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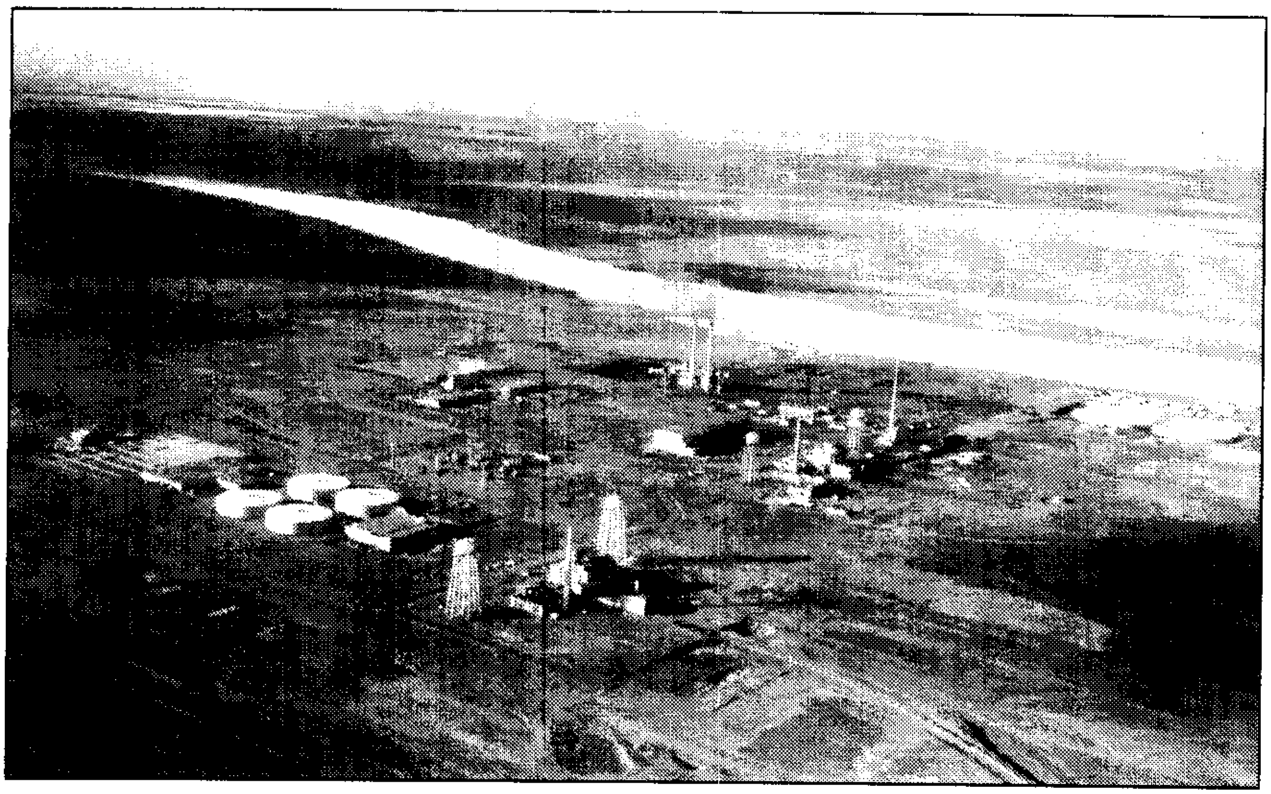
100 Area Source Operable Unit Focused Feasibility Study



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100 Area Source Operable Unit Focused Feasibility Study

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100 Area Source Operable Unit Focused Feasibility Study

Date Published
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EXECUTIVE SUMMARY

Purpose and Scope

The 100 Area is one of four areas at the Hanford Site placed on the National Priority List of waste sites in 1989 under the authority of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA). The *Hanford Federal Facilities Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) was developed jointly by the Washington State Department of Ecology (Ecology), the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Energy (DOE) to achieve compliance with CERCLA, including the *Superfund Amendments and Reauthorization Act* (SARA) remedial action provisions, and the *Resource Conservation and Recovery Act* (RCRA). The Tri-Party Agreement includes a site characterization and remediation strategy for 100 Area waste sites.

The Tri-Party Agreement strategy is supplemented by the *Hanford Past-Practice Strategy* (DOE-RL 1991), which emphasizes expedited remedial action by using Focused Feasibility Studies (FFS) and interim actions. This approach calls for FFSs at those waste sites identified as the higher priority sites (sites that have more wastes or pose higher risks). High-priority sites are designated as candidates for interim remedial measures (IRM) based on information contained in Operable Unit-specific Work Plans and Limited Field Investigations.

The purpose of this 100 Area Source Operable Unit FFS is to provide decision makers sufficient information to select interim Remedial Alternatives for IRM candidate waste sites within the 100 Areas. The scope encompasses high-priority source waste sites (sites at which there was direct disposal of wastes or a direct release of hazardous substances). Lower priority source waste sites, including the potentially impacted river sediments, will be considered in subsequent documentation. Separate groundwater FFSs will address groundwater contamination in the 100 Area.

100 Area Description

The 100 Area (approximately 69 km^2 [27.6 mi^2]) is located in the north-central part of the Hanford Site along the southern shore of the Columbia River. Between 1943 and 1962, nine water-cooled reactors were built along the shore of the Columbia River. The reactors are no longer operating.

Operations at the reactors in the 100 Area released radionuclides and inorganic and organic chemicals to soil and groundwater near the reactors. Releases occurred via leaks in the reactor cooling water transfer systems and the intentional disposal of cooling water effluent and miscellaneous effluents into cribs and trenches. In addition, solid wastes were buried in unlined trenches. The result was contamination of the soil and groundwater.

FFS Approach

The *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1993a) provided a general screening of remedial action alternatives for a wide range of waste sites and contaminated media types. This 100 Area Source Operable Unit FFS builds on the initial phases of the Feasibility Study and consists of three major components: (1) the Process Document, (2) a Sensitivity Analysis, and (3) Operable Unit specific FFSs. These major components and associated appendices are listed below.

- **Process Document** (main body of document, Sections 1.0 through 7.0 and Appendices A, B, and C)
  - Appendix A - Development of Preliminary Remediation Goals
  - Appendix B - Cost Estimate Summaries
  - Appendix C - ARAR Tables
- **Appendix D - Sensitivity Analysis** (with Attachments 1 through 6)
- **Appendices E through G: Operable Unit Specific FFS**
  - Appendix E - 100-HR-1 Operable Unit FFS
  - Appendix F - 100-BC-1 Operable Unit FFS
  - Appendix G - 100-DR-1 Operable Unit FFS

Process Document

Because there are more than 500 individual waste sites in the 100 Area, and many of these are similar to each other, they were grouped based on similar physical characteristics, operational history, and contaminated media. For example, there are cooling water retention basins at each reactor in the 100 Area, so all of the retention basins were placed into one waste site group. For the purposes of this FFS, the waste sites were grouped into the following 10 categories:

- Retention basins
- Sludge trenches
- Fuel storage basin trenches
- Process effluent trenches
- Pluto cribs
- Decontamination cribs and french drains
- Seal pit cribs
- Pipelines
- Burial grounds
- Decontaminated and decommissioned facilities.

Remedial action objectives were identified for remediation of these waste site groups as follows:

- Limit exposure of human receptors to contaminated soils
- Limit future impacts to groundwater
- Comply with applicable or relevant and appropriate requirements (ARAR)

- Limit exposure of ecological receptors to contaminants
- Avoid or minimize destruction of natural resources.

The remedial action objectives were then expressed numerically as preliminary remediation goals (PRG). These PRGs are constituent concentrations in soils that are protective of human health and the environment. The PRGs were calculated for each contaminant and represent the soil concentrations that could be left in place at the site after interim remedial action is completed.

The PRGs for soils developed in the Process Document are based on an exposure scenario that assumes occasional use of the land surface and remediation of soils sufficient to protect the groundwater as a drinking water source after interim remedial action is completed.

Six general categories of Remedial Alternatives previously identified in the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1993a) were retained as the most appropriate Remedial Alternatives to satisfy these PRGs. These are as follows:

- No action
- Institutional controls
- Containment
- Removal/disposal
- In situ treatment
- Removal/treatment/disposal.

The No Action Alternative represents a condition where no restrictions, controls, or active remedial measures are applied to a waste site. The Institutional Control Alternative includes administrative measures, such as monitoring and access restrictions to minimize potential contact with contaminants left in place. The Removal/Disposal Alternative involves excavation of contaminated materials and demolition of contaminated structures, and transportation of contaminated materials to a central disposal facility. The Containment Alternative includes surface barriers (caps) and surface water control structures to restrict contact with contaminants and/or limit the migration of contaminants left in place. The In Situ Waste Treatment Alternative uses technologies, such as grout injection for pipelines, dynamic compaction at solid waste sites, or In Situ Vitrification of contaminated soil, to minimize waste volumes and prevent migration of contaminants. The Removal/Treatment/ Disposal Alternative involves excavation of contaminated materials, onsite treatment of contaminants, such as soil washing, and transportation of remaining contaminants to a central disposal facility.

The Remedial Alternatives were evaluated first with respect to cleaning up waste site groups (in the Process Document), then with respect to cleaning up individual waste sites (in the Operable Unit specific FFSs). The Process Document evaluates each alternative with respect to CERCLA criteria, then compares the alternatives to each other. The CERCLA criteria (EPA 1988) are as follows:

- Overall protection of human health and the environment

- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance.

Other environmental considerations, such as potential impacts on transportation, ecological resources, air quality, noise, and cultural resources, were also considered in the analysis. Key discriminators defined as "criteria where differences between alternatives were observed" were selected within the evaluation criteria to assign a numerical ranking to compare remedial alternatives for each waste site group.

The Removal/Disposal Alternative ranked the highest of all remedial alternatives for all waste site groups. Because it removes contaminants from the waste site and disposes of them in a central disposal facility, it provides a high degree of overall protection. This alternative reduces the mobility of the contaminants at the waste site to a higher degree than other remedial alternatives, such as containment and in situ treatments. For technical and administrative reasons, this alternative is easier to implement than other remedial alternatives. The technical aspects of the Removal/Disposal Alternative, such as excavation and hauling, are routine. The cost for this remedial alternative is generally lower than other proposed alternatives.

Sensitivity Analysis

The Sensitivity Analysis (Appendix D) compares the potential differences in waste volumes, costs, and environmental impacts associated with different exposure scenarios. The five exposure scenarios addressed in the Sensitivity Analysis include (1) the scenario used in the Process Document (soil remediation consistent with occasional use of the land and frequent use of groundwater), (2) soil remediation to support occasional use of both the land surface and groundwater, (3) soil remediation to support frequent use of both land and groundwater, (4) modified frequent use (soil remediation to support frequent use of land with no use of groundwater), and (5) complete excavation.

A sixth scenario was added after the initial analysis was completed and is included as Attachment 6 of the Sensitivity Analysis. The new scenario is based on remediating soils to meet *Model Toxics Control Act* (MTCA) Method B standards for nonradiological contaminants and the EPA-proposed 15 mrem/yr above background exposure limit for radionuclides. This new scenario also includes remediating soils to protect onsite groundwater resources and groundwater flows into the Columbia River. This scenario closely approximates the frequent use exposure scenario that is addressed in the Sensitivity Analysis and is hereafter referred to as the revised frequent use scenario. Attachment 6 defines this new scenario and provides an analysis of how the existing analysis of alternatives in the Process Document changes under the revised frequent use scenario.

Operable Unit Specific FFSs (100-HR-1, 100-BC-1, 100-DR-1)

The operable unit specific FFSs (Appendices E, F, and G) for 100-HR-1, 100-BC-1, and 100-DR-1 evaluate the remedial alternatives based on the known characteristics of individual waste sites within the operable units. An analysis of remedial alternatives, using both the detailed and comparative analyses results from the Process Document, is included. If possible, the alternative analysis from the Process Document is used in the operable unit specific FFS if the individual waste site at the operable unit adequately matches the characteristics of its corresponding waste site group. If the match is not adequate, the operable unit specific FFS develops an independent analysis of alternatives based on site-specific information.

Sections 1.0 through 6.0 of the operable unit specific FFSs (Appendices E, F, and G) are based on the baseline exposure scenario used in the Process Document (soil remediation to support occasional use of the land surface and frequent use of groundwater). A new section has been added to each Operable Unit specific FFS to assess how the analyses conducted in the Process Document (Sections 1.0 through 6.0) change under the revised frequent use scenario discussed in Attachment 6 of the Sensitivity Analysis.

This 100 Area Source Operable Unit FFS provides the information and rationale to evaluate remedial actions at high-priority waste sites in the 100 Area. The analysis of remedial alternatives was conducted using several different exposure scenarios, and thereby provides a basis for the Tri-Parties and the public to evaluate the remedial alternatives as presented, and also to evaluate different combinations of remedial technologies and exposure scenarios. This 100 Area Source Operable Unit FFS is intended to provide the information base that will support the selection of an alternative.

ACRONYMS

ALI	annual limit on intake
ARAR	applicable or relevant and appropriate requirements
CAMU	corrective action management unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
DAC	derived air concentration
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FFS	focused feasibility study
HPPS	*Hanford Past-Practice Strategy*
ICRP	International Commission on Radiological Protection
IROD	Interim Record of Decision
LDR	land disposal restrictions
MT	metric tons
MTCA	*Model Toxics Control Act*
MTR	minimum technological requirements
NCRP	National Council on Radiation Protection and Measurements
NEPA	*National Environmental Policy Act*
NESHAP	National Emission Standards for Hazardous Pollutants
PQL	practical quantification limits
PUREX	Plutonium Uranium Extraction
RCRA	*Resource Conservation and Recovery Act*
TBC	to be considered
SVOC	semivolatile organic compounds
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
VOC	volatile organic compounds
WAC	*Washington Administrative Code*
W-025	Radioactive Mixed Waste Land Disposal Facility

CONTENTS

CONTENTS (continued)

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APPENDICES

FIGURES

TABLES

CONTENTS (continued)

TABLES (continued)

1.0 INTRODUCTION

The 100 Areas of the Hanford Site, along with the 200, 300, and 1100 Areas (Figure 1-1), were placed on the U.S. Environmental Protection Agency's (EPA) National Priorities List on November 3, 1989, under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). Under the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement, Ecology et al. 1990) signed by the Washington State Department of Ecology (Ecology), EPA, and the U.S. Department of Energy (DOE), more than 1,000 inactive waste disposal and unplanned release sites on the Hanford Site have been grouped into a number of source and groundwater operable units. These operable units contain hazardous waste, radioactive/hazardous mixed waste, and other CERCLA hazardous substances. The Tri-Party Agreement requires that the remediation programs at the Hanford Site coordinate the requirements of CERCLA, the *Resource Conservation and Recovery Act* (RCRA), Washington State's dangerous waste (the state's RCRA-equivalent) program, and the *National Environmental Policy Act* (NEPA).

Because of the complexity of the operable units at the Hanford Site, signatories to the Tri-Party Agreement developed a coordinated CERCLA/RCRA site characterization and remediation strategy to comprehensively and expeditiously address environmental concerns associated with the Hanford Site. This strategy is known as the *Hanford Past-Practice Strategy* (HPPS) (DOE-RL 1991). The HPPS emphasizes integration of the results of ongoing site characterization activities into the decision-making process as soon as practicable (observational approach) and expedites the remedial action process by emphasizing the use of interim actions. In accordance with the HPPS, this 100 Area Source Operable Unit Focused Feasibility Study (FFS) will facilitate the selection of appropriate interim remedial measures for high priority source sites in the 100 Area. The HPPS and the associated interim remedial measure pathway leading to the generation of 100 Area FFS documents are presented graphically in Figure 1-2.

This 100 Area Source Operable Unit FFS contains three major components. The first major component of the report, Sections 1.0 through 7.0, and Appendices A, B, and C are referred to as the Process Document. The Process Document describes the Remedial Alternatives developed for remediation of the 100 Area source waste sites, evaluates these alternatives against CERCLA and other environmental criteria, and then compares the alternatives against each other. The Process Document, however, does not address individual waste sites; it addresses 10 waste site groups that represent logical groupings of the individual waste sites. The Process Document evaluates the Remedial Alternatives for each waste site group assuming their groundwater should be protected as a potential drinking water source and the remediated areas will be used for recreational or other occasional use scenarios (not residential or industrial use).

A second major component of this report, the Sensitivity Analysis (Appendix D), was prepared to evaluate how the analysis in the Process Document might change for different exposure scenarios. The additional scenarios considered ranged from frequent use with remediation of soils to support groundwater for drinking, to remediation to support occasional use of both the land and the groundwater.

The third major component comprises the operable unit specific FFSs prepared for the 100-HR-1, 100-BC-1, and 100-DR-1 Operable Units (Appendices E, F, and G). These FFSs evaluate the Remedial Alternatives for remediation of specific waste sites within each operable unit. The operable unit specific FFSs use the information in the Process Document and Sensitivity Analysis, along with the characteristics of individual waste sites, to complete a final evaluation of Remedial Alternatives.

The purpose and scope of the Process Document, the Sensitivity Analysis, and the operable unit specific FFSs for the source operable units is presented in Section 1.1. A brief overview of the 100 Area and a summary of Phases 1 and 2 of the feasibility study (DOE-RL 1993a) results are presented in Sections 1.2 and 1.3, respectively. A "plug-in" approach to the FFS for the 100 Area source operable units is introduced in Section 1.4. Section 1.5 addresses the incorporation of NEPA into the FFS process.

1.1 PURPOSE AND SCOPE

In accordance with the HPPS (Figure 1-2), FFSs are performed for those waste sites within source operable units that have been identified as candidates for interim remedial measures based on information contained in work plans and limited field investigations. These candidate waste sites are the sites considered high priority by EPA, Ecology, and DOE. The FFS constitutes the Phase 3 (detailed analysis) portion of the feasibility study process for the Remedial Alternatives initially developed and screened in the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1993a). The scope of this Process Document is limited to 100 Area source operable units. The first three of several operable unit-specific FFSs are included in this document as Appendices E, F, and G.

Additional source operable unit-specific FFS reports are currently in preparation. Also, impacted groundwater beneath the 100 Area is being addressed in separate operable unit-specific FFSs (i.e., 100-BC-5, 100-FR-3, 100-HR-3, 100-KR-4, and 100-NR-2 Groundwater Operable Units). In addition, low-priority sites and potentially impacted river sediments near the 100 Area are not currently considered candidates for interim remedial measures and will likely be addressed under the final remedy selection pathway of the *Hanford Past Practice Strategy* (Figure 1-2).

As shown in Figure 1-3, the FFS process for the 100 Area source operable units is conducted in two stages. The Process Document represents the first stage of the FFS process where interim remedial measure alternatives are developed and analyzed on the basis of waste site groups associated with the 100 Area source operable units (e.g., retention basins, or sludge trenches). The second stage is the site-specific evaluation of the Remedial Alternatives, which is presented in the operable unit-specific FFSs (Appendices E, F, and G).

The objective of this 100 Area Source Operable Unit FFS is to provide decision makers sufficient information to allow appropriate and timely selection of interim remedial measures for sites associated with the 100 Area source operable units. To select any remedial measure, certain information relating to future land use, groundwater use, cleanup goals, and public perspectives is critical. However, to provide "appropriate and timely" interim remedial measures, not every issue can be fully developed. As a result, the FFS needs to address these issues without the availability of final decisions on land use, groundwater use, etc. This requires balancing multiple issues, including, (1) establishing a baseline scenario for use during the analysis of alternatives, (2) assessing this baseline scenario to better understand the impact of changes in the baseline assumptions, and (3) preparing the documentation necessary to maintain flexibility in the process before the public review. To this end, the main text (Process Document) of this FFS develops a baseline detailed analysis and comparative evaluation. This baseline is then supplemented by the Sensitivity Analysis to investigate impacts caused by changes in the baseline assumptions. Finally, the operable unit-specific evaluations are provided in separate appendices and reflect the results of the Process Document and the Sensitivity Analysis.

New remediation goals based on cleaning up organic and inorganic chemicals to levels consistent with Method B of the *Model Toxics Control Act* (MTCA) and cleaning up radionuclides to EPA-proposed standards of 15 mrem/yr above background were introduced and agreed to by the Tri-Parties at a late date in the FFS documentation process. This new scenario also includes remediating soils to protect groundwater resources and groundwater flows into the Columbia River. These new remediation goals, based on a revised frequent use exposure scenario, have been written into the Proposed Plans for 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units. Because of the late introduction of these goals, the majority of the FFS documentation is unchanged, and the revised frequent use scenario is developed in two new locations:

- Appendix D, Sensitivity Analysis, Attachment 6, "Development and Analysis of New Remediation Concept."
- New Section 7.0 in each operable unit specific appendix (Appendices E, F, and G), "Site Specific Assessment of New Remediation Concept."

1.1.1 Process Document of FFS

The baseline analysis performed in the Process Document was based on objectives developed jointly by EPA, Ecology, and DOE:

- Analyze Remedial Alternatives based on a baseline land use scenario that is not too conservative, but still protective of the environment
- Evaluate the influence on the alternatives analysis of changing the land use assumptions with reference to the baseline land use scenario
- Provide flexibility so that a different mix of technologies and/or land uses could be developed to respond to public comments or agency concerns.

With these objectives in mind, the following scenario was selected as the baseline land-use scenario for use in the main text of the FFS:

- Recreational land surface use allowing for occasional use of the land and resulting in preliminary remediation goals that "middle ground" between the no land use and unrestricted land use scenarios.

- Protection of groundwater to drinking water standards. Alternate concentration limits could be developed for interim remedial measures; however, until such alternate concentration limits are developed, the only soil remediation standard that can be applied is soil remediation to support drinking water standards. Using the drinking water standards can then become the baseline for soil preliminary remedial goals even though a final groundwater protection decision has not been made. As discussed previously, a decision on groundwater use has not and cannot be made at this time, but an assumed groundwater use is required to establish information for comparative analysis purposes. The remediation of existing groundwater contamination is addressed in the upcoming FFSs for groundwater operable units; relationships with soil remediation that have not been addressed at this time can be addressed as part of that activity.

The process document also provides a brief description and historical overview of the 100 Area (Section 1.2), and presents the remedial action objectives and preliminary remediation goals for the 100 Area source operable units (Section 2.0). It also summarizes the results of the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1993a), a prior feasibility study that screened remedial technologies and developed the basic Remedial Alternatives for the 100 Areas. The implementation of an innovative streamlined FFS process used at the 100 Areas, referred to as the "plug-in" approach, is described in Section 1.4). The baseline analysis of alternatives is conducted by:

- Identifying each group (Section 3.0)

- Describing the 100 Area natural and cultural resources (Section 3.0)

- Describing the interim remedial measure alternatives (Section 4.0)

- Completing the detailed and comparative analyses of these Remedial Alternatives (Sections 5.0 and 6.0).

1.1.2 Sensitivity Analysis - Appendix D

Once the baseline comparative evaluation was completed in the Process Document, a range of land uses was examined to determine how the baseline evaluation would change under different land use assumptions. This assessment was done in the Sensitivity Analysis (Appendix D). The following objectives were established for the Sensitivity Analysis:

- Identify the effects of different exposure scenarios on the base case evaluation of alternatives presented in the Process Document.

- Identify the effect of changing the target incremental cancer risk for each scenario from 1×10^{-6} to 1×10^{-4}

- Evaluate the potential influence of different exposure pathways on the development of remediation goals.

A total of five exposure scenarios are addressed in the Sensitivity Analysis. Other scenarios are possible; however, the scenarios chosen provide the greatest amount of flexibility, and each scenario can be viewed as an indicator of the effects caused by a given change in land use and/or groundwater use.

- The baseline scenario from the Process Document (occasional use of the land surface and frequent use of groundwater)

- Occasional-use (occasional use of both the land surface and groundwater)

- Frequent-use (frequent use of both land surface and groundwater)

- Modified frequent-use (frequent use of land surface with no use of groundwater)

- Complete excavation (near total removal of contaminants to frequent-use 1×10^{-6} concentrations at all depths above groundwater).

Contaminated soil volumes and remediation costs were developed for each of the above scenarios for four representative waste sites, assuming the Remedial Alternative involves waste removal, treatment, and disposal. These results were extrapolated to the entire 100 Area by grouping 100 Area waste sites based on which of the four representative waste sites they matched best. Based on the estimated excavation, treatment, and disposal volumes, corresponding costs were developed for each scenario.

An attachment has been added to the Sensitivity Analysis to assess how the analysis performed in the Process Document would change if the new remediation approach introduced by the Tri-Parties were implemented. This discussion is provided as Attachment 6 to the Sensitivity Analysis.

1.1.3 Operable Unit Specific Appendices

In the operable unit specific FFSs (Appendices E, F, and G), the Remedial Alternatives based on the known characteristics of specific waste sites within the operable unit are evaluated for the baseline land use assumption (occasional-use of land surface and frequent use of groundwater). The operable unit specific FFSs draw from the baseline evaluation of alternatives presented in the Process Document to assess how site-specific information influences the comparative analysis. The Remedial Alternatives are ranked with respect to remediation of specific high-priority waste sites. Section 7.0 of each operable unit specific FFS has been recently developed to assess how the baseline analysis (Sections 1.0 through 6.0 of each operable unit specific appendix) changes under the new remediation approach introduced by the Tri-Parties.

Each operable unit specific FFS characterizes the operable unit that will be remediated (i.e., physical setting and existing natural and cultural sources), summarizes the results of the corresponding Limited Field Investigation report which identified the interim remedial measure candidate (high priority) sites within that operable unit, and develops a characterization profile for each high-priority waste site. The operable unit specific FFS then conducts an analysis of Remedial Alternatives using the detailed and comparative analyses results from the Process Document. If possible, the alternative analyses from the Process Document will be plugged into the site specific FFS if the individual waste site at the operable unit adequately matches the characteristics of the waste site group. If the match is not adequate, the operable unit specific FFS develops a site specific analysis of alternatives.

1.2 100 AREA OVERVIEW

The 100 Area (approximately 68.89 km^2 [26.6 m^2]) is located in the north-central part of the Hanford Site along the southern shoreline of the Columbia River (Figure 1-1). Between 1943 and 1962, nine water-cooled, graphite-moderated, plutonium production reactors were built along the shore of the Columbia River upstream from the now abandoned town of Hanford. All of these reactors (B, C, D, DR, F, H, KE, KW, and N) are now out of service.

Past waste disposal practices of the 100 Area reactor operations resulted in releases of radionuclides and other chemicals to soil and groundwater near the reactors. The primary source of these contaminants was cooling water that flowed through the reactor core. As a result of leaks in the reactor cooling water transfer systems and intentional effluent disposal into cribs and trenches, soil and underlying groundwater have been contaminated. In addition, solid wastes containing radionuclides were buried in unlined trenches to isolate those wastes from ongoing operations.

1.3 SUMMARY OF 100 AREA FEASIBILITY STUDY PHASES 1 AND 2

The initial identification and screening of cleanup technologies and development of Remedial Alternatives in the feasibility study process for the 100 Area are documented in the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1993a). Information contained in DOE-RL (1993a) includes preliminary identification of potentially applicable or relevant and appropriate requirements (ARAR), remedial action objectives, and general response actions.

General response actions potentially applicable to remediating the hazards associated with the 100 Area are identified in DOE-RL (1993a) as follows:

- No action
- Institutional controls
- Containment actions
- Removal/disposal actions
- In situ treatment actions
- Removal/treatment/disposal actions.

Technologies and process options for each general response action were evaluated and assembled into general Remedial Alternatives in the Feasibility Study Phases 1 and 2 report (DOE-RL 1993a). These general Remedial Alternatives were then used as the basis for the alternatives presented in the Process Document.

The ARARs and remedial action objectives identified in DOE-RL (1993a) are clarified in this Process Document based on the evaluation of additional operable unit-specific and waste site-specific information gathered in the limited field investigation (Section 2.0). In addition, the alternatives developed in DOE-RL (1993a) are clarified and modified in this Process Document, as necessary, in accordance with CERCLA methodology (EPA 1988), NEPA/CERCLA integration actions, and the "plug-in" approach described in the following section.

1.4 FOCUSED FEASIBILITY STUDY APPROACH

Because many of the waste sites within the 100 Area are similar, a "plug-in" approach to alternative development and evaluation has been adopted for this Process Document and subsequent operable unit-specific reports. This approach and its compatibility with the "analogous site" approach to site characterization outlined in the HPPS are discussed in this section.

The plug-in approach described in this document parallels the approach documented in 1993 by EPA Region IX for the Indian Bend Wash Superfund Site in Tempe, Arizona (EPA 1993). The need for a specialized approach to the feasibility study for the Indian Bend Wash site was because of the large number (approximately 70) of similar yet individual contaminant source areas located within the site. The source areas at Indian Bend Wash all exhibited volatile organic compound contamination of vadose zone soils. Traditional remedial investigation/feasibility study methodology dictates that these source areas be fully characterized before initiation of the remedy selection process. Because such an approach would have resulted in many redundant feasibility studies (one for each source area) with attendant schedule and budget requirements, EPA developed the plug-in approach to preclude these undesired impacts on the Indian Bend Wash project. Briefly, the approach specifies and analyzes Remedial Alternatives for a group of sites that have similar characteristics (e.g., physical attributes, contaminants, and contaminated media). Then, if it is determined that an 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.

Accordingly, the plug-in approach facilitates expeditious and cost-effective remedy selection for applicable sites by eliminating the time and associated cost required to generate multiple, redundant site-specific feasibility studies. For the purposes of this Process Document, the plug-in approach can be summarized as follows:

1) Assemble Site Groups and Associated Group Profiles

Assemble sites with similar characteristics (e.g., physical structure, function, and impacted media) into groups. These groups are based on the "analogous site" approach to site characterization discussed in the *Hanford Past-Practices Strategy* and shown in Figure 1-4. This Process Document addresses the site groups identified in Figure 1-4, with the exception of the septic systems and special use burial grounds. The septic systems and special use burial grounds are not included because they are not represented by any current interim remedial measure candidate site in the 100 Area. Specifically, the following waste site groups are evaluated in this Process Document:

- Retention basins
- Buried pipelines[1]
- Process effluent trenches
- Sludge trenches
- Fuel storage basin trenches
- Decontamination cribs/french drains
- Pluto cribs
- Seal pit cribs
- Burial grounds
- Decontaminated and decommissioned facilities.

A description or profile for each waste site group is developed that characterizes the sites within each group. Such a description is called the *group profile.* Data used to generate the group profiles for each site group were compiled from three 100 Area operable unit limited field investigations (i.e., 100-BC-1, 100-DR-1, and 100-HR-1 [DOE-RL 1993c, DOE-RL 1993b, and DOE-RL 1993d]). These three operable units are considered representative of the source areas in the 100 Area. Detailed discussion of the site groups and development of the associated group profiles are documented in Section 3.0 of this Process Document.

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[1]The buried pipelines included in this Process Document and subsequent operable unit-specific FFSs are located between the reactor facilities and the river outfall structure. The outfall structure and the pipelines extending under the river are addressed in the *100 Area River Effluent Pipelines Expedited Response Action Proposal* (DOE-RL 1994a).

2) Develop Remedial Alternatives

Develop basic Remedial Alternatives for the site groups, based on the group profiles. Also, identify additional components or enhancements that could be incorporated into the basic alternatives on a case-by-case basis so that the basic alternatives can be used at sites that differ slightly from the sites typical of the particular site group. For example, a thermal desorption treatment step can be added at sites containing organic contaminants so the basic alternative can be used at sites containing both inorganic and organic contaminants.

For each alternative, identify the critical site characteristics that must be met to successfully implement that alternative. These critical site characteristics are referred to as the "applicability criteria." For example, the No Action Alternative is acceptable only at sites where the concentrations of all the contaminants of potential concern are less than the cleanup goals. Another example is that the In Situ Vitrification Alternative can be used only at sites where the zone of contamination is equal to or less than 5.8 m (19.03 ft). The vitrification process doesn't effectively vitrify a waste zone thicker than 5.8 m (19.03 ft). The applicability criteria for each alternative are given in Section 4.0 of the Process Document.

3) Perform Detailed and Comparative Analyses

Perform detailed and comparative analyses of the Remedial Alternatives developed in step 2, above. The detailed and comparative analyses are presented in Sections 5.0 and 6.0, respectively, of this Process Document.

4) Develop Individual Site Profiles

Develop a site profile for each high-priority waste site within an operable unit. Development of individual site profiles are documented in Section 2.0 of the applicable operable unit-specific FFS. Three of these site-specific FFSs (100-HR-1, 100-BC-1, and 100-DR-1) are in Appendices E, F, and G, respectively, of this report.

5) Identify Representative Group

Compare the individual site profile to the group profiles presented in this Process Document to determine which waste site group the individual site belongs. Also compare the site characteristics to the applicability criteria for the alternatives developed for the waste site group, noting any deviations that may result in a requirement for alternative enhancement. The identification of the appropriate waste site group and the comparison to the associated alternative applicability criteria for each site are documented in Section 3.0 of the applicable operable unit-specific FFS (see Appendices E, F, and G).

6) "Plug-In" the Alternatives Analysis or Perform Site-Specific Analysis

a. If the individual site profile matches the group profile, and the applicability criteria are met based on the comparison conducted in step 5, the individual waste site plugs into the analysis of alternatives already completed for the site group. Because the appropriate alternative for the site group has already been evaluated in Sections 5.0 and 6.0 of the Process Document, the operable unit-specific FFS can use that analysis and proceed directly to prepare the site-specific volume and cost estimates (Section 5.0 of the operable unit-specific FFS).

b. If the individual site profile does not match the group profile or the applicability criteria are not met, the individual site does not plug into the analysis of alternatives for the site group. Section 4.0 of the operable unit-specific FFS will identify those individual sites that do not "plug-in" to the analysis of alternatives for the site group. A reevaluation of alternatives based on site-specific conditions is then performed and documented in Sections 5.0 and 6.0 of the operable unit-specific FFS (see Appendices E, F, and G).

