to the facilities for use in plant processes. The waste liquid was typically benign with only very small concentrations of radionuclides in the stream.

As was the case for steam condensate, cooling water was generally regarded to be uncontaminated until it came in contact with cooling coils and condenser chambers in vessels throughout a plant. Cooling coil failures with significant contaminant releases occurred, but at less frequent intervals than noted for steam coils.

Wastewater associated with 284-East and 284–West powerplant operations was discharged to the environment in ditches which drained, respectively, to either the 216-B-3 or 216-U-10 Ponds and their associated ditches. This waste stream consisted of cooling water for turbines, boiler water jackets, compressors, generators, water softener system regeneration, and boiler blowdown (scale removal) discharge. Low-volume chemical additions such as sodium chloride, sodium sulfite, sodium hydroxide, and ethylenediaminetetraacetic acid (EDTA) were used to soften the water, and suppress corrosion and scale buildup (WHC 1990).

Chemical Sewer. Virtually every process step in any of the separations and radionuclide recovery projects required addition of solid chemicals, or more routinely, pre-mixed chemical solutions. Liquid concentrated nitric, phosphoric, and formic acids; sodium hydroxide; and aluminum nitrate were brought to the canyon buildings in railcar quantities and unloaded into the 211 Chemical Storage Tank Farm at each separation building. Most other chemical solutions were mixed on site to pre-established concentrations and volumes in the Aqueous or Solvent Makeup sections of the plant. Dry chemicals were weighed and added to demineralized water, also produced in the plants. Liquids such as acids and caustics were piped into large tanks in the same area.

As described in the introduction, chemical sewer wastes consisted primarily of makeup tank rinses, with lesser quantities of off-specification batches of chemicals, or overflow chemicals from tanks during aqueous makeup. Improper valving at outdoor chemical storage tanks during chemical unloading or transfer operations may have also yielded chemical sewer wastes.

The construction of separate waste sites for chemical sewer wastes generally emerged as a development in the REDOX plant's waste treatment and was later applied to the PUREX and Waste Fractionization processes. These wastes were discharged to separate ditches or ditch/pond systems. The Laundry waste stream is included here because of the significant quantities of detergents used in cleaning contaminated and noncontaminated work clothing.

In almost all respects, the inventory of contaminants in these waste streams is difficult to assess. Only incomplete records of wastes disposed to sites in this waste group are known. However, several sites were issued RCRA Part A Permits based on reported but unreferenced waste discharge inventories. Most of the chemicals disposed to these streams are expected to have broken down or reacted in the environment and are expected to be largely undetectable. Some inorganic compounds (e.g., cadmium, chromium, and nitrate) could remain sufficiently intact and would be detectable in the environment. Except for chlorinated hydrocarbons, most organic compounds and reactive inorganic compounds are expected to have been biodegraded or to have reacted in the environment.

G1.1.3.3 Chemical Waste Category. The radionuclide species potentially associated with laboratory wastes reflect the operations of the facility supported. Except for the PFP facility laboratory, all 200 Area laboratories potentially handled any radionuclide associated with irradiated fuel. The PFP facility routinely processed only actinide (e.g., plutonium, americium) radioisotopes and actively excluded materials with significant amounts of fission products. The 222-S and 300 area "320 series" laboratories provided the widest support to overall Hanford operations and were equipped to accept the highest activity samples into remotely-operated "hot cells."

The nonradioactive contaminants potentially associated with laboratory operations compete with chemical sewers as the most poorly defined and most variable of all the waste group streams. A well-stocked analytical laboratory chemical stockroom may have hundreds of different chemicals (varying from small to multi-kilogram quantities). This is particularly true at facilities where nonroutine analytical or developmental work (e.g., at 222-S and the "320's" facilities) was being performed. Routine and specific product-related laboratories (e.g., 222-T, 222-U) were normally much less variable in waste output compositions. It should be noted that the laboratories associated with the PUREX and PFP facilities were part of the "main" building. Liquid wastes were combined with other facility wastes not routinely discharged as separate streams.

Overall discharges of laboratory waste were usually small in comparison to operating production facilities in the 200 Areas. Even the highest use chemicals were consumed in bottle and drum quantities, not tank car and truck amounts. The primary high-use chemicals fall into three major categories, acids, bases, and solvents. Acids and bases were heavily used in sample dissolution and preparation, as nearly all analyses require that the component to be measured be reduced to liquid form at least some point during the analytical process. Historically, most solvent use was for separations and cleaning. Most aqueous streams associated with this group were neutralized before discharge and did not contain visible separable organic layers.

Ongoing operations (primarily at 222-S) minimize the potential for discharge of radioactive or hazardous chemicals to the environment, but will remain a potential source of waste materials for the future.

G1.1.3.4 Miscellaneous Waste Category. Miscellaneous wastes are composed of a wide variety of waste streams characterized by a generally small volume of liquid, very limited quantities of radiological and chemical contaminants, and the small size of the respective receiving waste sites. There are several subgroups among the waste generating processes but no unifying theme, as for the previous groups. The primary waste-generating processes in this section are equipment decontamination, and plant, stack, and tank ventilation systems with a number of minor sources. French drains and reverse wells commonly received liquids from the low-volume streams. Cribs receiving moderate flows are also included. These cribs were often waste sites receiving multiple waste streams which could not be readily assigned to another waste grouping.

At least six waste sites (216-S-12; 216-T-9, -10, -11, -13, -33; and 216-U-13), mostly clustered around 221-T Plant, are related to decontamination of vehicles and equipment. Most sites were trenches active between 1951 and 1956, although a few remained active into 1963-64. The 221-T Building became the site equipment decontamination facility in 1958 and remains so to the present. The trenches were exhumed in 1972 and downposted from radiological contamination status at that time. Data indicate that the T-13 and T-33 waste volumes were monitored and sampled with low concentrations of constituents noted.

Most facility building ventilation systems were equipped with liquid waste disposal sites such as cribs, reverse wells, and french drains. Reverse wells are associated with the 291-B and 291-C stacks (216-B-13 and 216-C-2) and received unknown and presumably small quantities of both liquids and radionuclides. The $BiPO_4$ building stacks also were capable of collecting and diverting condensed liquids to the 241-Tank Farms. The PUREX canyon building utilized a large number of french drains (216-A-11, -12, -13, -14, -26, -26A, -33, -35, and -41) and cribs (216-A-4, -21, and -27) for ventilation-related wastes. These sites were used primarily to dispose of liquids generated from stack condensates and liquids associated with either the stack sampling equipment, fan motor cooling, or ventilation seal water.

A number of minor waste streams were associated with tank farm ventilation systems for the 241-A and 241-U Tank Farms. In the case of the 241-U-110 tank condenser, liquid wastes were discharged to the 216-U-3 Crib. Similarly, the 216-A-22 Crib received a combination of steam condensate and sump waste from the 203-A Uranium Storage Tank Farm as well as from the drain at the 203-U truck loadout facility. The 216-A-4, 216-A-21 and 216-A-27 Cribs, consecutively, received laboratory cell drainage from 202-A, sump waste from the 293-A Facility, and the 291-A stack drainage between 1955 and 1970.

Constituents associated with the waste streams are largely unknown. PUREX laboratory wastes are assumed to have been similar to those noted in Section G1.1.3.3, but were mixed in unknown proportions with ventilation wastes. Decontamination wastes are also unknowns and are expected to vary over time. Also included in this group are those waste sites constructed, but never used, for waste disposal. These sites include the 216-A-38-1, 216-B-56, and 216-B-61 Cribs.

G1.1.3.5 Tank and Scavenged Waste Category. Tank wastes include those liquids that were derived from the overflow of highly radioactive wastes stored in the 241-B, -C, -T, and U Tank Farms generated from the $BiPO_4$ processes at 221/224-B and -T Plant. Scavenged wastes are also derived from these same tank wastes but were processed to recover the uranium held in solution. Soil column discharge was used to create extra tank space by reducing the volume of liquids held in the tank. Both processes relied specifically on the active precipitation of solids in the waste settling out of solution either by cooling and stilling of the liquid or through the addition of precipitating (scavenging) agents such as ferrocyanides. In both cases, the waste streams were not considered to be high activity wastes. Waite (1991) provides a historical overview of these wastes. Haney and Honstead (1958) provide an earlier view of tank waste discharge problems, with special attention to the operation of specific retention facilities, associated with the disposal of scavenged wastes. In addition, discharge of intermediate activity level streams from $BiPO_4$ process waste collection tanks contributed significant quantities of radionuclides and chemicals to the soil column.

A few waste sites in the tank wastes group received multiple streams over the life of the 221/224-B and -T Plants' operations. The generally high level of contaminants in these streams resulted in cribs being taken out of service when crib loading factors were reached and reactivated when radioactive decay allowed or need required them to be used again. Some waste streams diverted from one waste site were sent to another for several months or years before being rerouted to yet a third site, which makes assigning a particular portion or quantity of the site inventory to a specific waste stream difficult. Crib and trench waste sites were commonly used for waste disposal, but several reverse well sites were active in the first years of the $BiPO_4$ process.

Tank Wastes. Direct releases of contaminants to the ground are reported from almost the start of tank farm operations in the 200 Areas. Tank capacity was taxed by production demands and construction of new tanks was required. One solution was to release to the soil column the lowest of the four high-level radioactive tank farm waste streams, the second-cycle decontamination waste. Second-cycle decontamination waste contained an estimated 0.1% of the initial long-lived fission product inventory and less than 1% of the total plutonium inventory.

Most of the high activity tank farm process wastes coming out of the $BiPO_4$ plants were rich in suspended or dissolved materials (sludge), which contained a large fraction of both the uranium and radioactive fission products in neutralized acidic wastes. Decanting of these wastes in a three-tank cascade system led to a clarified less radioactive supernatant, with much of the original suspended radionuclide load deposited as a salt cake at the bottom of the tanks.

Wastes from these sources were discharged to several cribs adjacent to the 241-B (cribs 216-B-7, 216-B-8, 216-B-9) and 241-T (216-T-5, 216-T-7, 216-T-19, 216-T-32) tank farms. These tank wastes were relatively well characterized prior to release. An average of 10%, by weight, inorganic anions (phosphate, sulfate, fluoride, nitrate) and cations (sodium, potassium, ammonium) is reported in Stenner et al. (1988). Accordingly, these wastes were termed high-salt wastes. All of the waste sites had relatively short lives and were taken out of service when contamination began showing up in nearby groundwater wells. Ground disposal of second-cycle cascade liquid streams lasted from 1946 to 1952 and 1956 for B Plant and T Plant, respectively (Waite 1991).

First-cycle decontamination wastes were discharged to the soil column, in a more limited and controlled manner between 1953 and 1954. These wastes originally contained an estimated 10% of the fission product load entering the $BiPO_4$ plants and small concentrations of plutonium and uranium. The wastes were discharged to specific retention facilities, notably the 216-BX, -T and -TX trenches (216-B-35, 216-36, 216-B-38-41; 216-T-14 to-17 and 216-T-21 to -24). Specific retention disposal, described in more detail in Scavenged Wastes below, was a requirement to not saturate or flood the soil column under the trench or crib when discharging more highly contaminated liquids. Specific retention used about 30-50% of the 20% soil column pore volume as a basis for both sizing the receiving facility and capping the quantity of wastes discharged.

In contrast to the second-cycle decontamination wastes, the first-cycle decontamination liquids had been stored in tanks for a number of years, and much of the fission products and plutonium originally present had either decayed or more fully settled. Nonetheless, the concentration of radionuclides in this waste stream was slightly higher than for second-cycle decontamination wastes. The inorganics present were also slightly more concentrated and of a somewhat different mix than the second-cycle wastes. With approximately a 20% by weight average chemical content, this waste stream was also considered to be a high-salt waste.

Intermediate Wastes. Two intermediate-level waste streams grouped as part of the tank wastes were discharged to the soil column from the $BiPO_4$ process. One waste stream from the 224-B and -T Concentrator Building's waste concentration tank were noted for a relatively high plutonium concentration which was initially discharged to deep reverse wells (216-B-5 and 216-T-3) and later to cribs (216-B-7, 216-T-6, and others). This stream was also high in precipitated material and the 136,260-L (36,000-gal) 241-B/T-361 settling tanks were used to contain much of the resulting sludge. For a part of the facilities' operations, only decanted liquid was introduced into the soil column. After some period of time, the tank filled up with sludge, and more of the highly contaminated, suspended load was able to enter the reverse wells. A plume of short-lived alpha and beta contaminants was detected around the 216-B-5 reverse well in September 1947 (Brown and Ruppert 1950), resulting in that waste site's abandonment. The waste stream directed to the 216-T-3 reverse well had already been diverted to the 216-T-6 Crib by August 1946, and contamination was not observed in the groundwater.

The other waste stream, the 221-B and -T canyon building's cell 5-6 drainage, was a low- to intermediate-level stream that received diluted process liquids from cell rinses and spills to the plant waste collection tank, #6, located in cell 5. This stream was a composite of the individual steps used in the $BiPO_4$ process. The wastes were discharged to a series of cribs clustered near the 241-B and T tank farms (216-B-7, 216-B-8, 216-B-9, 216-T-6, 216-T-7, and 216-T-32). The waste stream had a relatively lower, but still significant, quantity of both chemicals and radionuclides than did the other streams in this category.

One other stream in this group is the 242-B and 242-T Evaporator bottoms waste discharged to the 216-B-37 and 216-T-25 Trenches. The waste stream for 216-B-37 Trench is defined (Stenner et al. 1988) as first-cycle bottom supernatant wastes from the waste evaporator and 242-B. The waste stream for the 216-T-25 Trench is a similar stream from the 242-T (evaporator) Building. The evaporator bottoms were discharged back to the BY and TY tank farms, respectively, with residual supernate disposal to the trenches. There is nearly a four-fold increase in the quantity of chemicals sent to the B-37 trench compared to the T-25 trench because of the longer operational time of 242-B. Both waste streams contained large quantities of Cs-137 (1,470 to 4,220 Ci), and short-lived beta emitters (2,820 to 8,080 Ci) with minor quantities of Sr-90, Pu-239/240, U-238, and Co-60 (DOE-RL 1997a, Appendix A).

Scavenged Wastes. Scavenged waste was generated from the treatment of high-level metal (uranium) waste originally discharged to tank farms from the $BiPO_4$ process. Metal waste contained 95% or more of the uranium in a chemical-rich solution along with ~ 90% of the long-lived fission products (GE 1945). This material was the most contaminated of the four waste streams generated, and comprised a greater volume of waste than any of the other high activity waste stream. Tank space and a shortage of uranium became a problem at about the same time and reprocessing of the stored wastes was undertaken at the URP at 221/224-U Plant.

The recovery process generated more waste liquids than it removed. Disposal to the soil column was the chosen solution if the fission product concentration could be reduced. The Sr-90 fraction was already in an insoluble sludge form and would readily settle out in tanks without adding a chemical scavenger. A step was developed that added ferrocyanide and nickel salts to the end of the URP stream, precipitating out much of the Cs-137. The wastes were then transferred to the 241-B tank farms, and passed through a tank cascade. The supernate was then overflowed to the ground, relatively free of fission product contaminants. This step was implemented after the URP had been operational for several years. The stream carried a moderate uranium inventory, a negligible plutonium inventory, and small quantities of Tc-99, H-3, and Co-60. The scavenged wastes contained an inventory of salts that averaged approximately 26% by weight of the total liquid solution. Most of the scavenged wastes were discharged to the ground in 200 East Area, at the 216-BY Cribs (216-B-42 to B-49) and, later, at the 216-BC Cribs/Trenches (216-B-14 to B-34), south of the 200 East Area. One crib site, 216-T-18, is known in the 200 West Area.

Beginning in 1955, the stored unscavenged tank wastes from early URP runs were treated in the 241-CR Vault using the same scavenging agents as at URP. The wastes were then transferred to 241-B tank farms for decanting, in what was termed "In-farm" scavenging. It is unclear if the URP-scavenged waste was segregated from or mixed with the in-farm scavenged waste at the time of discharge, or if only certain cribs or trenches received liquid wastes from one of the two sources. Scavenged waste discharges were halted in early 1958, shortly after the cessation of the URP in December 1957.

Scavenged waste discharges contributed perhaps the largest liquid fraction of contaminants to the ground in the 200 Areas. Based on data in Haney and Honstead (1958), Stenner et al. (1988), and Maxfield (1978), the total included over 4.749×10^7 kg of inorganics, 10,800 Ci of Cs-137, 19,700 Ci of Sr-90, 5,700 kg of uranium, and 108 g of plutonium. In addition, Waite (1991) indicated that over 1,000,000 Ci of short-lived beta emitters were also discharged at these sites. The short-lived beta-emitting radionuclides have decayed to undetectable levels, while Sr-90 and CS-137 have decayed to levels no more than 35% to 38% of the original amount discharged.

The scavenged waste discharged to the BY cribs may have behaved as a high-density liquid (Sp G.=1.2) mass upon reaching the groundwater table. The limited evidence for this behavior has been summarized in Kasza (1993) and discussed in Smith (1980) and DOE-RL (1996). This mechanism is considered to be viable from a chemical/material behavior standpoint. The wastes are thought to have descended to the bottom of the unconfined aquifer and remained as a coherent mass for some time, slowly dissolving into the groundwater. Smith (1980) noted increased concentrations of fission products at the top of basalt around the B-5 site, possibly attributed to the density phenomena.

G1.1.3.6 Tanks/Lines/Pits/Boxes Category. This group of waste sites contains all the pipelines, encasements, diversion boxes, valve pits, catch tanks, vaults, and other structures that were used to convey high-level liquid wastes between tank farms, separations buildings, evaporators, vaults, etc., in both 200 East and 200 West Areas. The 241-Tank Farm operable units are not considered to be part of current Implementation Plan scope, as they are currently managed by the Project Hanford Management Contractors (PHMC). Since these operable units are normally bounded by their fence lines, the Tanks/Lines/Pits/Boxes group covers those related facilities outside the fence lines. Although the generating processes have stopped, high-level waste treatment is expected to continue for several more decades and future uses for the waste units in this group must be considered.

The diversion boxes, valve pits, pipelines, sampler pits, and other structures directing and regulating wastewater flow to crib, pond or ditch waste sites are considered to be separate from the structures in the Tanks/Lines/Pits/Boxes group. Rather, these structures are regarded as being part of the respective waste group sites characterization effort, equal in importance to that of the actual waste site.

At the beginning of 200 Area operations, a number of pipelines connected each separations building with its respective tank farms. With time, new facilities and more tank farms were required. Construction of new tank farms and the startup of new processes generally required the additional construction of new pipelines, encasements, diversion boxes, catch tanks, storage vaults, etc. The URP required construction of (1) a multi-pipe, cross-site transfer line between the 200 East and 200 West Areas; (2) a vent station, (3) terminal diversion boxes at either end of the cross-site line, (4) several large vaults for waste pre-treatment and storage, and (5) high-pressure pipelines running between the tank farms and the terminal diversion boxes and vaults. Inside the tank farms, two to three new diversion boxes (one per active tank cascade) and a master diversion box were added to facilitate extraction and pumping transfers. A smaller but similar construction program was required for the Waste Fractionization program at B Plant and included construction of the 244-AR Vault, a lift station, and pipelines connecting the 241-A tank farms to the vault.

In the early 1980s, the pipeline and diversion box system was reconfigured to isolate unused pipeline, encasements, catch tanks, and diversion boxes from active facilities and transfer lines. Pipelines constructed before approximately 1960 were not routinely provided with any secondary containment to protect against leaks. Many of these were later encased in covered concrete boxes with regularly spaced access risers to permit leak detection.

It is expected that contamination is present at most, if not all, of the sites in this group due to leaks, spills, and unplanned releases. Most encasements are known to be contaminated, as are all diversion boxes, catch tanks, lift stations, and vaults. Spills and releases to the surrounding areas are also known and are correlated with those facilities where data allows.

G1.1.3.7 Unplanned Releases Category. In general, an unplanned release site is the result of an airborne release, or liquid or solid spill that contaminates surrounding areas. Unplanned releases have been tracked over the years and, where possible, were related to the generating facility or activity. The releases have been categorized and labeled several times with either a UPR (Stenner et al. 1988) or UN letter prefix, an area code (200-E, 200-W) and a unique number. Over time, several unplanned releases have been duplicated using different numbers or have been dually classified as a liquid or solid waste site. The WIDS database is the current means for tracking these releases and resolving discrepancies.

In the Implementation Plan at least three separate subdivisions of unplanned releases are considered. The first are the releases that can be correlated to a specific waste site in one of the other groups or categories in DOE-RL (1997d). Another subdivision is attributed to those from facilities in the 200 Areas Tank Farm Operable Units, which are listed in Appendix B of the *Waste Site Groupings for 200 Areas Soil Investigations* (DOE-RL 1997a). The final subdivision of Unplanned Releases is the Grouping Document's Unplanned Releases category. This broadly defined group covers a host of waste sites generated by generally unknown facilities or by spills and releases tied to transporting waste materials on site.

One-hundred eleven of the 283 unplanned releases originally counted are grouped with their respective waste sites. Another 79 unplanned releases are grouped with the tank farms operable units and result from incidents at tanks, vaults, boxes, and pipelines inside or directly adjacent to the tank farm fence line. Some of the remaining 93 unplanned releases may be reassigned to other groups as more information is found.

G1.1.3.8 Septic Wastes Category. There are at least 55 septic tanks and/or drain fields in the 200 Areas and adjacent 600 Areas. Virtually every building where office or workspace was provided to employees had its own septic system or shared one. Few septic systems are close to soil column disposal sites. Sanitary waste streams included toilet discharge, shower water, kitchen wastewater, janitorial sink wastewater, and similar liquid wastes. The systems were sized depending on the office capacity of the building being served.

Radiological contamination of these waste streams is assumed to be exceptionally low, although there are reports that some of the contents sampled for disposal at to the 100-N-Area sewage lagoon are mildly contaminated. The volume and inventory of these sites were not routinely tracked. These are one of the few continuing sources of soil column discharge at the Hanford Site.

G1.1.3.9 Active Waste Sites Category. Two active, state-approved liquid waste disposal sites are located in the 200 Areas. The State Approved Land Disposal Site (SALDS) crib is located north approximately 360 m (1,200 ft) of the 200 West Area fence line. It receives slightly tritiated but otherwise uncontaminated water from the Effluent Treatment Facility, located in the 200 East Area. Effluent is batch collected and discharged after verification through laboratory analysis. Each tank batch averages 1,892,500 to 2,460,250 L (500,000 to 650,000 gal) and is emptied on an as-needed basis. The Treated Effluent Disposal Facility (TEDF) consists of two ponds located east of the 216-B-3C Pond. TEDF receives treated effluent from 221-T Plant, PFP, 222-S Laboratory, 283-W Water Treatment Facility, 283-E Water Treatment Facility, 241-A Tank Farm, 242-A Evaporator, 242-A-81 Water Services Building, 244-AR, WESF, and package boiler annexes. During routine operations, this site receives an average of 75.7 to 567.8 L/min (20 to 150 gal/min). Discharge rates increase to approximately 11,355 L/min (3,000 gal/min) when steam condensate and cooling water are discharged during 242-A Evaporator operations. No treatment is performed at the TEDF.

In addition, there are over 140 minor, uncontaminated, unregulated liquid waste sites associated with the 200 Areas. No radiological or hazardous/dangerous chemical waste components are associated with these streams. These minor streams arise from a number of sources: steam traps, high tank overflows, equipment drains, air conditioner condensate drains, etc. (DOE-RL 1997e).

At present, solid waste is being disposed of to the 218-E-10, E-12B, W-3A, W-3AE, W-4B, W-4C, and W-5 Burial Grounds, and property lines are designated for future use at the 218-W-6 Burial Ground. These sites will remain active until individual burial ground capacity is reached or until the Hanford site facilities are permanently closed.

G1.2 Waste Site Types and Operational Parameters

Previous sections provided background data related to the origins, chemical and radionuclide constituents, and volumes of wastewater discharged to the soil column (see Table 3-10). The waste sites themselves exerted some control over the distribution and depth of placement of contamination, especially the larger ponds, cribs, and trenches. This section discusses important characteristics of waste site design and construction, as well as plant and waste site operation. These data will assist in understanding conceptual model development and site characterization requirements. For additional discussion on these structures, refer to Maxfield (1979), the ten AAMS report documents (DOE-RL 1992a, 1992b, 1992c, 1992d, 1993a-f), the six technical baseline documents prepared for the AAMS reports, and the WIDS database.

Pipelines, holding tanks, diversion boxes, retention basins, valve pits, sampler pits, and a host of related engineered structures are associated with many of the waste sites described below. These items are not specifically addressed for each site, but are considered to be part of the site and need to be addressed either by plant D&D activities or by this project.

Except for certain types of trenches, waste site operations and usage were unregulated; i.e., unlimited flow over any number of years was permitted to the waste sites as long as waste stream contaminants were routinely below discharge standards. From at least the mid-1950s on, waste site's operation was regulated by its impact to the groundwater, as defined by standards in force at the time of operation. A 200 Area crib was able to receive waste as long as radionuclides with half-lives less than 3 years were not observed in the groundwater by nearby wells (Haney and Honstead 1958). This was based on an assumed travel time to the Columbia River of 50 to 100 years. Discharge standards were changed over time with regulatory standards promulgated by the responsible government agency.

G1.2.1 Waste Site Types

A number of waste site types were used at the Hanford Site for liquid and solid waste disposal. Terminology for these sites has changed over the years, and misuse has caused some confusion. This section provides a definition for specific waste site types and discusses the design, design changes, and improvements made over time.

Liquid wastes were discharged either to surface sites (ponds and ditches) or to underground sites (cribs, trenches, french drains, and reverse wells) depending on the levels of radiological contaminants. As part of the design process for a generating facility or for a process modification, waste stream characteristics were estimated before a waste site was designed. Underground disposal was required for those contact streams that had known levels of contamination or where there was some potential for large-scale releases through vessel failure. Surface disposal was acceptable where noncontact operations yielded large quantities of wastewater with negligible radiological contamination or with smaller potential vessel failures.

In the early stages of the Hanford project, impacts of exposure to contaminated wastewater were not well understood. Further, almost no data were available that documented the impacts of any type of chemical or radiological waste disposal to the soil, or consequences of migration to groundwater. Initial plans for the less concentrated, non-tank wastes recommended disposal to surface pond sites. However, this idea was quickly abandoned when the potential for contamination spread via drying and blowing of soils was recognized (Brown and Ruppert 1948). Underground disposal in reverse wells and wood crib structures became the design basis and was implemented before the start of plant operations.

Simultaneously or shortly afterward, research was initiated on the soil column's retention properties for radionuclides. It was quickly realized that the 200 Area's thick vadose zone, combined with the sorptive properties of the sediments, was able to provide considerable protection against groundwater and, ultimately, Columbia River contamination by 200 Area wastes. Specifically, Pu-239/240, Cs-137, and Co-60 were recognized to be generally immobile in the soil, and strontium was shown to be somewhat more mobile.

G1.2.1.1 Reverse Wells. Reverse wells were the first type of liquid waste disposal sites constructed in the 200 Areas, and all are associated with either the $BiPO_4$ separations or the 231-Z isolation buildings. As the name suggests, a reverse well, also known as an injection well or dry well, is a drilled, cased borehole, with perforations (holes were drilled or punched in the casing) along the bottom of the well. Liquid wastes were discharged either directly from the generating facility into the pipe or were first passed through settling tanks, as at 216-B-5 and 216-T-3. These tanks were labeled 241-B/T/U/Z-361. Each tank was 6.1 m (20 ft) in diameter and had a 136,260-L (36,000-gal) storage capacity at an overflow depth of 4.6 m (15 ft). The term "dry well" was often used in place of reverse well, but was also confusingly applied to both french drains and tank farm monitoring wells (GE 1945).

Eight reverse wells were drilled in the 200 Areas, to depths of 22.9 to 92.1 m (75 to 302 ft). Most reverse wells were 61 m (200 ft) deep or less and were typically 10.2, 15.2, or 20.3 cm (4, 6, or 8 in.) in diameter with starter casings up to 50.8 cm (20 in.) in diameter for the first 9.2 to 12.2 m (30 to 40 ft). Smaller diameter pipe was telescoped into the larger casing and grouted in place until the design depth was reached. Two reverse wells (216-B-5 and the first 216-T-3) were drilled to depths of 85.4 to 92.1 m (280 to 302 ft), and may have been drilled into or very near groundwater. A 92.1-m-(302 ft) deep reverse well was drilled at the 214-U-361 settling tank, but was never used for waste disposal. (This unused reverse well was the location where uranium-rich perched crib water from 216-U-16 penetrated the 200 West Area caliche zone in the 1980s and migrated to the groundwater.) Waste volumes discharged to the reverse wells are generally unknown, but are assumed to be fairly low. Where known, as at 216-B-5 and T-3, the systems appear to have been cyclically flooded, based on routine batch discharge operations (GE 1945).

Use of reverse wells was recognized as a mistake early in Hanford's operating history due in part to operating difficulties, but more so because several sites had probably contaminated groundwater (Brown and Rupert 1948, Parker 1954). The main waste disposal problem associated with reverse wells was that a much smaller thickness of sediments was available to neutralize the impacts and spreading of wastes below the bottom of the well casing. Operating difficulties included plugging of perforations by running sand, which was caused by intermittent operation. Sludge in the waste stream may have also plugged the well. Reverse well use began in 1945, and the last well was taken out of service in 1955. However, most sites were closed by 1950. Two other structures, 216-B-11A and 216-B-11B, are referred to as reverse wells, but their actual design is that of a french drain, and they are considered as such in this appendix.

G1.2.1.2 Cribs. Cribs were designed to receive low to moderate volume waste streams with generally higher levels of radionuclides resulting from direct contact with process chemistry. Cribs were also constructed to receive steam condensates at continuously operating separations plants where coil failures were possible and significant contamination releases were possible.

A crib's basic design created a greater unit volume of below-ground, open void space than otherwise occurred as a result of the soil column's porosity. This design offered a significant underground receiving space, a physical barrier against surface exposure, and restricted upward moisture/vapor migration or animal and plant root penetration.

The term "crib" was derived from the initial wood timber design, which resembled embankment or mining support structures. The initial crib designs consisted of a series of six wood beams assembled into a square frame with two parallel crossbraces. The frames were stacked, rotated 90 degrees to one another, forming a box-like structure with four internal columns at the crossbrace overlaps, and nine open cells. The boxes were roofed with beams, and the sides were usually covered with tarpaper. Two cribs usually served one waste stream. Each box was buried in a separate excavation, and the downstream box was connected with an overflow pipe. Several 231-Z cribs were constructed of wood, but to different designs. Several pipes penetrated both the sides and the roof, providing access for the effluent pipes, ventilation pipes, liquid-level gauging wells, and soil column monitoring wells. Wooden cribs were usually 3.7 to 4.9 m (12 to 16 ft) square, 1.2 to 2.7 m (4 to 9 ft) tall, and were commonly buried beneath a 4.6- to 6.1-m (15- to 20-ft) thick soil cover. Past collapses are known and/or assumed probable for all wood cribs. Concrete beams, cinder blocks, and steel plates were occasionally used in place of wood at several sites across the 200 Areas.

Crib effluent data suggest that effluent pipeline placement did not allow much liquid to reach the second crib. The effluent lines entering the cribs were placed at levels at or above the crib roof. To get liquid into the second crib required flooding of, or high flow rates into, the first crib. Drilling data (Brown and Ruppert 1948) support the observation that little liquid flow ever reached the downstream crib, where the amount of contamination found beneath several 241-T Tank Farm cribs was much greater under the first box than under the second box.

Designs using multiple wooden cribs in one large gravel-filled excavation (216-B-12 and 216-U-8) and single wooden cribs with a gravel tile field for overflow (216-B-9, 216-T-7) represented transitional steps between the all-wood and all-gravel designs. However, cribs had evolved into the standard, coarse gravel/cobble-filled excavation by the early to mid-1950s, and appear to be similar to tile field designs used for septic systems. At that time, the gravel-filled cribs were called "caverns," to distinguish them from the wooden structures, but this terminology was not used after 1956.

The all-gravel cribs usually consisted of a single, 20-40 cm (8-16 in.)-diameter, horizontal, perforated pipe that extended the length of the crib. The pipe was typically submerged just beneath the top of a 1.2- to 2.1-m (4- to 7-ft) thick, coarse gravel/cobble fill, which in turn was covered with a heavy plastic or sisalkraft-paper (brown-bag) vapor and root barrier. This barrier was covered with a backfill of the excavation soils. Other piping designs included a herringbone arrangement of perforated lateral pipes connected to the main distribution line and a series of unperforated distribution lines with 90-degree connections to perforated laterals. Liquids sent to the 216-BY Cribs went to four 1.2-m-(4-ft) diameter culvert pipe segments placed vertically in the gravel fill.

Gravel crib sizes vary significantly. Small cribs (i.e., 216-U-3, A-22, and A-28) are 3.0 to 6.1 m (10 to 20 ft) in diameter and 3.0 to 3.7 m (10 to 12 ft) deep with a gravel fill placed in the excavation bottom. The largest cribs (i.e., 216-A-24, A-30, A-37-2) have bottom dimensions of 426.8 to 457.3 m (1,400 to 1,500 ft) long, 3.0 m (10 ft) wide, and 3.0 to 4.6 m (10 to 15 ft) deep. Most cribs are smaller, with an average length of 60.1 to 152.4 m (200 to 500 ft), widths of 3.0 to 6.1 m (10 to 20 ft), and 4.6 to 10.7 m (15 to 35 ft) deep. In general, at least 1.5 to 1.8 m (5 to 6 ft) of soil covered the gravel bed. All linear cribs were constructed with a 0.5% to 1% slope along the axis of the excavation to facilitate flow along the structure. Several cribs such as the 216-S-5/S-6, 216-U-16, and 216-W-LC Cribs were large rectangular structures, 60.1 to 91.5 m (200 to 300 ft) in length and 30 to 45.7 m (100 to 150 ft) in width.

Uniformly graded coarse gravel, fine to medium cobbles, and, on occasion, crushed rock were used to provide a network of large, interconnecting pore spaces that would quickly accept discharged liquids and conduct the liquids to the bottom and along the length of the crib excavation. Porosities of 40% to 45% could be expected using these materials compared with the 20% to 30% pore space found in sands and well-graded sediments. In addition, the individual pore spaces in gravels are much coarser than in well-graded sands and gravels. Layering of gravel- and cobble-sized rock was tried at several sites.

Gravel cribs were usually equipped with ventilation/filters systems to allow the crib gravels to "breathe" as water entered the structure. These fixtures were ready sources for localized surface contamination of the risers and the surrounding soils. In addition, liquid-level gauges using floats or conductivity probes were installed to monitor crib percolation performance. Vadose zone and groundwater monitoring wells were often drilled through or at the edge of the crib to monitor vertical contaminant migration into the soil column and to detect contamination reaching the groundwater.

For several processes associated with PUREX and REDOX, two or three waste sites were constructed for higher volume streams. These sites were equipped with diversion boxes and valve pits to control routing between cribs. Sampler pits and flow-measuring/recording devices were also placed on some of the waste streams. Most of these facilities were not given separate identification numbers. The 216-A-8/A-24 and 216-A-30/A-37-2 Cribs are representative of crib system complexity and required several diversion structures. Diversion boxes were also built at the 426.8- to 457.3-m (1,400- to 1,500-ft) long 216-A-24, 216-A-30, and 216-A-37-2 Cribs to split wastewater flow between crib lines that discharged at the head end and at the center of the crib. This design ensured a more even distribution of wastewater to the entire length of the crib, which would otherwise not be able to accept the potentially large volumes of water generated by the waste stream.

Neutralization of crib wastes was occasionally performed on-line at underground, limestone-charged, flowthrough tanks. This treatment was applied at the 216-B-12 and 216-U-8 Cribs, which received large volumes of acidic process condensate from the URP. Laboratory tests indicated that this step could neutralize low pH values of acidic wastes from 2 to 4 to 6 or greater. Several concerns were associated with this practice, one of which was the regularity with which the limestone was monitored and replaced. There was also some concern that calcium liberated from the limestone actually out-competed cesium for exchange sites in the soil column.

Lint buildup was an isolated problem specific to the laundry crib. That structure was designed to allow access to unclog the individual drainage laterals. In addition, filters were installed in large terminal caissons to capture and remove lint.

G1.2.1.3 French Drains. French drains were commonly used for very low-volume streams where contamination through contact with a process stream was likely. French drains were constructed out of metal or concrete culvert piping placed on end in an excavation. The culvert pipe varied from 76 to 180 cm (30 in. to 6 ft) in diameter and was installed to depths of 3 to 12 m (10 to 40 ft). For consistency, the 1.2-m (48-in.) diameter/ 12.2-m (40 ft)-deep 216-B-11A and -11B "reverse wells" are considered here as french drains. Also, the term has been incorrectly applied to several small cribs (216-U-3, 216-A-22, 216-A-28), which were essentially excavated holes into which a thickness of gravel was placed and into which a pipe emptied. The typical french drain structure was partially filled with gravel and was covered with a wood, steel, or concrete lid. Effluent and vent pipes commonly penetrated the lids or culvert sides. Discharge rates and contaminant concentrations to these structures were usually not documented but likely did not exceed 5 to 10 L/min.

G1.2.1.4 Ponds. High-volume, low-concentration waste streams were discharged primarily to surface structures, or ponds. The first ponds were initially termed "swamps," primarily because the waste stream was routed to a topographic low point around the plant and allowed to flow across the ground. Seven swamps/ponds began operating in the 1940s with startup in the 200 Areas (Haney and Honstead 1950), by discharges from the B Plant, 200–E Powerhouse, 200-W Powerhouse, the T Plant, and the three 212 buildings in the 200 North Area. Ponds supporting REDOX and PUREX discharges were built later. The wetted areas became marshy and were noted for the potential to spread contamination during windstorms. Dikes and embankments across the drainages were apparently constructed, but the early structures appear to have been little more than a bulldozed dike, with no engineering design.

Ponds were typically the end point for any pond-ditch system and were regarded as the primary soil column percolation sites of the two components. Wastewater was conveyed to the ponds through a combination of buried pipelines, retention basins, and open ditches. Wastewater from the $BiPO_4$, REDOX, and URP plants was initially collected in one of two 1,892,500-L (500,000-gal) basins at the 207 Retention Sites. When the basin was filled, the basin water was sampled and held until contaminant levels were below release standards. Upon release of wastewater from the first basin, the other basin was closed to allow filling. Offline retention basins were provided for the PUREX wastewater. This system relied on waste stream beta and gamma monitors connected to valves which automatically diverted water to the basin if elevated levels of contamination were detected.

All waste sites were subject to loss of percolation/porosity due to deposition of windblown debris. Ponds were especially susceptible to such losses because of their open construction and large surface exposure. Occasional experiments to control and settle out unplanned release contamination through the addition of clays reduced pond percolation capacity significantly. Percolation rates for some ponds dropped to less than 40.7 l/m^3/day (1 gal/ft^2/day) over their operational life. By the latter part of its operations, most of the wastewater entering the main lobe of B Pond was passing through to the downstream lobes. Vegetation such as trees, shrubs, cattails, and water grasses commonly grew in or along the margins of ponds and ditches. The growth was regarded as beneficial in maintaining percolation rates through plant root action.

Surface soil, vegetation, and algal uptake and concentration of contaminants is well documented and posed occasional problems, particularly following major releases. On these occasions, new material was usually bulldozed over the pond margins to isolate the soil-, algae- and vegetation-concentrated radionuclides. Old pond margins need to be carefully defined for characterization and remediation purposes.

Pond sizes varied depending on the generating plant's output, but ranged from 6,073 to 323,914 m^2 (1.5 to 80 acres). Depths were generally shallow, 0.6 to 2.4 m (2 to 8 ft), but B Pond was at least 3.7 m (12 ft) deep. Ponds were usually built in connected or cascading systems, such as the U-10 Pond/U-9 and -11 Ditch system, and the 216-A-25/B-3 pond lobes and ditches. Cascades and lobes were constructed as necessary for increased flows or as the result of releases from breached dikes. When lobes were added, spillways, pipes, diversion structures, and gates were also added to regulate the flow of liquids to the downstream structures. In areas where early operations discharged to swamps rather than ponds, the extent of contamination across an area is likely greater than shown by early drawings and has generally been defined by radiological boundaries.

An operational penalty of sorts was exacted on plants that discharged to ponds and ditches. Due to previously deposited contamination, temporary interruptions of liquid discharges to a site were not allowed. The contaminated soil had to remain covered with water to prevent drying out contaminated sediments, which could then be transported by wind. Consequently, a significant fraction of wastewater discharged to ponds was raw water and carried no process contamination. Raw water was routinely discharged from inactive plants and facilities to maintain liquid levels.

G1.2.1.5 Ditches. Ditches were constructed either to convey wastewater to a pond or to serve as the only soil column percolation structure. It is uncertain why ditches were added to pond disposal systems or why ponds were not directly connected to retention basins only by pipelines. Cost of construction and the then-significant distance from the plant are the most likely reasons.

A number of ditches, (e.g., 216-S-10, 216-T-1, and 216-B-63) were operated either without connecting to a pond or with only short-lived pond connections. Ditches were generally not considered important percolation structures, particularly when they were part of a pond system. They were, in fact, responsible for a significant (if largely unknown) fraction of percolation to the ground. Ditches were generally 1.8 m (6 ft) wide at the bottom of the excavation and constructed with side slopes that averaged at a 1.5:1 (H:V) ratio. Ditch depths and widths varied with topography, but were usually 1.8 to 3 m (6 to 10 ft) deep. The maximum surface width of a ditch at the 216-S-10 site was approximately 15.2 m (50 ft). Ditches normally began at the concrete headwalls of pipeline outfalls and occasionally returned to pipelines at engineered structures.

G1.2.1.6 Trenches. Trenches were excavated to handle one-time "emergency" discharges of high-level wastes, or otherwise low-level, "un-cribbable" wastes. Specifically, significant quantities of scavenged and tank wastes were discharged to both trench and crib facilities on an as-needed basis. However, a number of trenches were used for disposal of other materials, including cold startup wastes and retention basin sludges. Wastes in these categories were richer in radionuclides and/or chemical contaminants than most other waste streams. The term "un-cribbable" waste was given to wastes that exceeded the normal concentration standards for continuous discharge of radioactive liquid wastes to the ground.

Trenches were excavated close to the process facility, at the tank farms where the waste was stored, or at more remote locations (e.g., south of the 200 East Area at the BC-Cribs/Trenches area) connected by pipelines. Most trenches that received tank or scavenged waste were 61.0 to 152.4 m (200 to 500 ft) in length, 3 m (10 ft) wide, and at least 3 m (10 ft) deep. Trenches receiving cold start-up wastes were usually smaller, on the order of 6.2 by 15.2 m (20 by 50 ft). Other trenches, which received wet contaminated sludge from retention basins or 212 Building cleanout sludge were 3.0 to 6.1 m (10 to 20 ft) wide, 4.6 to 24.4 m (15 to 80 ft) long, and 1.8 m (6 ft) deep. Wastes were delivered by over-ground hose or pipeline connections from a holding tank, valve pit or diversion box. Holding tanks are present at both the 216-BY and 216-BC areas. Other trenches in the 216-BC area continued to receive low volumes of liquid wastes. Until 1967, the 300 Area Laboratory waste collected in the 340 Facility was discharged to the 216-B-54 to 216-B-58 Trenches.

A means of ensuring greater excavation utilization was required at the longer BC Trenches. Typically, low dams or berms were built at regular intervals along the excavation axis, and piping/hose connections were routed to the individual segments to ensure more even waste distribution. Also, at most trenches, temporary vapor barriers were built of wood frames and plastic covers to prevent drying and dispersion of the liquids. When a trench reached its design capacity, the excavation was backfilled. It is uncertain if the wood and plastic covers were buried in place or reused (Corley 1956).

An evolution of trench design and use parallels experiences with disposal of the tank and scavenged wastes described in Section G1.1.3.5. Cribs located around the 241-B and 241–T tank farms were the first sites that routinely received tank overflow wastes. With a shift toward specific retention-type operations, these cribs were replaced in both areas with a series of smaller trenches that were located at the 241-BX (216-B-36, 38-41) and 241-T tank farms (216-T-14 to T-17). Then, as noted above, the URP wastes exceeded available tank capacity but were too rich in fission products to be discharged to the soil column. A chemical process inducing precipitation, or scavenging, of the fission products was developed, and lower activity liquid wastes were then sent to the ground after some residence time in the tanks.

Based on the generally successful operation of the 216-BX trenches, other sites were developed to receive decanted scavenged wastes. The 216-BY waste sites were designed as cribs but were proposed to be the first waste sites to test specific retention (Clukey 1954). However, the sites were either treated as cribs or their retention capacity was overestimated. Cesium and cobalt were detected in the groundwater within 10 months of start of operations. Cobalt-60 was an unexpected contaminant in the groundwater as its mobility was generally very low (Thomas et al. 1956).

Six new cribs were built at the 216-BC area before problems with the BY cribs were fully realized. The 216-BC Cribs were presumably operated as specific retention facilities, but were later supplanted by trenches. The BC facilities were specifically operated to the most conservative standards of any specific retention facility. The BC-trenches received wastes between 1956 and 1958 with no obvious signs of contamination in the groundwater.

G1.2.1.7 Solid Waste Burial Grounds. There are two general types of radioactive, solid waste disposal sites and a wide variety of nonradioactive sites. For storage of a broad array of solid radioactive wastes, large multi-trench burial grounds were constructed. Several currently active burial grounds will be utilized well into the future. Alternately, smaller one-trench burial grounds were created adjacent to surface storage pads for one-time disposal of contaminated equipment and materials. In a few cases, in-place disposal of failed utility lines was considered as a burial ground.

In addition, there are wooden, small-volume disposal vaults/caissons near the 222-B, -S and -T Buildings for laboratory wastes and at least 16 steel-drum caissons at several 200 West Area burial grounds for storage of small volume, highly radioactive and TRU wastes. Low-level solid wastes were placed in drums, plastic bags, and cardboard or wooden boxes and stored in trenches. Small volumes of liquids were placed in the burial grounds but were encased in concrete-filled drums.

Trench bottom dimensions varied considerably. Trench lengths were proportional to the site boundaries (avg. 61 – 274.4 m [200 - 900 ft long]), were usually less than 16.8 m (55 ft) wide, and were typically 3.7 – 7.6 m (12 to 25 ft) deep. They were constructed with sideslopes of 1.5:1 (H:V) ratios and had surface footprints up to 27.4 m (90 ft) wide. As a general rule, trench spacing was equal to, or somewhat less than, the footprint of the individual trench excavation. A standard 1.2-m (4-ft) soil cover was required over all low-level wastes to avoid cave-in problems associated with cardboard or wooden boxes and settling wastes.

Waste segregation was not practiced initially at the Hanford Site, but became standard practice by 1970. Segregation of the site's TRU waste to the 200 Areas was initiated in 1963. By 1967, all solid waste from the 100-N and 300 Areas was shipped to the 200 Areas burial grounds, along with offsite waste including naval vessel reactor cores, Three Mile Island wastes, and the Shippingport pressure vessel. The burial grounds constitute the largest concentration of radionuclides of all waste site types addressed by the Implementation Plan, and have significant inventories of plutonium, uranium, and fission products.

Depending on their nature and volume, nonradioactive wastes were either segregated according to type and disposed to landfills or dumped in less controlled manners. Generally, large volume solid wastes were disposed to engineered burial grounds or non-engineered pits and landfills. Pits near the 200 Areas power plants received coal ash. Other pits were used to burn solvents, paint, office wastes, and tumbleweeds, or to detonate shock-sensitive chemicals. The large Central Waste landfill (CWL) southeast of the 200 East Area received large quantities of office solid waste (paper), construction and demolition debris, medical wastes, empty containers, appliances, office furniture, and inert debris. The adjacent NRDWL received small quantities of laboratory chemicals, spent organic chemicals, spent solvents, paints and thinners, and their containers. Liquid sewage and 1100 Area catch basin wastes were discharged to trenches in the CWL.

Other landfills and dumps were scattered throughout the 200 Areas in the early days of operations, but are not well documented. A number of discovery sites are known and tracked by WIDS. These waste sites are generally smaller in areal extent and are associated with old construction or support function activities/sites.

G1.2.1.8 Septic Tanks and Tile Fields. The sites for human sewage, kitchen wastes, and janitorial wastes disposal were very similar in design to gravel cribs. These facilities usually consisted of a large holding tank for solids and a gravel tile field for liquid overflow percolation. Piping in the tile fields is normally configured in a herringbone arrangement and is made of concrete, vitrified clay, or plastic pipe.

At least 56 of these sites are currently known to exist in the 200 Areas. Historical records of old facilities and plans for new facilities are also known. Many current sites use the same designation as the older septic systems they replaced. Consequently, a precise count on the number of sites is difficult to determine.

Each septic system is sized for the human occupancy in the facilities served, and dimensions of holding tanks and tile fields vary accordingly. Septic tank size varied from several hundred to several thousand gallons capacity. The tile fields average about 15.2 m (50 ft) wide by 30.5 m (100 ft) long. The WIDS database indicates that most of the septic tanks have drain fields associated with them, but few details are available.

G1.2.2 Waste Site Design Considerations

Several aspects of waste site operations may have impacted the distribution of contaminants in the waste site and soil column, and should be considered during characterization. Factors affecting the distribution of contaminants will require additional investigation and research for each group. This section suggests some approaches by which the factors may be evaluated. At larger facilities such as cribs, ponds, ditches, and trenches, these factors are expected to be more clearly demonstrated than at the smaller sites.

G1.2.2.1 Contamination Form. The form of contaminants entering a waste site is important to determine where they might enter the soil column. Specifically, the contaminants may exist as dissolved solids in the wastewater, may be colloidal in nature, or may occur as particulate matter. The former condition would imply contaminant spreading evenly in the waste site and the soil column. Particulate matter would settle out according to Stoke's Law such that, as the velocity of water in motion drops, particulates would drop out of suspension according to size. As a result, although the specific sizes of suspended matter are unknown, contamination would be expected to be more concentrated near the head end of the crib or pond. Also, if contamination were in a particulate form, there would be less potential for contaminant migration into the soil column. Colloidal material, being intermediate in size, would be expected to occupy an intermediate position in the waste site. These effects are known or expected to have impacted all waste site types. Of the waste site types, cribs, ponds, and ditches are expected to demonstrate impacts of contaminant form differences.

Determining the form of contaminants in waste streams that have been out of service for a long period of time poses significant problems. Existing literature documenting process flow and laboratory testing of contaminated soils or wastes is available and may provide an indication. A basic understanding of Hanford process chemistry, coupled with data regarding the specific gravity of waste streams, might also be helpful.

G1.2.2.2 Waste Site Sizing. While not reported in most cases, engineering studies were usually conducted to determine the porosity and/or percolation rates for the larger waste sites and, specifically, the cribs. Engineering documentation on crib design is rare and most likely exists in the specific project documentation for crib construction. Percolation testing was reported for several cribs, but it is unclear what methods were used. Regardless of the test results, an average design value of 407.2 L/m^2/day (10 gal/ft^2/day) was accepted for an active waste site with a saturated soil column and appears to have been used as the design basis for many waste sites. Over time, percolation rates declined as the waste site pore space became clogged, and replacement facilities were occasionally built.

From data presented in Appendix A of DOE-RL (1997a), among the various categories and groups, process cooling water waste streams comprised the overwhelming majority (93.6%) of liquid wastes, by volume. In decreasing order, process condensate, chemical sewers, steam condensates, chemical laboratory wastes, tank and scavenged waste, and miscellaneous wastes constitute the remainder of the liquid wastes. For solid wastes, radiologically contaminated materials far exceed the nonradiological wastes.

G1.2.2.3 Rate of Discharge to a Waste Site. It is unclear if an average discharge rate or a daily volume was the basis for crib sizing and, further, if either approach affected contaminant distributions in the soil column and the crib. Based in part on the form of the contamination discussed in Section G1.2.2.2, discharge rates to facilities may be important to the distribution of contaminants in a waste site and soil column. As suggested above, there were different styles of liquid discharge rates to waste sites. Continuous discharges were commonly associated with pond and ditch operation where plant water flows were continuous. When occurring as separate streams, steam condensate and chemical sewer discharges were also continuously operated. At the other extreme, batch release was a common method of liquid waste discharge. The rate of release from the holding tank storing the liquid depended on its capacity and the rating of the pump used to drain the tank. The daily total volume depended on the number of times the holding tank was emptied.

Wastewater flowing through a crib is assumed to be retarded by the tortuosity of the combined flowpaths through the crib pipe and the gravel pore spaces. Water entering a crib exited the pipe at the first available perforations and flowed down through the gravel to the crib floor. At that point, the water began to move laterally through the gravel. Under any rate of flow greater than the instantaneous percolation rate of the crib's underlying sediments, the level in the crib will rise. Similarly, when the wastewater cannot exit the pipe perforations fast enough for the upstream flow, or where the uppermost part of the crib becomes flooded, some part of the wastewater will flow further down the pipe and exit into the gravel where it can again move away from the pipe. At some flow rate the crib will flood and lateral movement into the surrounding soil column will begin to occur. At discharges where the rate of release is less than the crib's instantaneous percolation rate, only vertical flow into the soil column will occur.

This model influences the distribution of contaminants in the waste site and the soil column, depending on the nature of the contaminants. Cribs that are flooded or saturated are expected to deliver each size fraction of contamination to greater areas of the crib. Cribs in which only partial saturation occurred would be expected to have contaminants concentrated around the head end and centerline of the crib.

Continuous flooding results when plant waste discharge exceeds the crib's design capacity and results in continuously standing water in the waste site. The level of standing water may increase over time and indicate an approaching waste site failure. Routine flooding conditions are known at a few sites (e.g., the 216-U-16, S-5, S-26, and A-8 Cribs), and suspected at others. Flooded cribs sometimes exhibited signs of excessive liquid or vapor migration to the ground surface.

Rough approximations regarding the degree of waste site saturation or flooding can be made using available monthly discharge data and using an assumed design percolation rate. More refined estimates can be obtained from details of the process and support equipment feeding the waste site, coupled with operating procedures. Operational surveillance records for waste sites may provide indications of waste site performance, but would be difficult to locate.

G1.2.2.4 Waste Stream Characteristics. Although chemical properties of waste streams have been discussed elsewhere, physical waste stream characteristics have not. Factors of concern here are viscosity, density, and temperature. In general, most waste streams were classified as low salt (i.e., not needing significant in-plant neutralization) and neutral or basic. They are regarded as having density and viscosity properties equivalent to that of water. In several groups, high-salt conditions are noted, which were produced either by actual neutralization of acidic wastes (as required for release to tank farms) or the result of post-tank farm processing such as for the URP/Scavenged Wastes. These wastes had higher density values (specific gravity = 1.2) and may have been more viscous. Available literature to document the latter parameter is not available.

Temperatures of waste streams varied from ambient to near boiling, depending on process origin and proximity to the generating facility. For example, process condensates discharged from the URP left the holding tanks at temperatures of 170°F. Those wastes sent to the 216-B-12 Crib were reported to have been at 110-120°F following a more than 6.4-km (4-mile) path through buried pipelines, and are expected to have been much warmer at the 216-U-12 Crib. Imperfections in or the lack of a vapor barrier may have allowed transport of contaminants to the ground surface. Maxfield (1979) reported the presence during the winter of 1971-1972 of a white, slightly radioactive alkaline deposit that formed on the entire surface of the 426.8-m (1,400-ft) long 216-A-30 Crib. The deposit was covered with a layer of sand and a plastic sheet, which in turn was covered with a 0.6-m (2-ft) layer of sand. Thermal impacts of wastewater at other sites are not known, but may exist.

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Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
(24 Pages)

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-PW-1, Plutonium/Organic-Rich Process Waste Group Lead Regulatory Agency: EPA								
200-PW-1	216-T-19	216-T-19, 241-TX-153 Crib and Tile Field, 216-TX-1, 241-TX-3, 216-T-19TF	Crib	Inactive	CPP	EM-40	200-TP-2	
200-PW-1	216-Z-1&2	216-Z-1&2, 234-5 No. 1 Crib, 216-Z-7, 234-5 No. 2 Crib, 216-Z-1 & 2TF, 216-Z-1 and 216-Z-2 Cribs	Crib	Inactive	CPP	EM-40	200-ZP-2	
200-PW-1	216-Z-1A	216-Z-1A, 216-Z-1A Tile Field, 216-Z-7, 234-5 Tile Field, 216-Z-1AA, 216-Z-1AB, 216-Z-AC	Drain/Tile Field	Inactive	CPP	EM-40	200-ZP-2	X
200-PW-1	216-Z-3	216-Z-3, 216-Z-3 Culvert, 216-Z-8, 234-5 No. 3 & 4 Cribs	Crib	Inactive	CPP	EM-40	200-ZP-2	
200-PW-1	216-Z-9	216-Z-9, 216-Z-9 Cavern, 234-5 Recuplex Cavern, 216-Z-10, 216-Z-9 Crib, 216-Z-9 Trench	Trench	Inactive	CPP	EM-60	200-ZP-2	X
200-PW-1	216-Z-12	216-Z-12, 241-Z-12	Crib	Inactive	CPP	EM-40	200-ZP-2	
200-PW-1	216-Z-18	216-Z-18, 216-Z-18 Crib	Crib	Inactive	CPP	EM-40	200-ZP-2	
200-PW-1	241-Z-361	241-Z-361, 241-Z-361 Settling Tank	Settling Tank	Inactive	CPP	EM-60	200-ZP-2	
200-PW-1	UPR-200-W-103	UPR-200-W-103, 216-Z-18 Line Break, UN-216-W-13, UN-200-W-103	Unplanned Release	Inactive	CPP	EM-60	200-ZP-2	
200-PW-1	UPR-200-W-110	UPR-200-W-110, Contaminated Soil at 216-Z-1, UN-216-W-20	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-PW-2, Uranium-Rich Process Waste Group Lead Regulatory Agency: Ecology								
200-PW-2	216-A-1	216-A-1, 216-A-1 Cavern, 216-A-1 Trench	Crib	Inactive	RPP	EM-40	200-PO-5	
200-PW-2	216-A-3	216-A-3, 216-A-3 Cavern, 216-A-3 Crib	Crib	Inactive	RPP	EM-40	200-PO-2	
200-PW-2	216-A-5	216-A-5, 216-A-5 Cavern	Crib	Inactive	RPP	EM-60	200-PO-2	
200-PW-2	216-A-10	216-A-10, 216-A-10 Crib	Crib	Active	TSD	EM-40	200-PO-2	X
200-PW-2	216-A-18	216-A-18, 216-A-18 Excavation, 216-A-18 Grave, 216-A-18 Sump, 216-A-18 Crib	Trench	Inactive	RPP	EM-40	200-PO-5	
200-PW-2	216-A-19	216-A-19, 216-A-19 Test Hole, 216-A-19 Grave, 216-A-19 Sump, 216-A-19 Crib	Trench	Inactive	RPP	EM-40	200-PO-5	X
200-PW-2	216-A-20	216-A-20, 216-A-20 Test Hole, 216-A-20 Grave, 216-A-20 Sump, 216-A-20 Crib	Trench	Inactive	RPP	EM-40	200-PO-5	
200-PW-2	216-A-28	216-A-28, 216-A-28 French Drain, 216-A-28 Crib	Crib	Inactive	RPP	EM-60	200-PO-2	
200-PW-2	216-A-36A	216-A-36A, 216-A-36 Crib	Crib	Inactive	RPP	EM-60	200-PO-2	
200-PW-2	216-A-36B	216-A-36B, 216-A-36 Crib, Purex Ammonia Scrubber Distillate (ASD)	Crib	Active	TSD	EM-40	200-PO-2	X
200-PW-2	216-B-12	216-B-12, 216-ER Crib, 216-ER-1,2,3 Cribs	Crib	Inactive	RPP	EM-40	200-BP-9	X
200-PW-2	216-B-60	216-B-60, 216-B-60 Crib	Crib	Inactive	RPP	EM-60	200-BP-6	
200-PW-2	216-C-1	216-C-1, 216-C Crib	Crib	Inactive	RPP	EM-40	200-SO-1	
200-PW-2	216-S-1&2	216-S-1&2, 216-S-5 Crib, 216-S-1 & 2	Crib	Inactive	RPP	EM-40	200-RO-2	
200-PW-2	216-S-7	216-S-7, 216-S-15	Crib	Inactive	RPP	EM-40	200-RO-2	
200-PW-2	216-S-8	216-S-8, Cold Aqueous Trench, Cold Aqueous Crib, 216-S-3, Unirradiated Uranium Waste Trench, Cold Aqueous Grave	Trench	Inactive	RPP	EM-40	200-RO-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98. (24 Pages)

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-PW-2	216-U-1&2	216-U-1&2, 361-WR (Crib 2), 216-U-3, 216-UR #1&2 Cribs, 216-U-1 & 2	Crib	Inactive	RPP	EM-40	200-UP-2	
200-PW-2	216-U-5	216-U-5, 216-U-4, 221-U Cold U Trench #2	Trench	Inactive	RPP	EM-40	200-UP-2	
200-PW-2	216-U-6	216-U-6, U Facility Unirradiated Uranium Waste Trench, 221-U Cold U Trench, 216-U Cold U Trench #1, 216-U-5, 221-U Cold U Grave #1	Trench	Inactive	RPP	EM-40	200-UP-2	
200-PW-2	216-U-8	216-U-8, 216-WR-1,2,3 Cribs, 216-U-9	Crib	Inactive	RPP	EM-40	200-UP-2	X
200-PW-2	216-U-12	216-U-12, 216-U-12 Crib	Crib	Active	TSD	EM-40	200-UP-2	X
200-PW-2	241-U-361	241-U-361, 241-U-361 Settling Tank, 361-U-TANK	Settling Tank	Inactive	RPP	EM-40	200-UP-2	
200-PW-2	270-E-1	270-E-1, 270--E CNT, 270-E Condensate Neutralization Tank, 216-ER-1	Neutralization Tank	Inactive	RPP	EM-60	200-BP-6	
200-PW-2	270-W	270-W, 270-W Tank, 270-W Neutralization Tank	Neutralization Tank	Inactive	RPP	EM-30	200-UP-2	
200-PW-2	UPR-200-E-39	UPR-200-E-39, Release from 216-A-36B Crib Sampler, UN-200-E-39	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-PW-2	UPR-200-E-40	UPR-200-E-40, Release from the 216-A-36B Crib Sampler, UN-200-E-40	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-PW-2	UPR-200-E-64	UPR-200-E-64, UN-216-E-64, Radioactive Contamination from 270-E-1 Neutralization Tank, UN-200-E-64 UN-216-E-36	Unplanned Release	Inactive	RPP	EM-60	200-BP-9	
200-PW-2	UPR-200-W-19	UPR-200-W-19, 361-U Overflow, UN-200-W-19	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-PW-2	UPR-200-W-36	UPR-200-W-36, Groundwater Contamination at 216-S-1 and 216-S-2	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-PW-2	UPR-200-W-163	UPR-200-W-163, Contaminated Vegetation at the 216-U-8 Pipeline, UN-216-W-33	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-PW-3, Organic-Rich Process Waste Group Lead Regulatory Agency: EPA								
200-PW-3	216-A-2	216-A-2, 216-A-2 Cavern	Crib	Inactive	CPP	EM-60	200-PO-2	X
200-PW-3	216-A-7	216-A-7, 216-A-7 Cavern	Crib	Inactive	CPP	EM-40	200-PO-5	
200-PW-3	216-A-8	216-A-8, 216-A-8 Crib	Crib	Inactive	CPP	EM-30	200-PO-5	X
200-PW-3	216-A-24	216-A-24	Crib	Inactive	CPP	EM-40	200-PO-5	
200-PW-3	216-A-31	216-A-31	Crib	Inactive	CPP	EM-60	200-PO-2	
200-PW-3	216-A-524	216-A-524, 216-A-524 Control Structure, 216-A 524 Weir	Control Structure	Inactive	CPP	EM-40	200-PO-5	
200-PW-3	216-C-4	216-C-4	Crib	Inactive	CPP	EM-40	200-SO-1	
200-PW-3	216-S-13	216-S-13, 276-S Crib, 216-S-6	Crib	Inactive	CPP	EM-40	200-RO-2	X
200-PW-3	216-S-14	216-S-14, Buried Contaminated Hexone, Cold Organic Trench or Grave, 216-S-4 Burial Contaminated Hexone	Trench	Inactive	CPP	EM-40	200-RO-3	
200-PW-3	216-U-15	216-U-15, UN-216-W-10, 388-U Tank Dumping, UPR-200-W-125, UN-200-W-158, U-152 Interface Crud Burial	Trench	Inactive	CPP	EM-40	200-UP-2	
200-PW-3	UPR-200-E-56	UPR-200-E-56, Excavated Contamination Adjacent to 216-A-24 Crib, UN-200-E-56, UN-216-E-33, 200-E-16	Unplanned Release	Inactive	RPP	EM-40	200-PO-5	
200-PW-3	UPR-200-W-125	UPR-200-W-125, 216-U-15, UN-200-W-125	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	