The plug-in approach has many benefits. First, redundant FFSs for source sites within the 100 Area are avoided. Because there are many individual 100 Area source sites, this approach is expected to save a significant amount of time and money. Second, the plug-in approach focuses ongoing data collection efforts at a site on the most likely interim remedial measure alternative(s); the pursuit of superfluous data is minimized. Third, the plug-in approach represents a logical extension of the "analogous site" approach to site characterization discussed in the *Hanford Past-Practices Strategy*, which states:

> "Within and among many of the operable units, there are areas that are geologically similar and that have experienced similar disposal activities. Significant savings in time, manpower and budget could be realized by using these analogous conditions and activities to reduce the amount of investigation required at the affected sites. ... ... adequate confirmatory investigations would be performed in lieu of full characterization efforts."

Therefore, the 100 Area FFS employs the plug-in approach by evaluating Remedial Alternatives for waste site groups in the Process Document, based on the premise that the analysis of alternatives for a group can also be applied to individual waste sites in the operable unit-specific FFSs.

1.5 INCORPORATION OF NATIONAL ENVIRONMENTAL POLICY ACT VALUES

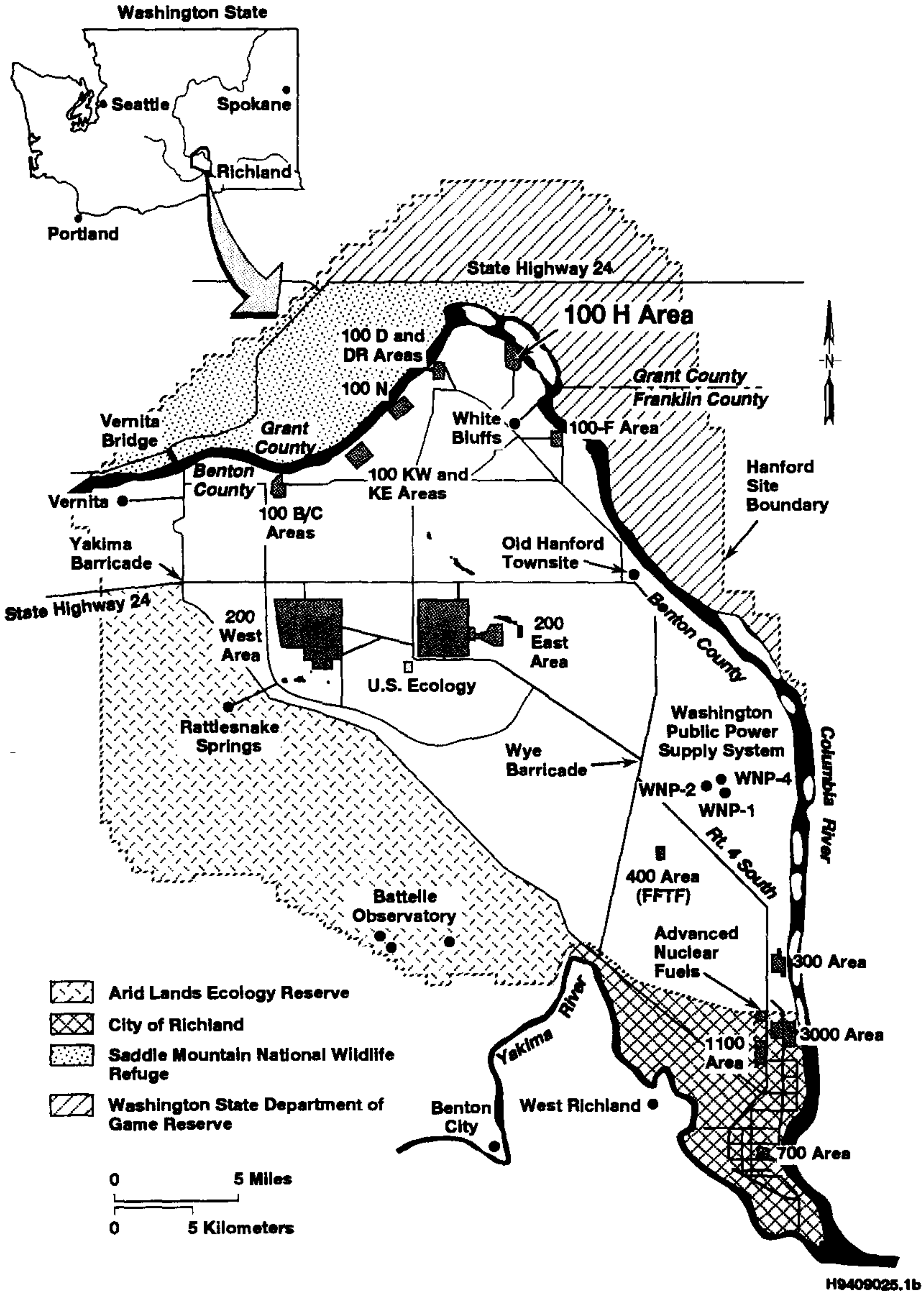
In accordance with DOE Order 5400.4 and Chapter 10 of the *Code of Federal Regulations* (CFR) Part 1021, the considerations (values) of the *National Environmental*

Policy Act of 1969 (NEPA) must be evaluated during the CERCLA process. Recent policy issued by the DOE Secretary's Office (DOE, 1994) states:

> "To facilitate meeting the environmental objectives of the CERCLA and respond to concerns of regulators, consistent with the procedures of other Federal agencies, DOE hereafter will rely on the CERCLA process for review of actions to be taken under CERCLA and will address NEPA values and public involvement procedures as provided below. ...
>
> The DOE CERCLA documents will incorporate NEPA values such as analysis of cumulative, offsite, ecological, and socioeconomic impacts, to the extent practicable."

The NEPA values are incorporated in this Process Document (Section 3.3) and subsequent FFSs.

Figure 1-1. Hanford Site Map.



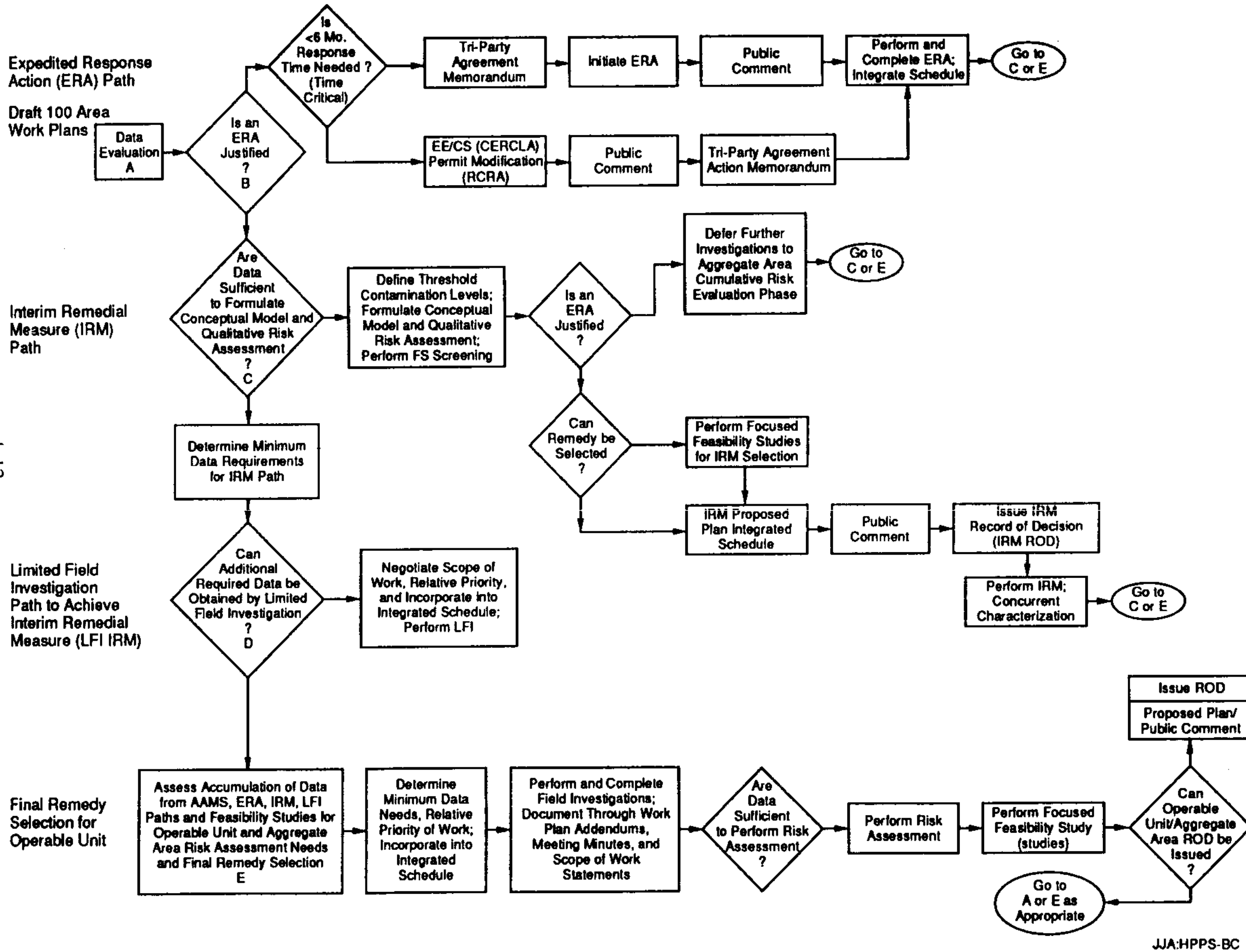


Figure 1-2. Hanford Past-Practice Strategy.

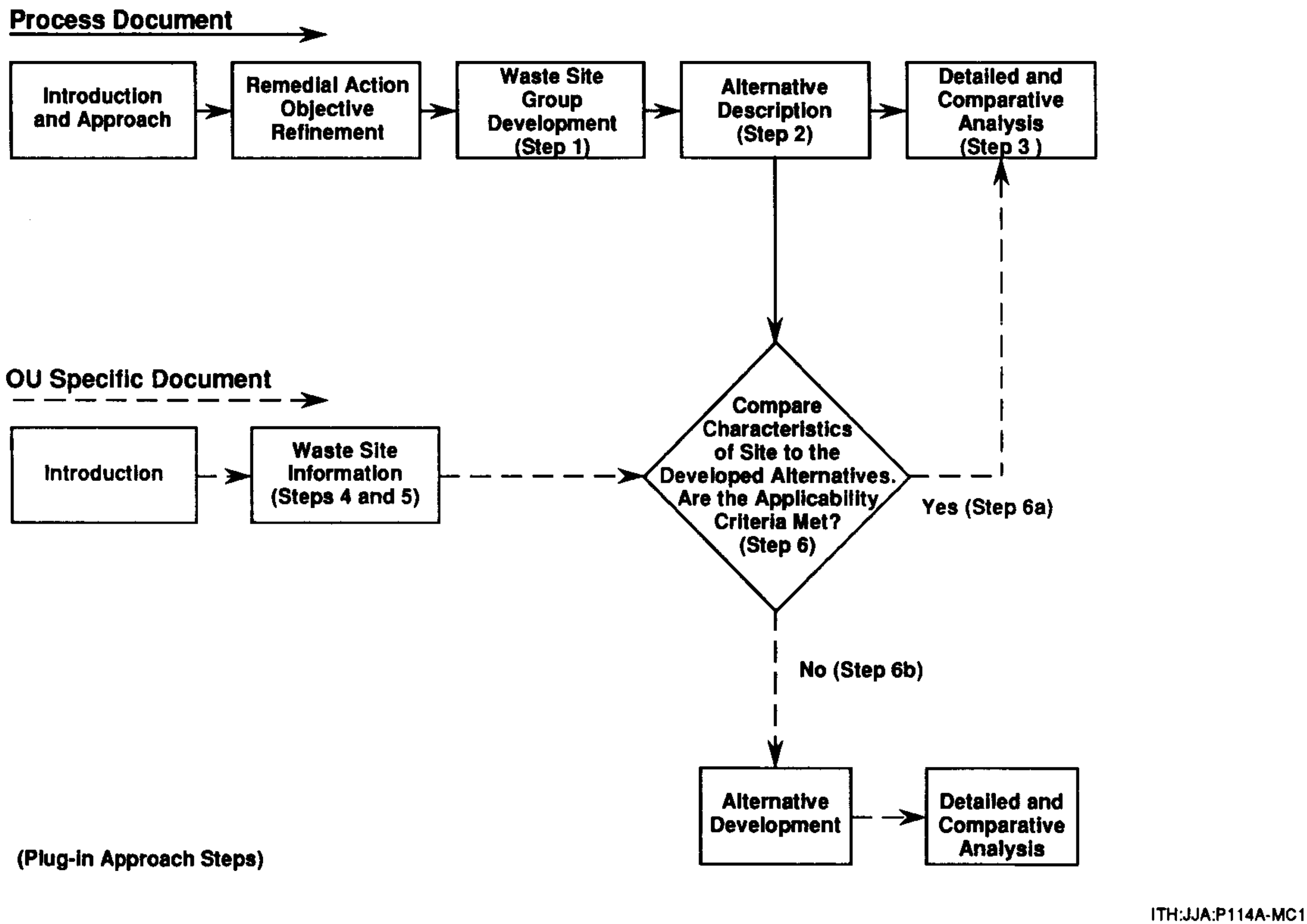


Figure 1-3. 100 Area Source Operable Unit FFS Process.

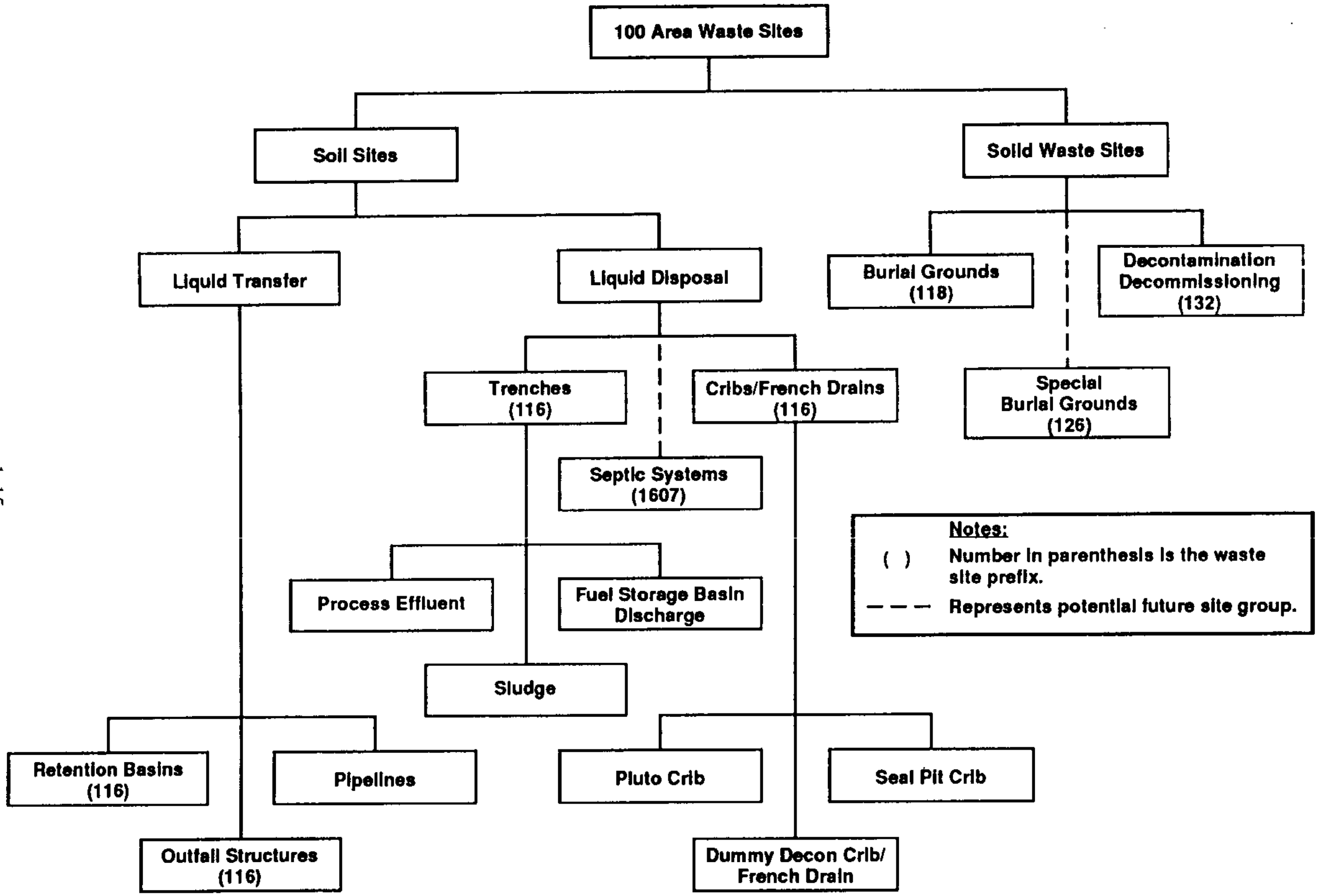


Figure 1-4. Analogous Waste Sites.

ITH:JJA:P114A-Mc2

2.0 REMEDIAL ACTION OBJECTIVES AND GOALS

Remedial action objectives are general descriptions of the objectives the remedial action is expected to accomplish. The remedial action objectives provide a basis to evaluate the ability of a specific Remedial Alternative to achieve compliance with ARARs or an intended level of risk to human health or the environment. Remedial action objectives, therefore, are developed before evaluating Remedial Alternatives. The remedial action objectives are defined as specifically as possible, and address the following:

- The media of interest (soils and solid wastes in this case)
- The types of contaminants at the site
- The potential receptors (humans, plants, and animals)
- The possible exposure pathways
- The levels of contaminants acceptable after remediation.

Remedial action objectives initially were developed in the *100 Area Feasibility Study Phases 1 and 2* report (DOE-RL 1993a) for soils, solid wastes, groundwater, and riverbank sediments. Because this Process Document addresses actions to remediate soils and solid wastes (and not groundwater or other media), the initial remedial action objectives for these two media, as presented in Table 4-2 in the feasibility study Phases 1 and 2 report (DOE-RL 1993a), serve as a starting point for this Process Document. The remedial action objectives are further defined in Subsection 2.4 below.

Once the remedial action objectives have been established, they can be numerically expressed as preliminary remediation goals. Preliminary remediation goals are chemical and radionuclide concentrations in soils (for the purposes of this Process Document) that protect human health and the environment. These preliminary remediation goals consider exposure pathways (how the contaminants are transported to places accessible to receptors) and exposure zones where receptors could come in contact with, or be directly exposed to radioactive contaminants. The numeric remediation goals developed in this Process Document are preliminary and serve as a basis to define the extent of contamination and compare interim remedial measure alternatives. The final remediation goals or remediation criteria will be defined when final land use and appropriate exposure scenarios are defined.

This section of the Process Document consists of eight subsections. Section 2.1 provides information on the types of contaminants at the 10 waste site groups listed in Section 1.4 of this report and identifies the contaminants of potential concern associated with soils and solid wastes in the 100 Area. Section 2.2 describes the existing and potential future land uses at the Hanford Site; Section 2.3 identifies the potential human and ecological receptors that may be exposed to contaminated soils and solid wastes in the 100 Area, based on the potential land uses. Section 2.3 also discusses the exposure pathways and exposure point locations that are used to develop preliminary remediation goals. The remedial action objectives (Section 2.4) describe the general objectives that the remedial action is expected to achieve, while the preliminary remediation goals (Section 2.5) and the chemical-specific ARARs (Section 2.6) establish the specific contaminant concentrations used to estimate the quantity of contaminated soils and solid wastes that must be remediated to attain the remedial action objectives. One of the remedial action objectives requires compliance with all action- and location-specific ARARs, as well as the chemical-specific ARARs.

Finally, this section compares the onsite concentrations of the contaminants of potential concern to the preliminary remediation goals to determine which contaminants will drive remedial actions at the waste sites. The contaminants of potential concern were initially identified during the qualitative risk assessment process at each operable unit, and represent the contaminants that exceed Hanford Site background and certain risk-based screening levels. These contaminants of potential concern are presented in Section 2.1 below. In Section 2.7, the contaminants of potential concern that exceed the preliminary remediation goals are identified. These contaminants, and their associated preliminary remediation goals, are used in subsequent sections of this Process Document to determine how much soil and solid wastes must be contained, treated, or removed from the site to meet the remedial action objectives.

The preliminary remediation goals discussed in the Process Document are based on a specific scenario for future use of the land surface and groundwater at the 100 Area. A Sensitivity Analysis (Appendix D) was performed to evaluate the effects of different human exposure scenarios on the preliminary remediation goals, the soil volumes requiring remediation, and the estimated costs for remedial action.

2.1 CONTAMINANTS OF POTENTIAL CONCERN

The contaminants of potential concern at the 100 Area source operable units for human receptors are shown in Table 2-1. They represent a cumulative list of the contaminants of potential concern that were identified in the limited field investigation and qualitative risk assessment reports for the three 100 Area source operable units (100-BC-1, 100-HR-1, and 100-DR-1) that are considered representative of the source operable units in the 100 Area (DOE-RL 1993c and WHC 1994a, DOE-RL 1993d and WHC 1994b, and DOE-RL 1993b and WHC 1994c). The contaminants of potential concern are specifically those contaminants in soil that were identified by the qualitative risk assessment as exceeding one or both of the following criteria:

- Exceedance of Hanford Site Background (95% upper tolerance limit for inorganics)
- Exceedance of preliminary human risk-based screening values based on a 1×10^{-7} incremental cancer risk and a noncancer hazard quotient of 0.1 (developed using residential exposure assumptions).

To identify the contaminants of potential concern for ecological receptors, the constituents were screened only against the background concentrations. No risk-based screening was used because there are no standard EPA recognized risk-based effect levels for plants and animals, and numerous species of plants and animals are potentially involved. This Process Document considers contaminants at all depths because the remedial action objectives include protection of groundwater as well as protection of human and ecological receptors.

2.2 LAND USE

Regional Land Use. Land use in the areas surrounding the Hanford Site includes urban and industrial development, irrigated and dry-land farming, grazing, and designated wildlife refuges. The region consists of the incorporated cities of Richland, Pasco, and Kennewick (Tri-Cities) and surrounding communities in Benton and Franklin counties. Industries in the Tri-Cities are mostly related to agriculture and electric power generation. Wheat, corn, alfalfa, hay, barley, and grapes are the major crops in Benton and Franklin counties.

Hanford Site Land Use. The Hanford Site encompasses 1,450 km^2 (560 mi^2) and includes several DOE operational areas. The major areas are as follows:

- The entire Hanford Site has been designated a National Environmental Research Park.
- The 100 Area, bordering the south shore of the Columbia River, is the site of the nine retired plutonium production reactors. The 100 Area encompasses about 68 km^2 (26 mi^2).
- The 200 West and 200 East Areas are located on a plateau about 8 and 11 km (5 and 7 mi), respectively, from the Columbia River (Figure 1-1). These areas have been dedicated to waste management and disposal activities. The 200 Areas cover about 16 km^2 (6.2 mi^2).
- The 300 Area, located just north of the City of Richland, is the site of nuclear research and development. This area encompasses 1.5 km^2 (0.6 mi^2).
- The 400 Area is about 8 km (5 mi) north of the 300 Area and is the site of the Fast Flux Test Facility formerly used in the testing of breeder reactor systems. Also included in this area is the Fuels and Material Examination Facility.
- The 1100 Area includes the 3000 Area and the Horn Rapids Landfill. It is used for Hanford Site support services.
- The 600 Area includes all of the Hanford Site not occupied by the 100, 200, 300, 400, or 1100 Areas. Land uses within the 600 Area include the Fitzner-Eberhardt Arid Land Ecology Reserve, a U.S. Fish and Wildlife Service wildlife refuge, support facilities for controlled access areas, and other lands leased to Washington state and the Washington Public Power Supply System (Cushing 1994).

100 Area Land Use. Existing land use in the 100 Area includes the following land use categories: facilities support, waste management, and undeveloped. Facilities support activities include operations such as water treatment and maintenance of the reactor buildings. The waste management land use designation results from past-practice waste sites located throughout the 100 Area. Lastly, there are undeveloped lands located throughout the 100 Area. These areas are the least disturbed and contain minimal infrastructure. The shoreline of the Columbia River is a valued ecological area within the Hanford Site.

The *Hanford Future Site Uses Working Group* (DOE-RL 1992a) has recommended that the 100 Area be considered for the following four future use options:

- Native American uses
- Limited recreation, recreation-related commercial use, and wildlife use
- B Reactor as a museum and visitor center
- Wildlife and occasional-use

Furthermore, the Final River Conservation Study (National Park Service 1994) and Environmental Impact Statement for the Hanford Reach of the Columbia River (National Park Service 1993) has proposed that the Hanford Reach of the Columbia River and approximately 102,000 acres of adjacent lands be designated as a National Wild and Scenic River and a National Wildlife Refuge, respectively.

As explained in Section 1.0, an occasional-use exposure scenario was selected as the basis to develop preliminary remediation goals in this Process Document. The Sensitivity Analysis, presented in Appendix D, evaluates the potential changes to preliminary remediation goals, estimated waste volumes, and costs when scenarios other than this occasional-use scenario are considered. The occasional-use scenario assumptions are consistent with those defined for a recreational exposure scenario in *The Hanford Site Risk Assessment Methodology* (DOE-RL 1995).

2.3 RECEPTORS AND EXPOSURE PATHWAYS

Because remedial action objectives can be met by reducing contaminant concentrations at the site and/or by reducing or eliminating exposure to those contaminants, the receptors, exposure pathways, and points of contact must all be considered during development of remedial action objectives and associated remediation goals. This section describes the receptors and exposure pathways considered in development of preliminary remediation goals. A conceptual exposure pathway model, based on an occasional-use exposure scenario, is presented in Figure A-1 (Appendix A, Development of Preliminary Remediation Goals).

2.3.1 Receptors

The remedial action objectives and preliminary remediation goals are established to protect human and ecological receptors that could be present in the 100 Area following remediation. Under the occasional-use exposure scenario, humans, plants, and animals would all be present at the 100 Area.

For the purposes of establishing the preliminary remediation goals, the human receptors are assumed to be limited to individuals that will visit the site for recreational or other occasional-use purposes. Site workers who would work in the area to conduct remediation are not considered as receptors for purposes of developing preliminary remediation goals because the preliminary remediation goals define site conditions after remediation is complete. Short-term risks to workers who will be involved in the remedial actions are addressed in Section 5.2.2.5 of this Process Document.

The Great Basin pocket mouse is the biological receptor selected for this Process Document as representative of the terrestrial animals at the waste sites. The pocket mouse is common in the 100 Area and has a home range that approximates the size of many of the individual waste sites. The mouse lives in subsurface burrows and feeds on plants above ground at night. Therefore, pocket mice residing in the 100 Area may spend much of the time in contaminated areas. The major pathway through which pocket mice are exposed to contaminants in soils and solid wastes is considered to be ingestion of contaminants in food (primarily plant seeds).

Plants in the area represent the primary producers in the ecosystem. For the purposes of this Process Document, the exposure of plants to soil contaminants was considered by evaluating the potential phytotoxicity of the soil to plants in general. Therefore a generic plant, rather than a specific species, was selected as the biological receptor for this trophic level.

2.3.2 Exposure Pathways

The primary exposure pathways for human receptors, under the occasional use scenario, are external exposure to radiation, incidental ingestion of contaminated soils, and inhalation of particulates or vapors in air (Figure A-1, Appendix A). Other potential exposure pathways, such as dermal contact with contaminants and ingestion of plants or animals that could potentially accumulate contaminants from soil, do not provide significant contributions to total human exposure; therefore, these risks are not included in the calculation of preliminary remediation goals. The influence of the full set of exposure pathways from soil on total human health risk are discussed in Appendix D, the Sensitivity Analysis Report.

For the Great Basin pocket mouse, the primary exposure pathway is considered ingestion of contaminated food. The pocket mouse consumes primarily plant seeds; it is assumed that the plants and seeds could take up radionuclide and chemical contaminants from the soil. External exposure to radiation was not included in calculating preliminary remediation goals for the pocket mouse because external dose to wildlife from radionuclides has been shown to be a minor contributor to total dose (Poston and Soldat 1992).

2.3.3 Exposure Zone or Point of Compliance

The normal activities of humans, assuming the site is used for occasional use, will not bring individuals in contact with contaminants that are deeply buried at the site. Following remediation, it is assumed there will be no extensive soil disturbance or excavation associated with the occasional-use exposure scenario. Therefore, buried contaminants would not be transported to the surface. For developing preliminary remediation goals, it is assumed that humans would be exposed by ingesting and inhaling contaminants that exists only within a near surface zone (between the surface and a depth of 1 m [3 ft]). Also, radionuclide contaminants within the top meter of soil will expose human receptors to external radiation. However, it is assumed that humans would be protected from external exposure to radiation emanating from radionuclides below the 1 m (3 ft) level by the mass of the overlying uncontaminated soil. Therefore, for developing preliminary remediation goals for human exposure, only the upper 1 m (3 ft) of the soil strata was considered. This exposure zone is also referred to in this report as the point of compliance.

Burrowing animals at the site, such as the Great Basin pocket mouse, live in subterrarian burrows and may dig burrows down to around 1.8 m (6 ft). Burrowing animals at the site, therefore, may come in direct contact with contaminants that are as deep as 1.8 m (6 ft). The pocket mouse and several other animals also feed on plants and plant seeds, and some of those plants have roots that penetrate to depths of 1.8 to 2.7 m (6 to 9 ft) (Klepper et al. 1985). The exposure zone for the Great Basin pocket mouse is therefore considered to be the soil strata from the surface down to 3 m (10 ft). Appendix A discusses the exposure zone or point of compliance in more detail.

Contaminants at any depth may potentially leach from the vadose zone to groundwater. Therefore, the exposure zone, with respect to protection of groundwater, is the entire vadose zone (i.e., from the ground surface down to the groundwater table). Section 3.4 of Appendix A presents the methods used to calculate preliminary remediation goals protective of groundwater.

2.4 REFINED REMEDIAL ACTION OBJECTIVES

The initial remedial action objectives for the 100 Area were presented in the 100 Area FS Phases 1 and 2 report (DOE-RL 1993a). These initial remedial action objectives were updated using the most recent information on the contaminants in the 100 Area, the receptors considered, and the exposure pathways that link the contaminants to the receptors. These refined remedial action objectives for the 100 Area source operable units are as follows:

- <u>For Protection of Human Health</u>
  - Limit exposure of human receptors to contaminated surface and subsurface soils to limit the incremental cancer risk in the range of 1×10^{-4} to 1×10^{-6} for carcinogenic (cancer causing) contaminants (including radionuclides) and at or below a noncancer hazard quotient of 0.1 for noncarcinogen constituents. (The hazard quotient [remedial objective] for noncarcinogenic chemicals is set at 0.1, rather than 1.0, to accommodate the potential additive or synergistic affect of several chemical stressors acting on a receptor at the same time.)
  - Limit future impacts to groundwater by ensuring that contaminants remaining in the vadose zone that could potentially leach to

groundwater would result in contaminant concentrations in groundwater below groundwater protection standards.

- Comply with ARARs.

- For Environmental Protection

  - Limit exposure of ecological receptors to contaminants.

  - Comply with ARARs.

  - Avoid or minimize destruction of habitat and disruption of natural animal activities to the extent practicable.

These remedial action objectives can be accomplished by reducing contaminant concentrations in soil, by eliminating exposure pathways, or by retarding the transfer of contaminants through the exposure pathways.

2.5 PRELIMINARY REMEDIATION GOALS

The above remedial action objectives are the basis for developing criteria (described in terms of concentrations in soil) that serve as preliminary remediation goals. The preliminary remediation goals represent contaminant concentrations in soils and solid wastes that are considered protective of human health and ecological receptors. The preliminary remediation goals are used to identify what volumes of contaminated soil must be remediated at each site to meet the remedial action objectives. The volumes of soil requiring remediation are used to evaluate Remedial Alternatives and to estimate costs associated with potential remedial action at a site. Separate preliminary remediation goals are estimated for protection of human health, plant and animal populations, and groundwater use. If two or three of these preliminary remediation goals apply to the same exposure zone, then the most restrictive goal is used to determine the extent of remediation. Appendix A and Section 2.5 present more information on the calculation and application of the preliminary remediation goals. Also, because preliminary remediation goals vary with exposure scenarios, preliminary remediation goals are discussed in the Sensitivity Analysis (Appendix D).

Preliminary remediation goals are numeric expressions of the remedial action objectives discussed in Section 2.4. The preliminary remediation goals describe the concentrations of the contaminants in soils and solid wastes that are considered protective of human health and the environment. Soils exceeding the preliminary remediation goals must be contained, treated, or removed from the site. The preliminary remediation goals were developed considering human health risk levels, ecological risk levels, levels that are protective of groundwater, and concentrations that are based on regulatory requirements (i.e., chemical-specific ARARs). More details concerning the development and calculation of the preliminary remediation goals are presented in Appendix A.

The preliminary remediation goals presented here are not necessarily the remediation levels that will be set for the remedial action. The remediation levels for interim remedial action will be selected based on consideration of the occasional use exposure scenario used in this Process Document, plus the exposure scenarios presented in the Sensitivity Analysis (Appendix D), plus input from the regulatory and public communities. Final goals for remediation will be determined after final land use and appropriate exposure scenarios are defined.