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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-PW-4, General Process Waste Group Lead Regulatory Agency: Ecology								
200-PW-4	209-E-WS-3	209-E-WS-3, Critical Mass Laboratory Valve Pit	Valve Pit	Inactive	RPP	EM-30	200-SO-1	
200-PW-4	207-A-SOUTH	207-A-SOUTH, 207-A, 207-A Retention Basin, 207-A-SOUTH Retention Basin, 207-A South	Retention Basin	Active	TSD	EM-30	200-PO-5	X
200-PW-4	216-A-34	216-A-34, 216-A-34 Ditch, 216-A-34 Crib	Ditch	Inactive	RPP	EM-40	200-PO-5	
200-PW-4	216-A-37-1	216-A-37-1, 216-A-37 Crib	Crib	Active	TSD	EM-40	200-PO-4	X
200-PW-4	216-A-45	216-A-45, 216-A-45 Crib	Crib	Inactive	RPP	EM-60	200-PO-2	
200-PW-4	216-C-3	216-C-3, 201-C Leaching Pit, 216-C-3 Crib	Crib	Inactive	RPP	EM-40	200-SO-1	X
200-PW-4	216-C-5	216-C-5	Crib	Inactive	RPP	EM-40	200-SO-1	
200-PW-4	216-C-7	216-C-7, 216-C-7 Crib	Crib	Inactive	RPP	EM-30	200-SO-1	
200-PW-4	216-C-10	216-C-10	Crib	Inactive	RPP	EM-40	200-SO-1	
200-PW-4	216-S-4	216-S-4, 216-S-7, 216-S-4 Sump or Crib, UN-216-W-1	French Drain	Inactive	RPP	EM-40	200-UP-2	
200-PW-4	216-S-22	216-S-22	Crib	Inactive	RPP	EM-40	200-RO-3	
200-PW-4	216-S-23	216-S-23	Crib	Inactive	RPP	EM-40	200-RO-2	
200-PW-4	216-T-20	216-T-20, 155-TX, 216-TX-2, 216-T-20 Crib, Contaminated Acid Grave	Trench	Inactive	RPP	EM-40	200-TP-2	
200-PW-4	216-U-16	216-U-16, UO3 Crib	Crib	Inactive	RPP	EM-30	200-UP-2	
200-PW-4	216-U-17	216-U-17	Crib	Inactive	RPP	EM-30	200-UP-2	
200-PW-4	UPR-200-E-145	UPR-200-E-145, W049H Green Soil	Unplanned Release	Inactive	RPP	EM-30	200-PO-5	
200-PW-5, Fission Product-Rich Process Waste Group Lead Regulatory Agency: EPA								
200-PW-5	216-B-11A&B	216-B-11A&B, 216-B-11 Crib, 242-B-1 Crib, 216-B-11A & B	French Drain	Inactive	CPP	EM-40	200-BP-4	
200-PW-5	216-B-50	216-B-50, 216-BY-8 Crib, 216-BY-8 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	
200-PW-5	216-B-57	216-B-57, 216-B-57 Enclosed Trench	Crib	Inactive	CPP	EM-40	200-BP-1	X
200-PW-5	216-B-62	216-B-62, 216-B-62 Enclosed Trench, 216-B-62 Crib	Crib	Inactive	CPP	EM-30	200-BP-9	
200-PW-5	216-C-6	216-C-6, 241-CX Crib	Crib	Inactive	CPP	EM-40	200-SO-1	
200-PW-5	216-S-9	216-S-9	Crib	Inactive	CPP	EM-40	200-RO-2	X
200-PW-5	216-S-21	216-S-21, 216-SX-1, 216-SX-1 Cavern or Crib	Crib	Inactive	CPP	EM-40	200-UP-2	
200-PW-5	UPR-200-W-108	UPR-200-W-108, Line leak at 216-S-9 Crib, UN-216-W-18, UN-200-W-108	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-PW-5	UPR-200-W-109	UPR-200-W-109, UN-216-W-19, UN-200-W-109	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-PW-6, Plutonium Process Waste Group Lead Regulatory Agency: EPA								
200-PW-6	216-Z-4	216-Z-4, 231-W-3 Pit, 231-W-3 Sump, 231-W-3 Crib, 216-Z-3, 216-Z-4 Crib	Trench	Inactive	CPP	EM-40	200-ZP-2	
200-PW-6	216-Z-5	216-Z-5, 231-W Sumps, 231-W-1 & 2 Cribs	Crib	Inactive	CPP	EM-40	200-ZP-2	X
200-PW-6	216-Z-6	216-Z-6, 231-W-4 Crib, 231-Z-6, 216-W-4, 231-W "Trench" Crib, 216-Z-4, 216-Z-6 & 6A Crib	Crib	Inactive	CPP	EM-40	200-ZP-2	
200-PW-6	216-Z-8	216-Z-8, 234-5 Recuplex French Drain, 216-Z-9, 216-Z-8 Crib	French Drain	Inactive	CPP	EM-40	200-ZP-2	

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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-PW-6	216-Z-10	216-Z-10, 216-Z-2, 231-W Reverse Well, 231-W-150 Dry Well or Reverse Well	Injection/Reverse Well	Inactive	CPP	EM-40	200-ZP-2	X
200-PW-6	241-Z-8	241-Z-8, 241-Z-TK-8, Silica Slurry Tank, 216-Z-8	Settling Tank	Inactive	CPP	EM-30	200-ZP-2	
200-PW-6	231-W-151	231-W-151, 231-W-151 Vault, 231-W-151-001 (Tank), 231-W-151-002 (Tank), 231-Z Sump	Receiving Vault	Inactive	RPP	EM-30	200-ZP-2	
200-PW-6	UPR-200-W-130	UPR-200-W-130, Line Leak at 231-W-151 Sump, UN-200-W-130	Unplanned Release	Inactive	RPP	EM-30	200-ZP-2	
200-CW-1, Gable Mountain/B-Ponds and Ditches Cooling Water Group Lead Regulatory Agency: Ecology								
200-CW-1	200-E PD	200-E PD 200-E Powerhouse Ditch, 200 East Powerhouse Pond	Ditch	Active	RPP	EM-70	200-SO-1	
200-CW-1	207-B	207-B, B Plant Retention Basin, 207-B Retention Basin	Retention Basin	Inactive	RPP	EM-60	200-BP-8	
200-CW-1	216-A-9	216-A-9	Crib	Inactive	RPP	EM-40	200-PO-2	
200-CW-1	216-A-25	216-A-25, Gable Mountain Swamp, 216-A-25 Swamp, Gable Mountain Pond	Pond	Inactive	RPP	EM-40	200-IU-6	X
200-CW-1	216-A-40	216-A-40, 216-A-39 Crib, 216-A-39 Trench, 216-A-40 Ditch, 216-A-39 Ditch	Retention Basin	Inactive	RPP	EM-30	200-PO-2	
200-CW-1	216-A-42	216-A-42, 207-AA Retention Basin, 216-A-42 Trench, 216-A-42 Retention Basin, 207-A Retention Basin	Retention Basin	Active	RPP	EM-60	200-PO-4	
200-CW-1	216-B-2-1	216-B-2-1, 216-B-1, B Swamp Ditch, 216-B-2, B Ditch	Ditch	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	216-B-2-2	216-B-2-2, 216-B-2-2W, 216-B-1 Ditch	Ditch	Inactive	RPP	EM-40	200-BP-11	X
200-CW-1	216-B-2-3	216-B-2-3, B Pond Ditch, B Swamp Ditch, 216-B-2-2E	Ditch	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	216-B-3	216-B-3, B Pond, B-3 Pond, B Swamp, 216-B-3 Swamp, B Plant Swamp	Pond	Active	TSD	EM-40	200-BP-11	X
200-CW-1	216-B-3-1	216-B-3-1, B Swamp Ditch, 216-B-2, 216-B-3 Ditch	Ditch	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	216-B-3-2	216-B-3-2, 216-B Ditch, 216-B-1 Ditch, B Swamp Ditch, 216-B-2-2E	Ditch	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	216-B-3-3	216-B-3-3, B Swamp Ditch, 216-B-3-3 Ditch	Ditch	Active	TSD	EM-40	200-BP-11	X
200-CW-1	216-B-3A RAD	216-B-3A, B Pond Lobe A, B Pond First Expansion Lobe	Pond	Inactive	TSD	EM-30	200-BP-11	X
200-CW-1	216-B-3B RAD	216-B-3B, B Pond Lobe B, B Pond Second Expansion Lobe	Pond	Inactive	TSD	EM-30	200-BP-11	X
200-CW-1	216-B-3C RAD	216-B-3C, B Pond Lobe C, B Pond Third Expansion Lobe	Pond	Inactive	TSD	EM-30	200-BP-11	X
200-CW-1	216-B-59	216-B-59, 216-B-58 Trench, 216-B-58 Ditch, 216-B-59 Retention Basin, 216-B-59B	Trench	Inactive	RPP	EM-60	200-BP-6	
200-CW-1	216-B-59B	216-B-59 Retention Basin	Retention Basin	Inactive	RPP	EM-60	200-BP-6	
200-CW-1	216-C-9	216-C-9, 216-C-7 Swamp, Former 221-C Canyon Excavation, 216-C-9 Swamp, Semi-Works Swamp, 216-C-9 C Canyon Excavation Semiworks Swamp	Pond	Inactive	RPP	EM-40	200-SO-1	
200-CW-1	216-E-28	216-E-28, 216-E-25, 200 East Area Contingency Pond	Pond	Inactive	RPP	EM-30	200-BP-11	
200-CW-1	216-N-8	216-N-8, West Lake, West Pond, 216-N-8 Pond, Honeyhill Pond, Seepage Pond	Pond	Inactive	RPP	EM-40	200-IU-6	
200-CW-1	UPR-200-E-14	UPR-200-E-14, UN-200-E-14, 216-B-3 Pond Dike Break	Unplanned Release	Inactive	RPP	EM-30	200-BP-11	
200-CW-1	UPR-200-E-32	UPR-200-E-32, UN-200-E-32, Coil Leak from 221-B	Unplanned Release	Inactive	RPP	EM-60	200-BP-8	

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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-CW-1	UPR-200-E-34	UPR-200-E-34, Liquid Release to B-Pond and Gable Pond, UN-200-E-34	Unplanned Release	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	UPR-200-E-51	UPR-200-E-51, Liquid Release from Purex to B-Pond, UN-200-E-51	Unplanned Release	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	UPR-200-E-94	UN-216-E-22, UN-200-E-94, Vehicle Decon Area	Uplanned Release	Inactive	RPP	EM-40	200-BP-11	
200-CW-1	UPR-200-E-66	UPR-200-E-66, 216-A-42 Basin Contamination Release, UN-216-E-66, UN-200-E-66	Unplanned Release	Inactive	RPP	EM-60	200-PO-4	
200-CW-1	UPR-200-E-138	UPR-200-E-138, Liquid release from B-Plant, UN-200-E-138, UPR-200-W-66, UN-216-W-66	Unplanned Release	Inactive	RPP	EM-40	200-BP-8	
200-CW-2, S-Pond and Ditches Cooling Water Group Lead Regulatory Agency: EPA								
200-CW-2	207-S	207-S, REDOX Retention Basin, 207-S, 207-S Retention Basin	Retention Basin	Inactive	CPP	EM-40	200-RO-2	
200-CW-2	216-S-16D	216-S-16D, 202-S Swamp (New) and Ditch, 202-S Swamp #1, REDOX Pond #2, 216-S-24 Ditch	Ditch	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	216-S-16P	216-S-16P, 202-S Swamp and Ditch, 202-S Swamp #1, REDOX Pond #2	Pond	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	216-S-17	216-S-17, 202-S Swamp, 202-S REDOX Swamp, 216-S-1 REDOX Pond No. 1, REDOX Swamp, 216-S-1	Pond	Inactive	CPP	EM-40	200-RO-1	X
200-CW-2	216-S-172	216-S-172, 216-S-172 Weir Box and Control Structure, 2904-S-172 Weir, 216-S-172 Control Structure	Control Structure	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	2904-S-160	2904-S-160, 2904-S-160 Control Structure, 2904-S-160 Weir	Control Structure	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	2904-S-170	2904-S-170, 2904-S-170 Weir Box, 2904-S-170 Control Structure	Control Structure	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	2904-S-171	2904-S-171, 2904-S-171 Weir Box, 2904-S-171 Control Structure	Control Structure	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	UPR-200-W-13	UPR-200-W-13, Liquid Release from REDOX to 207-S and Swamp, UN-200-W-13	Unplanned Release	Inactive	CPP	EM-40	200-RO-2	
200-CW-2	UPR-200-W-15	UPR-200-W-15, Liquid Release from REDOX to the 207-S and Swamp, UN-200-W-15	Unplanned Release	Inactive	CPP	EM-40	200-RO-2	
200-CW-2	UPR-200-W-47	UPR-200-W-47, 216-S-16P Dike Release, UN-200-W-47	Unplanned Release	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	UPR-200-W-59	UPR-200-W-59, Contaminated Liquid Released to 216-S-16P	Unplanned Release	Inactive	CPP	EM-40	200-RO-1	
200-CW-2	UPR-200-W-95	UPR-200-W-95, UN-216-W-2, 216-S-207 Redox Retention Basin	Unplanned Release	Inactive	CPP	EM-40	200-RO-2	
200-CW-3, 200 North Cooling Water Group Lead Regulatory Agency: EPA								
200-CW-3	216-N-1	216-N-1, 212-N Swamp, 216-N-1 Swamp, 216-N-1 Covered Pond	Pond	Inactive	CPP	EM-40	200-NO-1	
200-CW-3	216-N-2	216-N-2, 212-N Storage Basin Crib #1, 212-N #1 Trench, 216-N-1 Trench, 216-N-2 Trench	Trench	Inactive	CPP	EM-40	200-NO-1	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-CW-3	216-N-3	216-N-3, 212-N Storage Basin Crib #2, 212-N #2 Trench, 212-N #2 Grave, 212-N-2 Trench, 212-N-3 Trench	Trench	Inactive	CPP	EM-40	200-NO-1	
200-CW-3	216-N-4	216-N-4, 216-N-2, 216-N-4 Swamp, 212-P Swamp	Pond	Inactive	CPP	EM-40	200-NO-1	X
200-CW-3	216-N-5	216-N-5, 212-P Storage Basin Crib, 212-P Trench, 212-P Grave, 216-N-5 Trench	Trench	Inactive	CPP	EM-40	200-NO-1	
200-CW-3	216-N-6	216-N-6, 212-R Swamp, 216-N-6 Swamp	Pond	Inactive	CPP	EM-40	200-NO-1	
200-CW-3	216-N-7	216-N-7, 212-R Storage Basin Crib, 212-R Trench, 212-R Grave, 216-N-7 Trench	Trench	Inactive	CPP	EM-40	200-NO-1	
200-CW-4, T-Pond and Ditches Cooling Water Group Lead Regulatory Agency: EPA								
200-CW-4	207-T	207-T, T Plant Retention Basin, 207-T, 207-T Retention Basin	Retention Basin	Inactive	CPP	EM-30	200-TP-3	
200-CW-4	216-T-1	216-T-1, 221-T Ditch, 221-T Trench, 216-T-1 Trench	Ditch	Inactive	CPP	EM-30	200-TP-4	
200-CW-4	216-T-4-1D	216-T-4-1D, 216-T-4 Ditch, 216-T-4 Swamp	Ditch	Inactive	CPP	EM-40	200-TP-3	
200-CW-4	216-T-4-2	216-T-4-2, 216-T-4-2 Ditch	Ditch	Inactive	CPP	EM-30	200-TP-3	
200-CW-4	216-T-4A	216-T-4A, 216-T-4 Swamp, 216-T-4-1 (P), 216-T-4-1 Pond	Pond	Inactive	CPP	EM-40	200-TP-3	X
200-CW-4	216-T-4B	216-T-4B, 216-T-4 New Pond, 216-T-4-2 (P), 216-T-4-2 Pond	Pond	Inactive	CPP	EM-30	200-TP-3	
200-CW-4	216-T-12	216-T-12, 207-T Sludge Grave, 207-T Sludge Pit, 216-T-11	Trench	Inactive	CPP	EM-30	200-TP-3	
200-CW-5, U-Pond/Z-Ditches Cooling Water Group Lead Regulatory Agency: EPA								
200-CW-5	207-U	207-U, 207-U Retention Basin	Retention Basin	Active	CPP	EM-40	200-UP-2	
200-CW-5	216-U-9	216-U-9, U Swamp-S Swamp Ditch, 216-U-6	Ditch	Inactive	CPP	EM-40	200-RO-1	
200-CW-5	216-U-10	216-U-10, 231 Swamp, U Swamp, 216-U-1, 216-U-10 Pond	Pond	Inactive	CPP	EM-40	200-UP-2	X
200-CW-5	216-U-11	216-U-11, U Swamp Extension Ditch, 216-U-12, 216-U-11 Trench, 216-U-11 Ditch, 216-U-11 (old ditch), 216-U-11 (new ditch)	Ditch	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	216-U-14	216-U-14, Laundry Ditch, 216-U-14 Ditch	Ditch	Inactive	CPP	EM-40/EM	200-UP-2	X
200-CW-5	216-Z-1D	216-Z-1D, 216-Z-1, Drain Ditch to U Swamp, Z Plant Ditch	Ditch	Inactive	CPP	EM-40/EM	200-UP-2	
200-CW-5	216-Z-11	216-Z-11, 216-Z-11 Ditch, Z Plant Ditch	Ditch	Inactive	CPP	EM-40	200-UP-2	X
200-CW-5	216-Z-19	216-Z-19, 216-U-10 Ditch, Z Plant Ditch, 216-Z-19 Ditch	Ditch	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	216-Z-20	216-Z-20, Z-19 Ditch Replacement Tile Field	Crib	Inactive	CPP	EM-30	200-UP-2	
200-CW-5	UPR-200-W-18	UPR-200-W-18	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	UPR-200-W-104	UPR-200-W-104, UN-216-W-14, 216-U-10 Pond Leach Trench	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	UPR-200-W-105	UPR-200-W-105, UN-216-W-15, 216-U-10 Pond Leach Trench	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	UPR-200-W-106	UPR-200-W-106, UN-216-W-16, 216-U-10 Pond Leach Trench	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	UPR-200-W-107	UPR-200-W-107, UN-216-W-17, 216-U-10 Pond Flood Plain, 216-U-10 Pond Leach Trench	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-CW-5	UPR-200-W-111	UPR-200-W-111, Sludge Trench at 207-U, UN-216-W-21	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	UPR-200-W-112	UPR-200-W-112, Sludge Trench at 207-U, UN-216-W-22	Unplanned Release	Inactive	CPP	EM-40	200-UP-2	
200-CW-5	UPR-200-W-139	UPR-200-W-139, Liquid Release to the 216-U-9 Ditch, UN-200-W-139, UPR-200-W-18	Unplanned Release	Inactive	CPP	EM-40	200-RO-1	
200-SC-1, Steam Condensate Group Lead Regulatory Agency: EPA								
200-SC-1	207-A-NORTH	207-A-NORTH, 207-A, 207-A Retention Basin, 207-A-NORTH Retention Basin, 207-A North	Retention Basin	Active	CPP	EM-30	200-PO-5	
200-SC-1	207-Z	207-Z, 207-Z Retention Basin, 241-Z Retention Basin, 241-Z-RB	Retention Basin	Inactive	CPP	EM-60	200-ZP-2	
200-SC-1	216-A-6	216-A-6, 216-A-6 Cavern	Crib	Inactive	CPP	EM-40	200-PO-4	X
200-SC-1	216-A-30	216-A-30, 216-A-30 Crib	Crib	Inactive	CPP	EM-30	200-PO-4	
200-SC-1	216-A-37-2	216-A-37-2, 216-A-37-2 Crib	Crib	Inactive	CPP	EM-30	200-PO-4	
200-SC-1	216-B-55	216-B-55, 216-B-55 Enclosed Trench, 216-B-55 Crib	Crib	Inactive	CPP	EM-30	200-BP-9	
200-SC-1	216-B-64	216-B-64, 216-B-64 Retention Basin, 216-B-64 Trench, 216-B-64 Crib	Retention Basin	Inactive	CPP	EM-60	200-BP-9	
200-SC-1	216-S-5	216-S-5, 216-S-5 Cavern #1, 216-S-6 Crib, 216-S-9	Crib	Inactive	CPP	EM-40	200-RO-1	X
200-SC-1	216-S-6	216-S-6, 216-S-6 Cavern #2, 216-S-5 Crib, 216-S-13 Crib	Crib	Inactive	CPP	EM-40	200-RO-1	
200-SC-1	216-S-25	216-S-25, 216-S-25 Crib	Crib	Inactive	CPP	EM-30	200-RO-1	
200-SC-1	216-T-36	216-T-36	Crib	Inactive	CPP	EM-40	200-TP-1	
200-SC-1	UPR-200-E-19	UPR-200-E-19, Contamination Release at 216-A-6 Sampler, UN-200-E-19	Unplanned Release	Inactive	CPP	EM-60	200-PO-2	
200-SC-1	UPR-200-E-21	UPR-200-E-21, 216-A-6 Overflow, UN-200-E-21	Unplanned Release	Inactive	CPP	EM-40	200-PO-4	
200-SC-1	UPR-200-E-29	UPR-200-E-29, 216-A-6 Overflow, UN-200-E-29	Unplanned Release	Inactive	CPP	EM-40	200-PO-4	
200-CS-1, Chemical Sewer Group Lead Regulatory Agency: Ecology								
200-CS-1	216-A-29	216-A-29, Snow's Canyon, PUREX Chemical Sewer (CSL)	Ditch	Active	TSD	EM-40	200-BP-11	X
200-CS-1	216-B-63	216-B-63, B Plant Chemical Sewer, 216-B-63 Trench	Ditch	Active	TSD	EM-30	200-BP-11	X
200-CS-1	216-S-10D	216-S-10D, 216-S-10D Ditch, 202 Chemical Sump #1 and Ditch, Chemical Sewer Trench, Open Ditch to the Chemical Sewer Trench, 216-S-10 Ditch	Ditch	Active	TSD	EM-40	200-RO-1	X
200-CS-1	216-S-10P	216-S-10P, 216-S-10P Pond, 202-S Chemical Sump #1 and Ditch, Chemical Sewer Trench	Pond	Active	TSD	EM-40	200-RO-1	X
200-CS-1	216-S-11	216-S-11, 202-S Chemical Sump #2 and Chemical Sewer Trench, 216-S-11 Swamp	Pond	Inactive	RPP	EM-40	200-RO-1	
200-CS-1	216-W-LWC	216-W-LWC, 216-W-LC, Laundry Waste Crib, 216-W-LWC Crib, 216-W-1	Crib	Inactive	RPP	EM-30	200-SS-2	
200-CS-1	UPR-200-W-34	UPR-200-W-34, Overflow at 216-S-10 Ditch, UN-200-W-34	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-LW-1, 300 Area Laboratory Waste Group Lead Regulatory Agency: Ecology								
200-LW-1	216-B-53A	216-B-53A, 216-B-53A Trench	Trench	Inactive	RPP	EM-40	200-BP-2	
200-LW-1	216-B-53B	216-B-53B, 216-B-53 Trench, 216-B-53B Trench	Trench	Inactive	RPP	EM-40	200-BP-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-LW-1	216-B-54	216-B-54, 216-B-54 Trench	Trench	Inactive	RPP	EM-40	200-BP-2	
200-LW-1	216-B-58	216-B-58, 216-B-58 Trench, 216-B-59 Crib	Trench	Inactive	RPP	EM-40	200-BP-2	X
200-LW-1	216-T-27	216-T-27, 216-TY-2 Cavern, 216-TY-2 Crib, 216-TX-2 Cavern, 216-TX-2 Crib	Crib	Inactive	RPP	EM-40	200-TP-2	
200-LW-1	216-T-28	216-T-28, 216-TY-3 Cavern, 216-TY-3 Crib, 216-TX-3 Cavern, 216-TX-3 Crib	Crib	Inactive	RPP	EM-40	200-TP-2	X
200-LW-1	216-T-34	216-T-34	Crib	Inactive	RPP	EM-40	200-TP-4	
200-LW-1	216-T-35	216-T-35	Crib	Inactive	RPP	EM-40	200-TP-4	
200-LW-2, 200 Areas Chemical Laboratory Waste Group Lead Regulatory Agency: Ecology								
200-LW-2	207-SL	207-SL, 222-S Retention Basin, REDOX Lab Retention Basin, 207-SL Retention Basin	Retention Basin	Active	RPP	EM-30	200-RO-3	
200-LW-2	216-A-15	216-A-15	French Drain	Inactive	RPP	EM-60	200-PO-2	
200-LW-2	216-B-6	216-B-6, 222-B-110 Reverse Well, 216-B-6 Dry Well, 216-B-6 Crib, 222-B-110 Dry Well	Injection/Reverse Well	Inactive	RPP	EM-40	200-BP-6	
200-LW-2	216-B-10A	216-B-10A, 222-B-1 Crib, 216-B-10 Crib, 292-B	Crib	Inactive	RPP	EM-40	200-BP-6	
200-LW-2	216-B-10B	216-B-10B, 222-B-2 Crib, 216-B-10 Crib	Crib	Inactive	RPP	EM-40	200-BP-6	
200-LW-2	216-S-19	216-S-19, 222-S Lab Swamp, 216-SL-1, REDOX Lab Swamp, 216-S-19 Pond	Pond	Inactive	RPP	EM-40	200-RO-1	
200-LW-2	216-S-20	216-S-20, 216-SL-1&2 Crib, 216-SL-2	Crib	Inactive	RPP	EM-40	200-RO-3	X
200-LW-2	216-S-26	216-S-26, 216-S-19 Replacement Facility, 216-S-26 Crib	Crib	Inactive	RPP	EM-30	200-RO-3	
200-LW-2	216-T-2	216-T-2, 222-T-110 Dry Well	Injection/Reverse Well	Inactive	RPP	EM-40	200-TP-4	
200-LW-2	216-T-8	216-T-8, 222-T-1 & 2 Cribs	Crib	Inactive	RPP	EM-40	200-TP-4	
200-LW-2	216-U-4	216-U-4, 222-U Dry Well, 222-U-110 Dry Well, 216-U-2, 216-U-4 Dry Well	Injection/Reverse Well	Inactive	RPP	EM-40	200-UP-2	
200-LW-2	216-U-4A	216-U-4A, 216-U-4 Reverse Well/4a French Drain, 216-U-4 Dry Well	French Drain	Inactive	RPP	EM-40	200-UP-2	
200-LW-2	216-U-4B	216-U-4B, 216-U-4B Dry Well, 216-U-4B French Drain	French Drain	Inactive	RPP	EM-40	200-UP-2	
200-LW-2	216-Z-7	216-Z-7, 231-W Crib, 231-W Trench, 216-Z-6	Crib	Inactive	RPP	EM-40	200-ZP-2	X
200-LW-2	216-Z-16	216-Z-16	Crib	Inactive	RPP	EM-40	200-ZP-2	
200-LW-2	216-Z-17	216-Z-17, 216-Z-17 Ditch	Trench	Inactive	RPP	EM-40	200-ZP-2	
200-LW-2	CTFN 2703-E	CTFN 2703-E, Chemical Tile Field North of 2703-E	Drain/Tile Field	Inactive	RPP	EM-70	200-SS-1	
200-MW-1, Miscellaneous Waste Group Lead Regulatory Agency: EPA								
200-MW-1	200-E-4	200-E-4, Critical Mass Laboratory Dry Well North	French Drain	Active	CPP	EM-30	200-SO-1	
200-MW-1	200-W PP	200-W PP, 200-W Powerhouse Pond, 200 West Powerhouse Ponds, 284-W-B	Pond	Inactive	CPP	EM-70	200-UP-2	
200-MW-1	209-E-WS-1	209-E-WS-1, 209-E French Drain	French Drain	Inactive	CPP	EM-30	200-SO-1	
200-MW-1	209-E-WS-2	209-E-WS-2, Critical Mass Lab French Drain	French Drain	Inactive	CPP	EM-30	200-SO-1	
200-MW-1	216-A-4	216-A-4, 216-A-4 Cavern	Crib	Inactive	CPP	EM-60	200-PO-2	X
200-MW-1	216-A-11	216-A-11	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-12	216-A-12	French Drain	Inactive	CPP	EM-60	200-PO-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-MW-1	216-A-13	216-A-13	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-14	216-A-14, French Drain - Vacuum Cleaner Filter Pit	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-21	216-A-21	Crib	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-22	216-A-22, 216-A-22 French Drain, 216-A-22 Crib	Crib	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-26	216-A-26, 216-A-26 French Drain, 216-A-26B	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-26A	216-A-26A, 216-A-25 Crib, 216-A-26 French Drain, 291-A French Drain	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-27	216-A-27	Crib	Inactive	CPP	EM-40	200-PO-2	
200-MW-1	216-A-32	216-A-32	Crib	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-33	216-A-33, 216-A-33 Dry Well, 216-A-26B	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-35	216-A-35 French Drain, 216-A-35 Dry Well	French Drain	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-38-1	216-A-38-1, 216-A-38	Crib	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-A-41	216-A-41	Crib	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	216-B-4	216-B-4, 216-B-4 French Drain, 216-B-4 Dry Well	Injection/Reverse Well	Inactive	CPP	EM-60	200-BP-6	
200-MW-1	216-B-13	216-B-13, 216-B-13 French Drain, 291-B Crib, 216-B-B, 216-B-13 Crib	French Drain	Inactive	CPP	EM-60	200-BP-6	
200-MW-1	216-B-56	216-B-56	Crib	Inactive	CPP	EM-40	200-BP-6	
200-MW-1	216-B-61	216-B-61	Crib	Inactive	CPP	EM-60	200-BP-1	
200-MW-1	216-C-2	216-C-2, 291-C Dry Well, 216-C-2 Dry Well	Injection/Reverse Well	Inactive	CPP	EM-40	200-SO-1	
200-MW-1	216-S-12	216-S-12, UPR-200-W-30, 291-S Stack Wash Sump, REDOX Stack Flush Trench	Trench	Inactive	CPP	EM-40	200-RO-3	
200-MW-1	216-S-18	216-S-18, 241-SX Steam Cleaning Pit, 216-S-14 Steam Cleaning Pit	Trench	Inactive	CPP	EM-40	200-RO-2	
200-MW-1	216-SX-2	Sanitary Crib	Crib	Inactive	CPP	EM-30	200-RO-4	
200-MW-1	216-T-9	216-T-9, Decontamination Trenches, Equipment Decontamination Area	Trench	Inactive	CPP	EM-40	200-TP-4	
200-MW-1	216-T-10	216-T-10, Decontamination Trenches, Equipment Decontamination Area	Trench	Inactive	CPP	EM-40	200-TP-4	
200-MW-1	216-T-11	216-T-11, Decontamination Trenches, Equipment Decontamination Area	Trench	Inactive	CPP	EM-40	200-TP-4	
200-MW-1	216-T-13	216-T-13, 269-W Regulated Garage, 269-W Decontamination Pit or Trench, 216-T-12, 269-W Regulated Garage Decontamination Pit	Trench	Inactive	CPP	EM-40	200-TP-2	
200-MW-1	216-T-29	216-T-29, 291-T Sand Filter Sewer, 216-T-29 French Drain	French Drain	Inactive	CPP	EM-30	200-TP-4	
200-MW-1	216-T-31	216-T-31	French Drain	Inactive	CPP	EM-30	200-TP-2	
200-MW-1	216-T-33	216-T-33	Crib	Inactive	CPP	EM-40	200-TP-4	X
200-MW-1	216-U-3	216-U-3, 216-U-11, 216-U-3 French Drain	French Drain	Inactive	CPP	EM-40	200-UP-2	X
200-MW-1	216-U-7	216-U-7, 221-U Vessel Vent Blower Pit French Drain	French Drain	Inactive	CPP	EM-40	200-UP-2	
200-MW-1	216-U-13	216-U-13, 216-U-13 Cribs, 216-U-13, 241-UR Steam Cleaning Pit	Trench	Inactive	CPP	EM-40	200-UP-2	
200-MW-1	216-Z-13	216-Z-13, 234-5 Dry Well #1, 216-Z-13 Dry Well	French Drain	Active	CPP	EM-60	200-ZP-2	
200-MW-1	216-Z-14	216-Z-14, 234-5 Dry Well #2, 216-Z-14 Dry Well	French Drain	Active	CPP	EM-60	200-ZP-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-MW-1	216-Z-15	216-Z-15, 234-5 Dry Well #3, 216-Z-15 Dry Well	French Drain	Active	CPP	EM-60	200-ZP-2	
200-MW-1	216-Z-21	216-Z-21, 216-Z-21 Seepage Basin, PFP Cold Waste Pond	Pond	Inactive	CPP	EM-30	200-ZP-2	
200-MW-1	2704-C-WS-1	2704-C-WS-1, 2704-C French Drain, Gatehouse French Drain	French Drain	Inactive	CPP	EM-40	200-SO-1	
200-MW-1	2718-E-WS-1	2718-E-WS-1, 2718 French Drain	French Drain	Inactive	CPP	EM-30	200-SO-1	
200-MW-1	616-WS-1	616-WS-1, 616 NDWSF French Drain	French Drain	Active	RPP	EM-30	200-IU-5	
200-MW-1	299-E24-111	299-E24-111	Injection/Reverse Well	Inactive	CPP	EM-40	200-PO-2	
200-MW-1	UPR-200-E-13	UPR-200-E-13, Overflow from 216-A-4, UN-200-E-13	Unplanned Release	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	UPR-200-E-15	UPR-200-E-15, Overflow at 216-A-4, UN-200-E-15	Unplanned Release	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	UPR-200-E-17	UPR-200-E-17, Overflow at 216-A-22, UN-200-E-17	Unplanned Release	Inactive	CPP	EM-60	200-PO-2	
200-MW-1	UPR-200-W-30	UPR-200-W-30, 216-S-12, UN-200-W-30	Unplanned Release	Inactive	CPP	EM-40	200-RO-3	
200-MW-1	UPR-200-W-138	UPR-200-W-138, 221-U Vessel Vent Blower Pit French Drain, UN-216-W-11, UN-200-W-138, UN-200-W-22,	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-TW-1, Scavenged Waste Group Lead Regulatory Agency: EPA								
200-TW-1	200-E-14	200-E-14, 216-BC-201 Siphon Tank, 216-B-201	Storage Tank	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-14	216-B-14, 216-BC-1 Crib	Crib	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-15	216-B-15, 216-BC-2 Crib	Crib	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-16	216-B-16, 216-BC-3 Crib	Crib	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-17	216-B-17, 216-BC-4 Crib	Crib	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-18	216-B-18, 216-BC-5 Crib	Crib	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-19	216-B-19, 216-BC-6 Crib	Crib	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-20	216-B-20, 216-BC-7 Trench, 216-B-20 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-21	216-B-21, 216-BC-8 Trench, 216-B-21 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-22	216-B-22, 216-BC-9 Trench, 216-B-22 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-23	216-B-23, 216-BC-10 Trench, 216-B-23 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-24	216-B-24, 216-BC-11 Trench, 216-B-24 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-25	216-B-25, 216-BC-12 Trench, 216-B-25 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-27	216-B-27, 216-BC-14 Trench, 216-B-27 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-26	216-B-26, 216-BC-13 Trench, 216-B-26 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-28	216-B-28, 216-BC-15 Trench, 216-B-28 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-29	216-B-29, 216-BC-16 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-30	216-B-30, 216-BC-17 Trench, 216-B-30 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-31	216-B-31, 216-BC-18 Trench, 216-B-31 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-32	216-B-32, 216-BC-19 Trench, 216-B-32 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-33	216-B-33, 216-BC-20 Trench, 216-B-33 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-34	216-B-34, 216-BC-21 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-B-42	216-B-42, 241-BX-8 Grave, 216-BX-8 Trench, 216-B-42 Trench	Trench	Inactive	CPP	EM-40	200-BP-3	
200-TW-1	216-B-43	216-B-43, 216-BY-1 Crib, 216-BY-1 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	
200-TW-1	216-B-44	216-B-44, 216-BY-2 Crib, 216-BY-2 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	
200-TW-1	216-B-45	216-B-45, 216-BY-3 Crib, 216-BY-3 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-TW-1	216-B-46	216-B-46, 216-BY-4 Crib, 216-BY-4 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	X
200-TW-1	216-B-47	216-B-47, 216-BY-5 Crib, 216-BY-5 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	
200-TW-1	216-B-48	216-B-48, 216-BY-6 Crib, 216-BY-6 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	
200-TW-1	216-B-49	216-B-49, 216-BY-7 Crib, 216-BY-7 Cavern	Crib	Inactive	CPP	EM-40	200-BP-1	
200-TW-1	216-B-51	216-B-51, 216-BY-9 Crib	French Drain	Inactive	CPP	EM-40	200-BP-4	
200-TW-1	216-B-52	216-B-52, 216-B-52 Trench	Trench	Inactive	CPP	EM-40	200-BP-2	
200-TW-1	216-BY-201	216-BY-201, Flush Tank 241-BY, 216-BY-47, Supernatant Disposal Flush Tank	Settling Tank	Inactive	CPP	EM-30	200-BP-1	
200-TW-1	216-T-18	216-T-18, Test Crib for 221-T Building, Scavenged TBP Waste, 216-T-17, 241-T-17 Crib	Crib	Inactive	CPP	EM-40	200-TP-2	
200-TW-1	216-T-26	216-T-26, 216-TY-1 Cavern, 216-TY-1 Crib, 241-TX-1 Cavern, 216-TX-1 Crib	Crib	Inactive	CPP	EM-40	200-TP-2	X
200-TW-1	UPR-200-E-9	UPR-200-E-9, Liquid Overflow at 241-BY-201, UN-200-E-9	Unplanned Release	Inactive	RPP	EM-40	200-BP-1	
200-TW-2, Tank Waste Group Lead Regulatory Agency: Ecology								
200-TW-2	216-B-5	216-B-5, 241-B-361 Reverse Well, 241-B-361 Dry Well, 241-B-5 Dry Well	Injection/Reverse Well	Inactive	RPP	EM-40	200-BP-6	X
200-TW-2	216-B-7A&B	216-B-7A&B, 241-B-1 Crib, 216-B-7 Crib, 216-B-7A Sump, 216-B-7B Sump, 241-B-1 and 2 Cribs, 216-B-7A & B	Crib	Inactive	RPP	EM-40	200-BP-4	X
200-TW-2	216-B-8	216-B-8, 241-B-3 Crib, 216-B-8, 216-B-8TF	Crib	Inactive	RPP	EM-40	200-BP-4	
200-TW-2	216-B-9	216-B-9, 241-B-361 Crib, 216-B-361 Crib, 216-B-9TF	Crib	Inactive	RPP	EM-40	200-BP-6	
200-TW-2	216-B-35	216-B-35, 241-BX-1 Grave, 216-BX-1 Trench, 216-B-35 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	
200-TW-2	216-B-36	216-B-36, 241-BX-2 Grave, 216-BX-2 Trench, 216-B-36 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	
200-TW-2	216-B-37	216-B-37, 241-BX-3 Grave, 216-BX-3 Trench, 216-B-37 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	
200-TW-2	216-B-38	216-B-38, 241-BX-4 Grave, 216-BX-4 Trench, 216-B-38 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	X
200-TW-2	216-B-39	216-B-39, 241-BX-5 Grave, 216-BX-5 Trench, 216-B-39 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	
200-TW-2	216-B-40	216-B-40, 241-BX-6 Grave, 241-BX-6 Trench, 216-B-40 Trench, 216-BX-6 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	
200-TW-2	216-B-41	216-B-41, 241-BX-7 Grave, 216-BX-7 Trench, 216-B-41 Trench	Trench	Inactive	RPP	EM-40	200-BP-3	
200-TW-2	216-T-3	216-T-3, 241-T-361-A Dry Well or Reverse Well, 361-T Reverse Well	Injection/Reverse Well	Inactive	RPP	EM-40	200-TP-4	
200-TW-2	216-T-5	216-T-5, 216-T-5 Grave, 216-T-12, 216-T-5 Trench, 241-T-5 Trench	Trench	Inactive	RPP	EM-40	200-TP-1	
200-TW-2	216-T-6	216-T-6, 241-T-361 (1&2 Cribs), 216-T-5, 361-T-1&2 Cribs	Crib	Inactive	RPP	EM-40	200-TP-3	
200-TW-2	216-T-7	216-T-7, 216-T-7TF, 216-T-7 Tile Field, 241-T-3 Tile Field	Crib	Inactive	RPP	EM-40	200-TP-1	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-TW-2	216-T-14	216-T-14, 241-T-1 Trench, 216-T-1 Grave, 216-T-13, 216-T-14	Trench	Inactive	RPP	EM-40	200-TP-3	
200-TW-2	216-T-15	216-T-15, 241-T-2 Trench, 241-T-2 Grave, 216-T-14, 216-T-15 Crib	Trench	Inactive	RPP	EM-40	200-TP-3	
200-TW-2	216-T-16	216-T-16, 241-T-3 Trench, 241-T-3 Grave, 216-T-15, 216-T-16 Crib	Trench	Inactive	RPP	EM-40	200-TP-3	
200-TW-2	216-T-17	216-T-17, 241-T-4 Trench, 216-T-4 Grave, 216-T-16	Trench	Inactive	RPP	EM-40	200-TP-3	
200-TW-2	216-T-21	216-T-21, 241-TX-1 Trench, 216-TX-1 Grave, 216-TX-3	Trench	Inactive	RPP	EM-40	200-TP-1	
200-TW-2	216-T-22	216-T-22, 241-TX-2 Trench, 216-TX-2 Grave, 216-TX-4	Trench	Inactive	RPP	EM-40	200-TP-1	
200-TW-2	216-T-23	216-T-23, 241-TX-3 Trench, 216-TX-3 Grave, 216-TX-5, 241-TX-3 Grave	Trench	Inactive	RPP	EM-40	200-TP-1	
200-TW-2	216-T-24	216-T-24, 241-TX-4 Trench, 216-TX-4 Grave, 216-TX-6	Trench	Inactive	RPP	EM-40	200-TP-1	
200-TW-2	216-T-25	216-T-25, 241-TX-5 Trench, 216-TX-5 Grave, 216-TX-7	Trench	Inactive	RPP	EM-40	200-TP-1	
200-TW-2	216-T-32	216-T-32, 241-T #1 & 2 Cribs, 216-T-6	Crib	Inactive	RPP	EM-30	200-TP-1	
200-TW-2	241-B-361	241-B-361, 241-B-361 Settling Tank	Settling Tank	Inactive	RPP	EM-40	200-BP-6	
200-TW-2	241-T-361	241-T-361, 241-T-361 Settling Tank, 361-T-TANK	Settling Tank	Inactive	RPP	EM-40	200-TP-4	
200-TW-2	UPR-200-E-7	UPR-200-E-7, UN-200-E-7, Cave-In Near 241-B-361 Crib	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1, Tanks/Lines/Pits/Boxes Group Lead Regulatory Agency: Ecology								
200-IS-1	200-W-7	200-W-7, 246-L, 243S-TK-1, 243-S-TK1	Catch Tank	Inactive	RPP	EM-30	200-UP-2	
200-IS-1	200-W-16	200-W-16, 292-T Underground Tanks	Storage Tank	Inactive	RPP	EM-30	200-TP-4	
200-IS-1	216-TY-201	216-TY-201, Supernatant Disposal Flush Tank	Settling Tank	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	224-B	224-B, 224-B Concentration Facility	Process Unit/Plant	Inactive	RPP	EM-40	200-BP-6	
200-IS-1	240-S-151	240-S-151, 240-S-151 Diversion Box	Diversion Box	Active	TSD	EM-30	200-RO-3	X
200-IS-1	240-S-152	240-S-152, 240-S-152 Diversion Box	Diversion Box	Active	TSD	EM-30	200-RO-3	X
200-IS-1	240-S-302	240-S-302, 240-S-302 Catch Tank	Catch Tank	Inactive	RPP	EM-30	200-RO-3	
200-IS-1	241-A-151	241-A-151, 241-A-151 Diversion Box	Diversion Box	Active	RPP	EM-30	200-PO-2	
200-IS-1	241-A-302A	241-A-302A, 241-A-302-A Catch Tank	Catch Tank	Active	RPP	EM-30	200-PO-2	
200-IS-1	241-A-302B	241-A-302B, 241-A-302-B Catch Tank	Catch Tank	Inactive	RPP	EM-30	200-PO-5	
200-IS-1	241-B-154	241-B-154, 241-B-154 Diversion Box	Diversion Box	Active	TSD	EM-30	200-BP-6	X
200-IS-1	241-B-302B	241-B-302B, 241-B-302-B Catch Tank, 241-B-302	Catch Tank	Inactive	RPP	EM-30	200-BP-6	
200-IS-1	241-BX-154	241-BX-154, 241-BX-154 Diversion Box	Diversion Box	Active	TSD	EM-30	200-BP-6	X
200-IS-1	241-BX-155	241-BX-155, 241-BX-155 Diversion Box	Diversion Box	Active	TSD	EM-30	200-BP-6	X
200-IS-1	241-BX-302B	241-BX-302B, 241-BX-302-B Catch Tank	Catch Tank	Inactive	RPP	EM-30	200-BP-6	
200-IS-1	241-BX-302C	241-BX-302C, 241-BX-302-C Catch Tank	Catch Tank	Inactive	RPP	EM-30	200-BP-6	
200-IS-1	241-C-154	241-C-154, 241-C-154 Diversion Box	Diversion Box	Active	TSD	EM-30	200-SO-1	X
200-IS-1	241-CX-70	241-CX-70, 241-CX-TK-70 Tank, Strontium Hot Semi-works	Storage Tank	Active	TSD	EM-40	200-SO-1	X
200-IS-1	241-CX-71	241-CX-71, 241-CX-TK-71, 241-CX Neutralization Tank, Strontium Hot Semi-works	Neutralization Tank	Active	TSD	EM-40	200-SO-1	X
200-IS-1	241-CX-72	241-CX-72, 241-CX-TK-72 Vault and Tank, 241-CX-72 Waste Self Concentrator, Strontium Hot Semi-works	Storage Tank	Active	TSD	EM-40	200-SO-1	X