2.5.1 Human Health Preliminary Remediation Goals

The preliminary remediation goals for the protection of human health are developed in accordance with guidance provided by EPA (EPA 1989, EPA 1991a, EPA 1991b) and procedures described in DOE-RL (1993e). As discussed previously, the preliminary remediation goals for protection of human health are based on an assumed occasional-use exposure scenario. Three exposure pathways (soil ingestion, inhalation, and external radiation exposure) were evaluated for this scenario. As discussed in Section 2.3, the preliminary remediation goals based on these pathways are protective of human health for sites in the 100 Area. The preliminary remediation goals for protection of human health developed in this Process Document represent soil concentrations of carcinogenic contaminants (including radionuclides) that correspond to an incremental cancer risk of 1×10^{-6}, and soil concentrations of noncarcinogenic contaminants that correspond to a noncancer hazard quotient of 0.1. Both the incremental cancer risk and hazard quotient target risk levels account for the potential additive effects of contaminants. The preliminary remediation goals for protection of human health apply to contaminants within the top 1 m (3 ft) of soil, the exposure zone where humans may come in contact with the contaminants under the occasional use scenario.

2.5.2 Ecological Preliminary Remediation Goals

In contrast with the extensive CERCLA-based guidance that exists for assessing human health risks and estimating exposure levels considered safe for humans (EPA 1989), there are relatively few techniques to establish contaminant levels considered safe for plants and animals. Most risk-based methods appropriate for animal populations are for aquatic rather than terrestrial ecosystems. The result is that in the qualitative risk assessment reports for the source operable units (i.e., terrestrial ecosystems), the risks estimated for animals are based on a simple exposure scenario and are limited to one biological receptor, the Great Basin pocket mouse (WHC 1994a, WHC 1994b, and WHC 1994c). Furthermore, the estimated risks represent risks to an individual pocket mouse rather than a population or community of pocket mice. Estimating risks to a single individual has limited meaning in an ecological context because the goal for remediating hazardous waste sites is to protect populations or communities, not individual plants or animals.

The uncertainties in assessing ecological risks make it difficult, if not impossible, to develop meaningful remediation goals based on ecological risks. Therefore, when developing preliminary remediation goals based on ecological risks, the initial ecological remediation goals were compared to the preliminary remediation goals for the protection of human health and groundwater. This comparison illustrated that the ecological-based preliminary remediation goals were usually not the remediation goals that controlled the extent of remediation required. This fact, plus the knowledge that the ecological-based preliminary remediation goals may not be relevant for protecting populations, led to the decision to use human health preliminary remediation goals in this Process Document for protecting plants and animals, in lieu of ecological preliminary remediation goals. This remediation approach will protect plants and animals by mandating that the human health preliminary remediation goals be applied to the exposure zone for plants and animals. In other words, plants and animals will be protected by remediating contaminants that occur from ground surface to a depth of 3 m (10 ft) (see Section 2.3.3) that exceed the human health preliminary remediation goals.

The following subsections discuss the rationale for using human health values in lieu of ecological-based values to protect ecological receptors. As the remedial efforts continue at the Hanford Site, DOE will continue its efforts to develop ecological-based remediation values that are based on contaminant concentrations protective of native plant and animal populations.

Radiological Preliminary Remediation Goals

Several agencies responsible for protecting humans and environmental resources from the harmful effects of radiation have indicated that human health protection levels are likely adequate for protecting plant and animal populations. For example, the National Academy of Science (NAS 1972) stated that, ".... there is no present evidence that there is any biological species whose sensitivity is sufficiently high to warrant a greater level of protection than that adequate for people." Similarly, the International Commission on Radiological Protection (1977) has stated:

> "Although the principal objective of radiation protection is the achievement and maintenance of appropriately safe conditions for activities involving human exposure, the level of safety required for the protection of all human individuals is thought likely to be adequate to protect other species, although not necessarily individual members of those species."

In the recent "Issues Paper on Radiation Site Cleanup Regulations," the Environmental Protection Agency (1993) concurred with the above conclusions.

Although human health criteria can be used to protect animal and plant populations, preliminary remediation goals based on the pocket mouse were calculated and compared to the human health preliminary remediation goals to see which goals were more restrictive. These calculations, based on the food exposure pathway used in the qualitative risk assessments (Appendix A), were used to estimate concentrations in soil corresponding to a dose rate of 1 rad/day. This dose rate is identified in DOE Order 5400.5 as protective of ecological receptors. While this approach does not represent the true risk to a natural population of mice, it provides initial animal-based preliminary remediation goals that can be compared to human health-based preliminary remediation goals. As shown in Table 2-2, the human health-based preliminary remediation goals for radionuclides are generally much more restrictive than the mouse-based preliminary remediation goals. Therefore, using human health preliminary remediation goals would protect the pocket mouse. Two exceptions can be noted in Table 2-2: the animal-based preliminary remediation goals for strontium-90 and technetium-99 are more restrictive than the human-based preliminary remediation goals. Because these animal-based preliminary remediation goals represent a potential hazard to individuals rather than populations, the human-based preliminary remediation goals for strontium and technetium may still be protective of animal populations. Furthermore, the transfer coefficients used to estimate the uptake of these two radionuclides by plants were conservative and tended to substantially overestimate the potential for accumulation of contaminants from soil into plants. Also, when strontium and technetium occur at source operable units in the 100 Area, other radionuclides present at the site are generally the drivers that control soil remediation (see Table A-2, Appendix A).

The soil-to-plant transfer coefficient, other input parameters, and the set of equations used to estimate the radiological dose to the Great Basin pocket mouse are currently under review; therefore, it is not considered appropriate to use these assumptions and equations at this time to calculate ecological remediation goals.

In summary, human health-based radiological preliminary remediation goals are used in this Process Document in lieu of developing animal-based preliminary remediation goals because (1) the scientific literature supports the use of human health protection criteria to protect animal and plant populations from radiological hazards, (2) many uncertainties are associated with developing ecological-based risk estimates, and (3) there are no standard techniques available to estimate hazard quotients applicable to populations. Appendix A provides more information on the equations used to estimate exposure to humans and animals.

Inorganic and Organic Preliminary Remediation Goals for Animals

Similar to the case for radiological contaminants, ecological-based preliminary remediation goals were initially estimated for individual pocket mice for the inorganic and organic contaminants found at the 100 Area sites. These preliminary remediation goals have an unknown relationship to soil concentrations that are protective of mouse populations. These initial estimates indicated that the animal-based preliminary remediation goals for inorganic contaminants were commonly lower (more restrictive) than the corresponding human health-based preliminary remediation goals, but were always higher than the preliminary remediation goals based on protection to groundwater (Table 2-3). In other words, remedial actions to address inorganic contaminants would be driven by the goal to protect groundwater resources. For organic compounds, the animal-based preliminary remediation goals were almost always higher than both the human-based values and the preliminary remediation goals to protect groundwater. That is, remedial actions for organic contaminants would be driven by the goal to protect human health or groundwater.

To estimate animal-based preliminary remediation goals for organic and inorganic contaminants, a soil concentration that is considered safe for the ecological receptor (i.e., pocket mouse) must be known or estimated. This safe concentration is frequently based on studies that determine a no observable adverse effect level or lowest observable adverse effect level for the animal species in question. Opresko, Sample, and Suter (1993) reviewed the literature concerning wildlife effect levels and developed toxicological benchmarks for wildlife. These benchmarks were used in this Process Document to derive the initial preliminary remediation goals. However, Opresko et al. (1993) stated that the benchmarks they presented were based on several assumptions and extrapolations, and should be used only as benchmarks for initial screening of site contaminants. They cautioned that because of the degree of uncertainty involved, the benchmarks should not be used to determine remediation criteria.

Table 2-3 shows that for several inorganic constituents (for example, manganese, mercury, and zinc), the animal-based preliminary remediation goals are lower than the known background soil concentrations at the Hanford Site. This indicates that the methodology used to estimate the animal-based preliminary remediation goals is overconservative, or that the existing background concentrations of several inorganic constituents in Hanford Site soils are hazardous to mice. Field ecology studies conducted at the Hanford Site, however, have not revealed any evidence suggesting that natural background concentrations are hazardous to mice or other animal populations.

In summary, human health-based preliminary remediation goals for inorganic and organic contaminants are used in this Process Document in lieu of animal-based preliminary remediation goals because (1) many uncertainties are associated with developing animal-based preliminary remediation goals and (2) there are no standard techniques available to estimate hazard quotients applicable to populations.

Inorganic and Organic Preliminary Remediation Goals for Plants

Soil concentrations that are considered nonhazardous for vegetation at the 100 Area were obtained from a report by Suter, Will, and Evans (1993). In that report the authors developed toxicological benchmarks for terrestrial plants, to be used for contaminant screening. Suter et al. (1993) stated that there are no standard benchmarks for assessing which soil concentrations are toxic to plants, and found that most of the literature on plants involved cultivated species, such as corn, wheat, and lettuce, tested in agricultural soils. Their plant benchmark values are, however, concentrations that are applicable to populations rather than just individual plants. The authors stated that if phytotoxicity is suspected, field surveys and toxicity tests based on site-specific soils should be conducted.

When these plant benchmark values are compared to human health-based preliminary remediation goals and protection of groundwater preliminary remediation goals (Table 2-3), the groundwater protection goals are generally the most restrictive for inorganic contaminants. For organics, the plant-based preliminary remediation goals are always less restrictive than both the human health and protection of groundwater preliminary remediation goals. Again, similar to the animal-based inorganic preliminary remediation goals, the plant-based preliminary remediation goals are frequently less than the natural background values found in soils at the Hanford Site. This suggests that the techniques used to develop the plant benchmarks are overconservative, at least for Hanford Site area soils.

In summary, human health-based preliminary remediation goals for inorganic and organic contaminants are used in this Process Document in lieu of plant-based preliminary remediation goals because (1) many uncertainties are associated with developing plant-based preliminary remediation goals and (2) the plant-based inorganic preliminary remediation goals are frequently lower than Hanford Site background soil concentrations.

2.5.3 Groundwater Protection Preliminary Remediation Goals

One of the remedial action objectives for the source waste sites is to limit future impacts to groundwater by contaminants that may be left in the vadose zone soils (Section 2.4). The groundwater protection preliminary remediation goals developed for the source waste sites, therefore, represent soil concentrations that will not cause local groundwater to exceed federal or state groundwater maximum contaminant levels (drinking water standards) for inorganics and organics, or the Derived Concentration Guides for radionuclides (DOE 1993c).

The groundwater preliminary remediation goals in soil (i.e., the concentrations in soil that would not result in groundwater exceeding the maximum contaminant limits or Derived Concentration Guides in groundwater) were calculated using the Summers Model (see Appendix A). The contaminant concentrations were conservatively assumed to be uniformly distributed throughout the vadose zone, and the Summers Model was used to calculate the contaminant concentrations in groundwater immediately under the site based on soil infiltration rates and groundwater flow rates. The groundwater protection preliminary remediation goals are applicable to soils at all depths in the vadose zone because it is assumed that contaminants can potentially leach from any soil depth to the groundwater.

2.5.4 Summary

The most restrictive preliminary remediation goal is used to determine if remedial action is required at a given exposure zone. For example, human health and protection of groundwater preliminary remediation goals (and human health in lieu of ecological) are all applicable to the 0 to 1 m (0 to 3 ft) exposure zone. Therefore, soils within the 0 to 1 m (0 to 3 ft) strata will be remediated to meet the most restrictive of these preliminary remediation goals. With this approach, the remedial action will meet all of the remediation goals for humans, animals and plants, and groundwater. If the most restrictive preliminary remediation goal for a particular contaminant is lower than the known background concentration or the analytical detection limit, then the background or detection limit becomes the remediation goal. This will preclude trying to remediate concentrations in soils to levels less than natural background, or to levels lower than can be reliably and consistently measured. Appendix A provides more details regarding the development and use of the preliminary remediation goals.

2.6 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section consists of a review of potential federal and state ARARs that may be pertinent to remedial activities. The ARARs development process is based on CERCLA guidance (EPA 1988a, 1988c). Identification of ARARs is directly impacted by characteristics of the site, contaminants present, and Remedial Alternatives developed; therefore, only specific sections of the regulations may be an ARAR. The identification of ARARs will be refined following identification of a preferred alternative.

Section 121(d) of CERCLA, as amended, establishes cleanup standards for remedial actions. This section requires 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 hazardous substance, pollutant, or contaminant remaining on site. A requirement promulgated under other environmental laws may be either "applicable" or "relevant and appropriate," but not both. Identification of ARARs must be done on a site-specific basis and involves a two-part analysis: first, a determination is made whether a given requirement is applicable; then, if it is not applicable, a determination is made whether it is nevertheless both relevant and appropriate. The EPA guidance also includes to-be-considered (TBC) materials that are advisories and nonpromulgated guidance issued by federal or state governments that are nonstatutory requirements evaluated along with ARARs as part of the risk assessment used to establish protective cleanup limits.

The EPA may waive ARARs and select a remedial action that does not attain the same level of cleanup as identified by ARARs. Section 121(d)(4) of CERCLA identifies six circumstances in which 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 by using 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.

The different types of requirements that CERCLA actions may have to comply with are identified as chemical-specific, location-specific, and action-specific ARARS. The following definitions are excerpts from EPA guidance in *CERCLA Compliance with Other*

Laws Manual: Interim Final (EPA 1988c). However, some requirements may not fall neatly into the classification system.

Chemical-specific requirements are usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These numbers establish the acceptable amount or concentration of a chemical that can be found in, or discharged to the ambient environment.

Location-specific requirements are restrictions placed on the concentration of hazardous substances or the conduct of activities because they occur in special or sensitive locations or environments.

Action-specific requirements are those that place either technology-based or activity-based requirements on remedial actions at CERCLA sites.

Federal and state regulations along with other guidance were evaluated as potential ARARs and TBC materials. Tables C-1 through C-3 present the potential list of laws and regulations that were evaluated as potentially ARARs for remedial activities. The following discussion of ARARs focuses only on the most significant potential ARARs.

2.6.1 Chemical-Specific ARARs

Chemical-specific ARARs may be federal or state statutory or regulatory requirements and other guidance that identify acceptable health- or risk-based contaminant levels for different media known to be contaminated.

2.6.1.1 Federal Chemical-Specific ARARs.

***Resource Conservation and Recovery Act* - Title 42 USC 6901 et seq**

The *Resource Conservation and Recovery Act* (RCRA) regulates the generation, transportation, storage, treatment, and disposal of hazardous waste. This law also provides authority for the cleanup of spills and environmental releases of hazardous waste to the environment because of past practices. Hazardous waste management regulations promulgated pursuant to RCRA are codified at 40 CFR 260 through 270. The regulations include chemical-specific standards for the designation of hazardous wastes, as well as standards for treatment of these wastes before disposal. Washington State Dangerous Waste Regulations implement the federal hazardous waste regulations and are administered by Ecology. Requirements established under RCRA are applicable because remediation activities may generate hazardous waste.

National Primary and Secondary Ambient Air Quality Standards - 40 CFR 50

National primary and secondary ambient air quality standards were established pursuant to the *Clean Air Act* to protect air quality and maintain public health. The EPA has promulgated national primary air quality standards for six criteria pollutants: sulfur oxides, particulate matter, carbon monoxide, ozone, nitrogen dioxide, and lead. The requirements of this standard are applicable because potential airborne emission of particulates or lead may result during remedial activities. Under the *Clean Air Act*, states are required to develop State Implementation Plans that outline how the state will implement, maintain, and enforce the national ambient air quality standards (NAAQS). Upon EPA approval, State plans become enforceable, and state requirements may become federal requirements.

National Emission Standards for Hazardous Air Pollutants - 40 CFR 61

The *Clean Air Act* directs the EPA to develop and periodically revise a list of National Emission Standards for Hazardous Air Pollutants (NESHAPs). Hazardous air pollutants are air contaminants that affect human welfare for which no ambient air quality standard exists. The NESHAPs are promulgated for emissions from specific sources, and only the NESHAPs established for radionuclide emissions from DOE facilities are applicable to remedial activities. Subpart H of 40 CFR 61 (National Emission Standards for Emissions of Radionuclides Other than Radon From Department of Energy Facilities) sets emissions limits from the entire facility (Hanford Site) to ambient air concentrations that would 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 on one contiguous site.

Standards for Protection Against Radiation - 10 CFR 20

The NRC Standards for Protection Against Radiation found in 10 CFR 20 are relevant and appropriate to the remedial activities because the regulation establishes standards for protection against radiation hazards that may result from occupational exposure or discharges to air and water. The standard is not applicable because it only applies to operations licensed by the NRC.

These regulations establish standards for protection against radiation hazards at facilities licensed by the NRC. Facilities must limit occupational dose to the following:

- An annual limit, which is the more limiting of (1) a total effective dose of 5 rem and (2) the total dose to any organ or tissue, other than the eye, equal to 50 rem

- The annual limits to the lens of the eye, to the skin, and to the extremities, which are (1) an eye dose equivalent of 15 rem and (2) a shallow-dose equivalent of 50 rem to the skin or to any extremity.

Derived air concentration (DAC) and annual limit on intake (ALI) values, presented in Table 1 of Appendix B of 10 CFR 20, were calculated based upon the occupational dose limits described above. The regulation also describes how to add external and internal doses to calculate the total effective dose equivalent. Dose limits for minors are 10% of the annual dose limits specified for adult workers.

In addition, the licensee must conduct operations so that the total effective dose equivalent to individual members of the public may not exceed 0.1 rem/year. The dose in any unrestricted area from external sources may not exceed 0.002 rem/hr. The licensee must survey radiation levels in unrestricted areas and radioactive materials in effluent released to unrestricted areas to demonstrate compliance with the dose limits for individual members of the public. The licensee must show compliance with the annual dose limit by:

- Demonstrating by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed operation does not exceed the annual dose limit

- Demonstrating that (1) the annual average concentrations of radioactive material released in gaseous and liquid effluent do not exceed the values specified in Table 2 of Appendix B of 10 CFR 20 and (2) if an individual were continually present in an unrestricted area, the dose from external sources would not exceed 0.002 rem/hr and 0.05 rem/yr.

Radiation Protection of the Public and Environment - DOE Order 5400.5

Radiation protection and radioactive waste management requirements issued under the *Atomic Energy Act* are implemented at DOE facilities as DOE Orders. Under CERCLA these standards are TBC for remedial activities because they are not promulgated regulations. However, compliance with DOE Orders is required at the Hanford Site.

DOE Order 5400.5, "Radiation Protection of the Public and Environment," establishes the standards and requirements for radiation protection of the public and the environment at DOE and DOE contractor facilities. This DOE Order defines members of the public as persons not occupationally associated with the DOE facility or operations. However, this DOE Order is discussed because it presents exposure limits for airborne and liquid effluent that may be useful as comparisons to occupational limits. This DOE policy is to implement all legally applicable radiation protection standards, and to adopt or consider recommendations from authoritative organizations, such as the National Council on Radiation Protection and Measurements and the ICRP. This DOE policy also includes implementation of standards generally consistent with NRC for DOE facilities not subject to NRC regulation.

The DOE Order applies the "As Low As is Reasonably Achievable" (ALARA) process to radiation protection. The ALARA process is not a dose-based limit, but a feasibility limit, in that exposures should be as far below applicable limits as practical. The feasibility limit should account for social, economic, technical, and public policy considerations. As part of the ALARA process, DOE operations monitor routine and non-routine exposure and assess the dose to members of the public. The ALARA process includes procedures for evaluating alternative operations and other factors to reduce radiation exposures.

This DOE Order adopts radiation protection dose standards consistent with the 1977 ICRP guidance that has been adopted and implemented world wide by countries with nuclear programs. Dose limits presented in this DOE Order are expressed both in terms of effective dose equivalents (ICRP guidance) and dose equivalents to specific organs or whole body to be consistent with pre-1977 standards or public dose limits established by EPA for selected exposure pathways or sources.

The DOE primary standard for allowable effective dose equivalent to members of the public in a year is 0.1 rem. The DOE-Headquarters is to be notified if an annual public exposure in excess of 0.01 rem occurs or is anticipated to occur. This dose considers all exposure modes resulting from DOE activities. "Effective Dose Equivalent", developed by the ICRP, is calculated by the weighted summation of doses to various organs of the body. The 0.1 rem effective dose equivalent in a year is the sum of all exposures from external sources plus the committed effective dose equivalent from sources taken into the body during the year. The public dose limit does not include medical exposures, exposure resulting from consumer products, residual fallout from past nuclear accidents and weapons tests, or naturally occurring radiation sources.

The DOE Order 5400.5 identifies circumstances where supplemental limits or exceptions to the standards may be implemented. A temporary public dose limit higher than 0.1 rem, but not to exceed 0.5 rem for the year, may be approved from the DOE Operations office in coordination with its Program Office. Situations identified by DOE that may warrant use of a supplemental standard include situations where remedial action would pose a clear and present risk to workers or members of the public using reasonable measures to reduce or avoid the risk.

Exposure to members of the public to airborne emissions released to the atmosphere that result from DOE operations must not cause members of the public to receive in a year, an effective dose equivalent greater than 0.01 rem, the same dose limit established by EPA regulation 40 CFR 61, Subpart H authorized under the *Clean Air Act*. Compliance may be demonstrated using models specifically approved in accordance with 40 CFR 61 requirements, or may also be demonstrated through environmental measurements using EPA-approved methods.

The DOE Order also adopts 40 CFR 191 exposure limits that members of the public may receive as a direct result of DOE management and operation of a disposal facility for spent nuclear fuel, high level or transuranic radioactive wastes that are not regulated by the NRC. The dose resulting from management of these wastes must not cause members of the public to receive, in a year, a dose equivalent greater than 0.025 rem to the whole body, or a committed dose equivalent greater than 0.075 rem to any organ.

Drinking water systems operated by DOE must meet the level of protection defined in 40 CFR 141, National Interim Primary Drinking Water Standards for community drinking water systems. The standard requires that community drinking water systems must not cause an effective dose equivalent greater than 0.004 rem in a year, the combined activity levels for radium-226 and radium-228 must not exceed 5 pCi/L, and gross alpha activity must not exceed 15 pCi/L.

The DOE Order presents derived concentration guides (DCG) for conducting radiological environmental monitoring programs at DOE facilities. The DCGs are presented for three exposure modes: ingestion of water, inhalation of air, and immersion in a gaseous cloud. The DCGs are not designed as occupational intake limits. The DCGs for internal exposure are based on a committed effective dose equivalent of 0.1 rem/year for radionuclides taken into the body through ingestion or inhalation. The DCGs may be used for evaluating compliance to the drinking water limit of 0.004 rem/year by using 4% of the DCG for ingestion. The exposure conditions used for development of the ingestion and inhalation DCGs are presented with the DCGs in table format.

Radiological protection requirements are also established for residual radioactive material and cleanup of residual materials. The basic public dose limit is 0.1 rem effective dose equivalent per year in excess of naturally occurring background. Additional guidelines for residual radioactive material in soils for radium and thorium are set at the levels issued under 40 CFR 192.

The proposed DOE rule, Radiation Protection of the Public and the Environment (10 CFR 834), published in the March 23, 1993 Federal Register (58 FR 16268), promulgates the standards presently found in DOE Order 5400.5. The proposed rule retains the substantive portions of the DOE Order and differs from the existing DOE Order in format, enhanced emphasis on the ALARA process, and changes in the usage of DCGs. 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. 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.

2.6.1.2 State of Washington Chemical-Specific ARARs. CERCLA 121(d) requires that, in addition to satisfying federal ARARs, any state standard, requirement, criterion, or limitation that is more stringent must also be met. State requirements must be legally enforceable regulations or statutes, identified in a timely manner, and be of general applicability to all circumstances covered by the requirement.

***Model Toxics Control Act* Cleanup Regulation - WAC 173-340**

Regulations under Chapter 173-340 WAC, which implement requirements of the *Model Toxics Control Act* (MTCA), establish the administrative processes and standards to identify, investigate, and cleanup facilities where hazardous substances have been released. These regulations are applicable to remedial activities undertaken in the operable units.

The MTCA regulations under WAC 173-340-700 establish three basic methods for determining cleanup levels. These include Method A - Tables, Method B - standard method, and Method C - Conditional method. Groundwater cleanup standards are presented in WAC 173-340-720, and soil cleanup standards are presented in WAC 173-340-740 and WAC 173-340-745. The MTCA regulations specify procedures for establishing levels that are protective of human health and the environment based on reasonable maximum exposure assuming either a residential site use (WAC 173-340-720 for groundwater and WAC 173-340-740 for soil) or industrial site use (WAC 173-340-745 for soil cleanup). Sections 720 and 740 establish standards under all three methods, and Section 745 uses only Methods A and C.

By definition (WAC 173-340-200), radionuclides are hazardous substances under MTCA, and are considered Group A (known human) carcinogens by EPA (56FR33050). However, Methods B and C equations are designed to provide cleanup levels for non-radioactive contaminants, not radionuclides.

Method A is generally used for routine cleanups with relatively few contaminants. Method A values come from tables in the MTCA rule, ARAR values (these do not include values established under WAC 173-360-720, -740, or -745 unless specifically listed in the tables), practical quantitation limits, and natural background. Standards for Method A cleanups are established based on other federal or state ARARs, including those developed:

- At a 1 x 10^{-6} risk-level, based on residential site use in WAC 173-340-720, -740
- At a 1 x 10^{-5} risk level, based on industrial site use in WAC 173-340-745
- Based on natural background concentrations
- Based on practical quantification limits (PQL).

Method B is the standard method for determining cleanup levels and assumes a residential site use. Method B levels are determined using federal or state ARARs or are based on risk equations specified in WAC 173-340-720, and -740. For individual carcinogens, the cleanup levels are based on the upper bound of the excess lifetime cancer risk of one in one million (1 x 10^{-6}). Total excess cancer risk under Method B for multiple substances and pathways cannot exceed one in one hundred thousand (1 x 10^{-5}).

Method C cleanup levels are used where Method A or B cleanup levels are below area background concentrations; cleanup to Method A or B levels has the potential for creating greater overall threat to human health and the environment than Method C; cleanup to Method A or B is not technically possible; or the site meets the definition of an industrial site. The requirements for qualification as a Method C site are specified in WAC 173-340-720, -740, and -745. Method C cleanups must comply with other federal or state ARARs, must use all practical levels of treatment, and must incorporate institutional controls as specified in WAC 173-340-706(1). Total excess cancer risk for Method C cannot exceed 1 in 100,000 (1 x 10^{-5}).

All three MTCA methods for determining cleanup levels require minimum compliance with other federal or state ARARs, and consideration of cross-media contamination.

Dangerous Waste Regulations - WAC 173-303

The Washington State Dangerous Waste Regulations implement the federal Hazardous Waste Regulations promulgated pursuant to RCRA. The regulation establishes requirements for generation, storage, treatment, and disposal of dangerous waste. Section WAC 173-303-070 establishes procedures and methods to determine if solid waste requires management as dangerous waste. These requirements are considered applicable as chemical-specific ARARs to wastes generated from remedial activities. Sections WAC 173-303-081 (Discarded Chemical Products), -082 (Dangerous Waste Sources), -090 (Dangerous Waste Characteristics), and -100 (Dangerous Waste Criteria) identify classes of dangerous wastes.

Section WAC 173-303-110 (Sampling and Testing Methods) identifies, by reference, standards for sampling and testing wastes for designation purposes.

State Radiation Protection Standards - Ch. 70.98 RCW

Washington State Radiation Standards (Ch. 70.98 RCW) were developed pursuant to the *Atomic Energy Act of 1954* and are implemented in WAC 246-220 through WAC 246-255. The WAC 246-221, Radiation Protection Standards is applicable because it establishes the maximum allowable radiation dose to individuals in restricted areas, exposure to minors and permissible levels of radiation from external sources in unrestricted areas. The occupational dose limit for adults, excluding planned special exposures, shall not exceed an annual limit of a total effective dose equivalent equal to 5 rem, or the sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye should not exceed 50 rem. An eye dose equivalent of 15 rem is set for exposure to the eye. The shallow dose equivalent for the skin or any extremities is 50 rem. Occupational dose limits for minors are set at 10% of the annual occupational dose limits for adults.

The standard identifies the methods required to demonstrate compliance and provides derived air concentration (DAC) and annual limit on intake (ALI) values that may be used to determine an individual's occupational dose limits. Dose limits that individual members of public may receive in unrestricted areas or from radioactive effluent are not to cause an individual continually present in an unrestricted area, to receive from external sources, more than 0.002 rem in an hour or 0.50 rem in a year. Chapter 246-221 also establishes concentration limits in effluent released to unrestricted areas. The WAC 246-247, Radiation Protection-Air Emissions, promulgates air emission limits for airborne radionuclide emissions at the same levels as defined in WAC 173-480, which are consistent with federal NESHAPs. The ambient standard requires that emission of radionuclides to the air must not cause a dose equivalent of 25 mrem/year to the whole body or 75 mrem/year to any critical organ.

2.6.2 Location-Specific ARARs

Location-specific ARARs are restrictions placed on the conduct of activities and location of remedial activities.

2.6.2.1 Federal Location-Specific ARARs.

The *National Historic Preservation Act of 1966* - 16 USC 470 et seq.

The *National Historic Preservation Act* requires that historically significant properties be protected. The Act requires that impacts posed to property listed on or eligible for inclusion on the National Register of Historic Places must be evaluated. The National Register of Historic Places is a list of sites, buildings, or other resources identified as significant to United States history. If facilities within the operable units are determined to be of historical significance, this Act is applicable.

The *Archeological and Historic Preservation Act* - 16 USC 469a

This Act is similar to the National Historic Preservation Act but differs in that it mandates only protection of historic or archaeologic data and not the actual archaeologic or historical site. If activities in connection with any federal project or federally approved project may cause irreparable loss to significant scientific, prehistorical, or archeological data, the Act requires that the agency responsible for the project preserve the data. This Act requires that actions conducted at a waste site must not cause the loss of any archeological and historic data. There are known and potential archeological sites in the 100 Area. This Act is, therefore, applicable.

The *Endangered Species Act* - 16 USC 1531

The *Endangered Species Act of 1973* establishes requirements to protect species threatened by extinction and habitats important to their survival. The *Endangered Species Act* is designed as a means for the conservation of flora and fauna that are threatened with extinction. Endangered species are identified under the Act as species that are in danger of extinction throughout all or a significant portion of their range. Threatened species are identified as species that are anticipated to be in danger of extinction within the foreseeable future. The Endangered Species Act provides for the designation of critical habitat, defined as "specific areas within the geographical area occupied by the (endangered or threatened) species ... on which are found those physical or biological features essential to the conservation of the species..." This Act is applicable because some threatened and endangered species are residents or seasonal visitors with the 100 Area.

Floodplain/Wetlands Environmental Review Requirements 10 CFR 1022

This regulation requires DOE and other federal agencies to comply with the requirements of Executive Order 11990 - Protection of Wetlands, and Executive Order 11988 - Floodplain Management. Executive Order 11988 requires DOE procedures to ensure that any action conducted in a floodplain shall consider alternatives to avoid adverse effects in the floodplains. Executive Order 11990 requires protection of wetlands from destruction. This regulation requires federal agencies to implement these considerations through existing federal standards, such as the *National Environmental Policy Act*. The U.S. Army Corp of Engineers has established a nationwide permitting program for actions that impact wetlands. Under CERCLA, onsite actions are not required to comply with administrative permit requirements of federal, state and local regulations; however, CERCLA actions must comply with substantive portions of the regulations. There are wetlands within the 100 Area operable units. The substantive requirements of these Orders are, therefore, relevant and appropriate.

2.6.2.2 State Location-Specific ARARs.

***Department of Game State Environmental Policy Act* Procedures - WAC 232-012**

The regulations include the State of Washington Department of Fish and Wildlife procedures for compliance with the *Washington State Environmental Policy Act* (SEPA). The

Act requires that management plans be developed if threatened, endangered, or sensitive wildlife or habitat are affected by remedial actions at the site. Even though the majority of these requirements are administrative in nature, remedial activities are required to meet the substantive aspects of the regulation and to adhere to the goals of protecting and enhancing wildlife resources. Since state-listed threatened and endangered species have been identified in the 100 Area, this Act is applicable. The Washington State Department of Fish and Wildlife will be consulted to determine management policies and any mitigation that may be necessary to minimize ecological impacts.

2.6.3 Action-Specific ARARs

Action-specific ARARs will be refined once general response actions have been formulated and alternative formulation and screening have been completed.

2.6.3.1 Federal Action-Specific ARARs

***Resource Conservation and Recovery Act*, as amended - Title 42 USC 6901**

The *Resource Conservation and Recovery Act* (RCRA) regulates the generation, transportation, storage, treatment, and disposal of hazardous waste. Washington State Dangerous Waste Regulations implement the federal hazardous waste regulations and provide for regulation of state-designated dangerous waste. On November 23, 1987, Ecology was given authorization by EPA to regulate the dangerous/hazardous component of mixed waste within the state.

Substantive sections of the RCRA regulations are applicable because remedial activities may generate dangerous/hazardous wastes. Land disposal restrictions (LDR), outlined in 40 CFR 268, identify hazardous wastes that are restricted from land disposal and defines those limited circumstances under which an otherwise prohibited waste may continue to be land disposed. These circumstances include treatment standards based on waste concentrations, waste extract concentrations, technology-based standards, or variances based on technical feasibility.

Radiation Protection for Occupational Workers - DOE Order 5480.11

DOE Order 5480.11, "Radiation Protection for Occupational Workers," establishes radiation protection requirements for worker protection from ionizing radiation at DOE and DOE contractor operations. These standards are TBC under CERCLA because they are not promulgated standards. However, compliance with DOE Orders is required at the Hanford Site. DOE policy is to implement all radiation protection requirements that are consistent with EPA guidance or based on the recommendations of authoritative organizations such as the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP). The DOE policy states that DOE operations are to be conducted so that radiation exposures are within the limits established by this Order and as far below the limits set in this Order as reasonably achievable. The DOE adheres to the ALARA policy on radiation exposure. The ALARA policy represents a process for monitoring and evaluating work practices so that radiation exposure is reduced to levels as far below the acceptable dose as socially, technically, and economically feasible.