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-IS-1	241-ER-151	241-ER-151, 241-ER-151 Diversion Box	Diversion Box	Active	RPP	EM-30	200-BP-9	
200-IS-1	241-ER-152	241-ER-152, 241-ER-152 Diversion Box	Diversion Box	Active	RPP	EM-30	200-BP-6	
200-IS-1	241-ER-311	241-ER-311, 241-ER-311 Catch Tank	Catch Tank	Active	RPP	EM-30	200-BP-9	
200-IS-1	241-ER-311A	241-ER-311A, 241-ER-311 Catch Tank, old 241-ER-311	Catch Tank	Inactive	RPP	EM-30	200-BP-9	
200-IS-1	241-SX-302	241-SX-302, 241-SX-302 Catch Tank, SX-304	Catch Tank	Inactive	RPP	EM-30	200-RO-2	
200-IS-1	241-TX-152	241-TX-152, 241-TX-152 Diversion Box	Diversion Box	Active	RPP	EM-30	200-TP-2	
200-IS-1	241-TX-154	241-TX-154, 241-TX-154 Diversion Box	Diversion Box	Active	RPP	EM-30	200-TP-4	
200-IS-1	241-TX-155	241-TX-155, 241-TX-155 Diversion Box	Diversion Box	Active	TSD	EM-30	200-TP-2	X
200-IS-1	241-TX-302B	241-TX-302B, 241-TX-302-B Catch Tank	Catch Tank	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	241-TX-302BR	241-TX-302BR, 241-TX-302BR Catch Tank, 241-TXR-302BR	Catch Tank	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	241-TX-302C	241-TX-302C, 241-TX-302-C Catch Tank	Catch Tank	Active	RPP	EM-30	200-TP-4	
200-IS-1	241-U-151	241-U-151, 241-U-151 Diversion Box	Diversion Box	Active	RPP	EM-30	200-UP-2	
200-IS-1	241-U-152	241-U-152, 241-U-152 Diversion Box	Diversion Box	Active	RPP	EM-30	200-UP-2	
200-IS-1	241-UX-154	241-UX-154, 241-UX-154 Diversion Box	Diversion Box	Active	RPP	EM-30	200-UP-2	
200-IS-1	241-UX-302A	241-UX-302A, 241-U-302 Catch Tank, 241-UX-302 Catch Tank, 241-UX-302	Catch Tank	Active	RPP	EM-30	200-UP-2	
200-IS-1	241-WR VAULT	241-WR VAULT, 241-WR Vault (Tanks -001 through -009), 241-WR Diversion Station Vault	Receiving Vault	Inactive	RPP	EM-40	200-UP-2	
200-IS-1	200-W-58	200-W-58, Z-Plant Diversion Box #1	Diversion Box	Inactive	RPP	EM-60	200-ZP-2	
200-IS-1	200-W-59	200-W-59, Z-Plant Diversion Box #2	Diversion Box	Inactive	RPP	EM-60	200-ZP-2	
200-IS-1	241-Z	241-Z, 241-Z Treatment and Storage Tanks, 241-Z Tank Farm, 241-Z Treatment and Storage System, 241-Z-D-4, 241-Z-D-5, 241-Z-D-7, 241-Z-D-8, 241-Z Sump	Neutralization Tank	Active	TSD	EM-60	200-ZP-2	X
200-IS-1	276-S-141	276-S-141, 276-S-TK-141, 276-S-306A, 276-S-141 Solvent Storage Tank, Tank 276-141, Hexone Storage Tank, 244-SX-15	Storage Tank	Active	TSD	EM-40	200-RO-2	X
200-IS-1	276-S-142	276-S-142, 276-S-TK-142, 276-S-306B, 276-S-142 Solvent Storage Tank, Tank 276-142, Hexone Storage Tank, 244-SX-15	Storage Tank	Active	TSD	EM-40	200-RO-2	X
200-IS-1	HSVP	HSVP, Hot Semiworks Valve Pit, 201-C Diversion Box, Semiworks Valve Pit	Valve Pit	Inactive	RPP	EM-40	200-SO-1	
200-IS-1	UPR-200-E-1	UPR-200-E-1, Waste Line Failure on South Side of 221-B	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-3	UPR-200-E-3, Line leak from 221-B to 241-BX-154, UN-200-E-3	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-41	UPR-200-E-41, UN-200-E-41 Soil Contamination in the Vicinity of R-13 Stairwell (221-B), UPR-200-E-85	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-44	UPR-200-E-44, UN-200-E-44, Waste Line Leak South of 221-B	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-45	UPR-200-E-45, UN-200-E-45	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-77	UPR-200-E-77, UN-216-E-5, 241-B-154 Diversion Box Ground Contamination, UN-200-E-77	Unplanned Release	Inactive	RPP	EM-30	200-BP-6	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98. (24 Pages)

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-IS-1	UPR-200-E-78	UPR-200-E-78, UN-216-E-6, 241-BX-155 Diversion Box ground contamination, UN-200-E-78	Unplanned Release	Inactive	RPP	EM-30	200-BP-6	
200-IS-1	UPR-200-E-80	UPR-200-E-80, UN-216-E-8, 221-B R-3 Line Break, R-3 Radiation Zone, UN-200-E-80	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-85	UPR-200-E-85, Line Leak at 221-B Stairwell R-13, UN-216-E-13, UPR-200-E-41, UN-200-E-85, UN-200-E-41	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-IS-1	UPR-200-E-87	UPR-200-E-87, UN-216-E-15, 224-B South Side Plutonium Ground Contamination, UN-200-E-87, 216-E-15	Unplanned Release	Inactive	RPP	EM-40	200-BP-6	
200-IS-1	UPR-200-E-84	UPR-200-E-84,241-ER-151 Catch Tank Leak, UN-200-E-84, UN-216-E-12	Unplanned Release	Inactive	RPP	EM-30	200-BP-9	
200-IS-1	UPR-600-20	UPR-600-20, UN-216-E-41, Cross Country Transfer Line	Unplanned Release	Inactive	RPP	EM-30	200-IU-5	
200-IS-1	UPR-200-E-25	UPR-200-E-25, Contamination Spread from the 241-A-151 Diversion Box, UN-200-E-25	Unplanned Release	Inactive	RPP	EM-30	200-PO-2	
200-IS-1	UPR-200-E-26	UPR-200-E-26, 241-A-151 Release, UN-200-E-26	Unplanned Release	Inactive	RPP	EM-30	200-PO-2	
200-IS-1	UPR-200-E-31	UPR-200-E-31, 241-A-151 Release, UN-200-E-31	Unplanned Release	Inactive	RPP	EM-30	200-PO-2	
200-IS-1	UPR-200-E-42	UPR-200-E-42, 241-AX-151 Release, UN-200-E-42	Unplanned Release	Inactive	RPP	EM-30	200-PO-2	
200-IS-1	UPR-200-E-65	UPR-200-E-65, UN-216-E-65, 241-A-151 Diversion Box Radioactive Contamination, UN-200-E-65	Unplanned Release	Inactive	RPP	EM-30	200-PO-2	
200-IS-1	UPR-200-E-96	UPR-200-E-96, Ground Contamination SE of PUREX, UN-216-E-24, UN-200-E-96	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-IS-1	UPR-200-E-117	UPR-200-E-117, Contaminated Liquid Spill, UN-200-E-117	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-IS-1	UPR-200-E-67	UPR-200-E-67, UN-216-E-67, Radioactively Contaminated Pipe Encasement, UN-200-E-67	Unplanned Release	Inactive	RPP	EM-30	200-PO-5	
200-IS-1	UPR-200-W-32	UPR-200-W-32, UNH Transfer Line Break, UN-200-W-32	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-IS-1	UPR-200-W-33	UPR-200-W-33, Ground Contamination at 224-U, UN-200-W-33	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-IS-1	UPR-200-W-49	UPR-200-W-49, UN-200-W-49	Unplanned Release	Inactive	RPP	EM-30	200-RO-2	
200-IS-1	UPR-200-W-114	UPR-200-W-114, UN-216-W-24, Ground Contamination East of 241-SX Tank Farm, UN-200-W-114	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-IS-1	UPR-200-W-35	UPR-200-W-35, Ground Contamination Near UNH Process Line, UN-200-W-35, REDOX to 224-U UNH Line Leak	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-IS-1	UPR-200-W-5	UPR-200-W-5, Overflow at 241-TX-155, UN-200-W-5	Unplanned Release	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	UPR-200-W-28	UPR-200-W-28, Release from 241-TX-155, UN-200-W-28	Unplanned Release	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	UPR-200-W-29	UPR-200-W-29, Transfer Line Leak, UN-200-W-29, UPR-200-W 27, UN-200-W-27, UN-216-W-5, 23rd and Camden Line Break	Unplanned Release	Inactive	RPP	EM-40	200-TP-2	
200-IS-1	UPR-200-W-113	UPR-200-W-113, Soil Contamination East of 241-TX, UN-216-W-23, UN-200-W-113	Unplanned Release	Inactive	RPP	EM-40	200-TP-2	
200-IS-1	UPR-200-W-131	UPR-200-W-131, Release from 241-TX-155	Unplanned Release	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	UPR-200-W-135	UPR-200-W-135, Release from 241-TX-155, UN-200-2-135	Unplanned Release	Inactive	RPP	EM-30	200-TP-2	
200-IS-1	UPR-200-W-2	UPR-200-W-2, UN-200-W-2	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
(24 Pages)

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-IS-1	UPR-200-W-21	UPR-200-W-21, UN-200-W-21, Ground Contamination at 241-TX-154 Diversion Box	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-IS-1	UPR-200-W-27	UPR-200-W-27, Transfer Line Leak, UN-200-W-27	Unplanned Release	Inactive	RPP	EM-40	200-TP-4	
200-IS-1	UPR-200-W-38	UPR-200-W-38, Line Break at 241-TX-302, UPR-200-W-160, UPR-200-W-40, UN-200-W-38, 216-T-30, UN-216-W-36,	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-IS-1	UPR-200-W-40	UPR-200-W-40, Line Break at 241-TX-154,UPR-200-W-38, UPR-200-W-160, 216-T-30, UN-200-W-40,	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-IS-1	UPR-200-W-98	UPR-200-W-98, UN-216-W-6, 221-T at R-19 Waste Line Break, UPR-200-W-98, UN-200-W-98	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-IS-1	UPR-200-W-102	UPR-200-W-102, UN-216-W-12, UN-200-W-102	Unplanned Release	Inactive	RPP	EM-40	200-TP-4	
200-IS-1	UPR-200-W-160	UPR-200-W-160, Line Break at 241-TX-302C, UPR-200-W-38, UPR-200-W-40, 216-T-30	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-IS-1	UPR-200-W-115	UPR-200-W-115, UN-216-W-25, Ground contamination Along Cooper Street	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-IS-1	UPR-200-W-161	UPR-200-W-161, UN-216-W-35, UN-200-W-161	Unplanned Release	Inactive	RPP	EM-30	200-UP-2	
200-IS-1	UPR-200-W-164	UPR-200-W-164, Overhead UNH Line Leak, UN-216-W-29	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-IS-1	UPR-200-W-79	UPR-200-W-79, Contamination Spread at 241-Z, UN-200-W-79	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-IS-1	UPR-200-W-6	N-200-W-6	Unplanned Release	Inactive	RPP	EM-30	200-UP-2	
200-IS-1	UPR-200-W-64	Road Contamination, UN-200-W-97	Unplanned Release	Inactive	RPP	EM-40	200-TP-2	
200-IS-1	UPR-200-W-97	Transfer Line Leak, UN-216-W-5, UN-200-W-97	Unplanned Release	Inactive	RPP	EM-40	200-TP-2	
200-UR-1, Unplanned Releases Group Lead Regulatory Agency: Ecology								
200-UR-1	UPR-200-E-63	UPR-200-E-63, Radioactively Contaminated Tumbleweeds, UN-216-E-63, UN-200-E-63	Unplanned Release	Inactive	RPP	EM-40	200-BP-2	
200-UR-1	UPR-200-E-89	UPR-200-E-89, UN-216-E-17, UN-200-E-89, Contamination Migration to the North East & West of BX-BY Tank Farms	Unplanned Release	Inactive	RPP	EM-40	200-BP-1	
200-UR-1	UPR-200-E-112	UPR-200-E-112, UN-200-E-112, Contaminated Railroad Track from B-Plant to the Burial Ground	Unplanned Release	Inactive	RPP	EM-60	200-BP-10	
200-UR-1	UPR-200-E-92	UPR-200-E-92, 216-E-20, UN-216-E-20, UN-216-20, Ground Contamination Outside 200 East Fence, UN-200-E-92, UN-216-E-92	Unplanned Release	Inactive	RPP	EM-40	200-BP-11	
200-UR-1	UPR-200-E-93	UPR-200-E-93, UN-216-E-21 Ground contamination along 200 East Area fence	Unplanned Release	Inactive	RPP	EM-40	200-BP-11	
200-UR-1	UPR-600-21	UPR-600-21, Contamination found Northeast of 200 East Area, UN-216-E-31	Unplanned Release	Inactive	RPP	EM-40	200-BP-11	
200-UR-1	UPR-200-E-83	UPR-200-E-83, UN-216-E-11, BC Cribs Controlled Area, UN-200-E-83	Unplanned Release	Inactive	RPP	EM-40	200-BP-2	
200-UR-1	UPR-200-E-144	UPR-200-E-144, Soil Contamination North of 241-B, UN-216-E-44	Unplanned Release	Inactive	RPP	EM-30	200-BP-4	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-UR-1	200-E-26	200-E-26, Heavy Equipment Storage Area, Diesel Fuel Contaminated Soil	Unplanned Release	Inactive	RPP	EM-70	200-BP-6	
200-UR-1	UPR-200-E-2	UPR-200-E-2, UN-200-E-2, Spotty Contamination Around the B and T Plant Stacks	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-52	UPR-200-E-52, UN-200-E-52, Contamination Spread Outside the North Side of 221-B	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-54	UPR-200-E-54, UN-200-E-54, Contamination Outside 225-B Doorway	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-55	UPR-200-E-55, UN-200-E-55	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-69	UPR-200-E-69, UN-216-E-69, Railroad Car Flush Water Radioactive Spill, UN-200-E-69	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-90	UPR-200-E-90, UN-216-E-18, Ground Contamination around B Plant Sand Filter, UN-216-E-90, Radioactive Spill Near 221-B Building, UN-200-E-90	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-103	UPR-200-E-103, UN-200-E-103, BCS Line Leak South of R-17 at 221-B	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-200-E-140	UPR-200-E-140, PCB Oil Spill at 211-B Bulk Storage Area, UN-200-E-140	Unplanned Release	Inactive	RPP	EM-60	200-BP-6	
200-UR-1	UPR-600-12	UPR-600-12, UN-600-12	Unplanned Release	Inactive	RPP	EM-40	200-IU-3	
200-UR-1	UPR-200-N-1	UPR-200-N-1, Unplanned release near 212-R railroad spur	Unplanned Release	Inactive	RPP	EM-70	200-NO-1	
200-UR-1	UPR-200-N-2	UPR-200-N-2, 200-N-2, Unplanned release near Well Pump House No. 2	Unplanned Release	Inactive	RPP	EM-40	200-NO-1	
200-UR-1	UPR-200-E-10	UPR-200-E-10, Contaminated Purex Railroad Spur, UN-200-E-10	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-11	UPR-200-E-11, Railroad Track Contamination Spread, UN-200-E-11	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-12	UPR-200-E-12, Contaminated Purex Railroad Spur, UN-200-E-12	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-20	UPR-200-E-20, Contaminated Purex Railroad Spur, UN-200-E-20	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-22	UPR-200-E-22, 291-A-1 Stack Fallout Area, UN-200-E-22,	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-UR-1	UPR-200-E-28	UPR-200-E-28, Contamination Release Inside the PUREX Exclusion Area, UN-200-E-28	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-UR-1	UPR-200-E-33	UPR-200-E-33, Contaminated Purex Railroad tracks, UN-200-E-33	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-49	UPR-200-E-49, Roadway Contamination, UN-200-E-49	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-58	UPR-200-E-58, Contaminated Tumbleweeds found on dirt road, UN-200-E-58	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-60	UPR-200-E-60, UN-216-E-60, Radioactively Contaminated Dirt Spill, UN-200-E-60	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98. (24 Pages)