Radiation protection standards for internal and external exposure for occupational workers are expressed in terms of stochastic and nonstochastic effects. Stochastic effects are effects such as malignancy or hereditary diseases that have a probability of occurring as a function of dose and that have no threshold dose for radiation protection purposes. Nonstochastic effects are effects for which the severity of the effect is related to the dose received and for which a threshold dose may exist. The exposure to workers as a result of DOE operations shall not result in exposure in excess of the limits established under this Order. The exposure limit for stochastic effects resulting from internal and external sources of exposure to any occupational worker must not exceed 5 rem/year. The annual dose equivalent received by an occupational worker for non-stochastic effects to individual organs and tissue is 15 rem to the lens of the eye, and 50 rem to any other organ, tissue (including skin of the whole body), or extremity of the body.

The maximum annual dose equivalent established for the protection of the unborn child (from conception to birth) as a result of occupational exposure is 0.5 rem. The employee is responsible for providing written notification of the pregnancy to their employer. Individuals under the age of 18 are not to be employed in or allowed to enter controlled areas if they will exceed an effective dose equivalent of 0.1 rem/year resulting from the sum of the committed effective dose equivalent from internal exposure and the annual effective dose equivalent from external exposure. This same exposure limit also applies to students and is considered as part of the minor's occupational exposure.

The DOE Order establishes annual dose limits for members of the public entering controlled areas at 0.1 rem effective dose equivalent per year. The effective dose equivalent includes the committed internal exposure and the effective dose equivalent external exposure.

Procedural requirements for calculating and evaluating the combined internal and external dose equivalents are provided in the Order. The methodology for calculating dose differentiates external dose to skin and extremities from the dose to external whole body exposures. Methods for calculating non-uniform exposures to skin are based on the surface area of the exposed skin. The Order also presents air and water concentration guides. Derived air concentration (DAC) values for radiation exposure control in the workplace were developed from ICRP publications and converted to units of rem and curie. The DAC values are for use in monitoring radiation control and are not to be used in the calculation of internal dose equivalent received by a worker. The DOE maintains a policy that drinking water in controlled areas is to meet EPA 40 CFR 141 drinking water standards.

Monitoring of occupational workers is required to demonstrate compliance with the radiation protection standards and under normal circumstances not to calculate the annual effective dose equivalent received from internal and external sources of radiation. Methods used for personnel dosimetry must be effective for monitoring compliance, and be performed using equipment that can be periodically calibrated and is maintained by an accredited laboratory. Ambient air monitoring is to be performed in any workplace where the potential to exceed 10% of the DAC is anticipated. Air samples are to be representative of locations where airborne contaminant concentrations are expected to be elevated. The results of ambient air monitoring are to be used in assessing radiation control practices and are not for use in evaluating the annual effective dose equivalent to workers.

The DOE Order outlines the requirements for release of equipment and materials from controlled to uncontrolled areas and general practices for facility design. Areas within DOE facilities are to be posted if radioactive materials are present in sufficient quantity to cause a worker to receive a dose equivalent greater than 5 mrem, but less than 100 mrem in one hour at 30 cm. Areas are to be posted as "high radiation areas" if the dose equivalent received in 1 hr at 30 cm exceeds 100 mrem but is less than 5 rem, and posted as a "very high radiation area" if the dose received in 1 hr at 30 cm exceeds 5 rem. Access to any area where airborne radioactive material concentration is greater than 10% of the DAC is to be posted. Entry and exit points from all radiological areas are to be controlled and equipped with visual or audio alarm systems. Records of employee training and exposure are to be maintained. Specific levels of training are required dependent on job function.

Radioactive Waste Management - DOE Order 5820.2A

This Order specifies the policies, guidelines, and minimum requirements for DOE management of radioactive and mixed waste at contaminated facilities. These standards are TBC under CERCLA because they are not promulgated standards. However, compliance with DOE Orders is required at the Hanford Site. Chapter III of DOE Order 5820.2A requires that low-level waste management practices limit external exposure to radioactive material released to the environment to levels that will not result in an effective dose equivalent to any member of the public in excess of 25 mrem/yr and that any air release meet the emission limits specified in 40 CFR 61. The DOE Order also specifies radiation exposure be limited to ALARA.

Guidelines for low-level waste management require that wastes are to be accurately characterized to allow proper management, and be tracked using a manifest system. Specific requirements are to be developed for the shipment and receipt of waste between the generator and treatment, storage, or disposal facilities.

***Clean Water Act* 33 U.S.C. 1251, et. seq.**

The *Clean Water Act* (CWA) was enacted to restore and maintain the chemical, physical and biological integrity of the nation's waters. This objective is achieved through the control of discharges of pollutants to navigable waters. The CWA has distinct regulatory features that include site-specific pollutant limitations and performance standards that are applied primarily for protection of surface water (e.g., regulating point and nonpoint source discharges to surface water). Unlike the RCRA program, the CWA does not have specific technology design and operating requirements that can be linked to specific remedial technologies. It does, however, have effluent limitations and guidelines and standards supported by technological bases for specified industrial categories, that may be relevant and appropriate to remedial activities.

***Clean Air Act of 1977*, as amended - Title 42 USC 4201 et seq.**

The *Clean Air Act* regulates emission of hazardous pollutants to the air. Requirements established under this Act are implemented by federal, state, and local regulations. Pursuant to the *Clean Air Act*, the EPA has promulgated National Ambient Air Quality Standards (40 CFR 50), National Emission Standards for Hazardous Air Pollutants (40 CFR 61), and New Source Review Standards (NSRS) (40 CFR 60). The National Ambient Air Quality Standards are applicable to airborne releases of radionuclides and criteria pollutants specified under the standard. Specific release limits for particulates are set at 50 $\mu g/m^3$ annually or 150 $\mu g/m^3$ per 24-hour period.

Subpart H of the National Emission Standards for Hazardous Air Pollutants (NESHAP) for emissions of radionuclides other than radon from DOE facilities are applicable to remedial activities because the potential to release radionuclides in air emission to unrestricted areas exists. The Subpart H emission limits to ambient air from the entire facility (Hanford Site) are 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 includes all buildings, structures, and operations on one contiguous site. Radionuclide emissions from remedial activities are required to be monitored and an effective dose equivalent value to members of the public calculated.

The *Clean Air Act* requires that states regulate emissions from existing sources for specific designated contaminants. New Source Performance Standards are considered relevant and appropriate because criteria established under this regulation may be used to evaluate remedial activities' impacts on air quality.

2.6.3.2 State Action-Specific ARARs. The most significant Washington State laws and regulations considered to be potential action-specific ARARs are discussed in the following section.

Dangerous Waste Regulations - WAC 173-303

The Washington State Dangerous Waste Regulations (WAC 173-303) implement the federal hazardous waste regulations for generation, treatment, storage, and disposal of dangerous waste. These regulations are applicable because the remedial activities may generate dangerous wastes.

The state land disposal restriction program contains requirements applicable to the disposal of dangerous waste regulated under WAC 173-303. WAC 173-303-140 contains a ban on the disposal of extremely hazardous waste in the State of Washington. However, Revised Code of Washington 70.105050, effective July 26, 1987, allows the disposal of radioactive mixed waste at units owned by the U.S. Department of Energy if "all reasonable methods of treatment, detoxification, neutralization, or other waste management methodologies designed to mitigate hazards associated with these wastes (are) employed, as required by applicable federal and state laws and regulations.) The WAC 173-303-140 also contains requirements to treat the following categories of dangerous waste accordingly before land disposal: liquid waste; organic/carbonaceous waste; solid acid waste. As is the case for compliance with the federal land disposal restriction program, generators of waste are responsible for assuring that dangerous wastes are treated according to this section before shipment to land disposal.

Model Toxics Control Act **- WAC 173-340**

The *Model Toxics Control Act* (MTCA) Cleanup Regulations established under WAC 173-340 are potentially applicable to remedial activities. This regulation establishes cleanup requirements that are protective of human health and the environment, and the methods necessary to achieve these goals. The MTCA has statutory preference for permanent solutions that minimize the quantity of hazardous contaminants remaining on-site. The hierarchy of preference for remediation favors destruction and treatment over disposal, containment and institutional controls. WAC 173-340-400 outlines specific requirements that ensure cleanup actions are designed, constructed, and implemented in a manner consistent with accepted engineering practices. Compliance monitoring requirements are specified in WAC 173-340-400, and requirements for institutional controls are specified in WAC 173-340-440.

Washington Clean Air Act **- Ch. 70.94 and Ch. 43.21A RCW**

The *Washington Clean Air Act* was enacted to comply with the federal Clean Air Act, as amended. The intent of the *Clean Air Act* is to ensure the protection of public health and the air resources of the state. The General Regulations for Air Pollution Sources (WAC 173-400) define the policies and authority of Ecology to control air pollution from air contaminant sources. The regulation is applicable to remedial activities because it establishes both technical and procedural standards for the control of air contaminant sources. Emission limits are established for visibility, particulates, fugitive odor, and hazardous air emissions. WAC 173-400-040 establishes standards for maximum emissions for source units identified under the regulation. The standard is relevant and appropriate because it establishes emission limits and requires that all emission units use reasonably available control technology, which for some source categories may be more stringent than the emission limitations listed.

Emission Standards for Sources Emitting Hazardous Air Pollutants are established in WAC 173-400-075. Requirements of this standard are applicable because remedial activities could result in the emission of hazardous air pollutants. The regulation requires monitoring, source testing, and the use of specific analytical methods for determining hazardous air pollutant emissions. The WAC 173-400-115, Standards of Performance for New Sources, adopts and incorporates CFR 60 as standards of performance for new sources. The regulation may be considered relevant and appropriate because it establishes review criteria that may be used to evaluate remedial activity impacts on air quality.

Requirements of WAC 173-480 are applicable to remedial activities. The Ambient Air Quality Standards and Emission Limits for Radionuclides specifies that the maximum allowable level for radionuclides in the ambient air shall not cause a maximum accumulated dose equivalent of 25 mrem/yr to the whole body, or 75 mrem/yr to any critical organ. The standard also states that the more stringent of any federal or state standard for the control of radionuclides supersedes the standards of WAC 173-480. The regulation also defines monitoring and compliance procedures, and defines enforcement authority to Ecology and local air pollution control authorities.

2.7 REFINED CONTAMINANTS OF POTENTIAL CONCERN

The contaminants of potential concern for the 100 Area source operable units were identified during the qualitative risk assessment/limited field investigation process, based on the 100-BC-1, 100-HR-1, and 100-DR-1 operable units (see Section 2.1 and Table 2.1 in this Process Document). In this Process Document, these contaminants of potential concern are compared to the preliminary remediation goals identified in Section 2.5 to determine which of the potential contaminants must actually be addressed by remedial actions. Those contaminants of potential concern that exceed the preliminary remediation goals, and therefore must be remediated, are referred to as the refined contaminants of potential concern. For the purposes of this Process Document, the refined contaminants of potential concern are identified for each of the waste groups (e.g., retention basins, process effluent trenches). Refined contaminants of potential concern for a waste group are those constituents that exceed preliminary remediation goal in the majority (at least half) of the sites where data was collected. The refined contaminants of potential concern for selected waste site groups are shown in Table 2-4. Waste site groups are discussed further in Section 3.0 of this document.

Table 2-1. Contaminants of Potential Concern for Soil and Solid Waste Sites (100 Area Source Operable Units).

Radionuclides	Inorganics	Organics
Americium-241	Antimony	Aroclor 1260 (PCB)
Carbon-14	Arsenic	Benzo(a)pyrene
Cesium-134	Barium	Chrysene
Cesium-137	Cadmium	Pentachlorophenol
Cobalt-60	Chromium VI	
Europium-152	Lead	
Europium-154	Manganese	
Europium-155	Mercury	
Nickel-63	Zinc	
Plutonium-238		
Plutonium-239/240		
Potassium-40		
Radium-226		
Sodium-22		
Strontium-90		
Technetium-99		
Thorium-228		
Thorium-232		
Tritium		
Uranium-233/234		
Uranium-235		
Uranium-238		

PCB = polychlorinated biphenyl

Table 2-2. Comparison of Human Health-based Preliminary Remediation Goals for Radionuclides with Soil Concentrations that Would Result in Exceedance of 1 rad/day to the Great Basin Pocket Mouse.

Soil Contaminant	Human Health PRG TR = 1 x 10^{-6} (pCi/g soil)	Soil Conc. Needed to Exceed 1 rad/day from External Dose (pCi/g soil)[a,c]	Soil Conc. Needed to Exceed 1 rad/day from Internal Dose (pCi/g soil)[b,c]
Americium-241	76.9	70,000	11,000,000
Carbon-14	44,200	no dose	350,000
Cesium-134	3,460	13,000	130,000
Cobalt-60	17.5	8,000	450,000
Europium-152	5.96	17,000	400,000,000
Europium-154	10.6	16,000	23,000,000,000
Europium-155	3,080	33,000	12,000,000,000
Nickel-63	184,000	no dose	6,500,000
Plutonium-238	87.9	13,000,000	1,600,000
Plutonium-239	72.8	9,000,000	1,700,000
Radium-226	1.1	no dose	2,700
Strontium-90	1,930	no dose	148
Technetium-99	28,900	no dose	400
Thorium-228	7,260	6,500,000	no dose
Thorium-232	162	12,000,000	no dose
Tritium	2,900,000	no dose	4,300,000

PRG = preliminary remediation goal
TR = target risk (in this case, 1 x 10^{-6} incremental cancer risk, using an occasional use scenario and accounting for radioactive decay to 2018).
[a]Calculated using external dose equation (Eq. E-6) in Appendix E of DOE-RL (1995).
[b]Calculated using internal dose equation (Eq. E-1), and assumptions listed in Table E-1; Appendix E of DOE-RL (1995)
[c]Exposure assumptions are that the 23.5 g mouse is underground for 24 hours and consumes 6.7 grams stored food during that period

Table 2-3. Comparison of Preliminary Remediation Goals Protective of Human Health, Ecological Receptors, and Groundwater Resources.

	HUMAN-HSRAM (b)		ECOLOGICAL (a)		PROTECTION OF GROUNDWATER (c)	BACKGROUND (d,e)	CRQL/CRDL(f) or as noted
	TR=1E-06	HQ=0.1	Mouse(g)	Plant(h)			
INORGANICS (mg/kg)							
Antimony	N/A	167	3	5	0.002	N/C	6
Arsenic	16.2	125	20	10	0.01	9	3(e)
Barium	N/A	29,200	90	500	300	175	2.7(e)
Cadmium	1,360	417	4	2	0.8	N/D	0.5
Chromium VI	200	2,086	1000	2	0.03	28	3(e)
Lead	N/C		200	50	8	14.9	1.1(e)
Manganese	N/A	2,086	40	500	10	583	1.8(e)
Mercury	N/A	125	0.3	0.3	0.3	1.3	0.16(e)
Zinc	N/A	100,000(k)	30	20	800	79	15.6(e)
ORGANICS (mg/kg)							
Aroclor 1260 (PCB)	4.34	N/A	20	40	1	0	0.464(e)
Benzo(a)pyrene	N/A	N/A	1	20	6	0	0.980(e)
Chrysene	N/A	N/A	NC	NC	0.01	0	0.980(e)
Pentachlorophenol	N/A	N/A	200	NCV	0.3	0	2.4(e)

N/A = not applicable; N/C = not calculated; TR = target risk; HQ = hazard quotient
CRDL = contract required detection limit
CRQL = contract required quantitation
HSBRDM = *Hanford Site Baseline Risk Assessment Methodology* (DOE-RL 1995)
(a)Risk-based numbers are expressed to one significant figure, consistent with EPA guidance.
(b)Occasional use (Recreational) Scenario
(c)Based on Summer's Model (EPA 1989b) as outlined in this Process Document.
(d)Status Report; Hanford Site Background; Evaluation of Existing Soil Radionuclide Data
(e)Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes, DOE/RL-92-24, Rev. 2.
(f)Based on 100-BC-5 OU Work Plan QAPjP (DOE-RL 1992c)
(g)Based on equations in Appendix A, assuming ingestion of contaminated plants by the pocket mouse.
(h)Soil concentrations considered to be phytotoxic (Suter, Will, and Evans 1993)

Table 2-4. Refined Contaminants of Potential Concern for the 100 Area Source Operable Units.

Contaminants of Concern	100 Area Waste Site Group							
	RETENTION BASINS	SLUDGE TRENCHES	FUEL STORAGE BASIN TRENCHES	PROCESS EFFLUENT TRENCHES	PLUTO CRIBS	DUMMY DECONTAMINATION CRIBS/FRENCH-DRAINS	PIPELINES	BURIAL GROUNDS
Radionuclides								
^{14}C	X	X						X
^{137}Cs	X	X	X	X		X	X	X
^{60}Co	X	X				X	X	X
^{152}Eu	X	X	X	X		X	X	X
^{154}Eu	X	X				X	X	X
^{155}Eu							X	
^{3}H								X
^{63}Ni							X	X
^{238}Pu	X	X					X	
$^{239/240}Pu$	X	X	X	X		X	X	
^{226}Ra			X		X			
^{90}Sr	X	X					X	X
^{228}Th	X	X						
Inorganics								
Arsenic	X	X						
Cadmium	X	X	X					X
Chromium VI	X	X	X	X				
Lead	X	X	X					X
Mercury								X

X: indicates presence of this contaminant at each waste site

3.0 WASTE SITE GROUPS AND SITE RESOURCES

As previously discussed in Section 1.4 of this document, the 100 Area contains multiple waste sites (sources). Sections 3.1 and 3.2 identify these waste sites and provide the information to assemble these sites into groups consistent with the analogous site approach described in Section 3.2. The waste site groups are based on similar characteristics, such as physical structure, function, and impacted media. Similarities and differences between the sites within each group are then evaluated and compared to develop a group profile that is representative of the associated waste sites. The group profiles form the basis for the subsequent development of interim remedial measure alternatives applicable to each site group in Section 4.0.

Section 3.3 provides Hanford Site background information and 100 Area specific information regarding geological, hydrological, meteorological, ecological, cultural, and visual resources associated with these waste sites. Discussions are also included regarding Hanford Site recreation, noise, socioeconomics, employment, economics, transportation, health care, police and fire protection, and utilities. These existing site resources provide the basis to assess potential impacts to resources regarding remedial measure alternative development. These impacts are discussed in Section 5.2.

3.1 GROUP DESCRIPTIONS

This Process Document addresses the waste site groups identified in Figure 1-4, except for the septic systems and special use burial grounds. These groups are not included because they are not represented by any current interim remedial measure candidate sites in the 100 Area. Retention basins, outfall structures, and pipelines represent those sites that transferred the contaminated reactor effluent for ultimate disposal to process effluent trenches or to the Columbia River. Trenches, cribs, and french drains are those sites that were used for the ultimate disposal of contaminated liquid wastes. Solid waste burial grounds and decontamination and decommissioning (D&D) sites are the contaminated solid waste sites discussed in this Process Document. Each group is described below.

3.1.1 Retention Basins

The 100 Area retention basins are rectangular concrete or circular steel structures that were used to retain cooling water effluent from the reactor for radioactive decay and thermal cooling before discharge to the river. Some of the basins were baffled to provide separate compartments. Initially, effluent was directed to only one side of the basin at a time allowing effluent contaminated by ruptured fuel elements to be diverted to other disposal facilities such as cribs and trenches. However, different temperatures between the basin halves resulted in cracks and leakage. This leakage and increased production rates forced simultaneous use of the retention basin compartments. After the reactors final shutdown, some of the retention basins were demolished and buried in-place. The basins have also been used as disposal places for contaminated piping and other demolition materials.

3.1.2 Outfall Structure

Outfall structures are compartmentalized boxes that were used to direct the liquid effluent from the retention basin to the river pipelines for discharge to the middle of the Columbia River. These structures were constructed of reinforced concrete with concrete or rip-rap spillways (spillways were used only in case of overflow). Most of the outfalls have been demolished to near-grade level and backfilled. The outfall structures have not been decontaminated or cleaned out in a manner similar to the D&D facilities; therefore, some contamination may still exist at the sites. Effluent was usually discharged via the outfall and river pipelines; however, effluent discharges sometimes overflowed the outfall structure and exceeded the capacity of the spillways resulting in overflow to surrounding soils.

Although the outfall structures were originally on the interim remedial measure pathway, they have been recently designated for an expedited response action. The *100 Area River Effluent Pipelines Expedited Response Action Proposal* (DOE-RL 1994a) indicates that the 100 Area outfall structures will be addressed concurrently with the river pipelines (Section 4.1.3). The outfall structures are therefore removed from the interim remedial measure pathway and are not addressed further in this Process Document. Should the expedited response action not be able to effectively address the outfall structures, the outfalls will return to the interim remedial measure pathway.

3.1.3 Effluent Pipelines

Effluent pipelines connect the reactors to the retention basins, the retention basins to the outfall structures, and the outfall structures to the discharge point in the middle of the Columbia River. The 100 Area has approximately 18,900 m (62,000 ft) of effluent pipeline ranging in size from 0.3 to 2.1 m (12 to 84 in.) in diameter (Adams et al. 1984). The pipelines were constructed of carbon steel, reinforced concrete, or vitreous tile. The pipelines include manholes, junction boxes, tie-lines between parallel legs, and valves. Most of the on-land pipelines are buried, although a portion of the effluent line in the 100-F Area is above ground.

This Process Document addresses only those pipelines connecting the reactor to the retention basin and from the retention basin to the outfall structures (on-land pipelines). The sections of pipeline that extend to the middle of the Columbia River from the outfall structures (river pipelines) are being addressed as an expedited response action. An engineering evaluation and cost assessment for addressing the river pipelines has been performed and is documented in *100 Area River Effluent Pipelines Expedited Response Action Proposal* (DOE-RL 1994a).

There are some pipeline leaks mainly at the junction boxes of the steel and concrete lines and the rubber joints of the tile lines (Dorian and Richards 1978). Effluent line contamination is primarily in these leakage areas and in the accumulated sludge in the pipes. Leakage area contamination is valid only if pipeline leakage is documented by data indicating soil contamination. Otherwise, only the pipeline and associated sludges are considered as the contaminated media.

3.1.4 Trenches

Trenches are unlined, open excavations that were used to dispose of contaminated liquids and sludges into the soil. Trenches used for disposal activities are described below:

- Sludge trenches - used to dispose of highly contaminated sludge that had accumulated on the floor of the retention basins.

- Fuel storage basin trenches - used only once to dispose of discharged shielding water from the fuel storage basin due to excessive levels of contamination.

- Process effluent trenches - used to dispose of highly contaminated cooling water that was diverted from the retention basins.

3.1.5 Cribs/French Drains

Cribs and french drains are in-ground structures filled with porous material used to dispose of liquid waste. Cribs are generally rock-filled buried structures. The first cribs in the 100 Area were usually open-bottomed and constructed of wooden timbers. The cribs generally range in area from 9.3 to 18.6 m^2 (100 to 200 ft^2). French drains are generally gravel-filled, and constructed of steel, concrete, or vitreous clay pipe. They are 0.9 to 1.2 m (3 to 4 ft) in diameter and range from 0.9 to 6.1 m (3 to 20 ft) deep. Cribs and french drains are similar because they are small, have similar structures and disposal volumes, and were used frequently. The crib/french drain sites are divided into the following four groups based on associated waste streams.

- Pluto cribs - received highly contaminated waste from reactor cooling water that was flushed directly from process tubes affected by fuel cladding failures.

- Dummy decontamination crib/french drains - received waste from laboratory or reactor equipment decontamination procedures, such as dummy fuel elements.

- Seal pit cribs - received condensate waste from the reactor filter building operations.

- Special cribs - received site-specific waste stream for a special facility or project. These sites require individual analyses and no group profile was developed.

3.1.6 Solid Waste Burial Grounds

Solid waste burial grounds used by the reactor facilities included trenches, pits, vertical pipes, and/or vault-like structures. The smallest burial ground is only a few feet wide and a few feet long; the largest burial ground is about 6.1 m (20 ft) deep, 91 m (300 ft) long, and 2.4 m (8 ft) wide (at the bottom). The deep narrow trenches contained large contaminated equipment; the pits and pipes contained small, contaminated reactor hardware, such as thermocouple stringers and horizontal control rod tips. A typical burial trench consists of layers of hard waste (metal components such as irradiated process tubes and fuel charge spacers) and soft waste (contaminated paper, plastic, and clothing). Hard waste was usually placed in the bottom of the trench. Soft waste consists of more than 75% of the contamination in the trenches, but contains <1% of the radioactive inventory (Adams et al. 1984). Miller and Wahlen (1987) estimated the total radionuclide inventory from reactor operations for these burial grounds to be about 4,000 curies, mostly from cobalt-60 and nickel-63. Inorganic wastes include boron, cadmium, graphite, lead, lead-cadmium alloy, and mercury.

3.1.7 Decontaminated and Decommissioned Facilities

As soon as the reactor operation was shut down, DOE began a D&D program of buildings and facilities to reduce the potential spread of radioactive contamination from the reactors. Most of the contaminated buildings and facilities were demolished and buried in place, disposed of in the clearwells associated with the water treatment facility (clean material only), or taken to the 200 Area for burial. Uncontaminated wooden buildings and equipment were salvaged, and some uncontaminated buildings were converted to storage facilities. New buildings were constructed on demolished building locations.

Decontamination and decommissioning activities included removing or fixing smearable contamination and sampling to determine residual contamination levels. The residual contamination is compared to allowable residual contamination levels (a method used to determine if the level of residual contamination is within release limits). The method to determine the allowable residual contamination levels is documented in Kennedy and Napier (1983). This analysis determines whether radioactively contaminated sites require further decontamination or remedial action before the site is "released." For a site to obtain an unrestricted release status, total radiation must be 10 mrem/yr or lower (Department of Health 1994). A number of these facilities have been cleaned up and released.

3.2 GROUP PROFILES

Based on the data from the 100-BC-1, 100-DR-1, 100-HR-1, and Source Operable Unit Limited Field Investigation (DOE-RL 1993c, DOE-RL 1993d, and DOE-RL 1993b), and the refined contaminants of potential concern discussed in Section 2.6, a profile for each waste site group has been developed. The 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units are considered adequately representative of the 100 Area waste sites; therefore, the interim remedial measure candidate sites from these operable units are used to define the group profiles. Site-specific deviations from these profiles will be identified and addressed in each operable unit-specific FFS document to ensure that characteristics not represented by the group profile defined here are given adequate consideration.

The group profile consists of waste site characteristics, such as the type of contaminated media/material, the extent of contamination, maximum concentrations of the refined contaminants of potential concern, and an assessment of whether soil concentrations are protective of groundwater under a reduced infiltration scenario. The profiles perform two functions: (1) they establish a baseline to determine appropriate Remedial Alternatives for the waste site group (i.e., the presence of contaminants such as organics that require special treatment enhancements) and (2) they function as a data base to determine costs and durations of remedial activities (i.e., generally the volume of contaminated material increases the cost of disposal and duration of excavation). The profile parameters are defined below. General group characteristics are detailed in Table 3-1.

3.2.1 Extent of Contamination/Selection of Representative Waste Site

The extent of contamination evaluation consists of estimating contaminated material, volume, length, width, area, and thickness. The values for these parameters are based on a comparison of all interim remedial measure candidate sites within a group. The extent of contamination from the site with the greatest amount of contamination is chosen to represent the extent of contamination for the group. Volume, length, width, and area do not necessarily influence the determination of appropriate Remedial Alternatives; however, they are important considerations for development of remedial action durations and costs. By using the site with the greatest amount of contamination, the cost and duration of the remedial action represents a worst-case scenario for the group. In addition, site-specific costs and durations are determined in each operable unit-specific FFS. Furthermore, thickness of the contaminated lens impacts the implementability of in situ actions, such as vitrification, which has a limited vertical extent of influence.

3.2.2 Contaminated Media/Material

Contaminated media and material are defined by any media and material present at any interim remedial measure candidate site within a group. Structural materials, such as steel, concrete, and wooden timbers influence the applicability of Remedial Alternatives, as well as equipment needed for actions such as removal. The presence of soils and sludges is necessary to implement treatment options such as soil washing. Presence of solid waste media influences material handling considerations and may require Remedial Alternatives, which vary from waste sites that have only contaminated soil.

3.2.3 Refined Contaminants of Potential Concern/Maximum Concentrations

Refined contaminants of potential concern for each site were selected by comparing the maximum concentrations detected at the site with the preliminary remediation goals. Contaminants with concentrations that exceeded the preliminary remediation goals were selected as refined contaminants of potential concern. Contaminant concentrations present in soil at a depth of 1 m (3 ft) or less were compared with preliminary remediation goals intended to protect human health. Human health preliminary remediation goals are based on achieving an incremental cancer risk of 1×10^{-6} or a noncancer hazard quotient of 0.1, based on occasional land use assumptions. As discussed in Section 2.5.2, these human health preliminary remediation goals are also considered to be protective of ecological receptors (plants and terrestrial organisms). Therefore, contaminant concentrations present in soil down to a depth of 3 m (10 ft) were also compared with the preliminary remediation goals intended to protect human health. Finally, contaminant concentrations present in soil at depths greater than 3 m (10 ft) were compared with preliminary remediation goals intended to protect groundwater. Groundwater preliminary remediation goals were based on achieving Maximum Contaminant Levels or Derived Concentration Guides in groundwater; the concentrations in soil corresponding to these levels in groundwater were calculated using the Summers Model. The assumptions and methods used to calculate these preliminary remediation goals are presented in Appendix A.

The refined contaminants of potential concern are used to estimate the volume of contaminated soil that requires remediation to protect human health and the environment. Refined contaminants of potential concern may also influence the applicability of specific Remedial Alternatives. For example, if the refined contaminants of concern at the site are limited just to radionuclides with short half-lives, the institutional control alternative would be applicable. Finally, the refined contaminants of concern may also determine if an enhancement is appropriate for the waste site. For example, if organic contaminants are present, thermal desorption should be considered.

3.2.4 Reduced Infiltration Concentration

The reduced infiltration concentration is the level that is considered protective of groundwater under a scenario where hydraulic infiltration is limited by applying a surface barrier. The source of this concentration is documented in Appendix A. The maximum concentration detected is compared to the allowable reduced infiltration concentration. Impact to groundwater will not be mitigated by Containment Alternatives for waste sites where concentrations of constituents in soil exceed the reduced infiltration concentrations.

3.2.5 Analogous Site Concept

In addition to being the basis for the detailed and comparative analysis performed in this Process Document (and in subsequent operable unit-specific reports) and in facilitating the use of the plug-in approach, developing a group profile helps implement the analogous site approach. The analogous site approach allows conditions from a site or sites with data, to be assumed for sites without data as long as the sites are analogous (i.e., within the same group). This minimizes the amount of site-specific investigations required to define waste site characteristics. The group profiles presented herein can serve as a basis to develop site-specific conditions addressed in each operable unit specific FFS. For the site-specific evaluation, the following methodology is used when assessing data from analogous waste sites:

- Contaminants:
  - Assume contaminant types (radionuclides, inorganic, or organics) are the same for all sites within a group unless site-specific data indicates otherwise
  - If a site has no contaminant data, use contaminant inventory (specific constituents) from the group profile.

- Extent of contamination:
  - Determine extent of contamination based only on site-specific data when available
  - If no contaminated data are available, use group profile data to assume extent of contamination.

The following sections discuss the profile for each waste site group. The specific elements of each profile are presented in Table 3-1.

3.2.6 Waste Site Group Representatives

Representative waste sites were selected within each waste site group from the 100-HR-1, 100-DR-1, and 100-BC-1 Operable Units to serve as examples to determine physical size, contaminants of concern, contaminated media, and other pertinent information. Specific waste sites that were used as representatives of a waste site group are presented below.

Waste Site Groups and Profile Examples

Waste Site Group	Waste Site Representing the Group
Retention Basins	116-DR-9
Sludge Trenches	107-D #2
Fuel Storage Basin Trenches	116-D-1A
Process Effluent Trenches	116-C-1
Pluto Cribs	116-D-2A
Dummy Decontamination Cribs/French Drains	116-B-4
Seal Pit Cribs	not applicable
Pipelines*	100-B/C pipelines
Burial Grounds	118-D-4A
Decontaminated and Decommissioned Facilities	not applicable

*Table 3-1 indicates that plutonium-239/240 exceeds the reduced infiltration concentration. This exceedance is invalid because the waste containing this contaminant is in the sludge within the pipeline and is assumed to be immobile.

Table 3-1 provides specific waste sites information for the waste site groups. All waste site groups are represented except for the seal pit cribs and the decontaminated and decommissioned facilities.

None of the seal pit cribs identifies as interim remedial measure candidates have contaminants with concentrations that exceed preliminary remediation goals. As a result, there is no contaminated volume for the seal pit cribs; thus, no representative site was selected and no profile parameters were defined.

Because of the decontamination and decommissioning process and the decontamination and decommissioning release methodology discussed in Section 3.1.7, it is assumed that sites that have been subject to decontamination and decommissioning pose no threat warranting an interim action. Therefore, no representative decontamination and decommissioning site has been selected and no profile parameters are defined. Site-specific reports for all sites that have undergone decontamination and decommissioning are available. These reports document the decontamination and decommissioning activities and substantiate the release of the sites under the allowable residual contamination levels methodology.

The estimated amount of contamination for each site is documented in the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Unit FFSs that are found in Appendices E, F, and G, respectively. Representative costs and durations for remediation actions at each waste site group are based on the physical dimensions; they are presented in detail in the 100-BC-1 and 100-DR-1 Operable Unit FFSs (Appendices F and G).

3.3 RESOURCES

The following sections provide Hanford Site wide information and 100 Area specific information regarding geological, hydrological, meteorological, cultural, ecological and visual resources. Discussions are also included regarding Hanford Site recreation, noise levels, socioeconomics, employment, economics, transportation, health care, police and fire protection, and utilities.

3.3.1 Geology

3.3.1.1 Hanford Site. The Hanford Site is situated in the Pasco Basin, a sediment-filled basin on the Columbia Plateau. The sediments of the Pasco Basin are underlain by the Miocene-age Columbia River Basalt Group, a thick sequence of flood basalts that cover a large area in eastern Washington, western Idaho, and northeastern Oregon. The sediments overlying the basalts, from oldest to youngest, include the Miocene-Pliocene Ringold Formation, local alluvial deposits of possible late Pliocene or probable early Pleistocene age, local early "Palouse" soil of mostly eolian origin derived from either the reworked Pleistocene unit or upper Ringold material, glaciofluvial deposits of the Pleistocene Hanford Formation, and surficial Holocene eolian and fluvial sediments.

3.3.1.2 100 Area. The 100 Area is spread out along the Columbia River in the northern portion of the Pasco Basin. All of the 100 Area, except the 100-B/C Area, lies on the north limb of the Wahluke syncline. The 100-B/C Area lies over the axis of the syncline (WHC 1993b). The top of the basalt in the 100 Area ranges in elevation from 46 m (150 ft) near the 100-H Area to -64 m (210 ft) below sea level near the 100-B/C Area.

The Ringold Formation shows a marked west-to-east variation in the 100 Area. The main channel of the ancestral Columbia River flowed along the front of Umtanum Ridge and through the 100-B/C and 100-K areas, before turning south to flow along the front of Gable Mountain and/or through the Gable Mountain-Gable Butte gap, leaving relatively thin deposits of sand and gravel in the 100-B/C and 100-K Areas. In the 100 Area, the Hanford formation consists primarily of Pasco Gravels facies, with local occurrences of the sand-dominated or slackwater facies (Cushing 1994).

Soils. The predominant soil types in this area are Burbank loamy sand (34%), Ephrata sandy loam (23%), Ephrata stony loam (23%), and Quincy sand (17%). Other soil types include Pasco silt loam, Kiona silt loam, and river wash (Hajek 1966).

3.3.2 Hydrology

3.3.2.1 Surface Water. Surface water at the Hanford Site includes the Columbia River (northern and eastern sections), Columbia Riverbank springs, springs on Rattlesnake Mountain, onsite ponds, and offsite water systems directly east and across the Columbia River from the Hanford Site. In addition, the Yakima River flows along a short section of the southern boundary of the Site (Cushing 1994).

Columbia River. The Columbia River is the second largest river in North America and the dominant surface-water body on the Hanford Site. The existence of the Hanford Site has precluded development of this section of river for irrigation and power, and the Hanford Reach is now being considered for designation as a National Wild and Scenic River as a result of congressional action in 1988 (Cushing 1994).

The primary uses of the Columbia River include the production of hydroelectric power, extensive irrigation in the Mid-Columbia Basin, and as a transportation corridor for barges. Several communities located on the Columbia River rely on the river as their source of drinking water. Water from the Columbia River along the Hanford Reach is also used as a source of drinking water by several onsite facilities and for industrial uses (Dirkes 1993). In addition, the Columbia River is used extensively for recreation, including fishing, hunting, boating, sailboarding, waterskiing, diving, and swimming (Cushing 1994).

Yakima River. The Yakima River borders a small length of the southern portion of the Hanford Site. Approximately one-third of the Hanford Site is drained by the Yakima River System (Cushing 1994).

Springs and Streams. Rattlesnake and Snively springs, located on the western part of the Hanford Site, form small surface streams. Rattlesnake Springs flows for about 3 km (1.6 mi.) before disappearing into the ground. Cold Creek and its tributary, Dry Creek, are ephemeral streams within the Yakima River drainage system along the southern portion of the Hanford Site. These streams drain areas to the west of the Hanford Site and cross, infiltrates rapidly and disappears into the surface sediments in the western part of the Hanford Site (Cushing 1994).

Columbia Riverbank Springs. The seepage of groundwater, or springs, into the Columbia River has been known to occur for many years. Riverbank spring discharges were documented along the Hanford Reach long before Hanford operations began during the second world war (Jenkins 1922). Riverbank springs are monitored for radionuclides at 100-N, the old Hanford townsite, and the 300 Area. These relatively small springs flow intermittently, apparently influenced primarily by changes in river level. Hanford-origin contaminants have been documented in these groundwater discharges along the Hanford Reach (Dirkes 1990; DOE 1992; McCormack and Carlile 1984; Peterson and Johnson 1992).

Flooding. Columbia River floods have occurred in the past (DOE 1987), but the likelihood of recurrence of large-scale flooding has been reduced by the construction of several flood-control/water-storage dams upstream of the Hanford Site. Major floods on the Columbia River typically result from rapid melting of the winter snowpack over a wide area augmented by above-normal precipitation. The probability of flooding at the magnitude of the 1894 and 1948 floods has been greatly reduced because of upstream regulation by dams.

There are no Federal Emergency Management Agency floodplain maps for the Hanford Reach of the Columbia River. Federal Emergency Management Agency only maps developing areas, and the Hanford Reach is specifically excluded (Cushing 1994).

Onsite Ponds. Currently, there are two onsite ponds at the Hanford Site. West Lake is located north of the 200 East Area, and is recharged from groundwater (Gephardt et al. 1976). The Fast Flux Test Facility Pond is located near the 400 Area, and was excavated in 1978 for the disposal of cooling and sanitary water from various facilities in the 400 Area (Cushing 1994). The ponds are not accessible to the public and do not constitute a direct offsite environmental impact. Periodic sampling provides an independent check on effluent control and monitoring systems (Woodruff et al. 1993).

3.3.2.2 Groundwater.

Hanford Site Aquifer Systems. The unconfined aquifer at the Hanford Site is referred to as the upper or suprabasalt aquifer system because portions of the upper aquifer system are locally confined or semiconfined. However, because the entire suprabasalt aquifer system is interconnected on a sitewide scale, it will be called the Hanford unconfined aquifer for the purpose of this report. Aquifers located within the Columbia River Basalts are referred to as the confined aquifer system (Cushing 1994).

Confined Aquifer System. Confined aquifers within the Columbia River Basalts are within relatively permeable sedimentary interbeds and the more porous tops and bottoms of basalt flows. Hydraulic-head information indicates that groundwater in the confined aquifers flows generally toward the Columbia River and, in some places, toward areas of enhanced vertical flow communication with the unconfined system (Bauer et al. 1985; Spane 1987; DOE 1988).

Unconfined Aquifer. Groundwater in the unconfined aquifer at the Hanford Site generally flows from recharge areas in the elevated region near the western boundary of the Hanford Site toward the Columbia River on the eastern and northern boundaries. The

Columbia River is the primary discharge area for the unconfined aquifer. Natural areal recharge from precipitation across the entire Hanford Site is thought to range from almost 0 to 10 cm (0 to 4 in.) per year, but is probably less than 2.5 cm (1 in.) per year (Gee and Heller 1985; Bauer and Vaccaro 1990). Since 1944, the artificial recharge from Hanford Site wastewater disposal operations has been significantly greater than the natural recharge. An estimated 1.68 by 10^{12} L (4.4 by 10^{11} gallons) of liquid was discharged to disposal ponds, trenches, and cribs (Cushing 1994).

3.3.2.3 Columbia River Water Quality. Washington State has classified the stretch of the Columbia River from Grand Coulee to the Washington-Oregon border, which includes the Hanford Reach, as Class A, Excellent (Ecology 1992). Class A waters are suitable for essentially all uses, including raw drinking water, recreation, and wildlife habitat.

Radiological monitoring indicate low levels of tritium, strontium, iodine-129, iodine-131, uranium, and cobalt-60 that were below concentration guidelines established by DOE and the EPA drinking water standards (PNL 1990). Nonradiological water quality parameters measured during 1989 were similar to those reported in previous years and were within Washington State Water Quality Standards (PNL 1990).

3.3.3 Meteorology

The Hanford Site is located in a semiarid region of southeastern Washington State. The Cascade Mountains, beyond Yakima to the west, greatly influence the climate of the Hanford area by means of their "rain shadow" effect; this mountain range also serves as a source of cold air drainage, which has a considerable effect on the wind regime on the Hanford Site (Cushing 1994). Climatological data are available for the Hanford Meteorological Station, which is located between the 200 East and 200 West areas.

Temperature. Ranges of daily maximum and minimum temperatures vary from normal highs to 2°C (36°F) in early January to 35°C (95°F) in late July. The record maximum temperature is 45°C (113°F) and the record minimum temperature is -31°C (-24°F) for the years 1912 through 1980.

Humidity. Relative humidity/dew point temperature measurements are made at the Hanford Meteorological Station and at the three 60 m (200 ft) towers located in the 300, 400, and 100-N areas. The annual average relative humidity at the Hanford Meteorological Station is 54%. It is highest during the winter months, averaging about 75%, and lowest during the summer, averaging about 35% (Cushing 1994).

Wind. Wind data are collected at the Hanford Meteorological Station. 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 14 to 16 km/h (8 to 10 mi/h). 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). These winds are most prevalent over the northern portion of the Hanford Site (Cushing 1994).

Precipitation. Average annual precipitation at the Hanford Meteorological Station is 16 cm (6.3 in.). Most precipitation occurs during the winter with more than half of the annual amount occurring from November through February. Days with more than 1.3 cm (0.51 in.) precipitation occur less than 1% of the year. Rainfall intensities of 1.3 cm/h (0.51 in./h) persisting for 1 hour are expected only once every 500 years. Winter monthly average snowfall ranges from 0.8 cm (0.32 in.) in March to 14.5 cm (6 in.) in December. The Snowfall accounts for about 38% of all precipitation from December through February (Cushing 1994).

Air quality. Air quality near the Hanford Site is considered good because there are only a few industrial sources of air pollutants. The Benton-Franklin Counties Clean Air Authority routinely compiles emission inventories for permitted major sources of pollutants. In areas where the National Ambient Air Quality Standards have been achieved, the EPA has established the Prevention of Significant Deterioration program to protect existing ambient air quality. The Hanford Site operates under a Prevention of Significant Deterioration permit issued by the EPA in 1980. The permit provides specific limits for emissions of oxides of nitrogen from the Plutonium Uranium Extraction (PUREX) and Uranium Oxide (UO_3) plants (Cushing 1994).

3.3.4 Cultural Resources

The 100 Area is rich in cultural resources. Burials, prehistoric and historic archaeological sites, sacred and traditional cultural areas, and historic structures are all examples of cultural resources that must be considered in planning and implementing cleanup activities. Human burials are the category of cultural resource that pose the most serious concern. In the 100 Area, several historic Wanapum cemetery locations are known, some of which are near areas scheduled for remediation. Burial locations that predate the memories of Wanapum people, however, are not known. Because the Hanford Reach was occupied continuously over the last 10,000 years, one can expect to uncover burials anytime ground-disturbing activities occur within 400 m (1,300 ft) of the Columbia River's edge or on upland areas.

In addition to burial sites, cultural and archaeological sites representing major Indian villages, fishing camps, religious areas, and traditional use areas (e.g., areas where plants with subsistence, medicinal, and ceremonial value were collected) are commonly found along the Hanford Reach, especially between the 100-B/C Area and 100-F Area. These sites have special significance to the tribes, and are generally considered as sacred connections to the past, and important places to preserve for future tribal generations. As the last free flowing stretch of the Columbia River, cultural and archaeological sites located along the Hanford Reach are the only remaining sites above water in the entire Columbia River system. This fact adds additional significance to these sites both to the Native American community and to the scientific community, who value this information resource potential for learning about Columbia River human adaptive systems over the past 10,000 years.

There are also historic-archaeological sites related to historic Indian and non-Indian habitations (e.g., townsites, farmsteads) that are important in understanding the history of human occupation of the Hanford Site. These sites must also be considered during project planning. Finally, many of the structures comprising the Hanford Site itself are historic. Impacts on these structures must be considered as projects are developed and implemented.

For the Hanford Site 100 Area, most of the operable units have been surface surveyed for archeological resources. Approximately 140 sites have been found. Several have been found to be eligible for listing in the National Register; however, the vast majority have yet to be evaluated. These sites are known because surface evidence exists. We do not know where buried sites are located, and there are probably many. Buried sites pose problems because they are often not discovered until construction is underway, at which point work must stop while the find is evaluated, and mitigation, if required, is completed. The Operable Unit specific Focused Feasibility Studies (Appendices E, F, and G) describe the cultural and historic resources known to occur within the operable unit, and discuss mitigation measures that may be taken prior to and during remedial actions.

3.3.5 Ecology

3.3.5.1 Hanford Site. In 1968, the Atomic Energy Commission designated 311 km^2 (120 mi^2) of the Hanford Site as the Arid Lands Ecology Reserve. During the 1970s, about 130 km^2 (50.2 mi^2) north of the Columbia River were leased to the United States Fish and Wildlife Service for the Saddle Mountain National Wildlife Refuge, and about 200 km^2 (77.2 mi^2) north and east of the river were leased to the Washington Department of Wildlife for outdoor recreation. In 1977, the Hanford Site was designated as a National Environmental Research Park by the United States Energy Research and Development Administration.

The Hanford Site is one of the few large areas of land in the region that has not been developed for agricultural use. It is unique because the general public's use of the area is restricted and limited to projects associated with the nuclear industry. The area in which the Hanford Site is located is bounded on the north by the Saddle Mountains, on the east by the Columbia River, and on the south and west by the Yakima River and Rattlesnake Hills, respectively. The dominant topographical features of the Hanford Site include Rattlesnake Mountain, the Columbia River and associated aquatic habitats, unstabilized sand dunes near the Columbia River, Gable Mountain and Gable Butte that interrupt the rolling landscape of the Hanford Site, and the 200 Area Plateau.

The Columbia River is not only an important fishery resource, its many islands also serve as nesting grounds for Canadian Geese and other waterfowl. All the ponds and ditches except West Lake are unique to this area because they were created as a result of Hanford Site activities and attract many animal species, particularly birds, that would not usually be found here.

Vegetation. The Hanford Site has been classified primarily as a shrub-steppe grassland (Daubenmire 1970) composed of the following plant communities:

- Sagebrush/bluebunch wheatgrass
- Sagebrush/cheatgrass or sagebrush/Sandberg's bluegrass
- Sagebrush-bitterbrush/cheatgrass
- Greasewood/cheatgrass-saltgrass

- Winterfat/Sandberg's bluegrass
- Thyme buckwheat/Sandberg's bluegrass
- Cheatgrass-tumblemustard
- Willow or riparian
- Spiny hopsage
- Sand dunes.

Almost 600 species of plants have been identified at the Hanford Site (Sackschewsky et al. 1992). Dominant plants include big sagebrush, rabbitbrush, cheatgrass, tumbleweed, tumblemustard, and Sandberg's bluegrass. Cheatgrass and tumbleweed, introduced invader species, thrive at the many disturbed areas on the Hanford Site. Other important understory plants include Indian ricegrass, needle-and-thread grass, and sand dropseed.

The dryland areas of the Hanford Site were treeless in the years before land settlement. However, for several decades before 1943, trees were planted and irrigated on most of the farms to provide windbreaks and shade. Today those trees that still persist provide nesting sites for many species of passerines and raptors, and roosting sites for bald eagles.

Insects. More than 300 species of terrestrial and aquatic insects have been identified at the Hanford Site (ERDA 1975). Grasshoppers and darkling beetles are among the more conspicuous groups and, along with other species, are important as food for many wildlife species. Harvester ants are also very common and have been implicated in the uptake of radionuclides from waste sites as a result of mound building activities.

Reptiles and Amphibians. Twelve species of amphibians and reptiles are known to occur on the Hanford Site (Fitzner and Gray 1991). The side-blotched lizard is the most abundant reptile on site. Short-horned and sagebrush lizards are also common in selected habitats. The most common snakes are the gopher snake, yellow-bellied racer, and the western rattlesnake. Striped whipsnakes and desert night snakes are infrequently observed. A few species of toads and frogs are located near aquatic habitats.

Birds. Approximately 238 species of bird have been observed at the Hanford Site (Landeen et al. 1992). The most common passerine birds include starlings, horned larks, meadow larks, western kingbirds, rock doves, barn swallows, cliff swallows, black-billed magpies, and ravens. The horned lark and western meadowlark are the most common nesting birds. Game birds on the Hanford Site include the chukar, gray partridge, mourning dove, ring-necked pheasant, and California quail. Sage grouse have not been observed at the site since the mid-1980s and probably are no longer located on the Hanford Site.

In recent years, the number of nesting ferruginous hawks on site have increased because of their use of transmission lines as nesting sites. Other raptor species that nest onsite include the prairie falcon, northern harrier, American kestrel, Swainson's hawk, and the red-tailed hawk. Burrowing owls, great horned owls, long-eared owls, short-eared owls, and barn owls also nest at the site. Other raptor species that have been documented to utilize the Hanford Site during the winter months include snowy owls, gyrfalcons, merlins, and rough-legged hawks.

Mammals. Approximately 40 species of mammals have been identified at the Hanford Site (Downs et al. 1993). The largest mammals at the Hanford Site are the Rocky Mountain elk and mule deer. The Rocky Mountain elk are present on the Fitzner-Eberhardt Arid Land Ecology Reserve. They have grown in number from approximately 6 animals in 1972 to over 200 animals. Elk and deer do well on the Fitzner-Eberhardt Arid Land Ecology Reserve because of available forage with no competition from domestic livestock, easy access to drinking water, mild winters, the ability to accommodate extreme summer temperatures, and hunting is not allowed. Mule deer are found throughout the Hanford Site, but are more common to riparian sites along the Columbia River and the Fitzner-Eberhardt Arid Land Ecology Reserve.

Other mammal species common to the Hanford Site include badgers, coyotes, blacktail jackrabbits, ground squirrels, pocket mice, pocket gophers, and deer mice. Badgers are known for their digging capability and have been implicated several times for encroaching into inactive burial grounds in the 200 Area. Most of the badger excavation areas result from badgers searching for prey (mice and ground squirrels). Coyotes are the principal Hanford Site predators, consuming such prey as rodents, insects, rabbits, birds, snakes, and lizards.

The Great Basin pocket mouse is the most abundant small mammal, which thrives in sandy soils and lives entirely on seeds from native and revegetated plant species. Other small mammals include the Townsend ground squirrel, western harvest mouse, white-footed deer mouse, and the grasshopper mouse.

Mammals associated more closely with buildings and facilities include mountain cottontails, house mice, Norway rats, and some bat species. Seven species of bats have been observed at the Hanford Site. Mammals such as skunks, raccoons, weasels, porcupines and bobcats have been observed on a few occasions.

3.3.5.2 100 Area Ecology. The following sections (Sections 3.3.5.2.1 through 3.3.5.2.4) discuss the aquatic and terrestrial ecology associated with the 100 Area based on ecological information obtained from several Hanford Site publications. The Operable Unit specific Focused Feasibility Studies (Appendices E, F, and G) describe the ecological resources within the Operable Unit in more detail.

3.3.5.2.1 Terrestrial Ecology. For the most part the ecological information given for the Hanford Site is pertinent to the 100 Area with a few exceptions. Cheatgrass is very abundant because of the past perturbations that have occurred.

Flora. The plant communities within the 100 Area operable units have been broadly described as riparian, adjacent to the Columbia River, and as a cheatgrass community, away from the shoreline (Rogers and Rickard 1977). In a broad sense, this classification is correct, but finer delineations are possible.

The community changes that can occur over the relatively narrow riparian zone of the Columbia River are described in Fickeisen et al. (1980) and Brandt et al. (1993). Most of the remaining area within the 100 Area operable units, beyond this distance from the shore, consists of old agricultural fields dominated by cheatgrass and tumblemustard, with scattered abandoned orchards and a few remnant pockets of big sagebrush and gray rabbitbrush.

Vegetation around 100-B include stands of willow, white mulberries, elms, and juniper trees. Vegetation around 100-D includes a large stand of elm trees surrounded by cheatgrass, sand dropseed, and tumblemustard. Vegetation around 100-F is dominated by cheatgrass with some rabbitbrush and sagebrush. Vegetation in the 100-H Area includes two stands of black locust and several large giant wildrye plants. The shoreline at 100-H is dominated by reed canarygrass. The rest of the area at 100-H is covered by gray rabbitbrush and cheatgrass. Vegetation around 100-K is primarily cheatgrass with some stands of sagebrush and Sandberg's bluegrass.

Fauna. The insects, reptiles, birds, and mammals in the 100 Area are the same as those common to the Hanford Site, with a few exceptions. California quail and ring-necked pheasants are more likely to be found near the Columbia River, and several of the mammals are more likely to be present near water.

The most common mammals in the 100 Area include the mule deer, coyote, Great Basin pocket mouse, jackrabbit, and cottontail rabbit. Mule deer use the islands in the Columbia River as fawning sites. The Columbia River and its shoreline support populations of beaver, muskrat, raccoon, and striped skunk.

Common bird species that reside in the 100 Area include the Canadian goose, horned lark, white-crowned sparrow, common raven, western meadowlark, starling, rock dove, great blue heron, cliff swallow, bank swallows, and several species of gulls. Islands in the river provide nesting for ring billed gulls, California gulls and Forster's terns. Shoreline trees serve as nesting sites for colonies of great blue herons. The most common waterfowl species of this area is the Canadian goose, which nests on the islands of the Hanford Reach. Twenty-three other waterfowl species also use the Hanford Reach for resting and feeding.

3.3.5.2.2 Aquatic Ecology. The Columbia River is the dominant aquatic ecosystem and supports a large and diverse community of plankton, benthic invertebrates, fish and other communities. Phytoplankton (suspended algae) include diatoms, yellow-brown algae, green algae, blue-green algae, red algae, and dinoflagellates. Periphyton (attached algae) reside on substrates where there is sufficient light for photosynthesis. Macrophytes such as rushes and sedges are in slack water areas. Macrophytes (rooted aquatic vegetation) provide food and shelter for juvenile fish. Zooplankton populations are generally sparse. Benthic macroinvertebrates such as caddisflies and midges, are dominant. Other benthic organisms include limpets, snails, sponges, and crayfish.

Over 43 species of fish have been documented as located in the Columbia River. Native fish species of the Hanford Reach include chinook salmon, steelhead trout, mountain whitefish, white sturgeon, and the sandroller. Small numbers of other salmon, such as coho and sockeye, also use the Hanford Reach. Some of the nonnative resident fish of the Hanford Reach include the smallmouth bass, largemouth bass, and walleye.

3.3.5.2.3 Species of Concern. There are several species of plants and animals that have been designated as species of concern by the state and/or federal government that reside in the 100 Area. These designations may be as a state or federal threatened, endangered, candidate, monitor or sensitive species. The only two wildlife species that are listed as threatened or endangered by the federal government are the bald eagle and peregrine falcon. There are no plant species at the Hanford Site listed as threatened or endangered by the federal government. A discussion of the plant and animal species of concern in the 100 Area is included in the following sections.

Flora. There are 12 species on or near the Hanford Site that are listed by the Washington State Natural Heritage Program (1990) as endangered, threatened, or sensitive (Sackschewsky et. al. 1992). The two state-endangered and two state-threatened species on this list are also listed as candidates for federal protection under the *Endangered Species Act of 1973*. Of these 12 listed species, the Columbia or persistant sepal yellowcress (Rorippa colubiae) has been found at many locations along the shoreline of the Columbia River. It is usually found near the waterline and is submerged during periods of high water. It has been observed at the Hanford Townsite, Whitebluffs Ferry Landing, 100-D Area, 100-H Area, and 100-B Area (Sauer and Leder 1985).

Fauna. Several wildlife species have been classified as sensitive species by the state and/or federal government (see Table 3-2). The American bald eagle and the peregrine falcon are the only two wildlife species listed as threatened or endangered by the federal government located on the Hanford Site. The bald eagle resides along the Columbia River from November to March feeding on dead salmon and waterfowl. Many of the trees near the reactors along the Columbia River are used by the eagles for perching and roosting. Bald eagles have not been documented to nest at the Hanford Site; however, nest building activities by eagles has occurred infrequently. In each case, the eagles have abandoned these attempts and migrated north. Peregrine falcons use the Hanford Site as a possible resting area during their spring and fall migration. Peregrine falcons have been observed very infrequently at the Hanford Site and in the 100 Area.

Several bird species classified as species of concern (candidate, sensitive, or monitor) have been documented as located in the 100 Area. The most important and/or common of these species include the American white pelican, sandhill crane, ferruginous hawk, loggerhead shrike, Swainson's hawk, common loon, golden eagle, burrowing owl, sage sparrow, western grebe, great blue heron, black-crowned night-heron, osprey, prairie falcon, long-billed curlew, caspian tern, and Forster's tern (Stegen 1992).

3.3.5.2.4 Sensitive Environments or Critical Habitats. Sensitive habitats include unique habitats and those areas that are required by a species to maintain healthy breeding populations. Two habitat types are especially important relative to the 100 Area. They are the riparian zone along the Columbia River and those areas of undisturbed shrub-steppe habitat.

The riparian zones along the Columbia River are sensitive because they may contain (1) wetlands and associated plants of concern, (2) wintering bald eagle roosting and perching areas, (3) Columbia yellowcress, and (4) large numbers of shorebirds and waterfowl. Some of the birds of concern include the American white pelican, great blue heron, sandhill crane, and black-crowned night-heron. Planted trees, which include Siberian elm, black locust, and white poplar, are used as nesting sites by northern orioles, robins, black-billed magpies, northern flicker, Swainson's hawks, red-tailed hawks, and great horned owls.

Undisturbed stands of shrub steppe habitat are especially important for such sensitive bird species as the loggerhead shrike, burrowing owl, and sage sparrow. Loggerhead shrikes and sage sparrows nest only in undisturbed sage steppe habitat (Poole 1992). These areas are also used as foraging sites by mammalian and avian predators. Shrub steppe habitat is classified as a priority habitat by the Washington Department of Wildlife (1991). Other habitats, such as sand dunes, could be classified as sensitive habitat because some of these sites harbor plant species of concern, such as the gray cryptantha.

State and federal wildlife refuges adjacent to the Hanford Site along the north side of the Columbia River are important areas for waterfowl and other wildlife as foraging and resting areas.

3.3.6 Recreation and Aesthetics

The convergence of the Columbia, Snake, and Yakima rivers offers the residents of the Tri-Cities a variety of recreational opportunities. The Lower Snake River Project provides boating, camping, and picnicking facilities in nearly a dozen different areas along the Snake River. The Columbia River also provides ample water recreational activities on the reservoirs formed by the dams upstream and downstream from the Hanford Reach. The Hanford Reach is a popular recreational sport fishing area. Anadromous salmonids represent the majority of the sport fish harvested. Other significant sport catches include white sturgeon (*Acipenser transmontanus*), smallmouth bass (*Micropterus dolomieui*), largemouth bass (*Micropterus salmoides*) and walleye (*Stizostedion vitreum*) (DOE-RL 1990a). Lake Wallula, formed by McNary Dam, offers a large variety of parks and activities, which attracted more than 3 million visitors in 1993 (Cushing 1994). Swimming and water skiing are popular recreational activities as well.

The Columbia Basin is a popular recreational hunting area, where deer, rabbits, waterfowl, and upland game birds are harvested. However, no hunting is allowed on the Hanford Site except within the Wahluke Slope Wildlife Area located north of the Columbia River.

3.3.6.1 Aesthetics and Visual Resources. Land on the Hanford Site is generally flat with little relief. Rattlesnake Mountain, rising to 1,060 m (3,478 ft) above mean sea level, forms the western boundary of the Hanford Site, and Gable Mountain and Gable Butte are the highest land forms on the Hanford Site. The Columbia River, flowing across the northern part of the site and forming the eastern boundary, and the spring-blooming desert flowers provide visual enjoyment to people. White Bluffs, the steep bluffs above the northern boundary of the river in this region, are a striking feature of the landscape (Cushing 1994).

3.3.7 Noise

Studies at the Hanford Site on the propagation of noise have been concerned primarily with occupational noise at work sites. Environmental noise levels have not been extensively evaluated because of the remoteness of most Hanford Site activities and isolation from receptors covered by federal or state statutes.

3.3.7.1 Background Noise Levels at the Hanford Site. Environmental noise measurements were made in 1981 during site characterization of the Skagit/Hanford Nuclear Power Plant Site (PSPL 1982). Fifteen sites were monitored and noise levels ranged from 30 to 60.5 dBA. The values for isolated areas ranged from 30 to 38.8 dBA. Measurements taken around the sites where the Washington State Supply System was constructing nuclear power plants (WNP-1, WNP-2, and WNP-4) ranged from 50.6 to 64 dBA. Measurements taken along the Columbia River near the intake structures for WNP-2 were 47.7 and 52.1 dBA compared to more remote river noise levels of 45.9 dBA (measured about 5 km [3 mi] upstream of the intake structures). Community noise levels in North Richland (3000 Area at Horn Rapids Road and the By-Pass Highway) were 60.5 dBA (Cushing 1994).

In addition, site characterization studies performed in 1987 included measurements of background environmental noise levels at five sites on the Hanford Site. Noise levels are expressed as equivalent sound levels for 24 hours (leq-24). Wind was identified as the primary contributor to background noise levels with winds exceeding 19 km/hr (12 mph) significantly affecting noise levels. Hanford Site background noise levels in undeveloped areas are described as a mean Leq-24 of 24 to 36 dBA. Periods of high wind, which normally occur in the spring, would elevate background noise levels (Cushing 1994).

3.3.7.2 Hanford Site Sound Levels. Most industrial facilities on the Hanford Site are located far enough away from the boundary that noise levels at the boundary are not measurable or are barely distinguishable from background noise levels. However, there is the potential for noise from field activities, such as well drilling activities involving operation of heavy equipment.

In the interest of protecting Hanford workers and complying with the Occupational Safety and Health Administration standards for noise in the workplace, the Hanford Environmental Health Foundation has monitored noise levels resulting from several routine operations performed at the Hanford Site. Occupational sources of noise propagated in the field are summarized in Cushing (1994).

3.3.8 Socioeconomic

The Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities (Richland, Pasco, and Kennewick) and other parts of Benton and Franklin counties. The agricultural community also has a significant effect on the local economy. Major changes in Hanford Site activity and employment would potentially affect the Tri-Cities and other areas of Benton and Franklin counties.

3.3.8.1 Employment and Income. Two major sectors are currently the principal driving forces of the economy in the Tri-Cities: (1) the DOE and its contractors, operating the Hanford Site; and (2) the agricultural community, including a substantial food-processing component. Most of the goods and services produced by these sectors are exported outside the Tri-Cities. In addition to the direct employment and payrolls, these major sectors also support a large number of jobs in the local economy through their procurement of equipment, supplies, and business services. In addition to the Hanford Site operations and agriculture, other major sources of income come from tourism and retired persons.

The unemployment rate fluctuates seasonally primarily because of the agricultural sector. The 1992 average unemployment for the Tri-Cities was 8.5%. Average unemployment in Benton and Franklin counties in 1992 was 7.6 and 11.9%, respectively. The unemployment rate in Franklin County was higher because of the larger agricultural sector (Washington State Department of Employment Security 1993).

3.3.8.2 Hanford and the Local and State Economy. In 1993, Hanford employment accounted directly for 25% of total nonagricultural employment in Benton and Franklin counties and slightly more than 0.6% of all nonagricultural statewide jobs. The total wage payroll for the Hanford Site was estimated at $740,557,781 in 1993, which accounted for an estimated 45% of the payroll dollars earned in the area (Cushing 1994).

Previous studies have revealed that each Hanford job supports about 1.2 additional jobs in the local service sector of Benton and Franklin counties (about 2.2 total jobs) and about 1.5 additional jobs in the Washington State's service sector (about 2.5 total jobs) (Scott et al. 1989). Similarly, each dollar of the Hanford Site income supports about 2.1 dollars of total local incomes and about 2.4 dollars of total statewide incomes. Based on these multipliers in Benton and Franklin counties, Hanford directly or indirectly accounts for more than 40% of all jobs (Cushing 1994).

3.3.8.3 Demography. Estimates for 1993 placed population totals for Benton and Franklin Counties at 122,800 and 41,100, respectively (U.S. Department of Commerce 1991). When compared to the 1990 census data in which Benton County had 112,560 residents and Franklin County's population totaled 37,473, the current population totals reflect the continued growth occurring in these two counties (8.3 and 8.8%, respectively). This growth reflects the steady increase occurring in eastern Washington population since 1987, with the rate of annual change climbing from 0.1 to 2.7% in 1993 (Cushing 1994).

Within each county, the 1993 estimates distribute the Tri-Cities population as follows: Richland 34,080; Kennewick 45,110; and Pasco 21,370. The combined population of Benton City, Prosser, and West Richland totaled 11,000 in 1990. The unincorporated population of Benton County was 32,610. In Franklin County, incorporated areas other than Pasco have a total population of 2,890. The unincorporated population of Franklin County was 16,840 (Cushing 1994).

3.3.8.4 Housing. In 1993, nearly 94% of all housing (of 40,344 total units) in the Tri-Cities was occupied. Single-unit housing, which represents nearly 58% of the total units, has a 97% occupancy rate throughout the Tri-Cities. Multiple-unit housing, defined as housing with two or more units, has an occupancy rate of 94%, a 3% increase since 1990. Pasco has the lowest occupancy rate, 92%, in all categories of housing; followed by Kennewick with 95%, and Richland with 96%. Representing 9% of the housing unit types, mobile homes have the lowest occupancy rate, 90% (Cushing 1994).