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-UR-1	UPR-200-E-88	UPR-200-E-88, TC-4 Spur Contaminated Railroad Track, UN-216-E-88, UN-216-E-16, UN-200-E-88. Ground Contamination Around the Western Purex Railroad Spur	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-UR-1	UPR-200-E-97	UPR-200-E-97, PUREX Railroad Tunnel Contamination, UN-216-E-25, UN-200-E-97	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-UR-1	UPR-200-E-114	UPR-200-E-114, UN-200-E-114	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-UR-1	UPR-200-E-142	UPR-200-E-142, 202-A Diesel Fuel Spill, UN-200-E-142	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-UR-1	UPR-200-E-143	UPR-200-E-143, Contamination Adjacent to 244-AR Lift Station, UN-216-E-43	Unplanned Release	Inactive	RPP	EM-30	200-PO-2	
200-UR-1	200-E-8	200-E-8, 200 East Trench 94 Diesel Spill	Unplanned Release	Inactive	RPP	EM-30	200-PO-6	
200-UR-1	UPR-200-E-50	UPR-200-E-50, Soil Contamination at the Overground Equipment Storage Yard, UN-200-E-50	Unplanned Release	Inactive	RPP	EM-40	200-PO-6	
200-UR-1	UPR-200-E-62	UPR-200-E-62, Transportation spill near 200-E Burning Ground, UN-216-E-62, UN-200-E-62,	Unplanned Release	Inactive	RPP	EM-40	200-PO-6	
200-UR-1	UPR-200-W-41	UPR-200-W-41, Railroad Contamination, UN-200-W-41	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-UR-1	UPR-200-W-42	UPR-200-W-42, Contamination found at 2706-S, UN-200-W-42	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-UR-1	UPR-200-W-51	UPR-200-W-51, UN-200-W-51, UPR-200-W-52	Unplanned Release	Inactive	RPP	EM-30	200-RO-2	
200-UR-1	UPR-200-W-52	UPR-200-W-52, UN-200-W-52, UPR-200-W-51	Unplanned Release	Inactive	RPP	EM-30	200-RO-2	
200-UR-1	UPR-200-W-69	UPR-200-W-69, Railroad Contamination, UN-200-W-69	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-UR-1	UPR-200-W-83	UPR-200-W-83, Radioactive Spill Near 204-S Radiation Zone, UN-216-W-82, UN-200-W-83	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-UR-1	UPR-200-W-123	UPR-200-W-123, 204-S Unloading Facility Frozen Discharge Line, UN-200-W-123	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-UR-1	UPR-200-W-127	UPR-200-W-127, Liquid Release from 242-S Evaporator to the Ground, UN-200-W-127	Unplanned Release	Inactive	RPP	EM-30	200-RO-2	
200-UR-1	UPR-200-W-165	UPR-200-W-165, Contamination Area East of 241-S, UN-216-W 30	Unplanned Release	Inactive	RPP	EM-40	200-RO-2	
200-UR-1	UPR-200-W-43	UPR-200-W-43, Contaminated Blacktop East of 233-S, UN-200-W-43	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-UR-1	UPR-200-W-56	UPR-200-W-56, Contamination at the REDOX Column Carrier Trench, UN-200-W-56	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-UR-1	UPR-200-W-57	UPR-200-W-57, UPR-200-E-120 (misassignment of area), UN-200-W-57	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-UR-1	UPR-200-W-61	UPR-200-W-61, REDOX Ground Contamination, UN-200-W-61	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-UR-1	UPR-200-W-87	UPR-200-W-87, UN-216-W-87, Radioactive Spill from Filter Housing, UN-200-W-87	Unplanned Release	Inactive	RPP	EM-30	200-RO-3	
200-UR-1	UPR-200-W-96	UPR-200-W-96, UN-216-W-4, 233-S Floor Overflow, 233-SA Floor Overflow	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-UR-1	UPR-200-W-116	UPR-200-W-116, UN-216-W-26, Ground Contamination North of 202-S, UN-200-W-116	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-UR-1	UPR-200-E-36	UPR-200-E-36, Road Contamination North of Semiworks, UN-200-E-36	Unplanned Release	Inactive	RPP	EM-40	200-SO-1	
200-UR-1	UPR-200-E-37	UPR-200-E-37, Contamination East of Hot Semi-Works, UN-200-E-37, UN-216-E-37	Unplanned Release	Inactive	RPP	EM-40	200-SO-1	
200-UR-1	UPR-200-E-98	UPR-200-E-98, UN-216-E-26, Ground Contamination East of C Plant, UN-200-E-98	Unplanned Release	Inactive	RPP	EM-40	200-SO-1	
200-UR-1	UPR-200-E-141	UPR-200-E-141, 2718-E Building Uranyl Nitrate Spill to Ground, UN-200-E-141	Unplanned Release	Inactive	RPP	EM-40	200-SO-1	
200-UR-1	UPR-200-W-88	UPR-200-W-88, Radioactive Spill from UNH Trailer, UN-216-W-88, UN-200-W-88	Unplanned Release	Inactive	RPP	EM-40	200-SS-2	
200-UR-1	UPR-200-W-14	UPR-200-W-14, Waste Line Leak at 242-T Evaporator, UN-200-W-14	Unplanned Release	Inactive	RPP	EM-30	200-TP-2	
200-UR-1	UPR-200-W-99	UPR-200-W-99, UN-216-W-7, 153-TX Diversion Box Contamination Spread, UN-200-W-99	Unplanned Release	Inactive	RPP	EM-40	200-TP-2	
200-UR-1	UPR-200-W-167	UPR-200-W-99, UN-216-W-7, 153-TX Diversion Box Contamination Spread, UN-200-W-99	Unplanned Release	Inactive	RPP	EM-30	200-TP-2	
200-UR-1	UPR-200-W-166	UPR-200-W-166, Contamination Migration from 241-T Tank Farm, UN-216-W-31	Unplanned Release	Inactive	RPP	EM-40	200-TP-3	
200-UR-1	200-W-9	200-W-9, W291 Excavation VCP Contamination	Unplanned Release	Active	RPP	EM-30	200-TP-4	
200-UR-1	UPR-200-W-3	UPR-200-W-3, Railroad Contamination, UN-200-W-3	Unplanned Release	Inactive	RPP	EM-40	200-TP-4	
200-UR-1	UPR-200-W-4	UPR-200-W-4, Railroad Contamination, UN-200-W-4	Unplanned Release	Inactive	RPP	EM-40	200-TP-4	
200-UR-1	UPR-200-W-58	UPR-200-W-58, Railroad Track Contamination, UN-200-W-58	Unplanned Release	Inactive	RPP	EM-40	200-TP-4	
200-UR-1	UPR-200-W-65	UPR-200-W-65, Contamination in the T-Plant Railroad Cut, UN-200-W-65	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-UR-1	UPR-200-W-67	UPR-200-W-67, Contamiantion near 2706-T, UN-200-W-67	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-UR-1	UPR-200-W-73	UPR-200-W-73, Contaminated Railroad Track at 221-T, UN-200 W-73	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-UR-1	UPR-200-W-77	UPR-200-W-77, Contaminated Coyote Feces, UN-200-W-77	Unplanned Release	Inactive	RPP	EM-40	200-TP-4	
200-UR-1	UPR-200-W-85	UPR-200-W-85, Radioactive Spill from Multipurpose Transfer Box, UN-216-W-85, UN-200-W-85	Unplanned Release	Inactive	RPP	EM-30	200-TP-4	
200-UR-1	UPR-200-W-39	UPR-200-W-39, UN-200-W-39, 224-U Buried Contamination	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-46	UPR-200-W-46, Contamianted Railroad Track, UN-200-W-46	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-48	UPR-200-W-48, Contaminated Railroad Track near 221-U, UN-200-W-48	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-55	UPR-200-W-55, Urainium Powder Spill at 224-U, UN-200-W-55	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-60	UPR-200-W-60, Railroad Contamination, UN-200-W-60	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-68	UPR-200-W-68, Road Contamination, UN-200-W-68	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-78	UPR-200-W-78, UO3 Powder Spill at 224-U, UN-200-W-78	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-UR-1	UPR-200-W-86	UPR-200-W-86, Contaminated Pigeon Feces at 221-U and 204-S, UN-200-W-86, UN-216-W-86	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-101	UPR-200-W-101, UN-216-W-9, 221-U Acid Spill R-1 through R-5, UN-200-W-101	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-117	UPR-200-W-117, Railroad Track Contamination, UN-216-W-27, UN-200-W-117	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-118	UPR-200-W-118, Contamination at 211-U, UN-216-W-28, UN-200-W-118	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-162	UPR-200-W-162, Contaminated Area on East Side of 221-U, UN-216-W-37	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-UR-1	UPR-200-W-23	UPR-200-W-23, Waste Box Fire at 234-5Z, UN-200-W-23	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-74	UPR-200-W-74, Overground Line Leak at 241-Z, UN-200-W-74	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-75	UPR-200-W-75, Contamination Spread at 241-Z, UN-200-W-75	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-89	UPR-200-W-89, Radioactive Contamination Southwest of 236-Z Building, UN-216-W-89, UN-200-W-89	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-90	UPR-200-W-90, Radioactive Contamination South of 236-Z Building, UN-216-N-90, UN-200-W-90	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-91	UPR-200-W-91, Radioactive Contamination near 234-5Z Building, UN-216-W-91, UN-200-W-91	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-159	UPR-200-W-159, Caustic Spill at Plutonium Finishing Plant, UN-200-W-159	Unplanned Release	Inactive	RPP	EM-60	200-ZP-2	
200-UR-1	UPR-200-W-44	UPR-200-W-44, Railroad Track Contamination, UN-200-W-44	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-UR-1	200-W-56	241-C Waste Line Leak #1	Unplanned Release	Inactive	RPP		200-SO-1	
200-UR-1	200-W-57	241-C Waste Line Leak #2	Unplanned Release	Inactive	RPP		200-SO-1	
200-ST-1, Septic Tank and Drain Fields Lead Regulatory Agency: Ecology								
200-ST-1	200-E-5	200-E-5, 2607-E2, 2607-E2 Septic Tank & Tile Field	Septic Tank	Unknown	RPP	EM-70	200-SS-1	
200-ST-1	200-E-6	200-E-6, Septic Tank, Sanitary Sewer Repair and Replacement 2607-E4	Septic Tank	Active	RPP	EM-60	200-BP-6	
200-ST-1	200-E-7	200-E-7, 2607-EO Septic Tank & Tile Field	Septic Tank	Unknown	RPP	EM-70	200-SS-1	
200-ST-1	200-E-9	200-E-9, 2607-EN, 2727-E Septic System, 2607-EN Septic Tank/Pump Station	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	200-E-24	200-E-24, 6607-11, 2704-HV Septic System	Septic Tank	Active	RPP	EM-30	200-BP-9	
200-ST-1	2607-E1	2607-E1	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-E3	2607-E3	Septic Tank	Active	RPP	EM-60	200-BP-6	
200-ST-1	2607-E4	2607-E4	Septic Tank	Inactive	RPP	EM-60	200-BP-6	
200-ST-1	2607-E5	2607-E5	Septic Tank	Active	RPP	EM-30	200-SO-1	
200-ST-1	2607-E6	2607-E6	Septic Tank	Active	RPP	EM-70	200-PO-2	
200-ST-1	2607-E7A	2607-E7A, 2607-E7	Septic Tank	Active	RPP	EM-30	200-SO-1	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
(24 Pages)

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-ST-1	2607-E7B	2607-E7B, 2607-E	Septic Tank	Active	RPP	EM-30	200-SS-1	
200-ST-1	2607-E8	2607-E8	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-E9	2607-E9	Septic Tank	Active	RPP	EM-30	200-BP-8	
200-ST-1	2607-E11	2607-E11	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-E12	2607-E12, 2607-E12 Septic System	Septic Tank	Active	RPP	EM-30	200-PO-5	
200-ST-1	2607-EA	2607-EA, 2607-EA Septic Tank and Drywell	Septic Tank	Active	RPP	EM-30	200-PO-2	
200-ST-1	2607-EC	2607-EC	Septic Tank	Active	RPP	EM-30	200-PO-5	
200-ST-1	2607-EE	2607-EE, 2607-EL	Septic Tank	Inactive	RPP	EM-60	200-PO-2	
200-ST-1	2607-EH	2607-EH	Septic Tank	Active	RPP	*	200-SS-1	
200-ST-1	2607-EK	2607-EK	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-EL	2607-EL Septic Tank/Pump Station	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-EM	2607-EM	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-EP	2607-EP	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-EQ	2607-EQ	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-ER	2607-ER	Septic Tank	Active	RPP	EM-70	200-SS-1	
200-ST-1	2607-FSM	2607-FSM, 609 Building Septic Tank 2607-FSM, 100 Area Fire Station Septic Tank, 1607-FSM, 6607-FSM	Septic Tank	Active	RPP	EM-70	200-IU-2	
200-ST-1	2607-FSN	2607-FSN, 609A Building Septic Tank 2607-FSN	Septic Tank	Inactive	RPP	EM-70	200-IU-5	
200-ST-1	2607-GF	2607-GF	Septic Tank	Active	RPP	*	200-SS-1	
200-ST-1	2607-N	2607-N	Septic Tank	Inactive	RPP	EM-40	200-NO-1	
200-ST-1	2607-P	2607-P	Septic Tank	Inactive	RPP	EM-40	200-NO-1	
200-ST-1	2607-R	2607-R	Septic Tank	Inactive	RPP	EM-40	200-NO-1	
200-ST-1	2607-W1	2607-W1	Septic Tank	Active	RPP	EM-70	200-SS-2	
200-ST-1	2607-W2	2607-W2	Septic Tank	Active	RPP	EM-70	200-SS-2	
200-ST-1	2607-W3	2607-W3	Septic Tank	Active	RPP	EM-30	200-TP-4	
200-ST-1	2607-W4	2607-W4	Septic Tank	Active	RPP	EM-30	200-TP-4	
200-ST-1	2607-W5	2607-W5	Septic Tank	Active	RPP	EM-40	200-UP-2	
200-ST-1	2607-W6	2607-W6	Septic Tank	Active	RPP	EM-30	200-RO-3	
200-ST-1	2607-W7	2607-W7	Septic Tank	Active	RPP	EM-40	200-UP-2	
200-ST-1	2607-W8	2607-W8	Septic Tank	Active	RPP	EM-60	200-ZP-2	
200-ST-1	2607-W9	2607-W9	Septic Tank	Active	RPP	EM-30	200-UP-2	
200-ST-1	2607-WA	2607-WA	Septic Tank	Active	RPP	EM-60	200-ZP-2	
200-ST-1	2607-WC	2607-WC, 2607-WC Septic System	Septic Tank	Active	RPP	EM-30	200-UP-2	
200-ST-1	2607-WL	2607-WL, 2607-WL Septic System	Septic Tank	Active	RPP	EM-30	200-ZP-3	
200-ST-1	2607-WWA	2607-WWA	Septic Tank	Active	RPP	*	200-ZP-3	
200-ST-1	2607-WZ	2607-WZ	Septic Tank	Inactive	RPP	*	200-RO-1	
200-ST-1	2607-Z	2607-Z	Septic Tank	Active	RPP	EM-60	200-ZP-2	
200-ST-1	2607-Z8	2607-Z8	Septic Tank	Active	RPP	EM-60	200-ZP-2	
200-ST-1	600 ESST	600 Area Exploratory Shaft Septic Tank, Septic Tank - Exploratory Shaft	Septic Tank	Inactive	RPP	EM-40	200-IU-1	
200-ST-1	600 NSTFST	600 NSTFST, 600 Area Near Surface Test Facility Septic Tank, Septic Tank, Near Surface Test Facility	Septic Tank	Inactive	RPP	EM-40	200-IU-2	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
(24 Pages)

Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-IS-1	600 NSTFUT	600 NSTFUT, 600 Area Near Surface Test Facility Underground Tank, Underground Tank, Near Surface Test Facility	Storage Tank	Inactive	RPP	EM-40	200-IU-2	
200-ST-1	622-R ST	622-R ST, 622-R Septic Tank, 622-R Atmospheric Physics Laboratory Septic Tank	Septic Tank	Active	RPP	EM-30	200-IU-5	
200-ST-1	6607-1	6607-1, H-40 Gun Site Septic Tank	Septic Tank	Inactive	RPP	EM-40	200-IU-3	
200-ST-1	6607-2	6607-2, Gun Site H-42 Septic Tank	Septic Tank	Inactive	RPP	EM-40	200-IU-3	
200-ST-1	6607-3	6607-3, Anti-Aircraft Artillery Site H-51 Septic Tank	Septic Tank	Inactive	RPP	EM-40	200-IU-1	
200-ST-1	6607-5	6607-5	Septic Tank	Active	RPP	EM-30	200-IU-5	
200-ST-1	TFS OF 218-E-4	TFS OF 218-E-4, Tile Field South of 218-E-4	Drain/Tile Field	Active	RPP	EM-60	200-BP-6	
200-SW-1, Non-Radioactive Landfills and Dumps Group Lead Regulatory Agency: Ecology								
200-SW-1	200 CP	200 CP, 200 Area Construction Pit, 200 Area Construction Waste Site, Hanford Site Gravel Pit #29	Depression/Pit (nonspecific	Inactive	RPP	EM-40	200-BP-10	
200-SW-1	200-E BP	200-E BP, 200-E Burning Pit, 200 East Burning Pit	Burn Pit	Inactive	RPP	EM-40	200-PO-6	
200-SW-1	200-E PAP	200-E PAP, 200-E Powerhouse Ash Pit	Coal Ash Pit	Active	RPP	EM-70	200-SS-1	
200-SW-1	200-E-1	200-E-1, 284E Inert Landfill	Dumping Area	Inactive	RPP	EM-70	200-SS-1	
200-SW-1	200-E-2	200-E-2, 2101-M SW Parking Lot, MO-234 parking Lot	Unplanned Release	Inactive	RPP	EM-70	200-SS-1	
200-SW-1	200-E-10	200-E-10, Paint Dump Near Sub Trenches	Dumping Area	Inactive	RPP	EM-40	200-PO-6	
200-SW-1	200-E-12	200-E-12, Sand Piles from RCRA General Inspection 200EFY95 Item #5	Dumping Area	Inactive	RPP	EM-70	200-PO-2	
200-SW-1	200-E-13	200-E-13, Rubble Piles from RCRA General Inspection #200EFY95 Item #7	Dumping Area	Inactive	RPP	EM-70	200-PO-2	
200-SW-1	200-N-3	200-N-3, Ballast Pits	Depression/Pit (nonspecific	Inactive	RPP	EM-70	200-NO-1	
200-SW-1	200-W ADB	200-W ADB, 200-W Ash Disposal Basin	Coal Ash Pit	Active	RPP	EM-70	200-SS-2	
200-SW-1	200-W BP	200-W BP, 200-W Burning Pit	Burn Pit	Inactive	RPP	EM-40	200-SS-2	
200-SW-1	200-W CSLA	200-W CSLA, 200-W Construction Surface Laydown Area, Non-Rad Burial Ground, Construction Surface Laydown Area	Burial Ground	Inactive	RPP	EM-40	200-UP-2	
200-SW-1	200-W PAP	200-W PAP, 200-W Powerhouse Ash Pit	Coal Ash Pit	Inactive	RPP	EM-70	200-SS-2	
200-SW-1	200-W-1	200-W-1, REDOX Mud Pit West	Mud Pit	Inactive	RPP	EM-40	200-RO-2	
200-SW-1	200-W-2	200-W-2, REDOX Berms West	Spoils Pile/Berm	Inactive	RPP	EM-40	200-RO-2	
200-SW-1	200-W-3	200-W-3, 2713-W North Parking Lot, 220-W-1	Dumping Area	Inactive	RPP	EM-70	200-SS-2	
200-SW-1	200-W-6	200-W-6, 200-W Painter Shop paint solvent disposal area	Dumping Area	Inactive	RPP	EM-70	200-UP-2	
200-SW-1	200-W-10	200-W-10, Item 10 (RCRA General Inspection), Grout Wall Test	Depression/Pit (nonspecific	Inactive	RPP	EM-30	200-UP-2	
200-SW-1	200-W-11	200-W-11, Concrete Foundation South of 241-S, S-Farm Foundation and Dump Site	Dumping Area	Abandone	RPP	EM-70	200-RO-1	
200-SW-1	218-E-6	218-E-6, B Stack Shack Burning Pit, Buried Contamination	Burial Ground	Inactive	RPP	EM-40	200-BP-6	
200-SW-1	218-W-6	218-W-6	Burial Ground	Active	TSD	EM-30	200-ZP-3	X
200-SW-1	600 CL	600 CL, 600 Area Central Landfill, Central Landfill, Central Waste Landfill, CWL, Solid Waste Landfill, SWL	Sanitary Landfill	Inactive	RPP	EM-70	200-IU-3	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-SW-1	600 BPHWSA	600 BPHWSA, 600 Area Batch {Plant HWSA, Hazardous Waste Storage Area (Batch Plant)	Storage Pad (<90 Day)	Active	RPP	EM-70	200-IU-5	
200-SW-1	600-ESHWSA	600 Area Exploratory Shaft Hazardous Waste Storage Area/600 Area Exploratory Shaft HWSA	Storage Pad (<90 Day)	Inactive	RPP	EM-40	200-IU-1	
200-SW-1	600 NRDWL	600 NRDWL, 600 Area Nonradioactive Dangerous Waste Landfill, NRDW Landfill, Nonradioactive Dangerous Waste Landfill (Central Landfill), NRDWL	Sanitary Landfill	Active	TSD	EM-40	200-IU-3	X
200-SW-1	600 OCL	600 OCL, 600 Area Original Central Landfill, Original CLF	Sanitary Landfill	Inactive	RPP	EM-40	200-IU-3	
200-SW-1	600-38	600-38, Railroad Siding "Susie", 600-25, Susie Junction	Dumping Area	Inactive	RPP	EM-70	200-NO-1	
200-SW-1	600-40	600-40, West of West Lake Dumping Area	Dumping Area	Inactive	RPP	EM-70	200-IU-6	X
200-SW-1	600-51	600-51, Chemical Dump	Dumping Area	Inactive	RPP	EM-70	200-NO-1	
200-SW-1	600-70	600-70, SWMU #2 - Miscellaneous Solid Waste	Dumping Area	Inactive	RPP	EM-40	200-RO-3	
200-SW-1	622-1	622-1	Dumping Area	Inactive	RPP	EM-40	200-IU-5	
200-SW-1	628-2	628-2, 100 Area Fire Station Burn Pit	Burn Pit	Inactive	RPP	EM-70	200-IU-2	
200-SW-1	OCSA	OCSA, Old Central Shop Area, Central Shop Area	Foundation	Inactive	RPP	EM-70	200-IU-5	
200-SW-1	Z PLANT BP	Z PLANT BP, Z Plant Burning Pit	Burn Pit	Inactive	RPP	EM-30	200-ZP-3	
200-SW-1	UPR-200-E-106	UPR-200-E-106, Contamination at a Burning Ground, UN-200-E 106	Unplanned Release	Inactive	RPP	EM-40	200-PO-6	
200-SW-1	UPR-200-W-37	UPR-200-W-37, Contaminated Boxes Found at 200 West Burning Ground	Unplanned Release	Inactive	RPP	EM-40	200-SS-2	
200-SW-1	UPR-200-W-70	UPR-200-W-70, Contamination Found at the 200 West Burning Ground	Unplanned Release	Inactive	RPP	EM-40	200-SS-2	
200-SW-2, Radioactive Landfills and Dumps Group Lead Regulatory Agency: Ecology								
200-SW-2	200-W-5	Burial Ground/Burning Pit, U-Plant Burning Pit, UPR-200-W-8	Burial Ground	Inactive	RPP	EM-40	200-UP-2	
200-SW-2	218-C-9	218-C-9, Dry Waste No.0C9, 218-C-9 Burial Ground	Burial Ground	Inactive	RPP	EM-40	200-SO-1	
200-SW-2	218-E-1	218-E-1, 200 East Dry Waste No. 001	Burial Ground	Inactive	RPP	EM-40	200-PO-2	
200-SW-2	218-E-2	218-E-2, 200 East Industrial Waste No. 002	Burial Ground	Inactive	RPP	EM-40	200-BP-10	
200-SW-2	218-E-2A	218-E-2A, Regulated Equipment Storage Site No. 02A, Burial Trench	Burial Ground	Inactive	RPP	EM-40	200-BP-10	
200-SW-2	218-E-3	218-E-3, Construction Scrap Pit	Burial Ground	Inactive	RPP	EM-40	200-SS-1	
200-SW-2	218-E-4	218-E-4, 200 East Minor Construction No. 4	Burial Ground	Inactive	RPP	EM-40	200-BP-10	
200-SW-2	218-E-5	218-E-5, 200 East Industrial Waste No. 05	Burial Ground	Inactive	RPP	EM-40	200-BP-10	
200-SW-2	218-E-5A	218-E-5A, 200 East Industrial Waste No. 005A	Burial Ground	Inactive	RPP	EM-40	200-BP-10	
200-SW-2	218-E-7	218-E-7, 200 East 222-B Vaults	Burial Ground	Inactive	RPP	EM-40	200-BP-6	
200-SW-2	218-E-8	218-E-8, 200 East Construction Burial Grounds	Burial Ground	Inactive	RPP	EM-40	200-PO-6	
200-SW-2	218-E-9	218-E-9, 200 East Regulated Equipment Storage Site No. 009, Burial Vault (HISS)	Burial Ground	Inactive	RPP	EM-40	200-BP-10	
200-SW-2	218-E-10	218-E-10, 200 East Industrial Waste No. 10	Burial Ground	Active	TSD	EM-30	200-BP-10	X
200-SW-2	218-E-12A	218-E-12A, 200 East Dry Waste No. 12A	Burial Ground	Inactive	RPP	EM-40	200-PO-6	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-SW-2	218-E-12B	218-E-12B, 200 East Dry Waste No. 12B, 218-E-12B Burial Ground - Trench 94	Burial Ground	Active	TSD	EM-30	200-PO-6	X
200-SW-2	218-W-1	218-W-1, 200-W Area Dry Waste No. 001 Solid Waste Burial Ground	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	X
200-SW-2	218-W-1A	218-W-1A, 200-W Area Industrial Waste Burial Ground #1, Industrial Waste No. 01A, Industrial Waste No. 001	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	218-W-2	218-W-2, 200-W Area Dry Waste No. 002, Dry Waste Burial Ground No. 2	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	218-W-2A	218-W-2A, Industrial Waste No. 002, 218-W-02A Burial Ground, 200-W Area Industrial Waste No. 02A	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	X
200-SW-2	218-W-3	218-W-3, Dry Waste No. 003	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	218-W-3A	218-W-3A, Dry Waste No. 003A	Burial Ground	Active	TSD	EM-30	200-ZP-3	X
200-SW-2	218-W-3AE	218-W-3AE, Industrial Waste No. 3AE, Dry Waste No. 3AE	Burial Ground	Active	TSD	EM-30	200-ZP-3	X
200-SW-2	218-W-4A	218-W-4A, Dry Waste No. 04A	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	X
200-SW-2	218-W-4B	218-W-4B, Dry Waste No. 04B	Burial Ground	Active	TSD	EM-30	200-ZP-3	X
200-SW-2	218-W-4C	218-W-4C, Dry Waste No. 004C	Burial Ground	Active	TSD	EM-30	200-ZP-3	X
200-SW-2	218-W-5	218-W-5, Dry Waste Burial Ground, Low-Level Radioactive Mixed Waste Burial Grounds	Burial Ground	Active	TSD	EM-30	200-ZP-3	X
200-SW-2	218-W-7	218-W-7, 222-S Vault	Burial Ground	Inactive	RPP	EM-40	200-RO-3	
200-SW-2	218-W-8	218-W-8, 222-T Vault	Burial Ground	Inactive	RPP	EM-40	200-TP-4	
200-SW-2	218-W-9	218-W-9, Dry Waste Burial Ground No. 9, Non-TRU Dry Waste No. 009	Burial Ground	Inactive	RPP	EM-40	200-RO-2	
200-SW-2	218-W-11	218-W-11, Regulated Storage Site	Burial Ground	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	291-C-1	291-C-1, 291-C-1 Stack, 291-C Stack Burial Trench	Burial Ground	Inactive	RPP	EM-40	200-SO-1	
200-SW-2	600-25	600-25, Susie Junction	Dumping Area	Inactive	RPP	EM-70	200-NO-1	
200-SW-2	UPR-200-E-24	UPR-200-E-24, Contamination Plume from the 218-E-12A Burial Ground, UN-200-E-24	Unplanned Release	Inactive	RPP	EM-40	200-PO-6	
200-SW-2	UPR-200-E-30	UPR-200-E-30, Contamination Within 218-E-12A, UN-200-E-30	Unplanned Release	Inactive	RPP	EM-40	200-PO-6	
200-SW-2	UPR-200-E-35	UPR-200-E-35, Buried Contamianted Pipe, UN-218-E-1, 218-E-13	Unplanned Release	Inactive	RPP	EM-60	200-PO-2	
200-SW-2	UPR-200-E-53	UPR-200-E-53, UN-200-E-53, Contamination at 218-E-1	Unplanned Release	Inactive	RPP	EM-40	200-PO-2	
200-SW-2	UPR-200-E-61	UPR-200-E-61, Radioactive Contamination from Railroad Burial Cars, UN-216-E-61, UN-200-E-61	Unplanned Release	Inactive	RPP	EM-30	200-BP-10	
200-SW-2	UPR-200-E-95	UPR-200-E-95, UN-216-E-23, UN-200-E-95, Ground Contamination Around RR Spur Between 218-E-2A and 218-E-2	Unplanned Release	Inactive	RPP	EM-60	200-BP-10	
200-SW-2	UPR-200-W-8	UPR-200-W-8, UN-200-W-8, 200-W-5, Old Burial/Burning Pit, U-Plant Bruning Pit/Burial Ground	Unplanned Release	Inactive	RPP	EM-40	200-UP-2	
200-SW-2	UPR-200-W-11	UPR-200-W-11, Burial Ground Fire, UN-200-W-11, UPR-200-W-16	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-16	UPR-200-W-16, Fire at 218-W-4A Burial Ground	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	

Table G-1. 200 Area Waste Sites (by Groups) as of 8/13/98.
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Operable Unit	Site Code	Site Names	Site Type	Site Status	Unit Category	DOE Program	Previous Operable Unit	Rep. Site or TSD
200-SW-2	UPR-200-W-26	UPR-200-W-26, Contamination Spread During Burial Operation	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-45	UPR-200-W-45, Burial Box Collapse	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-53	UPR-200-W-53, Burial Box Collapse	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-63	UPR-200-W-63, Road Contamination along the South Shoulder of 23rd Street, UN-200-W-63	Unplanned Release	Inactive	RPP	EM-40	200-TP-3	
200-SW-2	UPR-200-W-72	UPR-200-W-72, Contamination at 218-W-4A	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-84	UPR-200-W-84, Ground Contamination During Burial Operation	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-134	UPR-200-W-134, Improper Drum Burial	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	
200-SW-2	UPR-200-W-137	UPR-200-W-137, 218-W-7, UN-200-W-137	Unplanned Release	Inactive	RPP	EM-40	200-RO-3	
200-SW-2	UPR-200-W-158	UPR-200-W-158, Burial Box Collapse	Unplanned Release	Inactive	RPP	EM-40	200-ZP-3	

APPENDIX H

PROCESS DESCRIPTIONS AND FLOW DIAGRAMS

H1.0 PROCESS DESCRIPTIONS

This appendix presents a detailed summary of the major process activities in the 200 Areas and at each of the major facilities and supports summary information presented in Section 3.2.2, "Operational History." The text presents a brief description of each process, some of the details of which are shown in the accompanying figures (Figures H-1 to H-8). The text also presents the historical evolution of separations and waste management processes. Figures H-1 through H-8 take a more facility- and area-specific view and depict the important processes at the major plant buildings. These figures summarize the process steps leading to generation of liquid waste streams and the disposal of these streams to waste sites. The order of presentation generally follows that of radiological material moving through the 200 Areas. The figures do not track wastes currently generated and disposed at either the State Approved Land Disposal Site or the 200 Areas Effluent Treatment Facility. Likewise, solid and gaseous wastes are not tracked in this appendix.

This appendix also provides an expanded discussion of the nuclear interactions and processes, described in Section 3.2.1, used to manufacture plutonium. This information is valuable to understanding why many of the major potential radionuclide contaminants are regarded as important and others are not. Similarly, descriptions of the chemicals used in process steps will help to focus future sampling efforts on appropriate analytes at specific waste sites.

Process descriptions are keyed to the buildings where the individual steps took place. In the figures, arrows show the flow of materials and wastes. The raw materials (fuel rods, stored high-level tank wastes, raw water) entering the building are documented under the "Source" heading and are tracked across through the Process Building to the Process description. The Process description depicts, vertically, the general steps used in the specific plant's process and the key chemicals added at those steps. Alternately, the Process column depicts the different process projects used to recover key constituents such as plutonium at the Plutonium Finishing Plan. The Liquid Waste/Product Stream column shows the types of wastes generated by the general process steps or the movement of the process solutions. The Waste Disposal Site column shows the specific soil column disposal site(s) that received the liquid wastes.

Although the complexity inherent in many of these processes is demonstrated in the detail of the figures, the details of the process steps are much greater and have been simplified for presentation. The individual processes are described in the specific technical manuals, referenced in Section 3.0 of this document.

H1.1 OVERVIEW AND EVOLUTION OF THE 200 AREAS PROCESSES

The 200 Areas comprised three of a number of reserved areas throughout the Hanford Site, designated for a group of specific activities. Early in 200 Areas operations, the 200 North Area received irradiated fuel rods for storage in cooling water pools to allow decay of several of the more volatile, short-lived vapor-phase radionuclides. At the 200 East and 200 West Areas, efforts concentrated on extracting plutonium from fuel rods. All major chemical processing operations in the 200 Areas routed high-activity waste streams to massive underground storage tanks contained in multi-tank "farms." The waste management activities associated with these tanks became a major operation in the 200 Areas as well (see Section H1.1.2). All other liquid wastes were discharged (with or without minimal treatment) to the environment. Originally, environmental discharge methods were based primarily on expected activity and stream flow. The historical ordering of discharge site type, described in Appendix G, was injection (or reverse) wells, trenches, cribs, and ponds, in roughly decreasing activity and increasing overall flow volume.

H1.1.1 Fuel Rod Composition, Enrichment, and Major Potential Radiological Contaminants

Throughout the history of Hanford reactor operations, the primary fuel used was metallic uranium. Initially, the fuel rods were solid "slugs" clad in aluminum. Later designs, primarily at N Reactor, used an annular "ring within ring" design clad in a high-purity zirconium alloy (Zircoalloy). Some uranium oxide-based fuels were tested at the Hanford reactors, but these materials were incompatible with the primary recovery processes run in the 200 Areas. Irradiated thorium-based targets were also processed at the 200 Areas.

The isotope uranium-235 (U-235) was the fissionable fuel used in the Hanford reactors to generate neutrons and energy. The initial fuel rods contained primarily natural, unenriched levels of U-235 (0.72% by weight), while U-238 comprised the bulk (>99% in natural enrichment fuels) of the material present in the fuel rods. As power levels were increased in the reactors, slightly enriched uranium was also used. Data available for the C Reactor show that, over its operating life, 89% of the fuel rods charged were of natural enrichment (Roblyer 1997). Most of the remaining 11% of fuel rods were at 0.947% U-235 enrichment. Limited numbers of special slugs with U-235 enrichment levels of 1.75% to 7.5% were used in all reactors for power "smoothing." The maximum "normal" enrichment used at Hanford (at N Reactor) was 1.25% U-235, which did not comprise more than approximately 20% of a reactor charge. Reactor operations consume (burn) U-235, reducing its enrichment levels in the discharged fuel rods. Approximately 15% to 25% of the U-235 in the fuel as charged was consumed during the fuel rod's residence in the reactor. Overall enrichment levels in fuel processed in the 200 Areas may be assumed to be less than 0.9% U-235, and much was actually less than the 0.72% natural levels.

Radionuclides brought to the 200 Areas within irradiated fuel rods have three primary sources: radioisotopes from the unirradiated fuel elements (primarily the uranium isotopes making up the fuel), fission products, and products of neutron activation.

When uranium is found in nature, it is in equilibrium with nearly 30 radioactive daughter products. Decay of a radioisotope produces a new isotope, either radioactive or stable. The new isotope is the "daughter" of the "parent" from which it descended along an isotope-specific decay "chain." Decay chains for natural uranium isotopes are shown in Figure H-9. In nature, most of these daughters have the same "activity" (number of decays per minute) as the primary parents, U-238 or U-235. Note that, due to its low concentration, U-235 activity is less than 5% of U-238 activity in natural uranium. U-235 and its daughters do not contribute significantly to overall radioactivity of uranium materials until enriched to levels greater than 10%. Chemical separation and purification of uranium prior to fabrication into fuel rod elements effectively removes all daughter isotopes except uranium-234 (U-234). The removed daughters begin to be formed again immediately as (1) uranium decay produces radioactive daughters, and then (2) as those daughters decay to additional products further "down" the decay chain. Most uranium daughters "grow-in" very slowly (due to several long half-life daughters early in the decay chain). Daughter isotopes in the lower portions of the decay chain, those with mass number less than 231 (e.g., radon-226 [Ra-226], polonium-210 [Po-210]), require greater than 1,000 years and often greater than 10,000 years before returning to even 1% of the activity of the parent uranium. Thus, those daughters lower in the decay chain are not considered to be abundant in the 200 Areas.

Fission of U-235 yields a broad spectrum of isotopes, most of which are radioactive. Binary fission, the primary reaction, produces two new isotopes and free neutrons, which can produce further U-235 fission, or be captured by other elements via neutron activation. The favored fission path is asymmetrical, with one isotope at approximately one-third and the other at approximately two-thirds of the initial mass weight of the U-235 atom and, normally, two to three free neutrons. Sr-90 and Cs-137 are typical examples of this approximate split, although these two isotopes are not formed from the fission of a single U-235 atom. Other isotopes with shorter half-lives are formed as the fission pair. Formation (yield) of lighter or heavier fission product isotopes decreases rapidly from the one thirds and two thirds favored mass maximums. Thus, binary fission product isotopes are essentially limited to those with mass numbers of approximately 72 (e.g., zinc-72 [Zn-72]) through 166 (e.g., europium-166 [Eu-166]).

Most fission products are intensely radioactive. Fission product decay accounts for a significant fraction of the heat generated in an operating reactor. Fortunately, the relationship between isotope-specific activity (rate of decay per amount, usually weight, of isotope) and half-life is inverse (i.e., the highest activity has the shortest half-life). High-activity isotopes rapidly deplete themselves, ultimately forming stable isotopes. After 15 years of decay, more than 99% of the initial fission product activity has been exhausted. The high-activity fission products initially present in irradiated fuel (and of greatest importance during processing) have decayed to insignificance in Hanford material. Due to their half-lives (approximately 30 years) and significant fission yields, Cs-137, Sr-90, and their primary decay daughters now account for over 99% of all remaining nonactinide radioactivity (fission product and activation products) from the fuels materials brought to the 200 Areas.

Two other fission products may be included as potential contaminants because of their half-lives, yields, and potential for concentration or potential for high mobility: tritium (H-3) and technetium-99 (Tc-99). Tritium (typically as tritiated water) behaves chemically as any other water in separation processes. The potential exists for condensates from any contaminated aqueous streams to have H-3 as the primary (or only) radionuclide present. Tc-99 tended to follow the uranium in chemical processes used at the 200 Areas and potentially contributes significantly to the total radioactivity of uranium-rich streams and wastes.

Neutron activation (capture of a neutron by the nucleus of an atom of U-238) to ultimately form plutonium-239 (Pu-239) was the primary purpose and product (on a mass basis) of the Hanford reactors. Neutron activation is the source for all transuranium (elements with atomic number greater than 92 [e.g., uranium, neptunium, plutonium]) elements present in the fuel rods except U-234, U-235, and U-238. Once formed, each new isotope could accept another neutron. Thus, a fraction of the Pu-239 formed was converted to plutonium-240 (Pu-240) and a fraction of the Pu-240 became plutonium-241 (Pu-241). This step-wise addition of neutrons to form higher mass number isotopes was, at the highest Hanford reactor exposures (function of time in the reactor and reactor power level), only approximately 10% efficient for each additional isotope formed. Thus, on a weight basis, 1 g of initial U-238 yielded no more than approximately 0.1 g of Pu-239, which in turn produced no more than approximately 0.01 g of Pu-240, from which formed no more than approximately 0.001 g of Pu-241, etc). Mass numbers produced with at least four neutron additions were of inconsequential yield (less than 0.01%) at the Hanford Site. The primary actinide isotopes of concern from irradiation of U-238 are Pu-239, Pu-240, and Pu-241. Pu-241 is a special case due to its short half-life (14.4 years) and primary mode of decay (beta). Much of the Pu-241 generated at the Hanford Site has already decayed (the youngest irradiated N Reactor fuel is now at least 10 years old) to Am-241, which must be considered as a potential contaminant of concern whenever plutonium is known or expected to be present.

U-235, the primary fuel in the reactor, also was "neutron activated" to form uranium-236 (U-236). Fuel elements manufactured with recycled uranium recovered from reactor operations also contained U-236 as a result of this activation. Neutron addition to U-236, similar to that described for U-238, produced Np-237 and Pu-238. The overall yield of Np-237 was low (due to the relatively small amount of initial U-235) but may be included as a potential contaminant based on process knowledge of specific plant operations. Pu-238 yields at Hanford were even lower, but the significantly greater specific activity (relative to Pu-239) of Pu-238 results in a potential significant contribution to overall plutonium alpha decay activity in Hanford samples. Pu-238 is routinely measured as part of plutonium analyses.

Other contaminants in the fuel rods may have also undergone neutron activation to form a potentially radioactive isotope. The composition of the fuel and cladding materials was controlled to minimize the inclusion of elements having detrimental effects on reactor operations (neutron "poisons"). The vast majority of potential activation products have short to very short half-lives. Decay since discharge from the reactors (10 to 50 years) has reduced the number of isotopes potentially present at levels of potential concern to cobalt-60 (Co-60), nickel-63 (Ni-63), carbon-14 (C-14), and H-3. Tritium may also be present as a fission product. Co-60 has the shortest half-life of these (5.27 years) and is currently approaching its practical detection limits for routine analytical techniques.

Processing of irradiated thorium targets was a "special case" process performed on a very limited scale at the Hanford Site. The primary purpose of irradiation of thorium was to produce uranium-233 (U-233) by neutron activation of natural thorium-232 (Th-232). U-233 is another fissionable isotope of uranium and can be used as the heat source for remote (e.g., outer space) thermoelectric generators. The thorium targets would be expected to have similar levels of nonactinide activation products (similar trace contamination in the thorium metal and similar cladding materials) and essentially no fission products. The thorium processing was performed in specific "campaigns" in the same processes used for uranium/plutonium recovery (primarily REDOX and PUREX). Thorium targets represent a small fraction of these plants' overall production and contributed only a small potential additional source for radionuclides in the 200 Areas. For any streams unique to thorium processing, U-233 and Th-232 would be potential contaminants. During initial processing of the thorium, natural decay daughter products (except thorium-228 [Th-228]) would have been removed, analogous to uranium discussed earlier. However, unlike uranium, Th-232 decay daughters grow in much more quickly. In the 20 years since the last thorium recovery runs took place at the Hanford Site, any Th-232-containing material will have had the full decay chain rebuilt. All daughters are assumed to have returned to equilibrium with the parents within this time frame.

H1.1.2 Primary Processing – Fuel Dissolution and Plutonium Recovery

Three chemical extraction methods were used to recover plutonium in 45+ years of process operations: the bismuth phosphate ($BiPO_4$) batch process at the 221/224-B and –T Plants, the Reduction Oxidation (REDOX) continuous solvent extraction process at the 202-S Building, and the Plutonium/Uranium Extraction (PUREX) continuous solvent extraction process at the 202-A Plant. All processes were characterized by the initial dissolution of the fuel rod jackets; sodium hydroxide was used for aluminum-clad fuels and ammonium nitrate/ammonium fluoride was used for zirconium-clad fuels. Fuel decladding wastes were processed and routed to underground tank storage. The plutonium-bearing uranium fuel rods were dissolved using concentrated nitric acid. The chemical extraction of plutonium from the fuel rod solution then proceeded on either a batchwise or continuous basis depending on the plant. Multiple steps were usually required to separate plutonium from the associated uranium and fission products.

The two $BiPO_4$ plants had essentially the same design and operation. They began operating in late 1944 and 1945. Due to uncertainties in process design, each plant was constructed to a general design without exact specifications. The plants were fitted with a number of sections, groups of which contained similar sets of process vessels, centrifuges, receiving tanks, and utility connections suitable to a specific process step. The 221-T Plant was built with several additional sections, termed the head-end, that were used as a hot semiworks laboratory to test small batches of full-strength chemical solutions for use in trouble-shooting steps in the process. This facility had a number of other uses over time, for which documentation is not readily available.

The $BiPO_4$ process relied on multiple carrier-precipitation steps where $BiPO_4$ was used as the carrier in the initial steps and lanthanum fluoride was used in the final step to recover and purify plutonium. Three separate high-activity waste streams were produced in the process, plus the decladding waste stream. "Metal" wastes generated from the $BiPO_4$ process (which contained the bulk of the uranium and fission products) were recognized as the richest "deposit" of uranium known at that time. The first and second decontamination waste streams removed most of the remaining fission products and were normally sent to separate underground storage tanks (first-cycle wastes were frequently co-mingled with decladding wastes). The major drawbacks of the $BiPO_4$ process were its reliance on a time-consuming, step-wise batch processing with an attendant needed to heat, mix, cool, and mechanically separate solids and liquids and the quantities of high-activity wastes generated. In addition, uranium was discharged as a waste stream.

Emerging organic solvent extraction technologies during the 1940s were implemented for plutonium/uranium recovery. The REDOX process provided significant production improvements over the $BiPO_4$ process, which allowed the 221/224-B Plant operation to be shut down in 1952. With the advent of the PUREX process and process modifications in the REDOX plant, production rates were great enough that, even with significantly increased demands for weapons materials (Gerber 1997), the separations processes in 221/224-T Plant were concluded in 1956. Both the REDOX and PUREX systems used counter-current flow, solvent extraction columns to bring the organic solvents into intimate and well-mixed contact with the plutonium and uranium-bearing dissolved fuel rod solutions.

The first large-scale solvent extraction separation process was implemented in 1951 at the 202-S REDOX plant where MIBK was used to separate plutonium and uranium from the dissolved fuel rod solutions. The highly flammable nature of hexone placed stringent operating constraints on the process (e.g., inert gas blanketing of process vessels, explosion-proof electrical gear). The process used a multi-column approach to (1) extract the bulk of the fission products from the dissolved fuel rod solution, (2) separate the plutonium from uranium, and (3) refine both from the remaining fission products in two- or three-step decontamination systems. Large quantities of aluminum nitrate were used as a "salting" agent to increase plutonium and uranium extraction efficiencies. Highly radioactive wastes from fuel rod decladding and the first decontamination column were discharged to underground tank storage with minimal volume-reducing concentration steps. Wastes from other columns were collected and concentrated before discharge, and spent hexone solvent was recovered for reuse. Plutonium nitrate solution was concentrated, first in a loadout hood and later at the 233-S facility before being sent to the Plutonium Finishing Plant (PFP) facility. Uranium nitrate solution was sent to the 224-U facility for calcination into uranium oxide (UO_3) and was then shipped offsite. Limited quantities of other radionuclides were also recovered during REDOX processing, which ended in 1967. A waste concentrator was active at REDOX until 1973. It was used to concentrate decontamination waste from 221-T, N Reactor, 222-S Laboratory, and the 340 Facility.

The PUREX process was similar to the REDOX process in that it used solvent extraction technology to separate plutonium and uranium from fission products. The PUREX process featured a number of improvements over the REDOX process. It used a two-part solvent composed of tributyl phosphate (TBP) and a kerosene-like organic termed normal paraffin hydrocarbon (NPH). The TBP was the prime extractant that reacted with plutonium and uranium. The NPH functioned as a diluent, into which the TBP was dissolved to lower the overall solvent viscosity. The higher flashpoint for the TBP-NPH solution resulted in much less stringent operating conditions at PUREX than were required for REDOX. Additional improvements at PUREX included nitric acid reclamation, more effective pulse column (as opposed to Raschig-ring packed designs at REDOX) designs, and a headend treatment process capable of reducing the ruthenium content from the waste gas stream. PUREX also provided for recovery and reuse of the organic solvent. Most recovered plutonium nitrate solution was shipped to the PFP for conversion and refining, but some was calcined to plutonium oxide at PUREX. Uranium nitrate solution was sent to the 224-U Building for calcining into UO_3. PUREX operated continuously from 1955 to 1972, and intermittently from 1983 to 1989 when it was shut down.

H1.1.3 Plutonium Purification and Finishing Operations

Initially, the plutonium product of the $BiPO_4$ process was refined to a wet/pasty nitrate mass at 231-Z, prior to shipment offsite. Later, after startup of the Plutonium Finishing Plant (a.k.a., PFP, 234-5Z facility or Z Plant) in 1949, the 231-Z Plant was used only for initial steps in converting $BiPO_4$-based plutonium to a liquid nitrate form usable by PFP processes that yielded plutonium in a pure metallic form. The 231-Z Plant's production role was phased out when the $BiPO_4$ process at T Plant concluded; the building was cleaned out (Gerber 1997), and converted to perform other waste-generating tasks. Specifically, the building was used for plutonium metallurgical studies, weapons components fabrication and development, and reactor fuel development through the early 1980s. The last significant mission for this facility was to house the Soils and Sedimentation Characterization laboratory, a task completed in the late 1980s.

Z Plant was designed in 1946 to convert plutonium into more stable and safer oxalate, oxide, and metallic forms, and to fabricate plutonium metal shapes for assembly into weapons. The facility was operational by 1949, using a series of gloveboxes and a chemical process that required manual handling. This short-lived system continued operating into 1953, but was replaced in 1952 by the Remote Mechanical A line (RMA) process. A second Remote Mechanical line, RMB, was developed and assembled, but never operated. Additions and modifications to this line proceeded throughout the 1950's as new reactors and separations plants were brought online and continued through the mid-1960's. Modifications to the RMA line in 1959 made it a continuous process that remained active to 1979. Construction of the Remote Mechanical-C Line (RMC) an advanced self-contained, glovebox work space capable of converting plutonium solutions into metal or oxide form, began in 1955. The line became operational in 1960, and last ran in 1989.

Interest in plutonium waste treatment and recovery from metal and compound scraps generated during fabrication of plutonium buttons started at the beginning of PFP operations and became a target of studies at the 234-5 development laboratories. A recovery program design was finalized with the development of the RECUPLEX (RECovery of Uranium and Plutonium by Extraction) process, which became operational in 1955 and ceased operation in April 1962, following a criticality incident. Recovery from scrap was next undertaken by the Plutonium Reclamation Facility (PRF), housed in the 236-Z Building, which started in 1964 and was last run in 1987. Both the RECUPLEX and PRF processes were based on solvent extraction using TBP, like the PUREX process, as the active agent. Unlike PUREX, the diluent fluid chosen was carbon tetrachloride, primarily because of its extremely low flammability. The 232-Z incinerator was developed to recover plutonium from the combined treatment of leachable and burnable solid wastes. This facility operated from 1962 to 1973, when it was taken out of service. Another key waste recovery process was conducted at the 242-Z Waste Treatment Facility, which began operation in late 1963. The process utilized ion exchange extraction technology to recover both plutonium and americium-241 from RMA and RMC wastes. The facility was taken out of service in 1976 after a chemical explosion.

H1.1.4 Tank Waste Storage and Processing

In the $BiPO_4$ process, large quantities of uranium and fission products were stored as high-activity wastes in the 200 Area's underground waste storage tanks (tank farms). In the solvent extraction processes, fission product-rich wastes were sent to the respective tank farms. High-level waste production from the REDOX and PUREX processes was less on a per ton basis but typically more concentrated in fission products, and led to boiling tank waste conditions. The $BiPO_4$ tank wastes were heated by fission product decay, but did not boil.

Waste storage became an important separations area issue. Each $BiPO_4$ plant initially had two dedicated tank farms available for waste storage, both of which filled up rapidly. The 221-B Plant was connected to the 241-B and -C farms, while the 221-T Plant utilized the 241-T and U farms. By 1946, tank space limits in some of the three-tank cascades were being approached and less active supernatant liquids were discharged to the ground. This approach was restricted to the least contaminated waste streams and was allowed after precipitated solids were allowed to settle in either the smaller 208,125 L (55,000-gal) 200 Series tanks or in the 100 Series tank farm cascades. This material was discharged to cribs between 1946 and 1950. Even with this discharge, tanks filled up. Two new, nearly identical tank farms, 241-BX and -TX, were constructed and began receiving liquid by January 1948 and July 1949, respectively. Two additional farms, 241-BY and 241-TY, were constructed and became operational by January 1950 and March 1953, respectively.

Due to the recognition that high-activity waste storage problems could not be solved by additional tank farm construction, it was determined that volumetric waste reduction was necessary. A number of solutions were investigated. The 242-T Batch Evaporator at the 241-T Tank Farms began in May 1951, and the 242-B Batch Evaporator began operation in December 1951. Both facilities yielded an ~80% volume reduction in two passes for the B and T tank farm wastes and returned concentrated evaporator wastes to the tanks for cooling and settling. Discharge to the ground also resumed during 1953-1956 when additional treated $BiPO_4$ wastes were sent to cribs. Waite (1991) estimates that a total of 259 million liters (68,428,000 gal) of liquids were discharged to the soil column from the evaporators.

To resolve the tank waste storage problem, as well as the declining supply of mined uranium, a TBP organic separations program, effectively a forerunner of the PUREX process, was designed and installed in the 200 East and 200 West Areas. The tank wastes of concern were the Metal wastes where the $BiPO_4$ uranium and fission products were first separated from the plutonium. Although the Uranium Recovery Project (URP) process was centered at the 221-U Plant, a complex of tank waste removal equipment, interconnecting transfer lines, vaults, and diversion boxes within and between the 200 East and 200 West Areas, as well as waste disposal sites, were constructed. (These structures were designated with an R in the letter designator portion of the facility ID, such as the 241-CR Vault.) The project operated from 1952 to 1958 and was effective in recovering uranium.

Although the URP process recovered much of the uranium, it also generated new liquid wastes (requiring underground tank storage) at a 2:1 ratio for each gallon of tank waste processed. Wastes from the URP process were returned to any tank space available. Once this waste problem was recognized, methods of dealing with the declining tank space were sought. Since the 242-B and T evaporators were just becoming active, some space was made available in which to store the URP waste streams. The main approach, however, was the initiation of a ferrocyanide scavenging program at the end of the URP process. In this process, ferrocyanide was added and the fission products in the URP waste streams precipitated from solution in the Tank Farms. The liquid supernatant was sent to the ground via cribs.

Scavenging first occurred in October 1953, but did not become a standard practice until September 1954. It ran until 1957 when the URP was shut down. When the scavenging process was active, the scavenged waste was sent to 200 East Tank Farms for holding. The supernatant liquid was discharged to cribs and trenches, primarily north of the BY-Tank Farms and south of the 200 East Area in the 216-BC Cribs area. Samples were taken and analyzed before release to ensure the supernatant met the 1950's release limits. Some scavenged wastes were discharged to 200 West Area cribs as well.

Wastes discharged to the BY Cribs were found in the groundwater beneath the cribs shortly after discharge. (At present, a hot spot of Co-60, Tc-99, nitrate, and cyanide contamination centered at the 699-50-53A well is attributed to these wastes and was the target of one pump-and-treat test conducted at the 200-BP-5 Operable Unit in 1995 [DOE-RL 1996]). After some study, a release approach using the concept of specific waste retention was developed. Using specific waste retention, discharging a volume of liquid waste that was some small fraction of the total soil column pore volume was thought to slow, or prevent, the radionuclides from reaching the groundwater and, ultimately, the Columbia River.

By the time URP scavenging became routine, over 80.3 million liters (21.2 million gallons) of unscavenged waste had been returned to the 200 East and 200 West Area tank farms. The URP wastes held from pre-scavenging runs were treated between 1955 and 1957 at the 241-CR Vault, in what was termed the in-tank scavenging process. The URP material was pumped from the tank cascades, treated with ferrocyanide, and returned to available tank cascades for settling of precipitates. Once release criteria were met, the supernatant was discharged to the soil column, typically at the 216-BC cribs located south of the 200 East Area. Waste disposal at the BC crib and trench disposal structures followed, in part, the guidelines established for specific retention disposal.

High efficiencies were achieved in plutonium and uranium extraction by the PUREX and REDOX processes. Significant concentration of fission products in the high-level tank farm wastes was also realized and led to the investigation of allowing the wastes to boil (self-concentrate). The vapor condensate driven off was then discharged to the ground via cribs or returned to the tanks as makeup liquid, if needed. The technique was first used in the 241-SX farm tanks and was later applied at the 241-A, AX, AY, and AZ tanks. Not all tanks in the 241-A or SX farms became self-concentrating due to the more dilute startup nature of some wastes received. Many of the tanks required the addition of water to control the in-tank heating by maintaining a source of evaporative cooling. Boiling wastes in the 241-S and -SX Tank Farms resulted in the breaching of several tank bottoms in these farms and in the direct discharge of high-level waste materials to the soil underneath these tanks.

Two continuous evaporators were constructed in the 1970's to assist in reducing the liquid content of the 241-S series and 241-A series tank farms. The 242-S Evaporator began operating in 1973, and the 242-A Evaporator began operating in 1977. The 242-S Evaporator was taken out of service in 1979. Part of the 242-S Evaporator was used in 1986-87 to treat uranium-contaminated groundwater extracted from beneath the U-1/U-2 cribs, using ion exchange technology (Delegard et al. 1987). The 242-A Evaporator was taken out of service for several years in 1989 when halogenated solvents and ammonia-rich constituents were found in the process condensate. Prior to this, all evaporator condensates had been discharged to the ground at dedicated cribs. Extensive modifications followed and, when active, the 242-A process condensate is now sent to the Effluent Treatment Facility.

H1.1.5 Other 200 Areas Processes

New waste-generating missions were frequently developed for facilities whose previous mission was no longer required. The process of cleaning out a plant for equipment maintenance, removal, or facility overhaul yielded an additional set of waste streams. Each plant was subject to a major cleanout campaign to remove residual contaminants from vessels, pipes, and tanks at the end of a process' life. Strongly acidic solutions were used to attack and remove precipitates, heels, or sludges from the insides of the process system. Such solutions were usually processed to recover the plutonium (or other target analyte) and were then neutralized before being sent to the tank farms. Acid rinses were repeated as necessary and usually continued until the recovered solution showed little increase in target analyte content. A considerable variety of chemicals (e.g., boric acid, sodium dichromate, and ammonium compounds) were usually paired with sodium hydroxide to decontaminate the vessels, tanks, and piping. Water rinses usually followed these steps and concluded the internal decontamination. Most of the waste was discharged to the ground but usually represented a fairly small volume of liquid compared to that received over the life of the waste site.

Large quantities of solid waste were generated from the cleanout of major separations plants, particularly when a new process was being installed. Old vessels were usually too radiologically contaminated to be safely reconfigured for the incoming process, or were not of an acceptable design and needed to be replaced. In such cases, following decontamination, the equipment and piping would be packaged and transported to the burial grounds for disposal where it would join previously failed equipment, contaminated clothing, laboratory equipment, reactor wastes, and contaminated equipment and materials from offsite.

Within several years of cessation of the $BiPO_4$ process, the 221-T Plant was converted to a decontamination facility capable of handling both small and large items and equipment. The 221-U Plant was briefly used for decontamination. Decontamination permitted reuse of items, allowed less complex (i.e., direct) handling of contaminated equipment for burial, or allowed release and sale of clean material as scrap/salvage. Two separate decontamination lines were maintained, one for small equipment and one for larger items. The chemical constituents used for decontamination varied with time and experience. Strong acid washes followed by washes of caustic (sodium hydroxide) combined with sodium phosphate, sodium citrate, boric acid, versene, tartrate, and sodium dichromate were often followed by sand- and steam-blasting, high-pressure water spraying, and scrubbing with detergents (Gerber 1994). These were replaced by 1,1,1-trichloroethane or perchloroethene and chloride-based detergents. By the mid-1960s, commercial products based on oxalic acid-, phosphates-, potassium permanganate-, sodium bisulfate-, or nitric acid-ferrous ammonium sulfate-based compounds were used. Extremely contaminated solutions were routed to tank storage; low-level solutions were discharged to the ground via cribs. When internal decontamination was complete, external decontamination was then undertaken, whether the equipment was to be reused or removed for disposal to a burial ground.

Throughout the years of operation, the head-end section of T Plant was intermittently used and generated some volume of liquid wastes. Initial hot semiworks scale-up testing of the $BiPO_4$ process were conducted from 1944 to 1947. No further use of the facility appears to have occurred before 1964, when the facility was modified to test the explosive degradation of irradiated fuel elements. Thereafter, PNNL occupied the T Plant head-end for unspecified experimental work. Based on data presented in the T Plant AAMS report (DOE-RL 1992) a series of tests related to liquid metal reactor safety were conducted in either this facility or in the main part of T Plant between 1976 and 1985. Light-water reactor tests using nonradioactive materials were conducted from 1985 to 1990. PNNL's activities apparently terminated in 1990 with several light-water reactor experiments using nonradioactive materials and a plasma torch.

Fission product recovery from tank farm-stored wastes was undertaken at the refurbished B Plant. This began in 1963 with the start of a three-part waste fractionization program that concluded in the Waste Encapsulation and Storage Facility (WESF). Following decontamination of the 221-B facility, a number of the process cells were refitted with new process vessels. The process redissolved tank farm wastes, then separated and concentrated specific radionuclides from wastes primarily derived from PUREX and REDOX. The program developed and installed a multi-process approach for recovering cesium, strontium, technetium, cerium, promethium, rhodium, palladium, americium, neptunium, and antimony (to name a few) from a wide variety of high-level tank waste streams. Ion exchange column technology was applied to the recovery of cesium and technetium (as well as rhodium and palladium) from alkaline supernatant tank wastes. This process also used extensive quantities of complexents (primarily ethylene diamine- tri- and tetra-acetic acids – HEDTA and EDTA) to minimize coabsorption of metals on the ion exchange columns. Ammonium carbonate was used to elute and regenerate the ion exchange column. A sulfate-based precipitation process was used for separation of strontium, promethium, and rare earth elements and radionuclides. Solvent extraction technology based on the solvent mix of TBP and

Di-(2ethylhexyl) phosphoric acid (D2EHPA), again diluted with NPH, was applied to cesium, strontium, cerium, and promethium, recovery from specific waste PUREX streams and selected tank wastes. The main target radionuclides were strontium, cesium (primarily to reduce the heat generation in the tank farms but also, potentially, as a source for these radionuclides), and limited rare earth radionuclides, which were proposed for use for satellite and remote-location power applications (Richardson 1962). The 244-AR vault, located near the PUREX tank farms, was constructed to accumulate, sample, and blend B Plant bound wastes from the PUREX tank farms. Additionally, several lift stations and diversion boxes were added to provide routings to and from the tank farms to the 244-AR vault and B Plant.

The WESF was added to the 221-B Building and began operation in 1974. At WESF the solutions produced by the Waste Fractionization Program were used and the cesium carbonate and strontium nitrate liquids were converted into dry cesium chloride and strontium fluoride salts. The salts were then doubly sealed in welded capsules, which were externally decontaminated prior to storage in cooling pools. Waste fractionization activities continued into 1983, and the WESF chemical processes were stopped shortly thereafter. Capsule storage and cooling continues to the present.

In 1944, a laundry was established in the 200 West Area to clean all work clothing from the Hanford Site. "Hot" and "cold" areas of the laundry were used to segregate the radiologically contaminated (hot) and nonradiologically contaminated (cold) clothing. The laundry, which was enlarged during its years of operation, was closed in 1995 due to the costs to upgrade the aging facility and problems caused by the liquid discharge crib, which was plugged with lint. At this time, an offsite contractor took over the laundry task. In addition, the use of disposable clothing was implemented. Respirator cleaning, which previously was done at a facility near the laundry, was also turned over to the offsite contractor. Liquid wastes from the laundry were characterized by the presence of detergents, noted by Knoll (1957) to potentially increase the movement of radionuclides through the soil column.

A number of laboratories operated in the 200 Areas over the years in support of plant and facility operation. The 221-B, -U, and -T canyon facilities each had a 222 Laboratory that generated several small waste streams. These laboratories were used for process chemistry control, and analyses were primarily directed to determining the plutonium (uranium for 221-U) content during $BiPO_4$ processing. Similarly, analytical laboratories were included to support operation of the PFP plant, the 202-S REDOX plant, and the 202-A PUREX plant where other analytes of concern (uranium, americium, fission products, etc.) were also considered. The PFP, PUREX, and REDOX laboratories all generated much larger waste volumes than the B, T, and U laboratory, but still much smaller than the associated production facility. The diversity of the potential contaminants used in the laboratories is much greater than for the production facilities. The 222-S Laboratory was designed for more broad-based support activities to the 200 Areas and includes a number of hot cells capable of accepting high-activity samples such as tank wastes and the concentrated fission products recovered during B Plant's fission product recovery. The 222-S also performs routine monitoring analyses on near-environmental level media (soils, water, and air) samples.

The laboratories typically closed at the end of a separation mission for a plant. The 222-B, -T, and -U laboratories were closed in 1952, 1956, and 1970, respectively. The PUREX laboratory was closed in 1996. The PFP and 222-S laboratories remain operational. The 222-S facility is expected to continue operations into the future, although some environmental analytical work may be transferred to the Waste Sampling and Characterization Facility.

Major plant developments, initiated in the 1940s and 1950s, were conducted at the 201-C Hot Semiworks facility in the 200 East Area. This facility and its support buildings were used for pilot-scale tests using irradiated fuel rods or actual tank waste material for the REDOX, PUREX, and URP processes discussed above. Refinements to the $BiPO_4$ process were also tested here. The facility provided space and equipment sufficient to declad and dissolve fuel rods, operate and test solvent extraction columns or process vessels, store chemicals, sample the process solutions, and handle waste storage and disposal. The Semiworks area was connected to the 241-C Tank Farm for ready disposal of high-level wastes. Follow-on activities at Semiworks included a strontium recovery project; a cerium-promethium recovery run; and a combined americium, curium, and promethium recovery run that concluded Semiworks operations in 1967. Other activities in the Hot Semiworks area focused on criticality testing in the 209-E Building from 1961 to 1983. The 201-C area underwent D&D in the early 1990s.

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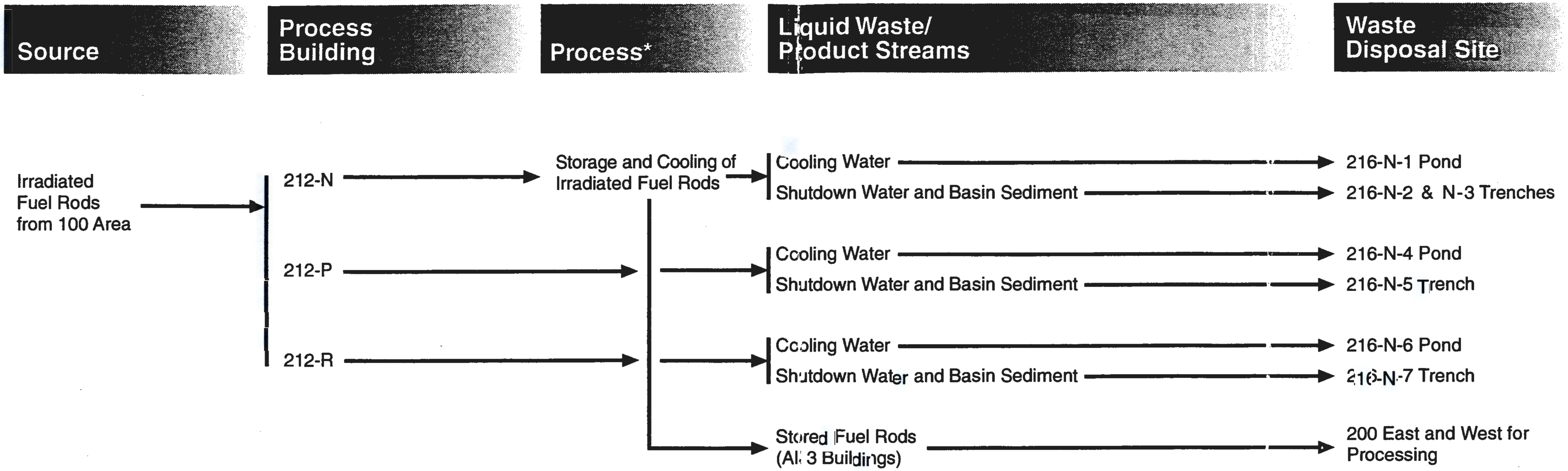
Figure H-1. 200 North Storage Building Major Waste Processes.