3.3.9 Transportation

3.3.9.1 Tri-Cities Area. The Tri-Cities serve as a regional transportation and distribution center with major air, land, and river connections. The Tri-Cities have direct rail service, provided by Burlington Northern and Union Pacific, that connects the area to more than 35 states. The Washington Central Railroad also serves eastern Washington. Union Pacific operates the largest fleet of refrigerated rail cars in the United States and is essential to food processors that ship frozen food from this area. Passenger rail service is provided by Amtrak, which has a station in Pasco (Cushing 1994).

Docking facilities at the Ports of Benton, Kennewick, and Pasco are important aspects of this region's infrastructure. These facilities are located on the 525 km (326 mi) long commercial waterway, which comprises the Snake and Columbia rivers, that extends from the Ports of Lewiston-Clarkston in Idaho to the deep-water ports of Portland, Oregon, and Vancouver, Washington. The average shipping time from the Tri-Cities to these deep-water ports by barge is 36 hours (Evergreen Community Development Association 1986).

Daily air passenger and freight services connect the area with most major cities through the Tri-Cities Airport located in Pasco. The airport is served by one national and two regional commuter airlines. There is a main runway and a minor crosswind runway. The main runway is 2,350 m (7,700 ft) long and 46 m (150 ft) wide, and can accommodate landings and takeoffs by medium-range commercial aircraft, such as the Boeing 727-200 and Douglas DC-9. The Tri-Cities Airport handled about 160,844 passengers in 1991, an increase of approximately 6% from 1990. Projections indicate that the recently expanded terminal can serve almost 300,000 passengers annually. The Richland and Kennewick airports serve only private aircraft.

The Tri-Cities are linked to the region by five major highways. Route 395 joins the area with Spokane to the northeast. Routes 395 and 240, which cross through the Hanford Site, connect with Interstate 90 to the north. Route 12 links the region with Yakima to the northwest, with Lewiston, Idaho to the east, and Walla Walla to the southeast. The area is also linked to Interstate 84 to the south, via Interstate 82 and Route 14. Interstate 82 also connects the area to the Yakima Valley and Interstate 90 in Ellensberg. Routes 240 and 24 traverse the Hanford Site and are maintained by Washington State.

3.3.9.2 Hanford Site. The Hanford Site railroad system extends from the west side of Richland, Washington throughout the Hanford Site. The DOE controls the rail access into the Hanford Site; the agency rail system ties in with the Union Pacific Railroad southeast of the Richland "Y" area near the U.S. Highway 12 and Route 240 interchange. Burlington Northern and Union Pacific have priority rights over the DOE rail system between the Richland "Y" area and the DOE 1100 Area. The DOE tracks serving the Hanford Site are installed parallel to the Route 240 bypass around the Richland, Washington urban area (DOE 1986).

The Hanford Site Road System includes 607 km (377 mi) of asphalt-paved road. Most of the Hanford Site roads were constructed in the 1940s as part of the Manhattan Project and subsequently did not meet current design criteria for lane width, shoulder width and slope, horizontal and vertical alignment, and drainage provisions. From 1981 to date, numerous projects have been completed to reconstruct portions of the road system to current design standards and correct traffic safety problems (DOE-RL 1989).

3.3.9.3 100 Area. Area roads are those roads that provide access within the individual areas on the Hanford Site. Paved surfaces for parking and walkways are included as part of the area road category. There are roughly 196 km (122 mi) of road and 836,000 m^2 (1,000,000 yd^2) of paved surfaces within the combined areas. There are an estimated 19 km (12 mi) of paved roads in the 100 Area (DOE-RL 1989).

3.3.10 Health Care and Human Services

The Tri-Cities have three major hospitals and five minor emergency centers. All three hospitals offer general medical services and include a 24-hour emergency room, basic surgical services, intensive care, and neonatal care (Cushing 1994).

The Tri-Cities offer a broad range of social services. State human service offices in the Tri-Cities include the Job Services of the Employment Security Department; Food Stamp; the Division of Developmental Disabilities; Financial and Medical Assistance; Child Protective Service; emergency medical service; a senior companion program; and vocational rehabilitation (Cushing 1994).

3.3.11 Police and Fire Protection

Police protection in Benton and Franklin counties is provided by Benton and Franklin counties' sheriff departments, local municipal police departments, and the Washington State Patrol Division headquartered in Kennewick. The Kennewick, Richland, and Pasco municipal departments maintain the largest staffs of commissioned officers with 58, 44, and 39, respectively (Cushing 1994).

The Hanford Fire Patrol, including 126 firefighters, is trained to dispose of hazardous waste and to fight chemical fires. During the 24-hour duty period, five firefighters cover the 1100 Area, seven protect the 300 Area, seven watch the 200 East and 200 West Areas, six are responsible for the 100 Area, and six cover the 400 Area, which includes the WPPSS area. To perform their responsibilities, each station has access to a hazardous material response vehicle that is equipped with chemical fire extinguishing equipment, a truck that carries foam, halon, and Purple-K dry chemical, a mobile air truck that provides air for gasmasks, and a transport tanker that supplies water to six brush trucks. They have five ambulances and contact with local hospitals (Cushing 1994).

3.3.12 Utilities

3.3.12.1 Water. The principal source of water for the Tri-Cities and the Hanford Site is the Columbia River. Richland, Pasco, and Kennewick used an average of 44.59 billion liters (11.78 billion gallons) in 1993. Each city operates its own supply and treatment system. The Richland Water Supply System gets about 67% of its water from the Columbia River, approximately 15 to 20% from a well field in North Richland, and the remaining from groundwater wells. The City of Richland's total usage in 1993 was 24.04 billion liters (6.35 billion gallons). This current usage represents approximately 58% of the maximum supply capacity. The City of Pasco's total usage in 1993 was 7.50 billion liters (1.98 billion gallons) of Columbia River water. The Kennewick system gets its water from two wells and the Columbia River. The Kennewick wells serve as the sole source of water between November and March and can provide approximately 62% of the total maximum supply of 27.6 billion liters (7.3 billion gallons). Kennewick's total usage in 1993 was 13.02 billion liters (3.44 billion gallons) (Cushing 1994).

3.3.12.2 Electricity. Electricity in the Tri-Cities is provided by the Benton County Public Utility District, Benton Rural Electrical Association, Franklin County Public Utility District, and City of Richland Energy Services Department. All the power that these utilities provide in the local area is purchased from the Bonneville Power Administration, a federal power marketing agency. Natural gas, provided by the Cascade Natural Gas Corporation, serves a small portion of residents, with 5,800 residential customers in December 1993 (Cushing 1994).

Electrical power for the Hanford Site is purchased wholesale from the Bonneville Power Administration. Energy requirements for the Hanford Site during fiscal year 1988 exceeded 550 average megawatts (Cushing 1992). The electrical power supplied by the Bonneville Power Administration is provided to the 100/200 Areas, 300 Area, and 400 Area systems on the Hanford Site (DOE-RL 1989). The City of Richland distributes power to the 700, 1100, and 3000 areas, which constitute approximately 2% of the total Hanford Site usage (DOE-RL 1993d).

3.3.12.3 100 Area Utilities. The water systems at the Hanford Site consist of a complex assortment of pumping, distribution, treatment, and storage facilities. These facilities have been constructed throughout the Hanford Site and use a variety of raw water sources to meet demand. The largest quantities of raw water are supplied through the Export Water System from the Columbia River.

The original Export Water System was designed to supply raw river water to 100-B, 100-D, 100-F, and 100-H Area reactor operations in addition to the 200 Area. This system was reconfigured to furnish water to the 200 Area when the production reactors were shut down. The primary pumping plant in this system, rated at 124,900 liters (33,000 gallons) per minute for its electric pumps and 45,420 liters (12,000 gallons) per minute for its diesel pumps, is located at 100-B. The backup pumping plant, which can supply 90,850 liters (24,000 gallons) per minute from electric pumps, is located at 100-D. The daily pumping averages are 72 million liters (19 million gallons) (DOE-RL 1989).

Because the 100-K Area was not supported by the original Export Water System, separate water systems were designed and constructed to supply water to operate the 105-KE and 105-KW Reactors and support facilities. Two systems pumped water from the Columbia River through filter plants and clearwells to the individual facilities within the 100-K Area. Each system consisted of six 37,850 liters (10,000 gallons) per minute submersible pumps, six 121,100 liters (32,000 gallons) per minute vertical pumps, two 34 million liters (9 million gallon) clearwells, and two 15,750 liters (4,160 gallons) per minute sanitary water service pumps. The 100-KW system and the emergency water pump house are no longer operating and are in excess status. Less than 10% of the 100-KE system capacity is in operation to supply current 100-K Area activities (DOE-RL 1989).

Power to the 100/200 Areas electrical system is provided by the Bonneville Power Administration Midway Substation at the northwest site boundary, and a transmission line from the Bonneville Power Administration Ashe Substation in the southeast portion of the Hanford Site. The 100/200 Areas electrical system consists of approximately 81 km (50 mi) of 230-kV transmission lines, six primary substations, 217 km (135 mi) of 13.8-kV distribution lines, and 124 secondary substations. The 100/200 Areas transmission and distribution systems, as with the Bonneville Power Administration source lines, have redundant routings to ensure electrical service to individual areas and designated facilities within those areas. The total 100/200 Areas substation transformer capacity is 195 megawatts. Each primary substation has at least twice the transformer capacity of the peak demand to enable handling the entire load on a single transformer under emergency conditions (DOE-RL 1989).

Table 3-1. Waste Site Group Profiles. (page 1 of 3)

Waste Site Group	General Group Characteristics (a)								
	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected	Are Reduced Infiltration Concentrations Exceeded?
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Thickness (m)				
Retention Basins	260,414	210.3	101.5	21345.0	12.2	Soil Concrete Steel Sludge	Radionuclides ^{14}C ^{137}Cs ^{60}Co ^{152}Eu ^{154}Eu ^{238}Pu $^{239/240}Pu$ ^{90}Sr ^{228}Th Inorganics Arsenic Cadmium Chromium VI Lead	pCi/g 429 3250 4390 29600 9940 9.4 340 770 4.4 mg/kg 47 1.2 609 564	 NO NO NO NO NO NO NO NO NO YES NO YES NO
Sludge Trenches	2316.0	38.1	15.2	572	4.0	Sludge	Radionuclides ^{14}C ^{137}Cs ^{60}Co ^{152}Eu ^{154}Eu ^{238}Pu $^{239/240}Pu$ ^{90}Sr ^{228}Th Inorganics Arsenic Cadmium Chromium VI Lead	assumed from retention basin data	NO NO NO NO NO NO NO NO NO NO YES NO YES NO

Table 3-1. Waste Site Group Profiles. (page 2 of 3)

Waste Site Group	General Group Characteristics (a)								
	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected	Are Reduced Infiltration Concentrations Exceeded?
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Thickness (m)				
Fuel Storage Basin Trenches	4409.0	43.3	6.7	290.0	15.2	Soil	Radionuclides	pCi/g	
							^{137}Cs	25.7	NO
							^{152}Eu	9.72	NO
							$^{239/240}$Pu	8.30	NO
							^{226}Ra	42.8	YES
							Inorganics	mg/kg	
							Cadmium	1.0	NO
							Chromium VI	108	YES
							Lead	51.9	NO
Process Effluent Trenches	31441.0	169.8	32.6	5535.0	5.8	Soil	Radionuclides	pCi/g	
							^{137}Cs	830.0	NO
							^{152}Eu	530	NO
							$^{239/240}$Pu	14	NO
							Inorganics	mg/kg	
							Chromium VI	186	YES
Pluto Cribs	14.4	3.1	3.1	9.6	1.5	Soil Timbers	Radionuclides	pCi/g	
							^{226}Ra	13	YES
Dummy Decontamination Cribs/French Drains	3.2	1.2 (dia.)	1.2 (dia.)	1.1	2.7	Soil Steel	Radionuclides	pCi/g	
							^{137}Cs	208	NO
							^{60}Co	268	NO
							^{152}Eu	420	NO
							^{154}Eu	45.4	NO
							$^{239/240}$Pu	8.60	NO
Seal Pit Cribs	0.0	0.0	0.0	0.0	0.0	NA	None	NA	NA

Table 3-1. Waste Site Group Profiles. (page 3 of 3)

Waste Site Group	General Group Characteristics (a)								
	Extent of Contamination					Media/ Material	Refined COPC	Maximum Concentration Detected	Are Reduced Infiltration Concentrations Exceeded?
	Volume (m^3)	Length (m)	Width (m)	Area (m^2)	Thickness (m)				
Pipelines	302973.0	6533.0	varies	varies	varies	Soil Steel Concrete	Radionuclides ^{137}Cs ^{60}Co ^{152}Eu ^{154}Eu ^{155}Eu ^{63}Ni ^{238}Pu $^{239/240}Pu$ ^{90}Sr	pCi/g 111,000 2,810 16,800 3,410 9,420 61,800 141 2,800 2,040	 NO NO NO NO NO NO NO YES(b) NO
Burial Grounds	4564.0	57.9	18.3	1059	6.1	Misc. Solid Waste	Radionuclides ^{14}C ^{137}Cs ^{60}Co ^{152}Eu ^{154}Eu ^{3}H ^{63}Ni ^{90}Sr Inorganics Cadmium Lead Mercury Organics no specific constituents identified, but 5% of volume is assumed to be contaminated by organics	(c)	NO: assume that the burial grounds contain immobile forms of waste
Decontaminated/Decommissioned Facilities	0.0	0.0	0.0	0.0	0.0	NA	None	NA	NA

(a) Group contaminated dimensions are based on a representative (maximum case) site. Refined contaminants of potential concern are a compilation of the maximum concentrations detected for each constituent above PRG for all sites within the 100-BC-1, 100-HR-1 and 100-DR-1 Operable Unit interim remedial measure candidate sites.
(b) This level is representative of only that waste which is in the pipeline and is not considered a potential impact to groundwater
(c) No quantitative data is available. Constituents are assumed from Miller and Wahlen 1987.
NA = Not Applicable
COPC = contaminant of potential concern
PRG = preliminary remediation goals

Table 3-2. Threatened and Endangered Candidate and Monitor Species on the Hanford Site. (page 1 of 4)

SPECIES	FEDERAL					STATE				
COMMON NAME / SCIENTIFIC	E	T	C_1	C_2	C_3	E	T	S	C	M
BIRDS										
Peregrine falcon* (Falco peregrinus)	X					X				
Bald eagle (Haliaeetus leucocephalus)		X					X			
Aleutian Canada goose* (Branta canadensis leucopareia)	X					X				
American white pelican (Pelecanus erythrorhynchos)						x				
Sandhill crane (Grus canadensis)						x				
Ferruginous hawk (Buteo regalis)				X			X			
Western Sage grouse (Centrocercus urophasianus)				X					X	
Loggerhead shrike (Lanius ludovicianus)				X					X	
Black tern (Chlidonias niger)				X						X
Swainson's hawk (Buteo swainsoni)					X				X	
Northern goshawk* (Accipiter gentilis)				X					X	
Common loon (Gavia immer)									X	
Golden eagle (Aquila chrysaetos)									X	
Flammulated owl* (Otus flammeolus)									X	
Sage thrasher (Oreoscoptes montanus)									X	
Sage sparrow (Amphispiza belli)									X	
Trumpeter swan* (Cygnus columbianus)				X						

Table 3-2. Threatened and Endangered Candidate and Monitor Species on the Hanford Site. (page 2 of 4)

SPECIES	FEDERAL					STATE				
COMMON NAME / SCIENTIFIC	E	T	C_1	C_2	C_3	E	T	S	C	M
BIRDS (continued)										
Lewis' woodpecker* (Melanerpes lewis)									X	
Western bluebird* (Sialia mexicana)									X	
Horned grebe (Podiceps auritus)										X
Red-necked grebe* (Podiceps grisegena)										X
Western grebe (Aechmophorus occidentalis)										X
Clark's grebe (Aechmophorus clarkii)										X
Great blue heron (Ardea herodias)										X
Great egret (Casmerodius albus)										X
Black-crowned night heron (Nycticorax nycticorax)										X
Turkey vulture* (Cathartes aura)										X
Osprey (Pandion haliaetus)										X
Merlin (Falco columbarius)										X
Gyrfalcon* (Falco rusticolus)										X
Prairie falcon (Falco mexicanus)										X
Black-necked stilt* (Himantopus mexicanus)										X
Long-billed curlew (Numenius americanus)					X					X
Arctic tern* (Sterna paradisaea)										X
Caspian tern (Sterna caspia)										X

Table 3-2. Threatened and Endangered Candidate and Monitor Species on the Hanford Site. (page 3 of 4)

SPECIES	FEDERAL					STATE				
COMMON NAME / SCIENTIFIC	E	T	C_1	C_2	C_3	E	T	S	C	M
BIRDS (continued)										
Burrowing owl (Athene cunicularia)				X					X	
Forster's tern (Sterna forsteri)										X
Snowy owl (Nyctea scandiaca)										X
Barred owl* (Strix varia)										X
Ash-throated flycatcher (Myiarchus cinerascens)										X
Grasshopper sparrow (Ammodramus savannarum)										X
Lesser goldfinch* (Carduelis psaltria)										X
REPTILES AND AMPHIBIANS										
Striped whipsnake (Masticophis taeniatus)									X	
Northern sagebrush lizard (Sceloporus graciosus)				X						
Woodhouse's toad (Bufo woodhousei)										X
Night snake (Hypsiglena torquata)										X
INVERTEBRATES										
Shortfaced lanx (Fisherola nuttalli)					X				X	
Columbia pebble snail (Fluminicola columbianus)				X					X	

Table 3-2. Threatened and Endangered Candidate and Monitor Species on the Hanford Site. (page 4 of 4)

SPECIES	FEDERAL					STATE				
COMMON NAME / SCIENTIFIC	E	T	C_1	C_2	C_3	E	T	S	C	M
FISH										
Mountain sucker (Catostomus platyrhynchus										X
Sand roller (Percopsis transmontana)										X
Piute sculpin (Cottus beldingi)										X
Pacific lamprey (Lampetra tridentata)				X						
Reticulate sculpin (Cottus perplexus)										X
MAMMALS										
Pygmy rabbit[A] (Brachylagus idahoensis)				X		X				
Northern grasshopper mouse (Onychomys leucogaster)										X
Sagebrush vole (Lagurus curtatus)										X
Merriam's shrew (Sorex merriami)									X	
Pallid bat (Antrozus pallidus)										X
Pacific western big-eared bat (Plecotus townsendii)				X					X	
Small-footed myotis (Myotis ciliolabrum)				X						X
Long-eared myotis (Myotis evotis)				X						X
Fringed myotis (Myotis thysanodes)				X						X
Long-legged myotis (Myotis volans)				X						X
Yuma myotis (Myotis yumanensis)				X						

Federal listings as of Nov. 15, 1994 and State listings as of April, 1994 Washington Dept. of Wildlife.

Federal

E Federal Endangered. A species in danger of extinction throughout all or a significant portion of its range.
T Federal Threatened. A species that is likely to become endangered in the foreseeable future.
C_1 Candidate taxa for which enough substantive information is available to support listing as threatened or endangered by the federal government.
C_2 Candidate taxa for which there is evidence of vulnerability, but not enough data to support listing proposals at this time.
C_3 Taxa that were once considered for listing as threatened or endangered, but are no longer candidates for listing.

State

E Endangered. Species in danger of becoming extinct in the near future if factors contributing to their decline continue.
T Threatened. Species that are likely to become endangered in the near future if factors contributing to their population decline or habitat degradation continue.
S Sensitive. Species that are vulnerable or declining, and could become endangered or threatened without active management or removal of threats.
C Candidate. Wildlife species native to Washington State that the Department of Wildlife will review for possible listing as endangered, threatened, or sensitive.
M Monitored. Wildlife species native to Washington State that are of special interest because: (1) they were at one time classified as endangered, threatened, or sensitive; (2) they require habitat that has limited availability during some portion of their life cycle; (3) they are indicators of environmental quality; (4) further field investigations are required to determine their population status; (5) there are unresolved taxonomic problems that may bear upon their status classification; (6) they may be competing with and impacting other species of concern; or (7) they have significant popular appeal.

4.0 DETAILED DESCRIPTION OF ALTERNATIVES

General response actions and Remedial Alternatives initially identified in DOE-RL (1993a) are discussed in detail in this section. According to the scope of this Process Document, only those alternatives applicable to source media (i.e., soil and solid waste) are considered. Specific technologies and process options that are components of the alternatives considered in this Process Document are presented in Section 4.1. Alternative descriptions, associated applicability criteria, and appropriate alternative enhancements are presented in Section 4.2.

4.1 DESCRIPTION OF TECHNOLOGIES AND TREATABILITY STUDIES

Technologies presented in this section are described below.

- Technologies as originally proposed in DOE-RL (1993a) are presented or modified based on standards of practice and applicability. Details are provided regarding implementation of the technology, its application limitations, and any changes imposed by the waste site groupings.

- Treatability studies (or similar applications) are presented to demonstrate how the technology is implemented. In addition to the technologies a discussion of innovative technology programs is presented in Section 4.1.7. The innovative technologies are in development and demonstration stages.

4.1.1 Institutional Controls

Institutional control technologies retained from DOE-RL (1993a) include groundwater surveillance monitoring and surface access restrictions. Access restrictions include deed restrictions and fencing. The following sections provide a discussion on each technology.

4.1.1.1 Groundwater Surveillance Monitoring. Groundwater surveillance monitoring will be performed at sites where contamination is left in place above the preliminary remediation goals; for example, if a surface barrier is selected as the primary remedial response and wastes are left in place. Groundwater monitoring is required in this case to evaluate the long-term effectiveness of the action. Also, because the remedial action selected as a result of this Process Document and the associated Focused Feasibility Study will be an interim action, groundwater monitoring will provide data for additional evaluation of the action before selecting a final action. The present network of groundwater monitoring wells is considered adequate for assessing potential groundwater impacts following interim action. However, site-specific hydrogeology and remedial action design activities should be used to reassess this assumption during implementation of remedial actions.

Monitoring potential pathways and impacts to groundwater from source operable units requires coordination with monitoring programs currently being performed for the groundwater operable units. Vadose zone contaminants considered to have potential impact on groundwater must be included in the groundwater monitoring program. A complete groundwater surveillance monitoring program, including all contaminants left in place, will be performed as soon as remediation at the waste site or operable unit is complete. The implementation of a complete groundwater surveillance program requires an assessment to evaluate the combined groundwater/vadose zone hydrologic system and define current and future probable impacts to groundwater.

4.1.1.2 Deed Restrictions. Deed restrictions are legal specifications for land use. Typical deed restrictions include a ban on activities that may bring humans in contact with contaminants. Deed restrictions may include (1) provisions that prevent the use of groundwater, (2) requirements for approval of excavations beyond a specified depth, or (3) limitations on land use by prohibiting activities such as grazing, farming, and extended camping. Successful implementation of deed restrictions requires administrative resources and visual monitoring. Placing "Keep Out" signs may help ensure compliance. Deed restrictions are required for areas where contamination is above preliminary remediation goals.

4.1.1.3 Fencing. "Fencing" is a physical barrier around a contaminated area that limits public access. A fence is easy to construct, but it cannot prevent animal intrusions. In the long term, fencing would reduce but not prevent human trespassing.

4.1.2 Removal

4.1.2.1 Description. Removal technologies involve excavation of contaminated materials, demolition of contaminated structures, and processing of materials to allow for proper treatment and/or disposal. Removal provides full implementation of the observational approach for remediation of the site. To be effective and safe, removal technologies must include real time analytical field screening, dust control, efficient transportation, and disposal. Removal technologies have previously been explored for use in the 100 Area on a large scale (WHC 1991a) and on a small scale (DOE-RL 1994b). The removal technologies described here are based on the assumption that the contaminated material is low activity waste (WHC 1991b). High-activity wastes, if encountered, would be remotely handled, shielded, and transported to a secure area. These high-activity wastes would then be disposed of according to the *Hanford Site Solid Waste Acceptance Criteria* (WHC 1993a).

The contaminated waste removal process, as applied to the 100 Area, involves the following steps (WHC 1993b):

- Remove and stockpile topsoil (if possible) and clean overburden, where present, to expose the contaminated material
- Excavate to remove contaminated media
- Demolish contaminated structures as part of or concurrent with the excavation
- Implement dust control measures and real time analytical field screening during excavation

- Support nearby structures affected by excavation (where necessary)
- Process materials removed (processing with equipment other than excavation equipment is discussed as a separate technology)
- Transport wastes to a disposal facility
- Reclaim the site with vegetation and soil
- Control erosion
- Protect cultural and natural resources.

Excavation will be performed using conventional equipment and methods. Excavation equipment may include excavators (backhoes), bulldozers, and wheeled loaders. Excavators with grappling attachments will be used to remove and process concrete, steel structures, and pipelines.

Retention Basin Sites will be remediated by first removing basin fill material with an excavator. Exposed concrete basin walls will be demolished using an excavator equipped with either a hydraulic hammer or a pulverizer attachment. Steel basin walls will be cut with a shear-equipped excavator. Demolished materials will be loaded into haul trucks with an excavator using both bucket and grapple attachments. Excavation of contaminated soil then proceeds in lifts using the excavator, bulldozer, and loader (Figure 4-1). This part of the excavation is guided by in situ analytical field screening, which delineates the zone of contaminated material with real time instruments. These excavations should be spacious, requiring the equipment to work within the excavation. Haul trucks, loaded in the excavation, will use ramps to enter and exit the site. Clean material will be stockpiled nearby the excavation for later use in reclamation of the site.

Liquid Disposal Trench Sites will be remediated by first removing any clean overburden with a bulldozer and a loader. Excavation of contaminated soil then proceeds in the same manner as the retention basin sites (Figure 4-1).

Buried Pipelines are located between the outfall structures and the reactor building, as discussed in Section 3.1.3. The effluent pipelines will be remediated by first removing any clean overburden with a bulldozer and loader. Material will then be removed from either side of the pipeline with the excavator. Working from the top and side of the excavation, an excavator with a shear attachment will be used to cut the pipe. Using a grapple attachment, sections of the pipe are then removed from the excavation (Figure 4-2). The excavator then continues to remove any contaminated soil. Ramp access to the bottom of the excavation is maintained allowing in situ monitoring. Removed sections of pipe are processed at the surface using an excavator with pulverizer or shear/densifier attachments. Processed pipe material is then loaded into haul trucks with a grapple.

Crib and French Drain Sites will be removed only with an excavator working from the surface (Figure 4-3). If the extent of contamination is beyond the reach of the excavator arm, the site is benched and access is provided to the bench.

Burial Ground Sites will be remediated by first removing clean overburden with a bulldozer and loader. Buried waste is then removed by the excavator with either the bucket or grapple attachment (Figure 4-4). Removed oversize objects are reduced in size at the surface by shear or densifier attachments; if size reduction is not necessary, they are shipped to the disposal site intact.

Decontaminated and Decommissioned Facilities will be remediated by first removing overburden and surrounding soil using an excavator with a bucket attachment. Demolition attachments, such as pulverizers or shears, will be used to demolish the remaining structures. Demolished material is loaded into haul trucks with the excavator using a grapple attachment. The demolished material may either be disposed or decontaminated and recycled, as applicable. Contaminated soil beneath the structure is removed in lifts using the excavator with a bucket.

Proper dust control is essential during excavation because operations may generate fugitive dust. Dust control measures will be performed to reduce the spread of contamination by entrainment of fugitive dust, minimize the impacts on local air quality, and minimize the exposure to onsite personnel. Water sprays are the primary means for controlling fugitive dust. Water is applied to an excavation area at approximately 1 gal/yd^2 (EPA 1985). Water is supplied to the excavation site by water trucks or local hydrants. Crusting agents may be applied to excavation areas before short-term work breaks. Access ramps and haul roads will also require dust suppression. Haul roads will be constructed and maintained using soil cementing agents.

Real time analytical field screening to define the extent of contamination during excavation is an integral part of removal in the observational approach. This eliminates the need for a detailed description on the extent of contamination before remediation. Such field screening requires the use of sophisticated detection equipment for in situ use and the use of onsite laboratories performing quick turn around radionuclide, inorganic, and organic analyses. Monitoring instruments include sodium iodide and hyperpure germanium gamma detectors for radionuclides, photoionization or flame-ionization detectors for volative organic carbon, x-ray fluorescence for metals, and high-volume samplers for respirable dust.

Support of nearby structures may be required if the amount of excavation compromises the foundation or stability of the structure. Such support requires excavation bracing. Applicable systems include soldier beams with horizontal timber sheeting and tiebacks. Additional measures will be required if contaminants extend beyond the boundaries of these structures.

Safe and efficient transport will be required if the contaminated soils are disposed at the Hanford Site (Section 4.1.6). Soil transport techniques have been developed, as demonstrated at the DOE Uranium Mill Tailings Remedial Action site. It is expected that the transport container and its lid will require a project-specific design, but that such development will not be excessive. A plausible concept to transport soils is as follows:

- The soils will be transported by truck using industrial containers located at the excavation

- The loaded soil is wetted before being transported to a local (central to the area being worked) facility

- The containers will be inspected and then covered with a tight fitting lid

- The exterior of the truck and container will be washed

- The truck then hauls the soil to the disposal facility.

4.1.2.2 Treatability Study. An excavation treatability study has recently been completed on 116-F-4 (DOE-RL 1994b) pluto crib site. Another excavation treatability study at the 118-B-1 burial ground was completed during the summer of 1994 (DOE-RL 1994c).

4.1.2.2.1 116-F-4 Pluto Crib Excavation. The purpose of the 116-F-4 excavation test was to provide design data, document the excavation costs, demonstrate the field analytical methods, and evaluate various dust control measures. The test included the following elements:

- A preliminary site characterization and waste site location

- An excavation of the waste site and associated contamination

- The segregation and stockpiling of excavation spoil

- A radiological screening and comparison of in situ measurements with laboratory analysis

- Effective dust control measures in the area of excavation, on roadways, and on stockpiles

- Final site reclamation.

Typical of many of the waste sites in the 100 Area, workers planning and conducting the excavation were unable to locate construction records for the 116-F-4 pluto crib. One borehole was completed near the crib riser pipe as part of the limited field investigation for the 100-FR-1 Operable Unit. A ground penetrating radar survey and a cone penetrometer investigation were conducted to determine crib coordinates and the limits of contamination. The ground penetrating radar survey was mostly unsuccessful because of the presence of fly ash on the surface. The cone penetrometer investigation consisted of pushing holes at 16 locations. The cone penetrometer was equipped with a sodium iodide gamma detector to provide gross gamma radiation measurements. The cone penetrometer typically met refusal in the 2.1 to 3 m (7 to 10 ft) interval, but proved to be an effective tool when penetration was possible. In the zones penetrated, the area of highest contamination was determined and the contaminant plume delineated laterally. Depth of contamination could not be determined because of refusal.

The excavation was performed using a CAT 245-B backhoe with a 2.2 m^3 (3 yd^3) bucket attachment proceeding in 6-m (2-ft) excavation lifts. Standard construction techniques provided a 1.5 horizontal to 1 vertical side slope for the planned 7.6-m (25-ft) depth of the excavation. Before each lift the excavated area was surveyed for radiation and the limit of the contaminated material described. Uncontaminated areas of the underlying lift were then excavated followed by the contaminated materials. Contaminated material was placed in an engineered onsite storage facility (Terra-stor). At the ninth lift, radiation was just above spectral background limits in a small area adjacent to the vadose borehole. The remaining contaminated material was excavated with the backhoe. Excavation began on September 20, 1993, and concluded on November 24, 1993. The typical work crew was between 11 and 20 workers. The normal work schedule was from 0700 to 1600 hours 5 days a week. Approximately 5.25 productive hours were realized each day. A total of approximately 3,440 m^3 (4,500 yd^3) was removed, of which 382 m^3 (500 yd^3) was designated contaminated. Excavation rates varied from 23 to 68 m^3/hr (30 to 90 yd^3/hr) during the operation of the excavation equipment, excluding field screening durations (DOE-RL 1994b).

In situ radionuclide concentrations were measured by a detection cart specially designed and constructed for in situ monitoring. The cart was equipped with five detectors: two thallium doped sodium iodide detectors, a hyperpure germanium detector, a prototype scintillation fiber optic beta detector, and a plastic scintillating beta detector. The cart was lowered into the excavation by a crane and moved from point to point by hand or crane. Samples were sent for laboratory analysis for comparison purposes. Each lift was screened and sampled at 16 points forming a 6.1 by 6.1 m (20 by 20 ft) grid. Small volume soil samples were taken at three locations on each lift for comparison. The small volume samples included only sand; however, approximately 75 to 85% of the soil was cobble size. As a result, a few 8-gallon samples were taken for segmented gamma scanning analysis. In situ measurements were adjusted for the weight percent of sand fraction to compare the laboratory results sand fraction analyses. Such corrections were only partially successful because contamination fixed on the cobbles was different than concentrations on the sand. All measurement locations were also surveyed with standard health physics instrumentation (zinc sulfide scintillation and Geiger-Muller detectors). Work with the cart took from 1 to 2 days to complete for each lift. This was primarily due to the time required to process detector data. The in situ detection equipment was successful at the action levels used in delineating the extent of strontium-90 and cesium-137 within the 6.1 by 6.1 m (20 by 20 ft) sampling grid.

In addition to radiological field measurements, screening was also performed for chemical constituents. Four samples from lift five were screened for heavy metals and hexavalent chromium. A portable x-ray fluorescent analyzer was used to check for concentrations of heavy metals. A water extraction and calorimetric determination was used to screen for hexavalent chromium. No evidence of heavy metals or hexavalent chromium was found in any of the samples.