200 North Storage Building Major Waste Processes



* Storage was for purpose of decaying off short half-life radionuclides primarily Iodine, 40-60 day period

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Figure H-2. **T-Plant Aggregate Area.** (2 Pages)

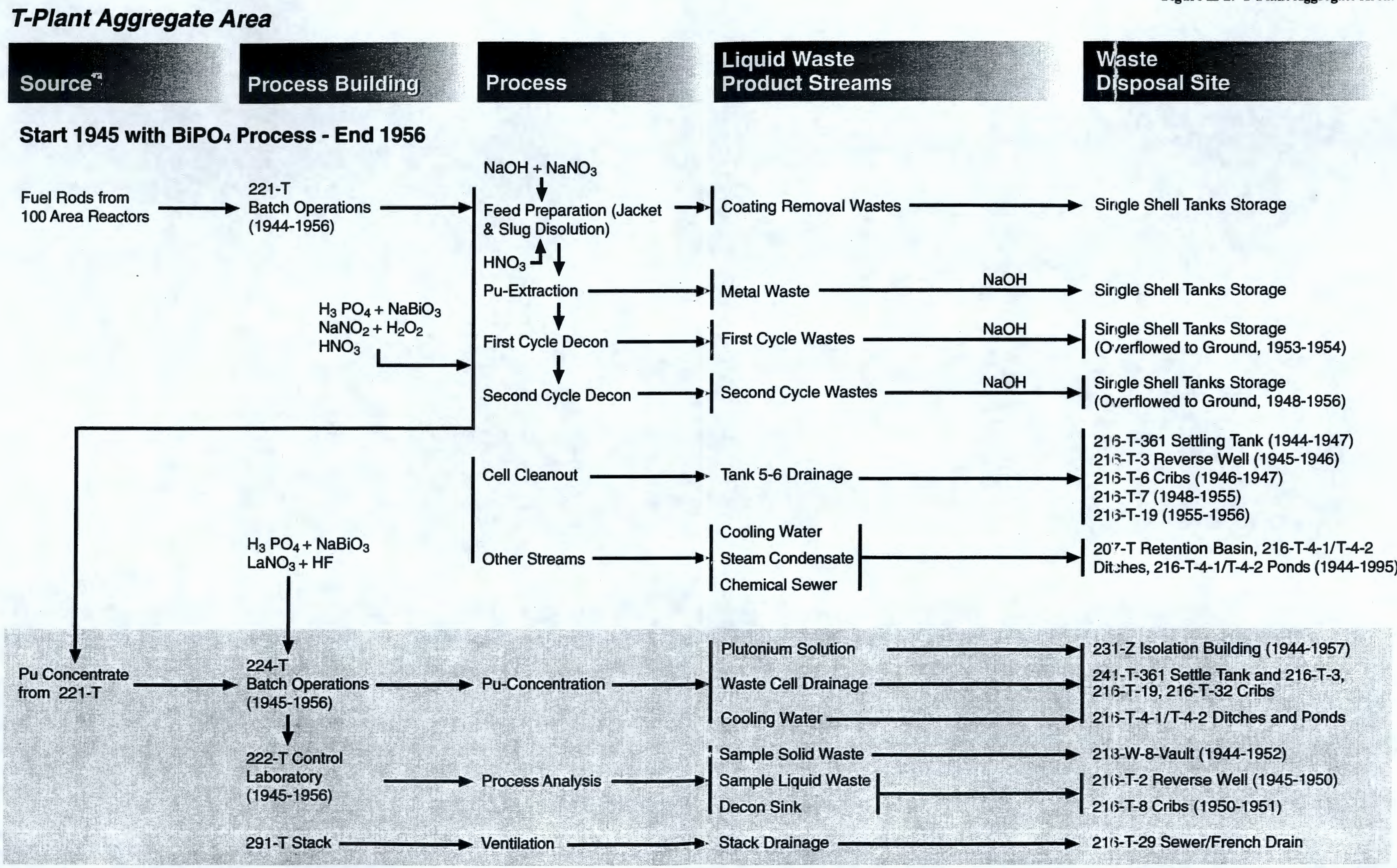

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Figure H-2. T-Plant Aggregate Area. (2 Pages)

T-Plant Aggregate Area

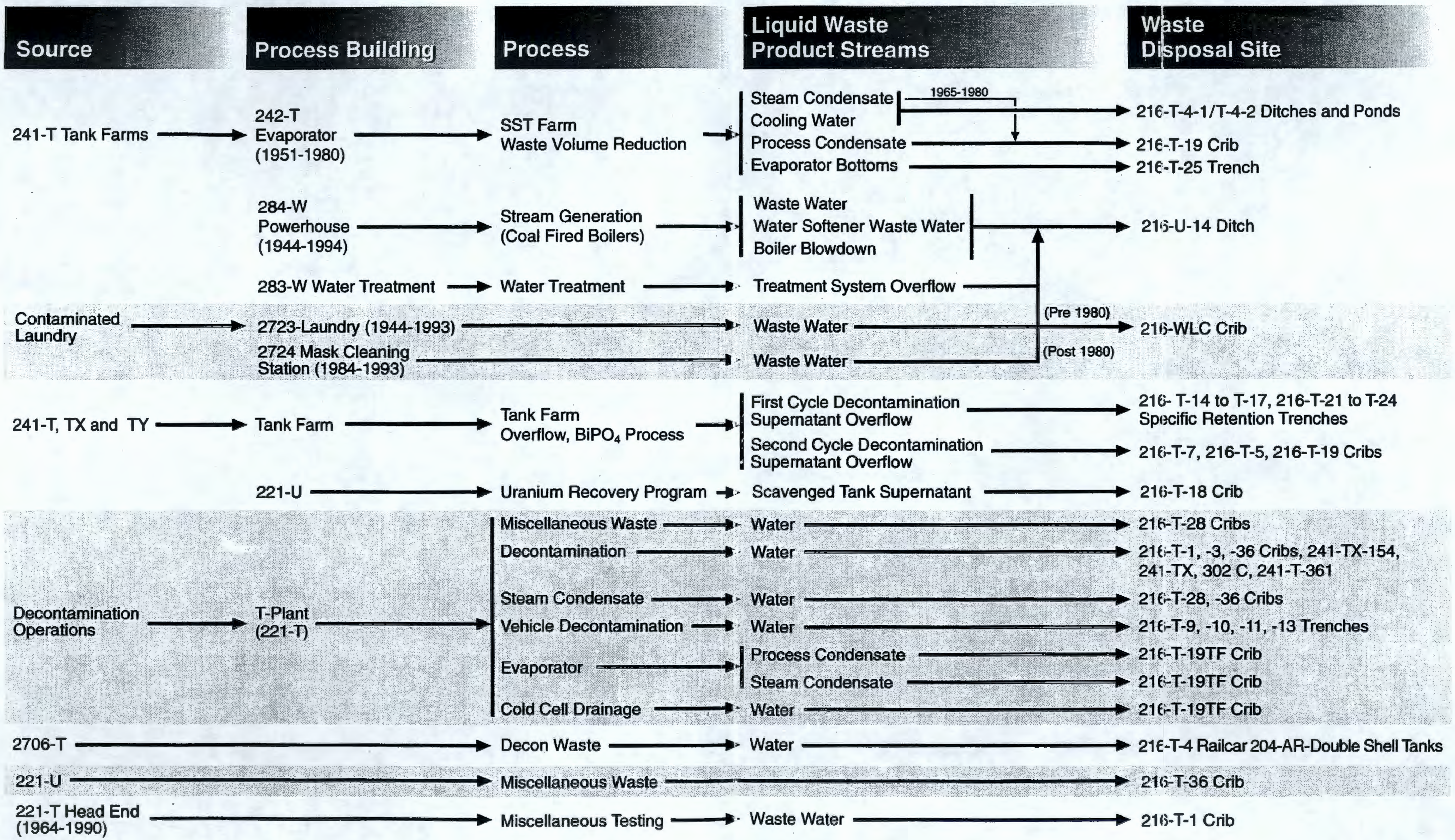

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Figure H-3. B-Plant Aggregate Area. (3 Pages)

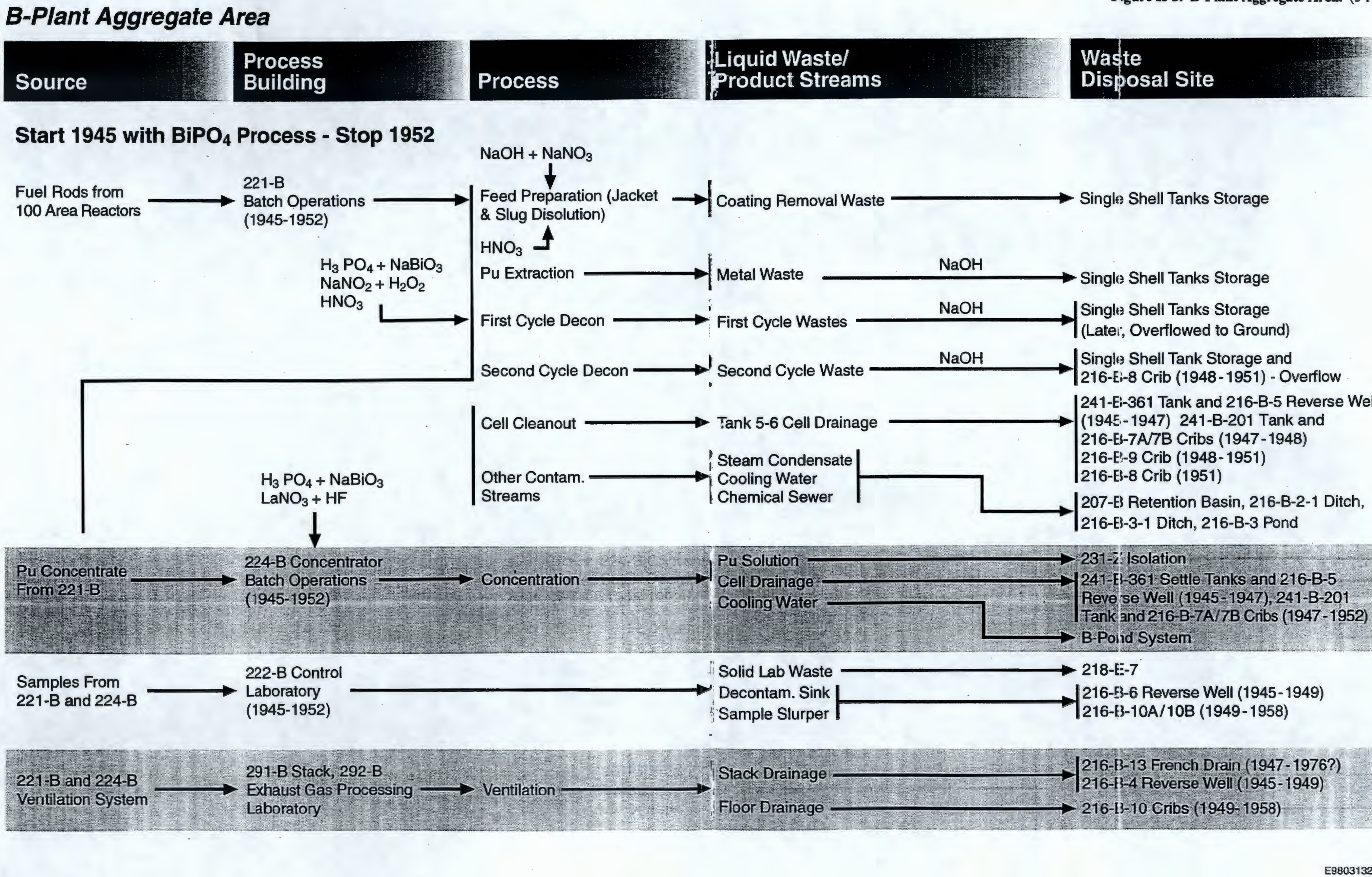

Figure H-3. B-Plant Aggregate Area. (3 Pages)

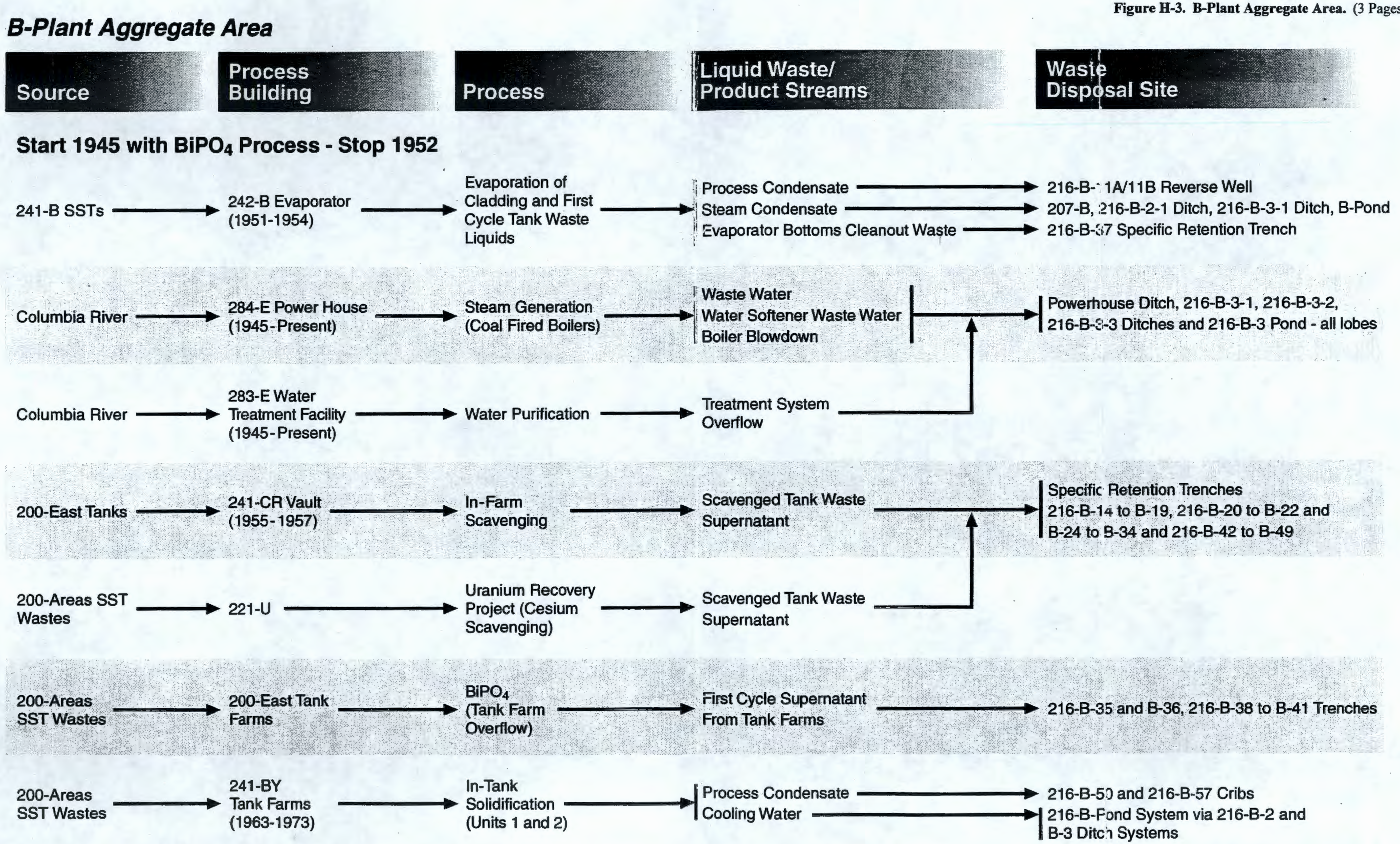

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Figure H-3. B-Plant Aggregate Area. (3 Pages)

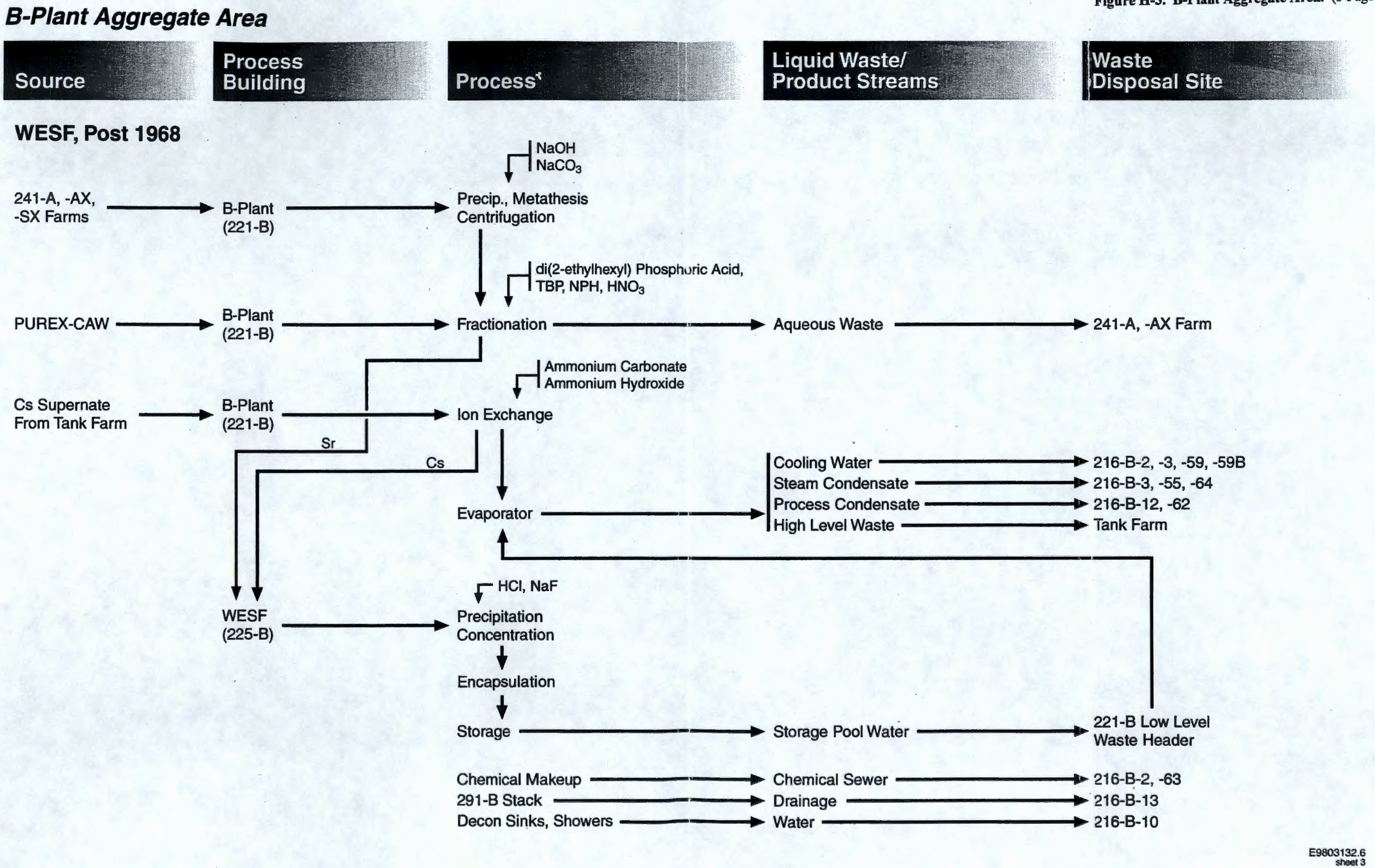

Figure H-4. Z-Plant Aggregate Area Major Processes.

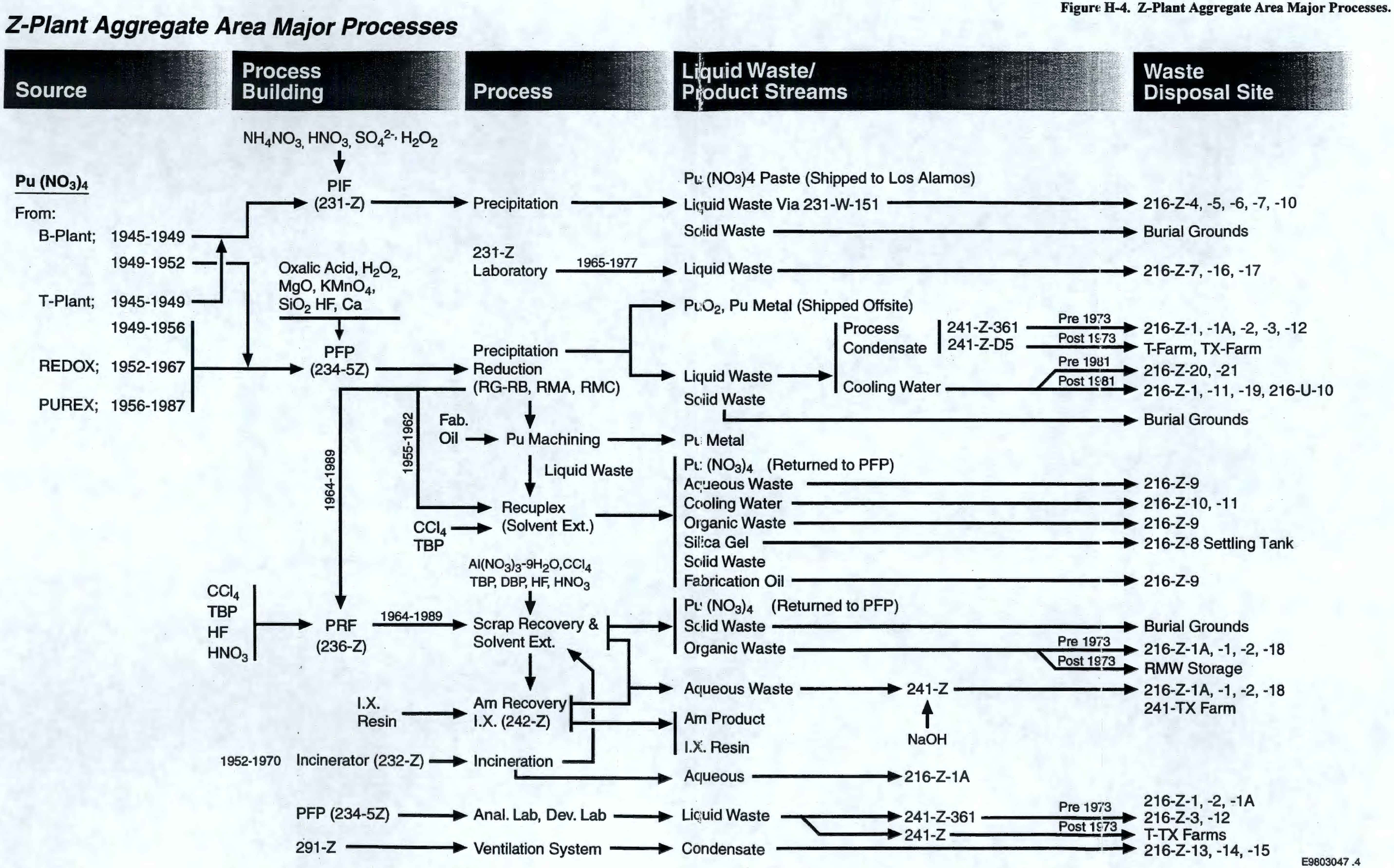

Figure H-5. Semi-Works.

Semi-Works

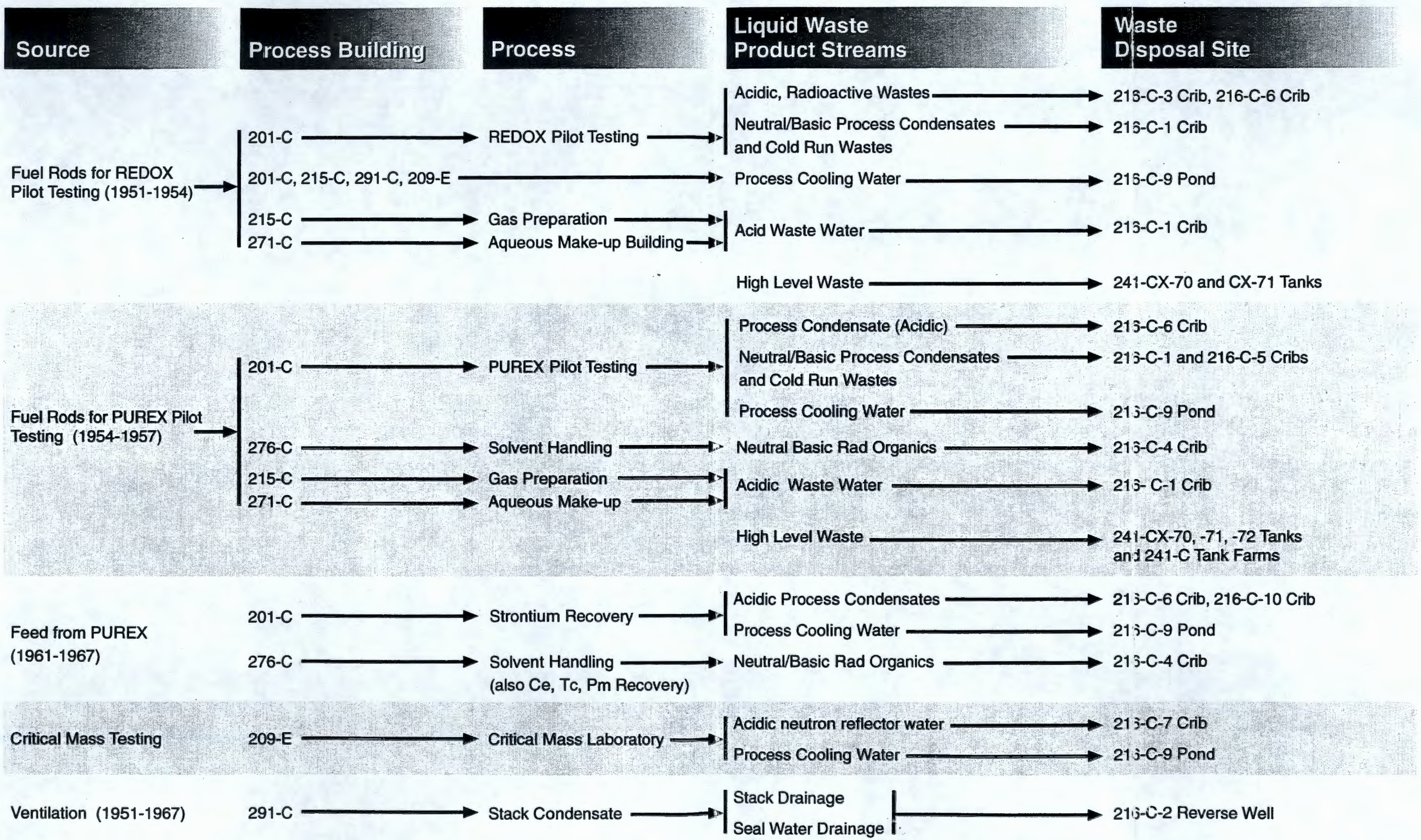

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Figure H-6. S-Plant Major Waste Producing Processes. (2 Pages)

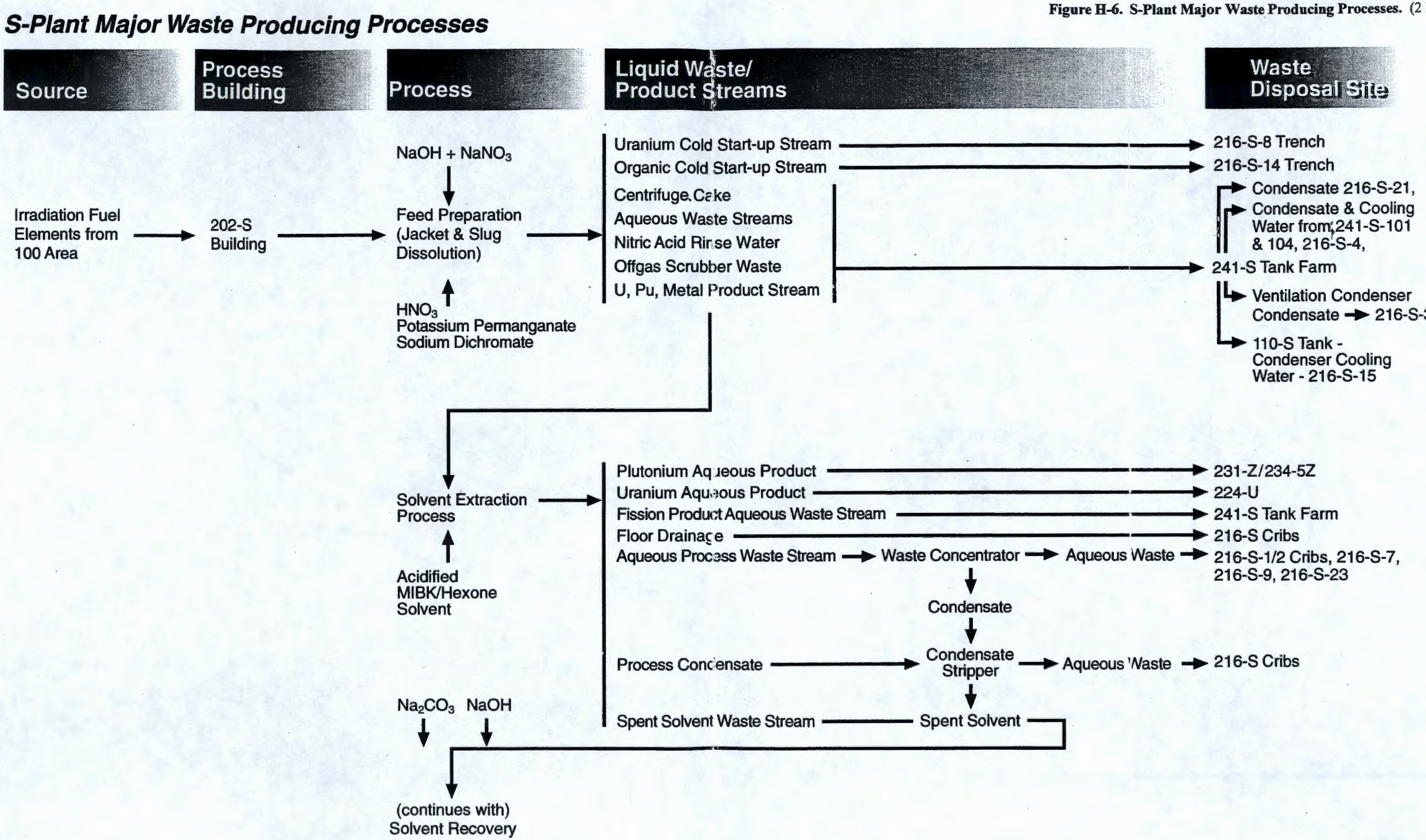

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Figure H-6. S-Plant Major Waste Producing Processes. (2 Pages)

S-Plant Major Waste Producing Processes

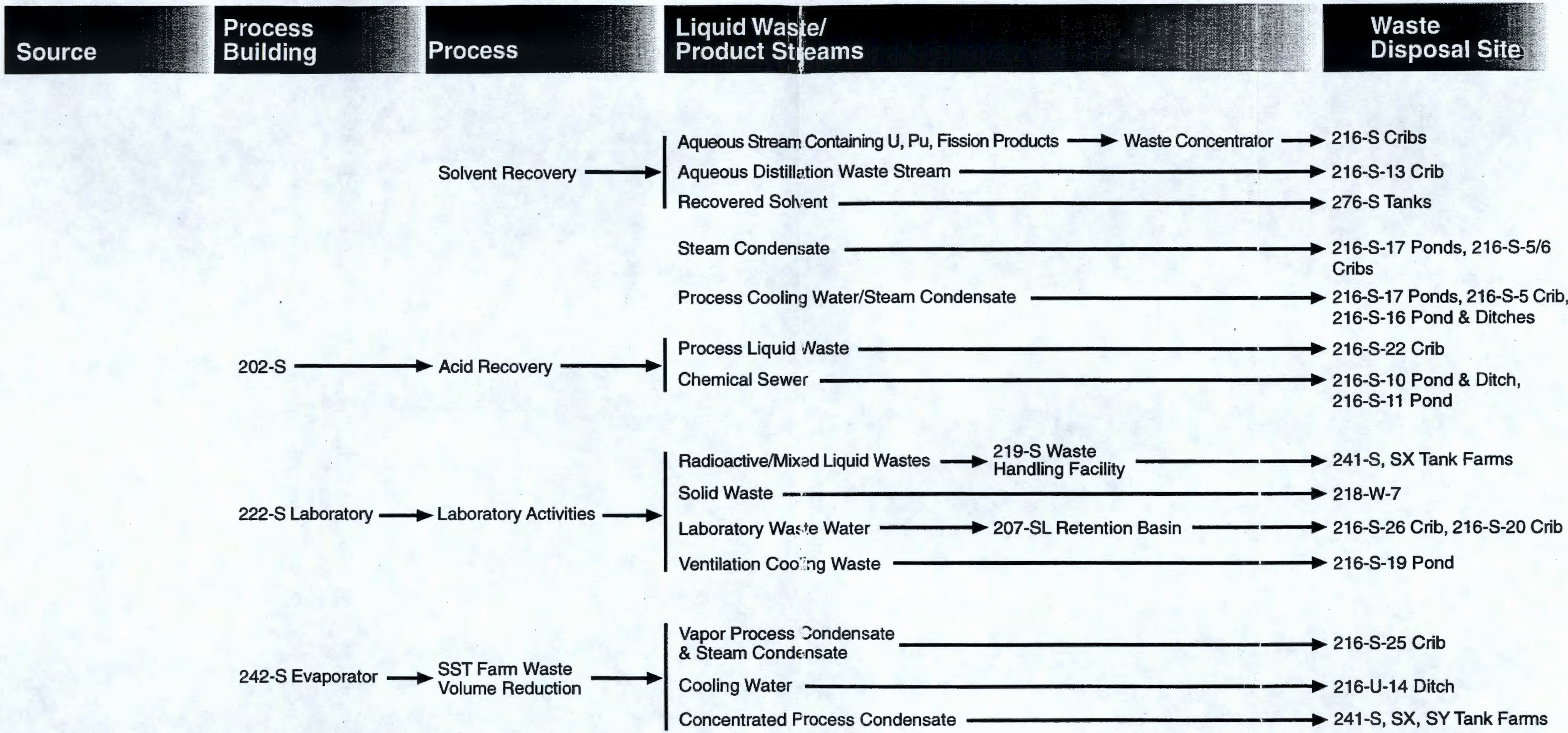

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Figure H-7. U-Plant Aggregate Area Major Processes.