During the excavation, the four types of dust control tests conducted were no control, control with water only, control with water and additives, and control with crusting agents. Two surfactants and four crusting agents were used. Low volume air samplers, personal air samplers, and real-time air monitors were used to help quantify dust generation. Evaluation of crusting agents were qualitative. Water was applied with hoses attached to a fire hydrant located nearby. Mixtures were applied with the use of a fugitive dust control unit obtained from Idaho National Engineering Laboratory. A thermoplastic adjustable fog nozzle was used for most applications. Water spray alone controlled dust adequately. Lignosite was the best "all-purpose" crusting agent while Road Oyl was the best product for high traffic areas. The surfactants were not used frequently enough to adequately assess their performance (DOE-RL 1994b).

Site restoration activities were initiated once dust control tests were completed. Restoration activities included surveying the former location of the crib and final lift depth, backfill of the excavation to grade level, demobilizing equipment and supplies, and final cover installation on the Terra-stor. A 11.5 m^3 (15 yd^3) truck and a front end loader were used to place and compact fill in 0.46 m (18-in.) lifts. A 7.6 m^3 (10 yd^3) truck supplied material to the excavation during restoration activities. The average fill production rate was 160 m^3 (210 yd^3) per hour.

4.1.2.2.2 118-B-1 Burial Ground Excavation. The excavation test being conducted at the 118-B-1 burial ground was initiated in August of 1994 (DOE-RL 1994c). The test objectives included testing different excavation methods, test sorting of waste material, and test screening of waste material based on preliminary waste acceptance criteria.

The test is expected to be complete by March 1995. The test report is scheduled to be sent to the regulators for review in May of 1995. The information below is preliminary. Data will be analyzed and summarized in a report scheduled for May.

To date, three different trenches have been excavated, with approximately 1,200 cubic yards of waste removed. Waste materials are mixed well with soil and cobble. In general, the soil/waste ratio is 60-80/40-20% by volume. Radiation levels varied a great deal with each trench but were generally lower than expected. Very little soft waste has been found. Some hazardous waste (i.e., lead and oils) have been recovered, though the volume of this material is less than 1% of the total volume excavated. Sorting tests were conducted on the second and third trenches. Sorting by mechanical means was not possible, so sorting is being done by hand.

4.1.3 In Situ Containment

In situ waste containment actions include physical measures to restrict the migration of contaminants from in-place wastes. Containment technologies include waste site isolation using surface barriers and surface water management.

A number of barrier types have been proposed for various applications at the Hanford Site. Existing short-term barrier designs (RCRA caps), recommended by the U.S. Environmental Protection Agency, are currently available, but are not considered further in this study for the following reasons. In general, the design life of these caps is for relatively short periods (around 30 years). However, the containment of radioactive wastes at the Hanford Site will require that wastes be isolated for much longer periods. In addition, the literature reports several failures for RCRA caps (Daniel 1994). The main problems with standard RCRA caps have been desiccation- or settlement-induced cracking of the low-permeability compacted clay layer.

Since 1985, the Hanford Site Barrier Development Program has been developing a long-term surface barrier that can function for a minimum of 1,000 years. This long-term barrier is commonly called the Hanford Barrier. For more than 9 years, field tests, experiments, lysimeter studies, computer simulation models, and analog studies have been conducted to determine the performance of various barrier components. These activities have provided a defensible foundation upon which barrier designs can be based.

A full-scale prototype barrier was constructed in 1994. This prototype barrier required that each component of the barrier be brought together into an integrated system. (Myers and Duranceau 1994).

In addition to the Hanford Barrier, a graded-barrier approach also is being considered for use on the Hanford Site. The approach would develop a suite of cost-effective, risk-based barriers that could be used in the remediation of various waste management situations. Much of the work conducted by the Hanford Site Barrier Development Program to develop of the Hanford Barrier can be used to develop graded-barrier designs. An understanding of how well the various graded barriers perform is required before determining a particular barrier's suitability for remediating a waste site based on specific design or cleanup criteria. Performance data on the various graded barriers currently being considered are not available. Therefore, this Process Document considers only the Hanford Barrier.

4.1.3.1 The Hanford Barrier.

4.1.3.1.1 Description. The performance objectives for the Hanford Barrier are summarized as follows (Wing 1993):

- Function in a semiarid-to-subhumid climate
- Limit the recharge of water through the waste to the water table to near-zero amounts (0.05 cm/yr, which is equivalent to 1.6×10^{-9} cm/sec)
- Be maintenance free
- Minimize the likelihood of plant, animal, and human intrusion
- Isolate wastes for a minimum of 1,000 years
- Minimize erosion-related problems
- Meet or exceed *Resource Conservation and Recovery Act of 1976* (RCRA) performance requirements

- Limit the exhalation of noxious gases

- Be acceptable to regulatory and public agencies.

The Hanford Barrier uses engineered layers of natural materials to create an integrated structure with redundant protective features. A variety of natural construction materials (e.g., fine soil, sand, gravel, riprap, asphalt) have been selected to optimize barrier performance and longevity. These construction materials are placed in layers to form an above-grade mound directly over the waste zone (Figure 4-5). Surface and subsurface markers, used to inform future generations of the nature and hazards of the buried wastes, are being considered for placement around the periphery of the waste sites and within the barrier itself.

The Hanford Barrier design consists of a fine-soil layer overlying other layers of coarser materials (e.g., sands, gravels, and basalt riprap) and a composite asphalt layer.

- **Fine-Soil Layers.** The uppermost portion of the barrier consists of two, 1-m (3-ft)-thick layers of fine soil that have been engineered with a gradual slope. The difference between the two layers is that the upper meter of fine soil has been mixed with pea gravel. The pea gravel and vegetation growing on the barrier surface will significantly reduce wind and water erosion.

  The fine-soil layers act like a sponge to store any precipitation that does not run off the barrier. The textural difference between the fine soils and underlying sand layer creates a capillary barrier that inhibits the downward percolation of water into the sand layer and other coarser materials below. Keeping the water in the fine-soil layers provides time for the processes of evaporation and plant transpiration to remove the excess moisture.

- **Sand and Gravel Filter Layers.** A graded filter, consisting of a 15-cm (6-in.)-thick layer of sand and 30-cm (11-in.)-thick layer of gravel is placed under the fine-soil layers. This graded filter minimizes the sifting of overlying fine-textured soils into the pore spaces of the coarser materials below. To maintain the textural difference between the silt loam and sand layers during construction, a geotextile is installed on the sand layer before placement of the fine-soil layers.

- **Fractured Basalt Riprap Layer.** A 1.5-m (4.92-ft)-thick layer of fractured basalt riprap is placed below the graded filter. The riprap provides structural stability to the barrier and creates another effective deterrent to inadvertent human intruders, burrowing animals, and plant roots that may try to penetrate deeper into the barrier profile.

- **Drainage Gravel.** A 30-cm (11-in.)-thick layer of gravel is placed directly below the fractured basalt riprap and on top of the composite asphalt layer. These gravels serve as a cushion to protect the composite asphalt layer and as a drainage medium.

- **Composite Asphalt Layer.** The low-permeability asphalt layer is a composite of two layers of compacted asphaltic concrete, each 7.5 cm (2.95 in.) thick, overlain by approximately 5 mm (0.20 in.) of polymer modified asphalt. If water reaches this depth, the composite asphalt layer will function like an umbrella, diverting the percolating water from the waste zone. The composite asphalt layer limits the exhalation of any noxious gases and also serves as an effective intrusion barrier.

- **Gravel Base Course.** A 10-cm (3.94)-thick layer of gravel is placed directly below the composite asphalt layer to provide a structurally stable medium upon which the composite asphalt layer can be compacted.

- **Native Soil Foundation.** The native soil foundation, or subbase material, is graded and compacted as necessary to provide a 2% slope that is maintained throughout all of the overlying layers.

The Hanford Barrier should inhibit the migration of contaminated materials present at the waste site. However, final site-specific design would require that additional investigations be performed to adequately locate and delineate the extent of contamination.

4.1.3.1.2 Treatability Study. In 1994, a 5-ac (2 ha) prototype Hanford barrier was constructed over the 216-B-57 Crib in the 200-BP-1 Operable Unit. This prototype barrier required that all of the various components of the barrier be brought together into an integrated system. A constructibility report summarizing the construction of the prototype barrier is summarized in DOE (1994).

The testing and monitoring of the performance of the prototype barrier will continue for at least 3 years (Gee et al. 1993 and DOE 1993a). Because only a limited amount of time exists to test a prototype barrier that is intended to function for a minimum of 1,000 years, the testing program has been designed to "stress" the prototype so that barrier performance can be determined within a reasonable time frame. Stressing the prototype can be accomplished by adding supplemental precipitation (rain and snow) at rates representative of anticipated future climatic changes.

The prototype barrier is well instrumented and designed to assess the movement of moisture within the various layers. The fine-soil layers and other layers of the prototype barrier are equipped with instruments, such as water collection basins, pan lysimeters, neutron probe access tubes, thermometers, and other transducers, to monitor the changes in soil water storage and the movement of water in general.

Initial test results show that, for the Hanford Site's arid climate, a well-designed capillary barrier limits water drainage through the barrier to imperceptible amounts. A subsurface asphalt layer provides additional redundancy. The data collected under extreme event testing (excess precipitation) are building confidence that the barrier will meet its performance objectives during the 1,000-year minimum design life.

4.1.3.2 Surface Water Management. Surface water management consists of measures to control the run-on and runoff of surface water to and from a waste site. Elimination of run-on to a waste site reduces the potential for infiltration through the barrier to contaminated materials, and the subsequent spread of contaminants. Collection of waste site runoff reduces the spread of contamination via water that has contacted contaminated materials. Surface water management may not comprise a remediation technology in itself, but is a necessary addition to many of the Remedial Alternatives.

Surface water can be controlled by constructing drainage channels, toe drains, culverts, and detention ponds. Control can also be attained by providing positive relief by redirecting the surface water in the area to be protected. Runoff of surface water that has been in contact with contaminated materials must be collected, held in detention ponds, tested, treated (if necessary), and released. Potential for runoff also exists during transportation. This potential can be eliminated by using covers for the transport containers.

In the 100 Area, surface soils are typically permeable, precipitation tends to infiltrate quickly, and little runoff occurs. None of the waste sites being evaluated are in areas susceptible to inundation or erosion during high precipitation events (Gee 1987).

4.1.4 In Situ Treatment

In situ treatment actions include grout injection, dynamic compaction, and In Situ Vitrification.

4.1.4.1 Grout Injection. Grouting is often used in construction projects to increase shear strength and density, or decrease the permeability of soil and rock. Grouting is gaining acceptance for the solidification of buried wastes and as a preconstruction procedure to eliminate problems that otherwise might occur during the construction phase. The two types of grout injection considered for use in Remedial Alternatives are void grouting and vibration-aided grout injection. Void grouting is used to fill large voids, specifically the effluent pipelines. Vibration-aided grout injection is used to solidify and stabilize buried solid wastes.

4.1.4.1.1 Void Grouting. Factors that must be considered when filling large void spaces with grout are the fluidity of the grout, curing time, shrink resistance, control of cracking, compatibility with materials in the void (for example, residual sediments in pipelines), compatibility of the grout with the walls of void, cured permeability, and cured strength. These factors can be controlled by using the proper mixture of cement, aggregate, and additives.

Void grouting is generally performed with sand-cement based grouts injected at low pressures (Navy 1983). Typical sand-cement ratios vary from about 2:1 to 10:1 (loose volume). Addition of bentonite or fly ash reduces segregation and increases pumpability. Portland Type I cement is sufficient unless special resistance or strength properties are required. Type IV cement provides superior curing properties for massive structures. Substitution of pozzolan for cement increases shrink resistance but decreases strength. Water-cement ratios vary from about 2:1 to 5:1 by volume. Final compressive strengths vary from 100 to 700 lb per square inch (psi). The appropriate grout mix design should be developed for the types of voids to be filled.

Selecting the proper grout mixing and placement system depends on the size of the grouting project. For small projects grout can be mixed in batches. For large projects a mobile continuous mixer is used. Sand-cement grout is typically placed using conventional long stroke slush pumps with large valve openings.

The effluent pipelines will require large volumes of grout. The pipelines can be accessed from junction boxes. Grouting should begin at the box lowest in elevation and end with the highest box. The lines are adequately sloped enabling the grout to flow through and completely fill the void space.

4.1.4.1.2 Vibration-Aided Grout Injection. Vibration-aided grout injection is an in situ stabilization/solidification technique involving the injection of cement grout into a contaminated zone with simultaneous vibration of the materials within the zone. This technology is a combination of vibro-densification and pressure grouting, two well-developed stabilization technologies. Vibration provides a nonintrusive means for mixing the materials with the grout. Successful completion provides encapsulation of waste into a monolithic block that resists leaching or migration of contaminants.

Vibration-aided grout injection is not a commonly applied technology for in situ treatment of waste materials. However, a similar technology using similar equipment is typically applied in the construction of vibrated beam slurry cutoff walls. The vibrated beam uses a crane-operated, vibrating driver and extractor unit that drives and extracts a wide flange structural beam. Grout pipes attached to the beam are for injection of a cement bentonite backfill. In the construction of cutoff walls, the beam is vibrated into the ground and a low permeability cement mixture is injected under pressure into the resulting void when the beam is withdrawn. For enhanced fluidity, the cement mixture can be thinned and vibration maintained during grouting. For vibro-densification, probes are typically placed at 1 to 3 m (3 to 10 ft) intervals. The vibratory hammer operates at 25 Hertz with vibrations of 1 to 2.5 cm (3/8 to 1 in.) of amplitude (vertical) (Navy 1983). Grout is injected until refusal pressures are attained (approximately 1 psi per foot of depth at the injection point) or grout returns to the surface. For heterogeneous buried waste, the degree of mixing with the grout may be difficult to control and the grout will generally follow preferential flow pathways. In addition, if not penetrated by the beam, sealed void spaces, such as closed containers or metal boxes, may not be grouted.

In situ grouting for stabilization requires a comprehensive characterization of the waste matrix to identify contaminants that may interfere with grout curing and to determine the number of injection points. The specific grout mixture cannot be specified without site-specific studies. Chemical grouts are typically best suited for fine-grained materials with small pores, and cement grouts are best suited for coarse-grained materials. A combination of grout types may also be used.

In situ grouting can be an effective way to immobilize and stabilize contaminated materials at waste sites. However, the grouting process, especially for complex subsurface geometries (such as burial grounds), is difficult to assess during implementation. The effectiveness of in situ grouting can be difficult to determine and may require an investigation before it is implemented. Long-term effectiveness in immobilizing radionuclides depends on the ability of the grouted mass to resist degradation. Final site-specific design of the grouting program will require that additional characterization be performed to adequately locate and determine the extent of contamination. No opportunity exists to follow an observational approach to determine the extent of contamination as in other methods of remediation such as excavation. In situ grouting is performed using equipment that has been developed specifically for the method. Site-specific studies must be performed to select the proper injection grout mixture(s) and determine appropriate locations of injection points. Used correctly, in situ grouting can reduce exposure risk at the site by reducing the potential for settlement and immobilizing waste through encapsulation. Grouting of buried mixed waste was not used as a remedial technology at the DOE's Savannah River Site (Bullington and Frye-O'Bryant 1993). Evaluations concluded that grouting would not fill enough voids without creating uncontrolled surface cracking and surface releases of grout contaminated with hazardous and radioactive constituents. Site-specific characterization in the 100 Area should be completed before implementation, and treatability studies may be needed to assess the applicability of in situ grouting at the Hanford Site.

4.1.4.2 Dynamic Compaction.

4.1.4.2.1 Description. Dynamic compaction is a technique used for in situ consolidation of soils and buried wastes. This process involves dropping a weight (tamper) from a predetermined height onto the area to be compacted. The heavy weight dealt to the soil causes deep densification. This method has been used for about 20 years to compact foundations for buildings, highways, and airfields. This method has been used to a limited degree in the hazardous waste industry. Successful completion of dynamic compaction reduces the pore spaces, minimizes groundwater contact, and minimizes potential subsidence for a subsequent barrier. The performance of compacted material, in regard to moisture migration potential, is a direct function of the void ratio after compaction, which is in itself a function of soil particle size distribution.

Procedures for dynamic compaction have been established. Spacial distribution and the time sequence of dropping the weights are critical. Effects on nearby structures, soil and waste conditions, and characteristics of transmitting impact and vibration energy must be considered. The cumulative applied energies of the process typically range from 30 to 150 ft-ton/ft^2 and may succeed in densifying soil or waste to a depth of 15.2 m (50 ft).

The effectiveness of the dynamic compaction technique can be determined by measuring the volume and area of the craters created by dropping the weights in a pre-planned sequence. The data can be used to calculate the increase in density and depth of influence. Evaluation can also be supported with standard penetration tests, cone penetration tests, or geophysical approaches.

The equipment required for the compaction technique is a steel or concrete tamper suspended from a crane. Tampers weigh from 5 to 20 tons and drop heights can be as high as to 30.5 m (100 ft). The most efficient tamper weight and drop height can be determined in a site-specific test program.

4.1.4.2.2 Similar Site. The Mixed Waste Management Facility at the DOE's Savannah River Site was recently remediated using dynamic compaction. The waste was sealed and closed under the weight of an RCRA closure barrier (Bullington and Fry-O'bryant 1993). The Mixed Waste Management Facility site was a 58-acre burial ground for low-level radioactive waste. Low-level waste was buried in trenches designed to accept only metal boxes (designated B-25 boxes) and 208.20-liter (55-gallon) drums. Boxes were stacked no more than four high and drums were placed between the boxes and the sloped walls of the trench. The filled trenches were covered with a minimum of 1.2 m (4 ft) of overburden. Closure of the waste site included dynamically compacting the waste trenches, then placing a 1-m (3-ft) kaolin barrier and a 0.6-m (2-ft) final vegetative layer over the area.

During feasibility evaluations conducted before closure, settlement of the trenches was expected to occur because of buckling of the B-25 boxes under the weight of the RCRA closure barrier. Various methods of inducing settlement were considered, including static surcharging, dynamic compaction, grouting, and construction of bridging covers. Dynamic compaction and surcharging were determined to be the most effective and practical methods to reduce further settlement. The dynamic compaction test showed that the crater depth for a given number of drops increased with the total energy of the drop rather than the energy per imprint area. A 20-ton weight was selected at a drop height of 12.8 m (42 ft).

The following procedures were followed at the Savannah River Site:

- Lampson LDC-350 cranes were obtained and modified specifically for dynamic compaction. The modifications included replacing two-line hoist with a single-line hoist to minimize friction losses. A 20-ton tamper, 2.4 m (8 ft) in diameter, was selected for use.

- The soil cover over the burial ground was increased to a thickness of 1.8 m (6 ft) allowing a maximum crater depth of 1.8 m (6 ft) to be obtained without exposing buried wastes.

- The surface of each burial trench, typically 6.1 m (20 ft) wide and 6.1 m (20 ft) long, was subdivided into 3 by 3 m (10 by 10 ft) grid.

- Initially, specifications called for the tamper to be dropped 20 times from a height of 12.8 m (42 ft) per grid point or until the maximum crater depth of 1.8 m (6 ft) was reached. Later a drop height test program was conducted and the drop height increased to 21 to 24 m (70 to 80 ft).

- The tamping pattern included primary drop points in a zig-zag pattern along the grid followed by secondary drop points to fill in the remaining grid nodes (Figure 4-6).

- An average of 13 drops were required at each drop point to obtain an average crater depth of 1.7 m (5.56 ft).
- Resultant craters were backfilled and compacted using the tamper at a drop height of 12.8 m (42 ft).

Closure of additional trenches adjacent to the Mixed Waste Management Facility have been conducted since the completion of the Mixed Waste Management Facility closure (Billington and Fry-O'bryant 1993). To perform these closures, additional studies were conducted to address vibrational damage to the existing barrier, waste disposal facilities, and utilities. These studies concluded that dynamic compaction should not be performed within 15.2 m (50 ft) of the existing barrier. During field testing, the criteria for discontinuing compaction was changed from the previously used maximum depth to an incremental depth (6 cm [0.2 ft] for two consecutive drops).

4.1.4.3 In Situ Vitrification.

4.1.4.3.1 Description. In Situ Vitrification is a thermal treatment process that converts soil and other materials into stable glass or glass-like crystalline substances. In Situ Vitrification uses joule heating to transmit electric energy to the soil, heating it, and producing a molten glass zone that stabilizes the contaminants in place. In Situ Vitrification produces an extremely durable product that is capable of long-term immobilization of many metals and radioactive wastes.

The In Situ Vitrification treatment system consists of the electrical power supply, the offgas hood, an offgas treatment system, a glycol cooling system, a process control station, and offgas support equipment (Freeman 1989). The offgas system consists of a gas cooler, two quench towers, hydrosonic tandem nozzle scrubbers, two heat exchangers, three vane-separated mist eliminators, two scrub solution tanks, two pumps, a condenser, and high-efficiency particulate air filters (PNL 1992). With the exception of the offgas hood, all process components are contained in three transportable trailers.

In the In Situ Vitrification process, electrodes are inserted into the soil and a conductive mixture of flaked graphite and glass frit is usually placed between the electrodes to act as the starter path for the electrical circuit. The current of electricity passing through the electrodes heats the soils and graphite to temperatures of approximately 2,000°C (3,632°F) and melts the soil. The graphite starter path is eventually consumed by oxidation and the current is transferred to the molten soil (now electrically conductive). As the vitrified zone grows downward and outward, metals and radionuclides are incorporated into the melt. Convective currents within the melt mix materials that are present in the soil. Organics are vaporized and then pyrolyzed as they pass upward through the melt. When the electrical current ceases, the molten volume cools and solidifies. A hood placed over the processing area provides confinement for the evolved gases, drawing the gases into an offgas treatment system.

In Situ Vitrification, although still innovative, has proven to be an effective remedial technology for the immobilization of inorganics, the application to a wide variety of contaminants (such as organics, metals, and radionuclides), and volume reduction. In Situ Vitrification is also safer to the public and workers because it avoids excavation, material handling, and disposal (EPA 1992). However, specific site characteristics must be considered to determine the implementability of In Situ Vitrification. The presence of excessive moisture or groundwater can limit the economic practicality of In Situ Vitrification because of the time and energy required to eliminate the water. Soils with low alkaline content may be unable to effectively carry a charge and thereby diminish the applicability of In Situ Vitrification (EPA 1992). Large quantities of combustible liquids or solids may increase the gas production rate beyond the capacity of the offgas system. In addition, the presence of metals in the soil can result in a conductive path that would lead to electrical shorting between electrodes. However, this problem can be avoided by innovative electrode feeding techniques. In Situ Vitrification is currently limited to a maximum depth of 5.8 m (19 ft) (EPA 1992).

Before using In Situ Vitrification, the location of the contaminants must be verified and the site prepared. Site preparation includes clearing vegetation, grading, and removal of uncontaminated overburden by excavation (the cost to excavate uncontaminated material is much lower than the cost to vitrify). The waste area is divided into vitrification settings based on an electrode spacing of 4.5 m (14.8 ft). Four electrodes are used at a time at a width of 7.8 m (25.6 ft) per setting. Therefore, approximately one setting will be needed for each 56 m^2 (602 ft^2) of waste area. After the system is prepared, the four electrodes are simultaneously fed into the soil initiating the melt. The electrodes are continually fed until the desired vitrification depth is achieved and the melt is completed. An In Situ Vitrification processing rate of approximately 4 to 5 tons/hour is anticipated (EPA 1992). Once solidified, the sunken vitrified area is backfilled to a minimum of 1 m (3 ft) above the block. A crane is used to transport the electrode frame and hood to the next setting.

4.1.4.3.2 Treatability Study. Two In Situ Vitrification treatability studies were conducted at the Hanford Site between 1987 and 1989 to evaluate In Situ Vitrification under site-specific conditions. Two waste cribs (216-Z-12 and 116-B-6A) were vitrified to depths of 4.9 and 4.3 m (16 and 14 ft), respectively. The depth limitation at the 116-B-6A crib area was believed to be the result of a cobble layer present at 4.3 m (14 ft). This resulted in preferential lateral growth rather than downward growth. When a large particle size layer is encountered, a high equilibrium temperature is necessary to achieve the same downward progression rate (PNL 1992). However, typically, heterogenous power distributions occur within the melt; half of the delivered power is held in the upper third of the melt, and power decreases as the depth increases. This results in a slower melt advance as the melt reaches an equilibrium, and finally melt advance stops (EPA 1992). Thus, the melt at the 116-B-6A crib may not have extended much deeper, regardless of the cobble layer.

Although treatability studies have demonstrated possible effectiveness problems because of depth limitations, the Hanford Site 100 Area includes locations where In Situ Vitrification may be used. In Situ Vitrification stabilizes radionuclide and metal contaminated soils if the contaminant material type, concentrations, and depth are within process parameter limitations. Equipment developed to implement In Situ Vitrification is not readily available, nor is the technology commonly applied.

4.1.5 Ex Situ Treatment and Processing

Ex situ treatment technologies provide treatment following waste removal. Technologies examined include thermal desorption, cement stabilization, vitrification, soil washing, and compaction.

4.1.5.1 Thermal Desorption. Thermal desorption is a process that uses indirect low temperatures to thermally remove volatile organic compounds (VOC) and some semivolatile organic compounds (SVOC) from contaminated soils, sediments, solids, or sludges. The process does not use incineration or pyrolysis to treat the contaminants, but instead volatilizes the organics leaving the processed solids virtually free of organic contaminants.

A thermal desorption system usually includes a rotary kiln with two concentric shells. The inside shell, or processor, is sealed and houses the contaminated material. The annular space between the two shells houses burners that indirectly heat the contents of the processor while kiln rotation allows for constant mixing and exposure for heat transfer. Depending on the design, the contaminated soils are heated to between 232 and 593°C (450 and 1,100°F) at residence times ranging from 60 to 300 minutes (Sudnick 1993 and Krukowski 1992). An inert carrier gas is sometimes used to remove and direct the VOC and particulates from the processor to the gas treatment system. The treatment system typically consists of heat exchangers and scrubbers that cool the process stream for the removal of VOC and particulates. The remaining vapor stream is passed through an abatement system to ensure regulatory compliance before atmospheric release. The majority of the treated vapor stream is preheated and recirculated back through the annular space between the shells for reuse in the desorption process.

Thermal desorption is a process that has been proven effective in removing VOC and some SVOC from soils and solids. The process can be more economical than other thermal processes, such as incineration or pyrolysis, because of the energy savings realized by the lower operating temperatures. Some factors that may influence operating efficiencies and costs include waste type, contaminant type, soil moisture content, particle size, and treatment goals.

Contaminant removal efficiencies vary with each compound and can affect treatment goals. Thermal desorption may not be effective in treating soils or solids contaminated with high boiling point SVOC. Fortunately, the SVOC that have been detected in soils and sediments at the Hanford Site 100 Area have boiling points within the operating temperature ranges previously discussed.

Soil moisture content is another variable that can drastically affect efficiency and cost. Most thermal desorption units operate economically at a soil moisture content of 20%. Soil containing moisture exceeding this value may require predrying or dewatering, resulting in increased costs.

Thermal desorption may be an effective process to treat the limited VOC and SVOC contamination in soils at the Hanford Site 100 Area. A variety of full-scale systems are readily available and could be easily implemented at any of the sites. However, a thermal desorption treatability study to support remedy design should be performed before full-scale operation (DOE-RL 1992b). The treatability study should incorporate an evaluation of various co-contaminants on the thermal desorption process.

4.1.5.2 Cement Stabilization.

4.1.5.2.1 Description. Cement stabilization involves mixing contaminated material with cement to reduce leachability and bioavailability. The cement mixture typically consists of pozzolanic agents such as fly ash or kiln dust and cement. Plasticizers, hardening agents, and other additives are available to adjust the required physical properties of the final product. The contaminants do not interact chemically with the solidification agents, but are mechanically bonded (i.e., encapsulated). Treated waste exists as a solidified mass similar to concrete with significant unconfined compressive strength.

Cement stabilization is an established technology for treatment of wastes and soils contaminated with inorganic compounds and radionuclides. A typical cement stabilization process involves the following steps:

- Contaminated materials are screened to remove oversized material
- Contaminated materials are introduced to a batch mixer and mixed with water, chemical reagents and additives, and cement
- After the material is thoroughly mixed, it is discharged into molds and allowed to solidify
- The solidified unit is then disposed.

The two most commonly used mixing systems are mobile plants and modular plants. The mixing system includes a silo for cement storage, a weight batcher for control of the cement feed, and a ribbon blender for mixing. Excavation equipment is used to load the material to be solidified into the unit. A modular mixing plant can produce approximately 180 yd^3 (137 m^3) of solidified waste a day (EPA 1986).

Cement stabilization is an effective way of immobilizing contaminants in materials excavated from waste sites. This technology is most applicable for materials with inorganic contamination. Verification of effectiveness typically requires sampling and testing the solidified product. Cement stabilization is widely used and is performed using equipment developed for the method. No specific ARAR exists to prohibit this action. Even though cement stabilization reduces exposure risk through immobilization the end product must still be disposed in a managed facility.

4.1.5.2.2 Treatability Study. A cement solidification/stabilization treatability study was recently completed for Operable Unit 1 of the Fernald Environmental Management Project (DOE 1993b). Cement solidification testing was performed on waste from six waste pits.

The waste treated was derived from Waste Pits 1, 2, 3, 4, 5, and 6. The waste composition was as follows:

Waste Pit 1: Filter cakes, vacuum-filtered sludges, magnesium fluoride slag, scrap graphite, and contaminated brick. Contains 1,075 metric tons (MT) of uranium.

Waste Pit 2: Same as Waste Pit 1. Also received raffinate residues. Contains 175 MT of uranium.

Waste Pit 3: Lime-neutralized raffinate slurries, contaminated storm water, vacuum-filtered production sludge, neutralized liquid from process systems, neutralized refinery sludges, and cooling water from heat treatment operations. Contains 846 MT of uranium and 97 MT of thorium.

Waste Pit 4: Solid wastes, including process residues, scrap uranium metal, off-specification intermediate uranium products and residues, thorium metal and residues, barium chloride, and contaminated ceramics. Also received noncombustible trash, including cans, concrete, asbestos, and construction rubble. Lime was occasionally added for uranium precipitation. Contains 2,203 MT of uranium and 74 MT of thorium.

Waste Pit 5: Slurries, including neutralized raffinates, acid leachate, filtrate from sump slurries, lime sludge, thorium in barium carbonate sludge, thorium in aluminum sulfate sludge, and uranium in calcium oxide sludge. Contains 527 MT of uranium and 72 MT of thorium.

Waste Pit 6: Magnesium fluoride slag, process residues, filter cakes, extrusion residue, and heat treatment quench water. Contains 1,432 MT of uranium.

Portland cement (Type I/II) and blast furnace slag were used as binders. Additives to the cement included Type F fly ash, site fly ash, absorbents, and sodium silicate. Solidified samples were tested for strength, leach resistance, permeability, and durability. The following results were obtained:

- All formulations passed toxicity characteristic regulatory criteria in the toxicity characteristic leaching procedure leachate.
- Leachability of uranium was controlled except when present in high concentrations (Waste Pit 4).
- No significant temperature increases or offgassing occurred during mixing.
- Formulations developed could be applied on a large scale.

- Formulations with >43% portland cement Type II were effective in meeting the 500 psi strength requirement set for an onsite retrievable waste form. This composition also effectively controlled leaching of uranium and gross alpha and beta.

- A significant increase in volume resulted from the cement stabilization process.

- Raffinate residues or lesser amounts of uranium (90% less than in Pit 1) in Pit 2 caused the percentage of organics in the waste to be at a much higher level.

- Permeabilities of all the solidified samples were low.

- Solidified samples passed criteria set for durability (wet/dry and freeze/thaw). Addition of blast furnace slag reduced durability.

4.1.5.3 Soil Washing.

4.1.5.3.1 Description. Soil washing is a remedial technology that may remove organic compounds, inorganic compounds, and radionuclides from soils. Soil washing can consist of (1) size separation of highly contaminated soil fractions (usually fines) from minimally contaminated soil fractions (typically course gravels and sands), (2) mechanical abrasion (such as trommels, ball mills, or autogenous grinding) to remove surface contamination (followed by separation), and (3) solvent extraction to chemically leach the contaminants from the soil particles. Each technique can be used independently or in combination with each other.

Soil washing using physical separation is performed when contaminants are concentrated in one soil size fraction. This method works best when the contaminants are in the finer soil fractions (because of the larger surface area per unit mass and the higher adsorption tendencies). The purpose of physical soil separation is to segregate the contaminated fractions from the relatively clean soil, and thereby reduce the volume of contaminated soil requiring disposal. Physical separation can involve wet or dry sieving alone, or it can be combined with gravity separation, classification, attrition scrubbing, or autogenous grinding, followed by some form of wastewater treatment involving suspended solids recovery. Attrition scrubbing (wearing away by friction) is a technique for physically removing contaminants that exist as coatings or precipitates on fine soil particles. Attrition scrubbing is used if the contaminants are found primarily in the sand-sized material at the site. Autogenous grinding serves the same purpose for coarse (cobbles and boulders) material. In this case the cobbles and boulders themselves provide the mechanical abrasion to remove the surface-deposited contaminants. Physical separation is most effective when most of the contaminants are concentrated on one soil size fraction and the contaminated soil fraction is a minor portion of the total soil mass. Soil washing by physical separation can also be performed as a preliminary step in soil washing by solvent extraction.

Soil washing by solvent extraction involves the selective removal of contaminants from soil particles by contact with a liquid. This process has been used extensively in the mining and metallurgy industries, and the same basic principles apply to the extraction of contaminants from soil. The success of this technique generally depends on the proper selection of extractants (chemicals) and in understanding the kinetics of the reactions of concern (DOE-RL 1993e). Typical extractants include aqueous acids, alkalis, organic solvents, and surfactants. Extraction solvents are not currently available for all contaminants, and extraction efficiencies may vary for different types of soils, concentrations of contaminants, and site-specific parameters (Freeman 1989). Solvent extraction usually involves mixing the soil and solvent in an extraction tank until close contact occurs. When close contact occurs, the suspended soil particles will settle to the bottom for collection. The solvent mixture is decanted and the fine particles are separated usually by centrifugal action.