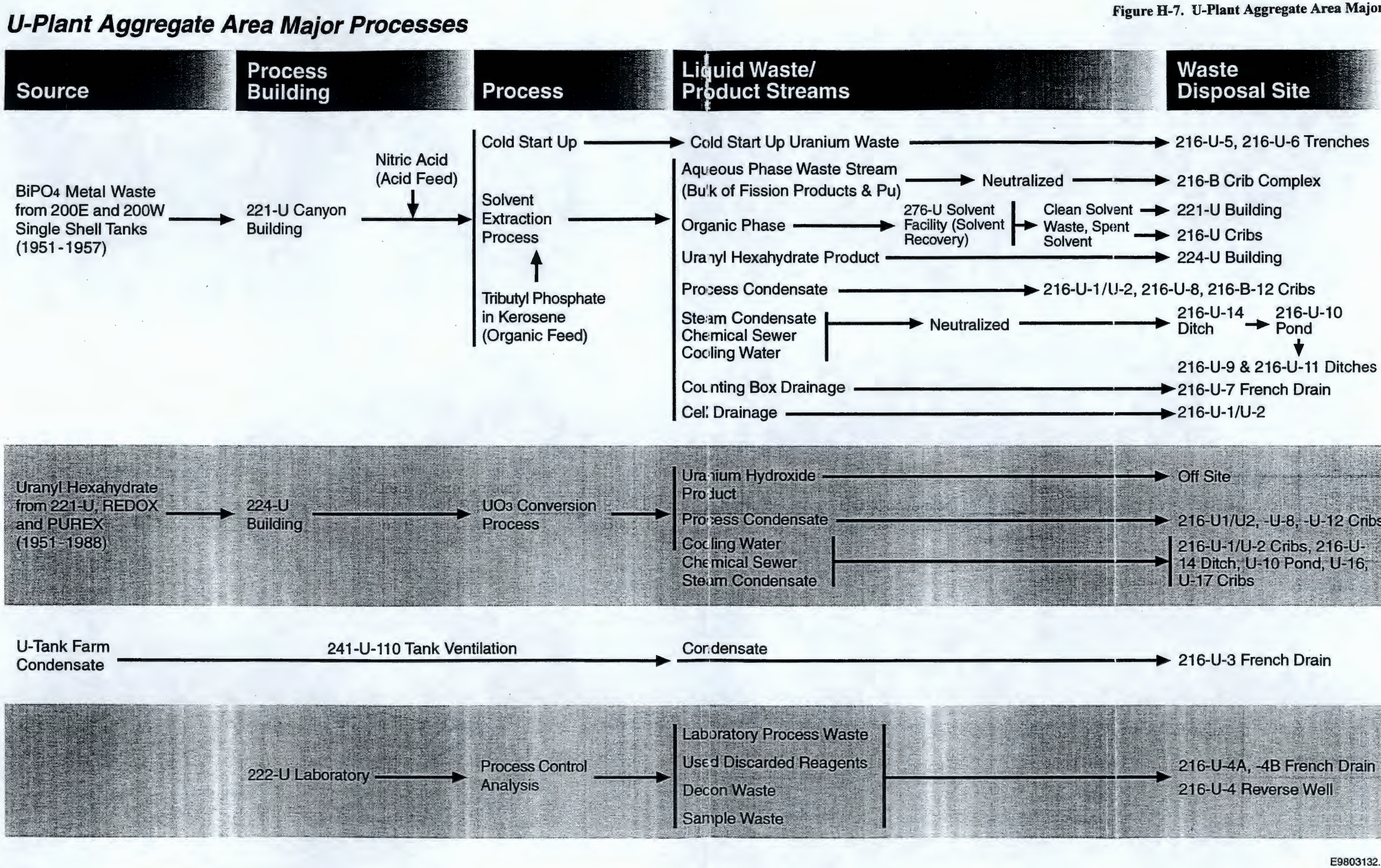


Figure H-8. PUREX Aggregate Area Major Processes. (2 Pages)

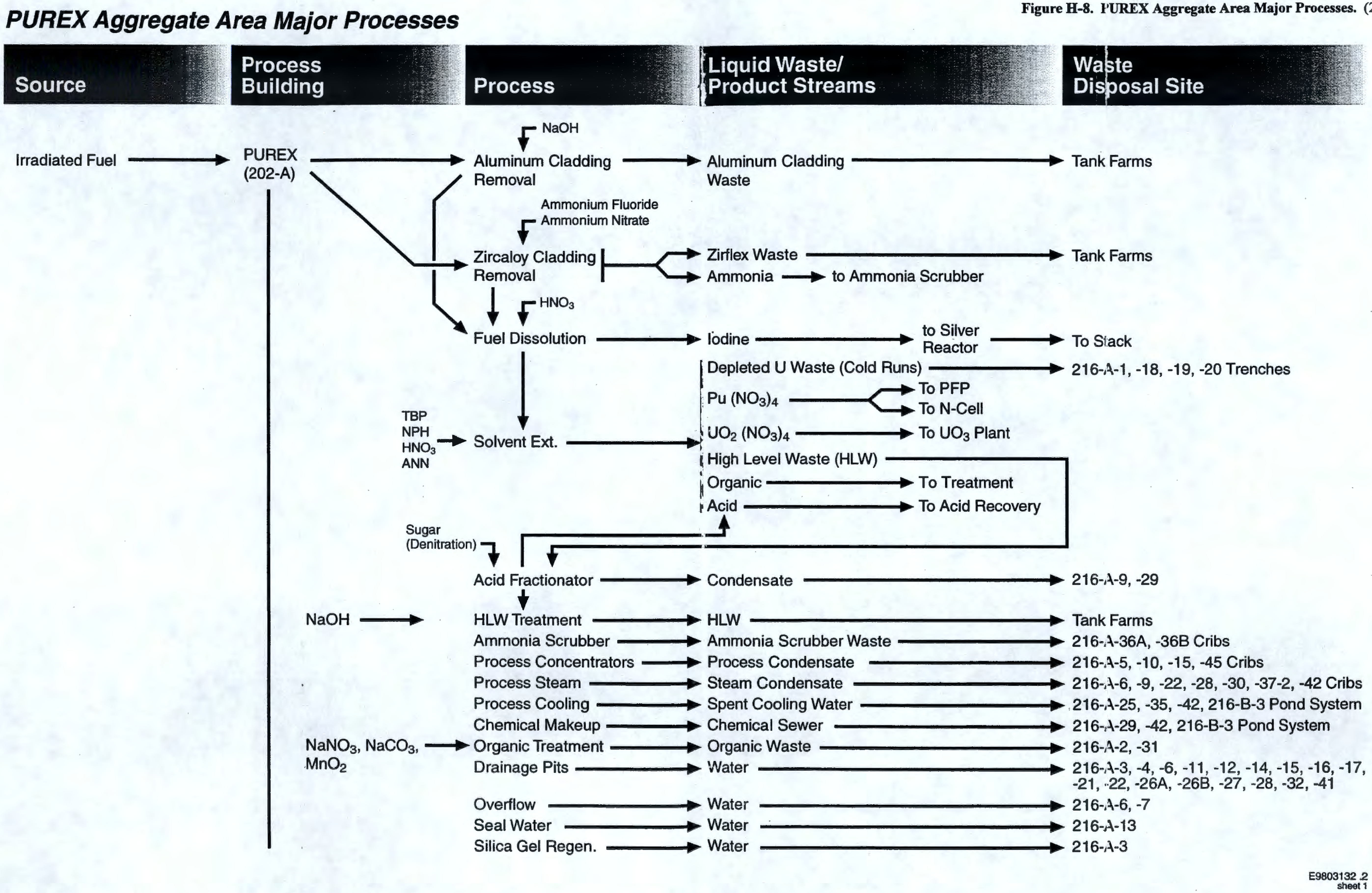
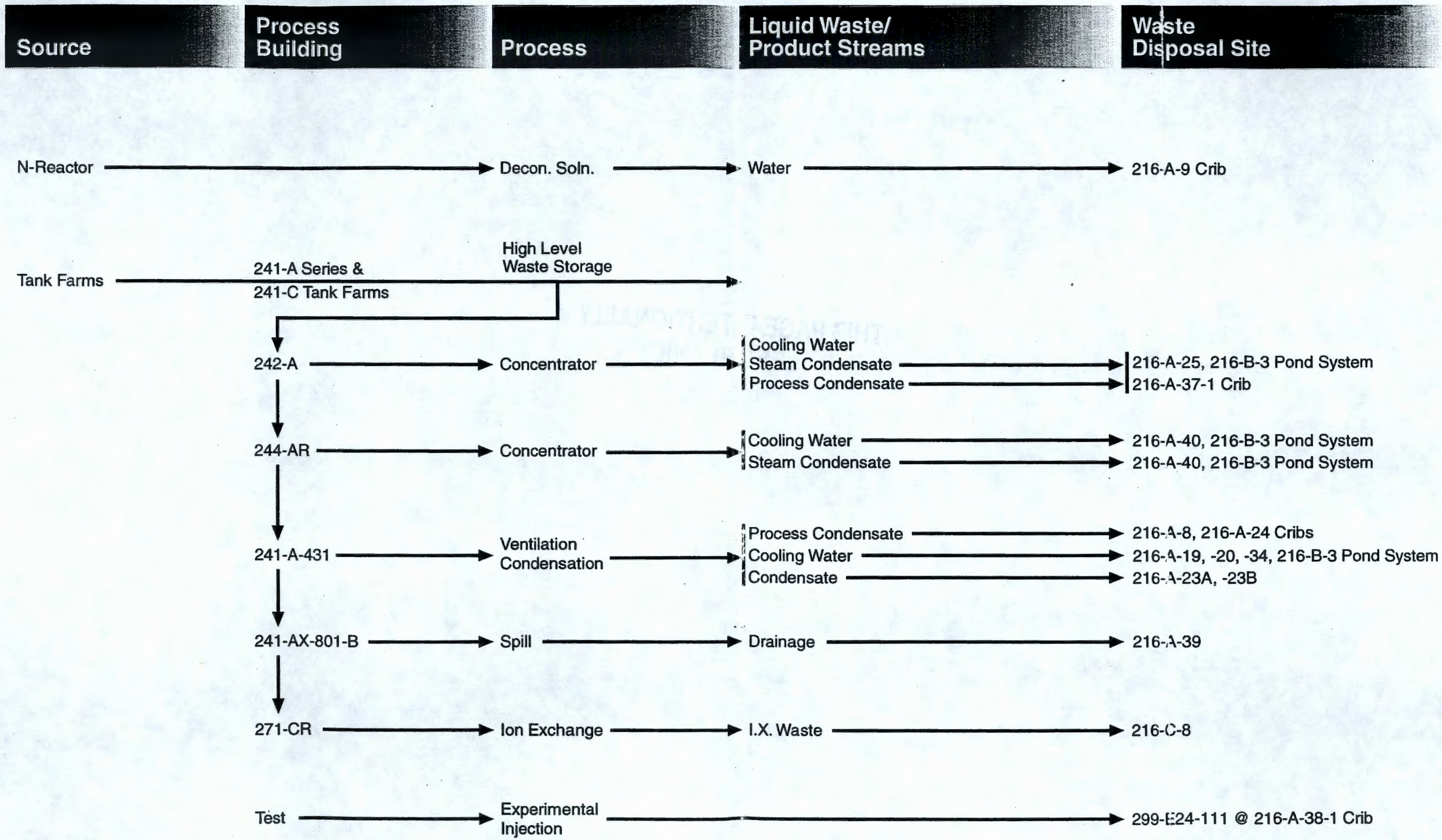


Figure H-8. PUREX Aggregate Area Major Processes. (2 Pages)

PUREX Aggregate Area Major Processes



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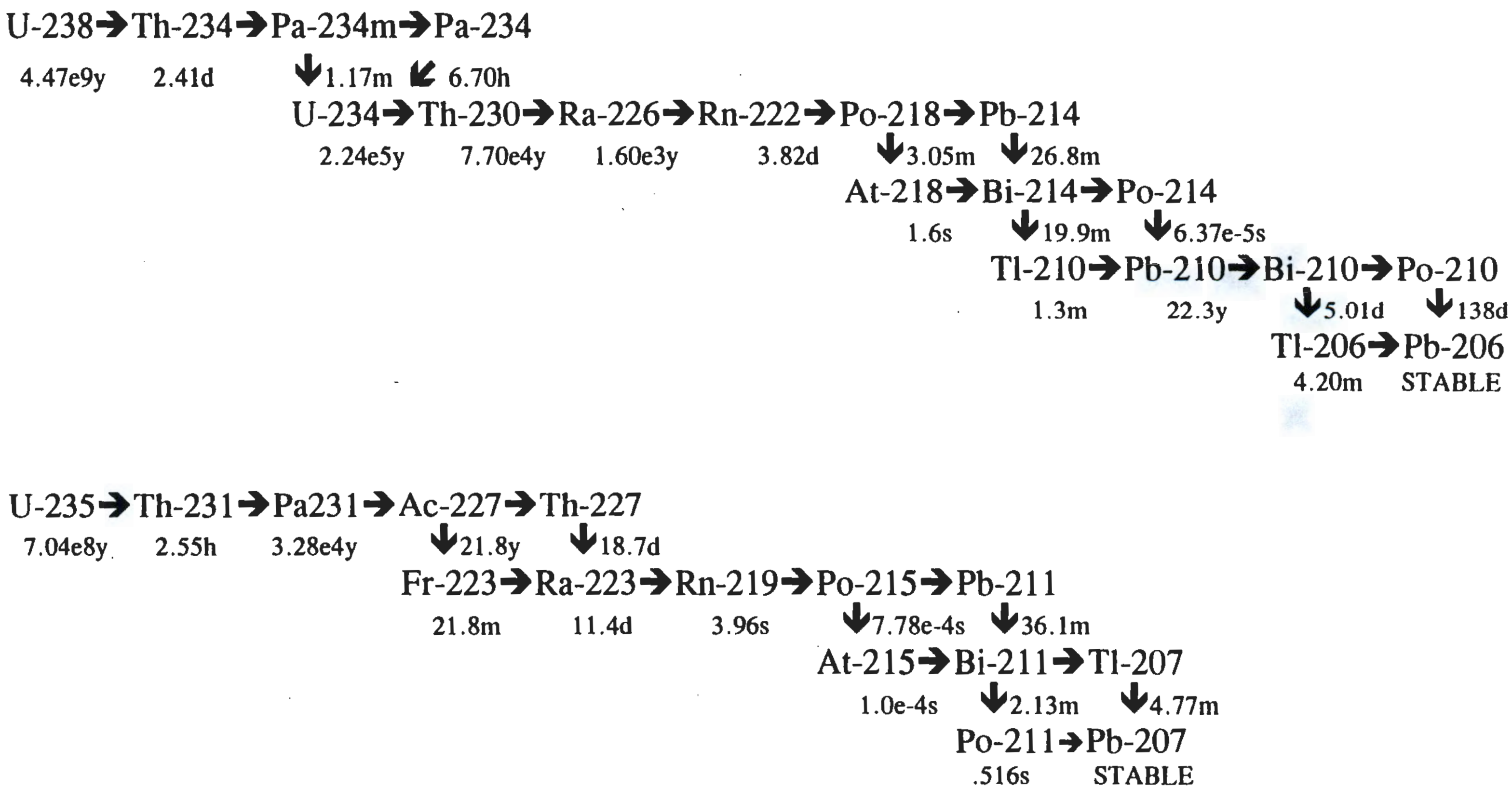


Half lives are shown in seconds (s), minutes (m), and years (y)

Figure H-9. Uranium Decay Chains.

APPENDIX I

ANNOTATED OUTLINE FOR A GROUP-SPECIFIC WORK PLAN AND RCRA TSD SAMPLING PLAN

I1.0 INTRODUCTION

During the development of the 200 Areas Implementation Plan, discussions were held to determine the content of future group-specific work plans. It was agreed that, in order to ensure consistency in future documents, an annotated outline for these work plans would be developed and included in the Implementation Plan.

As discussed in Section 2.3 of the Implementation Plan, it is the intent that these work plans provide group and site-specific background information for the waste site group being considered. Site characterization needs will be defined based on the data quality objective (DQO) process that will be conducted prior to, or in parallel with, development of each work plan. The work plan will include a sampling and analysis plan that will address the needs of both past-practice sites and *Resource Conservation and Recovery Act* (RCRA) treatment, storage, and/or disposal (TSD) units, where appropriate. Information contained in the work plan will also satisfy the requirements for the first five chapters of information typically found in RCRA closure plans, where a TSD unit is included in the waste site group being considered.

In addition to the standard executive summary, table of contents, and acronym list, the format of the work plan shall be as specified below.

I2.0 ANNOTATED OUTLINE

1.0 INTRODUCTION

The purpose of the work plan will be presented as a means to provide the waste group-specific details of field activities that were generally outlined in the Implementation Plan. The scope will include details for specific characterization activities (e.g., borehole or test pit designs, and sample locations) that are focused on representative sites that have been confirmed during group-specific DQO sessions. The work plan will include a discussion of how RCRA/*Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) integration will be applied to this specific waste group, a description of items that have been addressed in the Implementation Plan, and a schedule for subsequent assessment documentation for this particular waste group.

2.0 BACKGROUND AND SETTING

Provide a detailed description of the waste group, including site location, geologic, hydrogeologic, or other information that is pertinent to this particular waste group or the representative sites that have been selected for characterization. Discuss the common features found in the group-specific contaminant distribution model that were the basis for this group and the rationale for selection of the representative sites. Where a TSD unit is included in the waste group, the RCRA unit description and location information, and the Part A/Form 3 (Permit Conditions) will also be provided. (Note: Information from Section 4.2 to 4.24 of DOE/RL-96-81 {group description, known and suspected contamination, and conceptual model summary} will be incorporated in this section, or the next, of each respective group-specific work plan.)

3.0 INITIAL EVALUATION

A review of known and suspected contamination, including estimated waste volumes, will be presented for each representative site that has been identified. This will include a discussion of available monitoring information, including groundwater data where available. For RCRA TSD units, a description of the processes in place at the unit, including container, waste management, and waste generating practices, will be provided. Potential impacts to human health and the environment are represented in a conceptual exposure model, specific to the waste group and representative sites. This information is used to develop the Contaminants of Concern list.

4.0 WORK PLAN APPROACH AND RATIONALE

Results of the DQO process discussions for each representative site will be presented in order to discuss data uses, needs, quality, and quantity for the investigations to be conducted. This is followed by a discussion of the general approach to the investigation/characterization activities, with reference to the sampling and analysis plan in the appendices for more details.

5.0 REMEDIAL INVESTIGATION PROCESS

A detailed discussion of the work breakdown structure, project management organization, and approach is presented. This is followed by a description of field activities that cover all areas of characterization, including field procedures and protocols, laboratory analyses, data evaluation tasks, waste management, etc. This is typically followed by a discussion of the remaining portions of the remedial investigation/feasibility study (RI/FS) process, which include the RI report, feasibility studies/corrective measures studies, proposed plans, record of decision (ROD), and post-ROD activities. These post-ROD activities include confirmation sampling, generation of a Sampling Plan to be included in the Remedial Design Report/Remedial action Work Plan, remedial actions, verification sampling, and post-closure care. (Note: Options to perform the confirmation sampling pre-ROD will be investigated, pending the availability of funds to perform this activity. For waste groups containing TSD units, a description of where specific portions of the closure plan are located or where requirements have been met will be included. A brief discussion of Preliminary Remedial Action Objectives, General Response Actions, and Remedial Action Alternatives will also be included with reference to the Implementation Plan for details. A discussion of treatability testing needs will be included if enough information is available. However, this may need to be addressed in the RI report after data evaluations have been completed. Further analysis of applicable or relevant and appropriate requirements (ARARs) and remedial action alternatives will be addressed at the FS/corrective measures study (CMS) stage. (The ARARs discussion will include reference to the *Model Toxics Control Act* as the requirement for TSD units.)

6.0 PROJECT SCHEDULE

This chapter presents a detailed review of the schedule for all of the tasks to be completed for this waste group, including field activities, data evaluation, and document submittal, and presents potential milestones. It also addresses future activities through issuance of the ROD, and RCRA permit modification (if a TSD unit is included in the group). (Note: This schedule is just for characterization activities. The closure schedule for any TSD unit that is included will be located in the remedial design/remedial action work plan.)

7.0 REFERENCES

APPENDICES:

Sampling and Analysis Plan
Quality Assurance Project Plan
Project Management Plan
Others, as necessary
  - Waste Management Plan
  - Site-Specific Health and Safety Plan

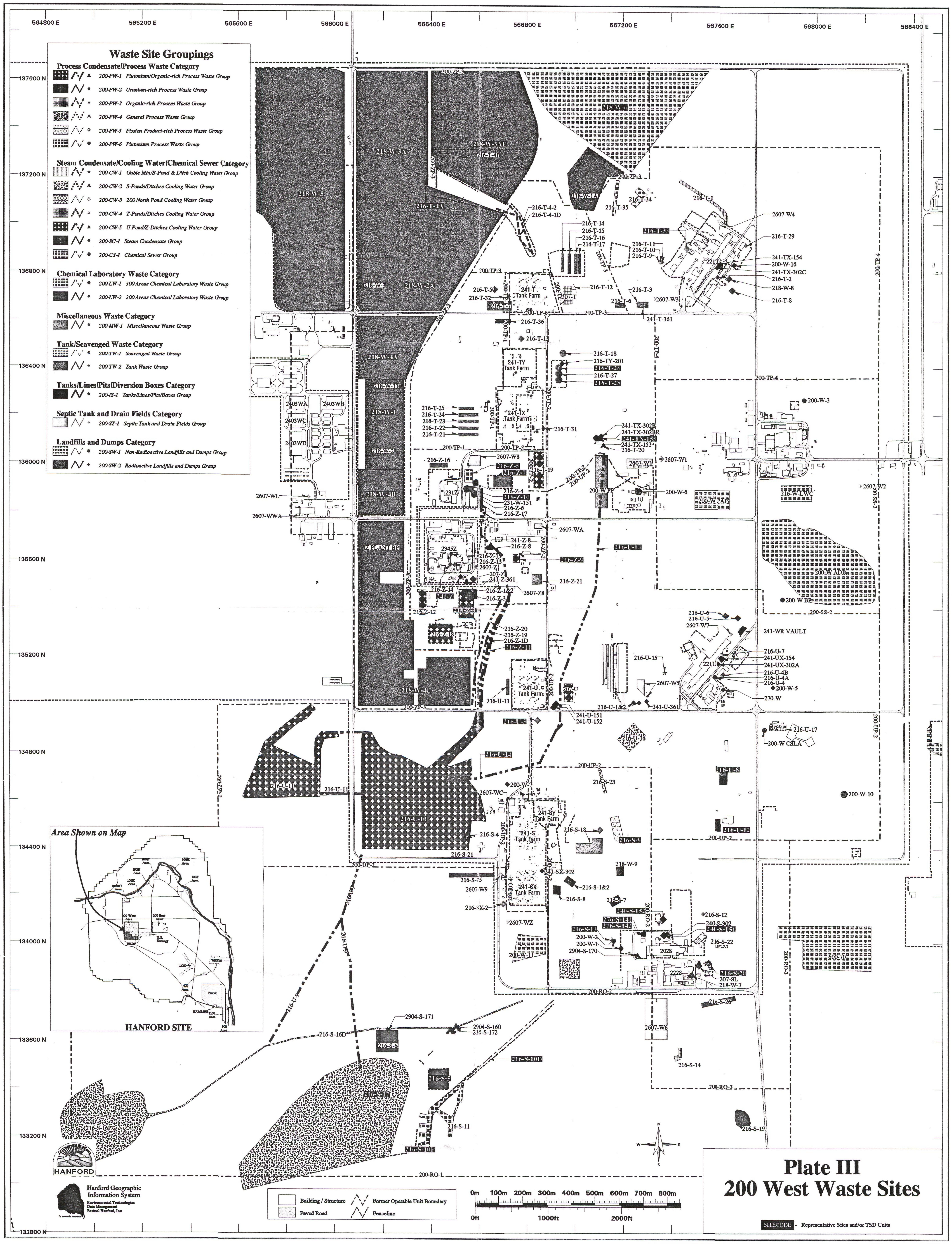
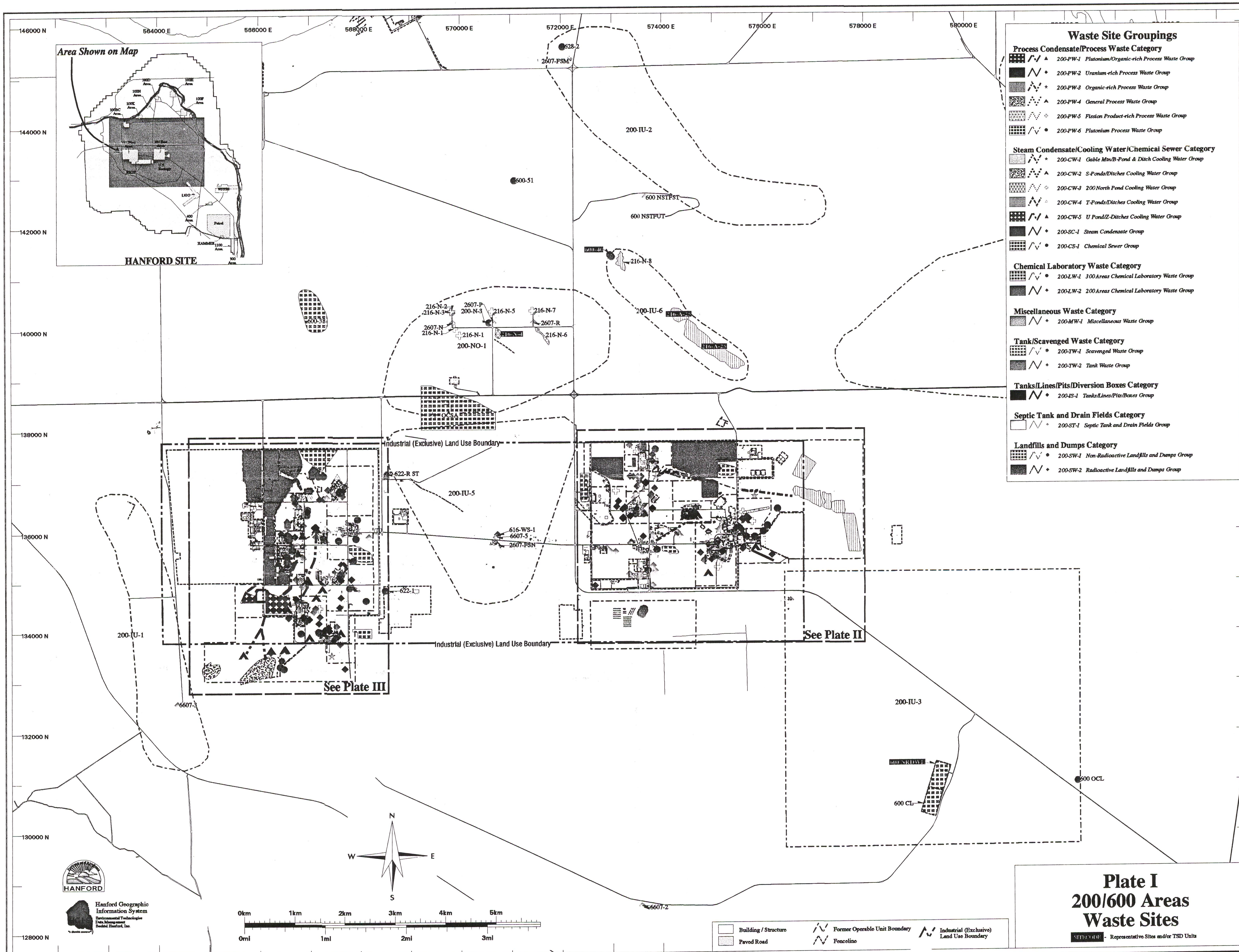


Plate III
200 West Waste Sites



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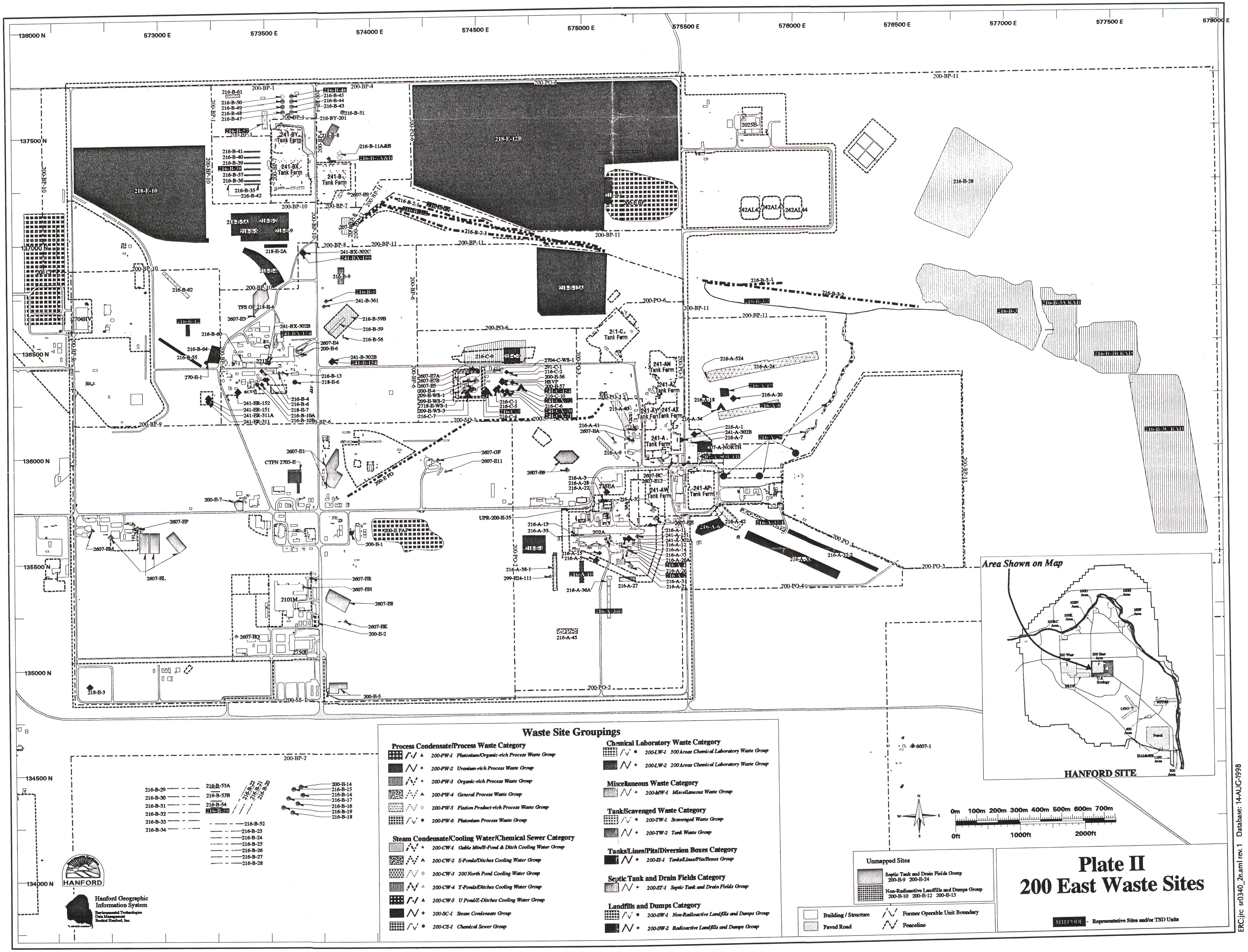

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