Two bench-scale treatability studies have been conducted on 100 Area soils in support of soil washing technologies. These studies are presented in Sections 4.1.5.3.2 and 4.1.5.3.3. The soil washing treatability studies indicated that soil washing can be somewhat effective on the 100 Area soils. As expected, soil samples indicated that the contaminants were present primarily on fines in certain areas. However, a large mass of cobbles and gravels were also affected by radionuclide contamination. The bench-scale studies provided insufficient data to recommend autogenous grinding or chemical extraction on a full-scale basis. A field-scale treatability test for autogenous grinding and chemical extraction must be performed to consider these technologies along with a soil washing alternative. Therefore, only physical separation and attrition scrubbing will be evaluated at this time as part of a soil washing alternative for the 100 Area soils.

A field-scale treatability study for soil washing is planned for the 100 Area. When the study is completed, this technology evaluation may be changed to incorporate the findings of the study.

4.1.5.3.2 100-D and 100-B/C Area Treatability Study. A bench-scale soil washing treatability study was conducted using soils from two 100 Area trenches (116-D-1A and 116-C-1). The objective of the study was to evaluate the use of physical separation systems and chemical extraction methods as a means of separating chemically- and radioactively-contaminated soil fractions from uncontaminated soil fractions (DOE-RL 1993e).

Before soil washing, soil samples were collected to determine the physical, chemical, and mineralogical characteristics of the soil. Moisture content analysis showed small amounts of clays and organic matter in the 100 Area soils. Particle size distributions confirmed the results of the moisture analysis. Coarse sands and gravels account for approximately 97% of the total mass of samples obtained from trench 116-C-1 and for approximately 50% of the total mass of samples obtained from trench 116-D-1B. Chemical characterization tests showed low total organic carbon values, slightly alkaline soils, and calcium as the dominant exchangeable cation indicating the ability to flocculate during washing (DOE-RL 1993e). All samples included cobalt-60, cesium-137, and europium-152. Maximum activities in the 116-C-1 trench occurred in the >2-mm (0.078-in.) fraction at levels of 525, 5,495, and 2,320 pCi/g for cobalt-60, cesium-137 and europium-152, respectively. Maximum activities in the 116-D-1B trench occurred in the <2-mm (0.078-in.) fraction at levels of 15, 205, and 177 pCi/g for cobalt-60, cesium-137 and europium-152, respectively. Mineralogical characterization tests indicated the presence of micas in the soils. This is important because mica contains wedge sites that have high affinities for cesium-137. Removal of cesium-137 from these wedge sites may not be possible through scrubbing only. The mobilization of cesium-137 occupying these wedge sites can only be accomplished by disrupting and/or dissolving the mineral structures (DOE-RL 1993e).

The soil washing treatability study was performed using both physical separation and solvent extraction techniques separately, as well as tests that evaluated the effectiveness of using both techniques together. Attrition scrubbing was performed on soil size fractions in the 2- to 0.25-mm- (0.078- to 0.01-in.) range, while autogenous grinding was performed on the >2-mm- (0.078-in.-) sized fraction. Chemical extractions were used on both soil size fractions.

Attrition scrubbing tests were performed on the soil using deionized water and electrolytes. Results of the tests using deionized water indicated a >90% reduction in cobalt-60 activity, a 61% reduction in europium-152 activity, and a 26% reduction in cesium-137 activity at an optimal pulp density of 83% and an energy input of 0.65 HP-min/kg (1.43 HP-min/lb). Attrition scrubbing using an electrolyte resulted in the removal of >80% for cobalt-60, 83% for europium-152, and 39% for cesium-137. Such enhanced removal by electrolyte addition appears to result from the synergistic combination of scrubbing action, the improved dissolution of radionuclide-bearing surface coatings, and the reduced readsorption of solubilized contaminants onto freshly exposed surfaces of the coarse-grained soil (DOE-RL 1993e).

Autogenous grinding was performed on gravels and cobbles from the 116-C-1 trench. The process effectively removed a maximum of 85% of cobalt-60 and 97% of europium-152. However, autogenous grinding was ineffective in removing cesium-137 from the cobbles and gravels because of the high initial cesium-137 activities.

Chemical extraction was performed using soils from both trench areas. A variety of chemical extracts were used that are typical of chemical extraction in soils, as well as some proprietary extractants. The extraction data showed that all extractants, except acetic acid, removed substantial fractions of cobalt-60 and europium-152 from the 2- to 0.25-mm- (0.078- to 0.01-in.) sized fractions of 116-D-1B trench soil. However, only the proprietary extractants were effective in removing cesium-137 from this soil fraction (85%). Extraction tests performed on gravels from the 116-C-1 trench were effective in treating cobalt-60 and europium-152, but were ineffective in treating cesium-137.

In addition to the previously discussed tests, two stage attrition scrubbing tests were performed on 2- to 0.25-mm- (0.078- to 0.01-in.) fractions soils using deionized water and electrolytes. The results indicated an increase in radionuclide removal over single stage scrubbing to levels of >79% for cobalt-60, 94% for europium-152, and 48% for cesium-137. Autogenous grinding experiments conducted on gravels using an electrolyte solution indicated removals of 88% for cobalt-60 and 94% for europium-152. Grinding with an electrolyte was ineffective in removing cesium-137 from gravels.

4.1.5.3.3 100-F Area Treatability Study. A bench-scale treatability study was conducted using soil from the 116-F-4 pluto crib. This study evaluated the use of physical separation (wet sieving), treatment processes (attrition scrubbing and autogenous surface grinding), and chemical extraction methods as a means of separating radioactively-contaminated soil fractions from uncontaminated soil fractions (WHC 1994b).

Data on the distribution of radionuclides on various size fractions indicated that the soil-washing tests should be focused on the gravel and sand fractions of the 116-F-4 soil. The radionuclide data also showed that cesium-137 was the only contaminant in this soil that exceeded the test performance goal. Therefore, the effectiveness of subsequent soil-washing tests for the 116-F-4 pluto crib soil was evaluated on the basis of activity attenuation of cesium-137 in the gravel- and sand-size fractions.

Two types of tests (physical and chemical) were conducted to reduce the activities of cesium-137 in the particle-size fractions of the 116-F-4 pluto crip soil. The physical tests included attrition scrubbing (2- to 0.25-mm- [0.078- to 0.01-in.] sized fraction) and autogenous grinding of gravel fractions. Chemical extractions were also conducted on the sand fraction.

The results of autogenous surface grinding experiments using a centrifugal barrel processor showed that 94% to 97% of total cesium-137 activity in the gravel fractions could be removed if grinding was conducted in a water medium. The data indicated that grinding was less effective when conducted in an electrolyte medium. Following autogenous surface grinding, the gravel fractions containing initial cesium-137 activities ranging from 186 to 391 pCi/g contained an average residual activity of 19 pCi/g. This value is well below the test performance goal of 30 pCi/g for cesium-137. The autogenous surface grinding data indicated that the bulk of the contaminant activity (about 74%) was located in the first millimeter of the gravel particle surface. The grinding data also showed that it is necessary to grind approximately a 3-mm (0.117 in.) surface layer off the gravel particles to reduce the residual cesium-137 activity below the test performance goal. On average about 30% by weight of fines (<0.25 mm [0.01 in.]) were generated during the autogenous surface grinding experiments. The residual cesium-137 activity in the treated gravel fraction was functionally related to the quantity of fines generated.

Because of the limited number of experiments, factors that influence autogenous surface grinding, such as consistency, uniformity of grinding, and energy requirements, were not evaluated. These additional data may be needed to evaluate the scale-up factors for conducting pilot- or field-scale autogenous surface grinding.

Based on the data from previous attrition-scrubbing tests on trench 116-D-1B soil from the 100 Area, optimized attrition scrubbing tests were conducted on the sand fraction (2- to 0.25-mm [0.078- to 0.01-in.]) of 116-F-4 pluto crib soil. Two-stage and three-stage attrition scrubbing was conducted in the presence of an electrolyte at an optimum pulp density of about 79% and an energy input of 0.68 HP min/kg (1.5 HP min/lb). The two-stage and the three-stage attrition scrubbing removed on average 50% and 60% of cesium-137 activity, respectively. The residual cesium-137 activities in scrubbed samples, ranging from 75 to 114 pCi/g, were well above the test performance goal for this radionuclide.

Chemical extraction experiments were also conducted on both untreated and attrition-scrubbed sand fractions from 116-F-4 pluto crib soil. Previous extraction experiments indicated (DOE-RL 1993a) that a proprietary extractant (Extractant II) was the most effective of all extractants tested in removing substantial amounts of radionuclides, including cesium-137 from Hanford Site soils. The chemical extraction data showed that one-quarter to one-half formal concentrations of Extractant II removed from 72 to 79% of the total cesium-137 activity from sand fractions resulting in residual activities that ranged from 52 to 77 pCi/g. Chemical extraction tests conducted on two-stage attrition scrubbed samples showed that the residual cesium-137 activity can be reduced to 27 pCi/g, a value below the test performance goal. These data indicated that a combination of two-stage scrubbing in electrolyte followed by chemical extraction can reduce initial cesium-137 activities of 210 to 260 pCi/g in sand fraction to below the test performance goal with concomitant generation of 2.3% contaminated fines (on bulk soil basis).

4.1.5.4 Vitrification. Vitrification is a process that converts soil and other materials into glass or glass-like substances using heat. Vitrification immobilizes inorganics, such as metals and radionuclides, by encapsulating or incorporating them into the structure of the glass. The resulting vitrified product is a glass matrix that is highly resistant to leaching. Ex situ joule heating vitrification uses furnaces that have evolved from glass melters in the glass industry. The electric furnace/melter uses a ceramic-lined, steel-shelled melter that contains the molten glass and waste materials to be melted (EPA 1992).

In a typical joule-heated ceramic melter, wastes are put into a molten glass bath between two electrodes that heat the contents to temperatures between 1,000°C (1,832°F) and 1,600°C (2,912°F). A cold cap is usually formed on the top of the melt as the feed is introduced and functions as the interface between the incoming material and the molten glass. The cold cap performs the important function of holding volatilized wastes, particularly metals, so that maximum contact time between the metals and the melt can occur, increasing the probability of metals dissolving in the melt (EPA 1992).

Some of the same limitations that apply to In Situ Vitrification also apply to joule-heated ceramic melter. Metals in their elemental form may sink to the bottom of the melt forming an electrically conductive layer that can short the system. Other processing problems may include slow processing rates due to high melt viscosity or increased melter corrosion due to low melt viscosity. However, feed modifications and other process control adjustments can be easily made with ex situ vitrification. For example, chemicals can be added to change the melt composition to enhance the solubility of the metals, as well as produce a more durable and leach-resistant product.

In DOE-RL (1993a), ex situ vitrification was considered in combination with a soil washing alternative to stabilize the radionuclides associated with the fines before disposal. The rigorous action of soil washing should remove any radionuclides capable of leaching from the soil. It is unlikely that anything not removed by soil washing will be removed by contact with rainwater. Also, the disposal facilities being considered are designed to prevent infiltration, and therefore, possible migration of contaminants. Thus, ex situ vitrification will not be considered further.

4.1.5.5 Compaction.

4.1.5.5.1 Description. Compaction of solid waste is a well-established technology developed to process and dispose of municipal waste. Materials from burial grounds, such as soft wastes and scrap metals, respond well to compaction. Baling achieves the highest degree of compaction. A baler has a series of hydraulic rams that compress solid waste into a small space. The resulting bales are bound with wire into dense manageable bricks. Baled waste is less likely to produce methane, will generally not support combustion, and produces a lower concentration of leachate (Corbitt 1990).

A typical baler has three rams that compress waste in three dimensions (Figure 4-7). The first ram compresses in a horizontal direction to a preset dimension, the second ram compresses in a horizontal direction to a preset dimension perpendicular to that of the first, and the third ram provides vertical compression to a predetermined gauge pressure. Many commercially available balers do not require material separation before compaction. Materials are loaded into a conveyor system that supplies the charging box of the baler.

Depending on the type of baler unit, the amount of waste can be reduced to 10% of the original amount. Final densities vary based on the types of materials processed and the ram pressure. Compression pressures vary from 500 to 4,000 psi. Below 70 kg/cm^2 (1,000 psi), unstable bales will be produced regardless of other parameters. Low pressure baling generally will require banding while high pressure baling does not. Approximately 20 to 50 tons of waste can be processed per hour. Typically, the high pressure balers are only available in the higher capacities (50 tons/hour). Final block sizes are typically 1 by 1 by 1.4 m (39 by 39 by 55 in.) (GEC 1975).

4.1.5.5.2 Similar Study. The American Public Works Association performed compaction experiments with a three-stroke scrap baler that was donated by General Motors Corporation from a test program conducted in 1970 (GEC 1975). The experiments were performed on a variety of municipal wastes consisting mostly of household refuse. Samples were subjected to pressures ranging from 35 to 246 kg/cm^2 (500 to 3,500 psi) with a few samples subjected to 422 kg/cm^2 (6,000 psi). The final high pressure stroke required 17 seconds. Bales produced typically measured 0.4 by 0.5 by 0.35 m (16 by 20 by 14 in.). Average density obtained at 246 kg/cm^2 (3,500 psi) was 1,483 kg/m^3 (2,500 lb/yd^3). Bale expansion was about 30% after compression at 246 kg/cm^2 (3,500 psi). Compaction pressures of less than 70 kg/cm^2 (1,000 psi) produced fragile bales. Bale stability increased with increasing pressure up to 141 kg/cm^2 (2,000 psi). Pressures above 141 kg/cm^2 (2,000 psi) did not increase bale stability. Increased bale stability resulted from increasing the amount of time that compaction pressures were maintained. The baling produced leachate and pollutants that were detected by analyses. The potential for leachate production by the compressed waste was reduced by reducing the permeability of the waste. The coefficient of permeability of compressed refuse was reduced from 13 m/day to 0.6 m/day (42.6 ft/day to 2.0 ft/day) with an increase in wet density from 572 to 1,137 kg/m^3 (965 to 1,917 lb/yd^3). Tests were conducted to measure gas production by taking compacted samples, immersing them in water baths at different temperatures, and buffering the solutions to high pH values to encourage gas production. The low permeability of the waste prevented penetration of the alkaline solution at a rate fast enough to counteract the internally generated organic acids. As a result gas generation ceased in tests after three days. The American Public Works Association tentatively concluded that baling may be less of an environmental hazard than other methods. At an experimental balefill site in Georgia, no shifting has been observed after 6 years of operation. A series of tests were also performed to assess the way that the bales were handled. The American Public Works Association concluded that strapping offered no real advantage in high-pressure bales. Rail haul tests of 1,126 km (700 miles) produced no damaged bales. The tests showed that bales should be loaded compactly into the railcars (GEC 1975). This indicates that once the waste is compacted by bailing, the bales are extremely structurally stable. Enhancing the bailing technology will satisfy health and safety requirements and protect the public.

4.1.6 Disposal

Onsite disposal (within the boundary of the Hanford Site) is being considered as an applicable technology. The two methods used for onsite disposal are trench and vault disposal. Before deciding on a disposal option, the waste acceptance criteria and availability of a disposal facility must be carefully evaluated.

4.1.6.1 Trench Disposal. Burial trenches are below grade excavations for waste disposal. Unlined disposal trenches have been used in the past at the Hanford Site, but are not considered for future actions. Applicable technology for trench disposal has been developed incorporating RCRA compliant designs. Currently a RCRA compliant facility, the W-025 Radioactive Mixed Waste Land Disposal Facility (W-025 Facility), is under construction in the 200 Area. Another facility is currently in the conceptual design phase, the Environmental Restoration Disposal Facility, which is planned to accept wastes generated from environmental restoration activities, including remediation of the 100 Area. The W-025 facility is planned to be operational by 1995. The construction of Phase I of the Environmental Restoration Disposal Facility is planned to be complete by the end of 1996. The entire Environmental Restoration Disposal Facility will be completed at a later date. Both facilities will incorporate an appropriate surface barrier as discussed in Section 4.1.3. The design of these facilities is discussed in the following paragraphs.

4.1.6.1.1 The W-025 Radioactive Mixed Waste Land Disposal Facility. The major components of the W-025 facility are the disposal trench, a contaminated water temporary storage facility, utility systems such as electrical and communications, a security system, a stormwater management system, and a control building. The facility is located within the existing Low Level Burial Area No. 5 between trenches 39 and 47 in the 200 West Area. The disposal trench is a rectangular landfill with a RCRA compliant liner. The trench will provide a burial capacity of 53,000 m^3 (69,000 yd^3); however, because of the required soil cover, the anticipated waste capacity is approximately 21,000 m^3 (28,000 yd^3). The landfill is being constructed with a primary leachate collection system, a secondary leachate collection system, and a RCRA compliant cover. Waste will be transported to the facility by truck from the source areas. The design and operations of the facility are presented in the design report (WHC 1990).

The facility will accept solid waste in accordance with the *Hanford Site Solid Waste Acceptance Criteria* (WHC 1993a), which meet the requirements of RCRA and DOE (DOE Order 5400.5).

4.1.6.1.2 Environmental Restoration Disposal Facility. The major components of the Environmental Restoration Disposal Facility are as follows:

- Waste disposal trench
- Leachate collection and storage
- Surface water run-on/run-off control system
- Real-time air monitors and samplers
- Groundwater monitoring
- Use of existing Hanford Site transportation system
- Security/Institutional controls
- Fuel and chemical storage and dispensing areas and other infrastructure facilities.

The ERDF site will cover a maximum of 4.1 km^2 (1.6 mi^2) on the Central Plateau, southeast of the 200 West Area and southwest of the 200 East Area. The initial construction of the facility will require 165 acres of this area.

Initial construction and operation of two disposal cells that are expected to provide an approximate waste disposal capacity of 1.2 million yd^3. These cells will be designed and constructed to RCRA minimum technological requirements (MTR) (40 CFR Part 264, Subpart N). The decision to expand the landfill in the future will be documented by amending the ERDF ROD or as part of the RODs for the Hanford Site operable units.

Waste acceptance criteria will be developed by DOE, in accordance with ARARs, risk/performance assessments, ERDF-specific safety documentation, and worker protection requirements. Upon approval by EPA (and consultation with Ecology), these criteria will govern what wastes from the Hanford NPL sites can be placed in the ERDF. No waste may be placed into the ERDF until the waste acceptance criteria have been approved by EPA and consultation with Ecology. Operable unit-specific waste disposal and treatment decisions will be made as part of the remedy selection and cleanup decision process for each operable unit.

The final cover for the disposal trench will be a modified RCRA-compliant closure cover. Some of the materials excavated for the trench may be used to construct the barrier.

4.1.6.2 Vault Disposal. Vaults are engineered containment facilities that provide a maximum of lateral and vertical confinement. Vaults were identified in DOE-RL (1993a) for disposal of organic wastes and transuranic waste.

Organic waste will decay in a standard landfill, promoting subsidence and subsequent failure of the landfill cover. The vault should be designed to prevent subsidence after the organic wastes have decomposed. This concept has been incorporated into the disposal trench design and, as a result, the separate vault concept has been abandoned. The most recent design of the Environmental Restoration Disposal Facility includes injection grouting of decomposable wastes, as necessary.

Transuranic waste originally identified for disposal in vaults will eventually be disposed off site. The transuranic wastes will be handled as outlined in the *Hanford Site Solid Waste Acceptance Criteria Manual* (WHC 1993a). The waste will be stored in the 200 Area, analyzed, packaged in the Waste Receiving and Packaging Facility, and submitted for final disposal as determined by DOE.

Transuranic waste has not been identified in any of the 100 Area investigations since the vault disposal technology was developed in the Phases 1 and 2 feasibility study (DOE-RL 1993a). Transuranic waste, therefore, is not expected to be encountered during remediation of 100 Area source operable units; the vault disposal technology is not considered further in this Process Document.

4.1.7 Innovative Technologies

The DOEs Environmental Management Office of Technology Development (EM-50) is implementing an aggressive national program for applied research, development, demonstration, testing, and evaluation to develop new technologies to remediate the DOE nuclear production and manufacturing sites and to manage DOE generated wastes more cost-effectively. The program is addressing several major problem areas, including groundwater and soil remediation and waste retrieval and processing. This Process Document evaluates two previously developed technology alternatives of the Office of Technology Development. These two technologies are In Situ Vitrification and a barrier. In addition to these two technologies, there are a number of complimentary technologies for environmental restoration in various stages of development and demonstration that will be ready for implementation in the near future.

4.2 DESCRIPTION OF ALTERNATIVES FOR SOIL AND SOLID WASTE

Alternatives associated with the six general response actions identified in DOE-RL (1993a) are described in this section. The general response actions are as follows:

- No action
- Institutional controls
- Containment
- Removal/disposal
- In situ treatment
- Removal/treatment/disposal.

For each general response action one or more Remedial Alternatives have been developed. Also, the site characteristics or conditions that are a prerequisite to effective application of the alternative (applicability criteria) are presented. Additional treatment components (enhancements) that may be incorporated into the alternatives on a case-by-case basis are also presented. The addition of enhancements increases the number of sites that may be effectively addressed by the developed alternatives, and thereby minimizes the need for site-specific development of alternatives in the subsequent operable unit-specific FFS.

Although single alternatives are generally evaluated in this Process Document to identify the potential interim remedial action (Table 4-1), a combination of alternatives may be preferred as more information is gathered through the observational approach. The results of this Process Document and the operable unit-specific FFSs (see Appendices E, F, and G) will be used in combination with information gathered during remedial action implementation to evaluate the appropriate alternative or combination of alternatives.

4.2.1 No Action General Response: Alternatives SS-1 and SW-1

The No Action Alternatives for soil and solid waste sites are SS-1 and SW-1, respectively (DOE-RL 1993a). The National Contingency Plan (40 CFR 300) requires that a "no action" alternative be evaluated. 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." For the No Action Alternative, contaminants are allowed to dissipate through natural attenuation processes. The acceptability of this alternative has been initially evaluated in the qualitative risk assessment. Generally speaking, a site that has been identified as an interim remedial measure candidate during the qualitative risk assessment process contains contaminants exceeding risk screening levels, and would not be an appropriate site for no action. However, exceptions do exist. The final decision on the applicability of the No Action Alternative is addressed on a site-by-site basis in the operable unit-specific FFS where site-specific information is reviewed against the remedial action objectives.

The No Action Alternatives require that a site pose no threat to human health and the environment or that the site has been effectively addressed in a prior action. In the context of interim action, only those sites that have contaminants below risk levels are appropriate for no action. This may result from natural degradation, or the fact that contaminants were reduced to acceptable levels by some prior action. The only waste site groups that meet this criterion would be the seal pit cribs and decommissioned and decontaminated facilities. Some of the decommissioned and decontaminated facilities have already been addressed through decommissioning and decontaminating actions and have been released based on allowable residual contamination levels (see Section 3.1.7).

The No Action Alternative for the source operable units in essence implies that nothing is done at the site to reduce contaminant concentrations or prevent receptors from being exposed to the contaminants. Because DOE will continue active ownership of the Hanford Site during the interim action period, there will be access restrictions in place, fencing to prevent unauthorized entry, site security, and some ongoing monitoring and surveillance activities. However, none of these ongoing actions would be controlled under the No Action Alternative. The actions would continue only as a result of DOE's decision to continue these actions for site-wide or other purposes. Furthermore, none of the information derived from the site-wide actions would be used to reassess the value of continuing the No Action Alternative.

There is one "applicability criterion" that must be met to consider no action; the concentrations of all contaminants of potential concern must be less than the preliminary remediation goals. Because some D&D sites may meet this criterion, no action may be appropriate. There are no technologies within this alternative because no action is taken (Table 4-1). Also, because there are no technologies there are no enhancements. The applicability criteria and enhancements for each alternative are listed in Table 4-2. This table also shows that the No Action Alternative is appropriate for only two of the waste site groups, Seal Pit Cribs, and the D&D group.

4.2.2 Institutional Control General Response: Alternatives SS-2 and SW-2

The institutional control alternatives for soil and solid waste sites are Alternatives SS-2 and SW-2, respectively. These alternatives involve deed restrictions (Section 4.1.1.2), groundwater surveillance monitoring (Section 4.1.1.1), and access restrictions (Table 4-1 and DOE-RL 1993a).

Access restrictions may be accomplished using site security personnel, fencing, and/or public notices. Access restrictions would reduce the potential for human exposure. However, this action would not necessarily preclude site trespassing. Fencing would provide a physical barrier to exclude humans and animals (to some extent), but would require maintenance and surveillance actions. Public notices and community relations efforts could supplement site security and fencing.

Deed restrictions would be incorporated at waste sites if and when DOE releases control of the area containing the waste sites. Deed restrictions could include preventing excavation below specified depths, precluding the use of local groundwater, or restricting agricultural practices. In the context of interim action, DOE will continue to control use of the 100 Area in the near term and can prohibit these land uses through administrative actions.

Because wastes would be left on site under this alternative, at least temporarily, groundwater monitoring would be required to track potential changes in groundwater quality. The present network of groundwater monitoring wells is assumed to be adequate for monitoring potential impacts to groundwater. Depending on the type and level of contaminants at the site, air quality, surface water quality, or wildlife distribution monitoring may also be considered.

The Institutional Control Alternative would be appropriate, for example, at a waste site containing only radionuclide contaminants that would decay to acceptable risk levels before DOE releases control of the area. Because the preliminary remediation goals for radionuclides are calculated by including a decay period to the year 2018 (Appendix A), the contaminants at the waste group would still have to meet the preliminary remediation goals identified in this Process Document. Therefore, the Institutional Control Alternative has one applicability criteria, the concentrations of all the contaminants of potential concern must be less than the preliminary remediation goals. Based on the data available on the waste site groups, no waste site groups meet the applicability criteria (Table 4-2). Therefore, this alternative is not evaluated in this Process Document for any of the waste site groups. No enhancements have been identified for the institutional controls alternatives.

4.2.3 Containment General Response: Alternatives SS-3 and SW-3

The Containment Alternatives for soil and solid waste sites are Alternatives SS-3 and SW-3, respectively (Table 4-1 and DOE-RL 1993a). These alternatives involve the following technologies:

- Surface Barrier (Section 4.1.3.1)
- Surface water controls (Section 4.1.3.2)
- Groundwater surveillance monitoring (Section 4.1.1.1)
- Deed restrictions (Section 4.1.1.2).

Operations for this alternative begin by designing the appropriate surface barrier for the waste site area. The waste site area is defined as the at-grade surface area projected from the waste site (i.e., the projection of the pipelines and the associated contaminated soil). In this Process Document, the Hanford Barrier was considered to be the appropriate barrier type. Should future characterization or monitoring activities of waste sites where other barriers have been placed indicate that less protection is needed, modifications can be made to this alternative. Because the lateral extent of the barrier is based on the extent of contamination present at the site, additional investigations will be needed to adequately locate and delineate the extent of contamination. For the purpose of this Process Document, an additional 12.2 m (40 ft) of effective barrier is assumed to be provided laterally beyond the known limits of contamination. The effective barrier is defined as the asphalt layer.

Surface water controls will be used both during and after construction of the barrier. Groundwater surveillance monitoring will be coordinated with existing groundwater monitoring programs. The present network of groundwater monitoring wells and sampling schedule are assumed to be adequate monitoring impacts to groundwater. Deed restrictions are provided for the area of the completed barrier and for the groundwater zone that may be impacted by the site.

The remedial action objectives are met by eliminating the exposure pathways through the construction of a physical barrier, that prevents receptors from contacting the wastes, and through protection of the groundwater by minimizing the spread of contamination by erosion or leaching.

The Containment Alternative is applicable for those sites where contaminant concentrations exceed the preliminary remediation goals, but the contaminant concentrations do not exceed levels that may impact groundwater under the reduced infiltration scenario. See Section 3.2.4 in the previous chapter and Section 3.4 in Appendix A for more information on the reduced infiltration scenario. Based on the data available, containment for in-place wastes is appropriate for only three of the waste site groups: the

Decontamination Cribs/French Drains, Pipelines, and Burial (Solid Waste) Grounds (Table 4-2). No enhancements have been identified for the Containment Alternatives.

4.2.4 Removal/Disposal General Response: Alternatives SS-4 and SW-4

The Removal/Disposal Alternatives for soil and solid waste sites are Alternatives SS-4 and SW-4, respectively. The alternatives involve removal (Section 4.1.2) and disposal (Section 4.1.6) technologies.

The first action under this alternative is the removal of soils and solid wastes. Additional investigations will be needed to adequately locate and delineate the extent of contamination. However, the removal technology provides the opportunity (for low-level contaminated materials) to characterize and segregate the wastes as excavation proceeds using an observational approach. Materials removed are separated as necessary for transportation to the disposal facility. Depending upon waste acceptance criteria and availability, soils may be disposed in either the W-025 Radioactive Mixed Waste Land Disposal Facility or the Environmental Restoration Disposal Facility. Solid waste removed from the burial grounds must be disposed in the Environmental Restoration Disposal Facility because of the restrictive waste acceptance criteria for the Radioactive Mixed Waste Land Disposal Facility. Therefore, remedial actions at solid waste sites shall not occur until the Environmental Restoration Disposal Facility is available (anticipated by end of 1996). Both the capacity at the intended waste disposal facility, and the waste acceptance criteria must be evaluated before the proper disposal facility is determined.

The remedial action objectives are met by removing the contaminated material that exceeds the preliminary remediation goal. Long-term risks to human and ecological receptors is eliminated by removing the contaminants from the waste site. Excavation will proceed to the depth required to remove all the contaminants exceeding protectiveness of groundwater concentrations.

The Removal/Disposal Alternative is applicable at sites where the contaminant concentrations exceed the preliminary remediation goals. As shown in Table 4-2, this alternative is appropriate for 8 of the 10 waste site groups. No enhancements have been identified for the Removal/Disposal Alternatives.

4.2.5 In Situ Treatment General Response: Alternatives SS-8A, SS-8B, and SW-7

The in situ treatment alternatives vary considerably depending on the waste site groups being considered. These alternatives may involve In Situ Vitrification of soils, void grouting of buried pipelines, or dynamic compaction of solid wastes. The following sections discuss each alternative.

4.2.5.1 Alternative SS-8A, In Situ Vitrification. This alternative, as originally described in DOE-RL (1993a), was applicable to all soil waste sites, except those containing effluent pipelines. This alternative involves the following technologies:

- In Situ Vitrification (Section 4.1.4.3)
- Surface water control (Section 4.1.3.2)
- Deed restrictions (Section 4.1.1.2)
- Groundwater surveillance monitoring (Section 4.1.1.1).

The In Situ Vitrification technology is effective in immobilizing contaminants located between the surface and a depth of no more than 5.8 m (19 ft). After the waste site has been vitrified, the area is backfilled with clean soils to a minimum of 1 m (3 ft) above the vitrified soil mass. Deed restrictions are provided for the area and groundwater (potentially impacted by untreated wastes) is monitored. The present network of groundwater monitoring wells and sampling schedule are assumed to be adequate to monitor impacts to groundwater.

The remedial action objectives are met by eliminating the exposure pathways through the solidification of the contaminated soil and by adding backfill. Groundwater is protected because the vitrified material minimizes the spread of contamination by erosion, leaching, or mobilization by biotic activity.

There are two applicability criteria for the In Situ Vitrification Alternative. In Situ Vitrification is appropriate when (1) the concentrations of the contaminants of potential concern exceed the preliminary remediation goals and (2) the contaminant zone does not exceed a thickness of 5.8 m (19 ft). The depth of the contaminated zone typically exceeds 5.8 m (19 ft) at the retention basins and the fuel storage basin trenches, so In Situ Vitrification is not appropriate at these waste site groups (Table 4-2). Vitrification is also not appropriate for sites containing pipelines and solid wastes (i.e., burial grounds) because large voids and the diversity of materials interfere with the vitrification process.

4.2.5.2 Alternative SS-8B, Void Grouting. Alternative SS-8B has been developed for the pipeline sites and is appropriate only for the pipeline sites. This alternative involves the following technologies:

- Void grouting (Section 4.1.4.1.1)
- Surface barrier (Section 4.1.3.1)
- Surface water controls (Section 4.1.3.2)
- Groundwater surveillance monitoring (Section 4.1.1.1)
- Deed restrictions (Section 4.1.1.2).

Pipelines must be surveyed by video before grouting. These surveys help determine whether grouting is a feasible remedial measure. If the camera survey of the pipeline shows no breaches in pipe integrity and no obstacles that would interfere with grouting, grouting is a feasible remedial measure. Should breaches in pipe integrity or plugs within the pipelines be observed during camera surveys, grouting may not be the appropriate remedial measure. If grouting is feasible, the survey will help determine proper injection grout mixture(s) and appropriate injection point locations. Large volumes of grout will be needed to backfill the lines. For example, approximately 0.76 m^3 (1 yd^3) of grout is required per 30.5 cm (1 ft) of 1.7-m (66-in.) diameter steel pipe. Approximately 3,200 m of 1.7 m diameter (10,500 ft of 66 in.) line exists in the 100-BC Area alone. Success of the grouting process would be determined by comparing the volume of grout material pumped into the pipe to the annular volume of pipe to be grouted. The closer this ratio is to unity, the more successful the grouting.

Areas surrounding the effluent pipelines that have exterior soil contamination would require the addition of a surface barrier. The lateral extent of the barrier is delineated based on the extent of contamination present at the site to be covered. Additional investigations will be required to adequately locate and delineate the extent of contamination. For the purposes of this Process Document, an additional 12.2 m (40 ft) of effective barrier is assumed to be provided laterally beyond the limits of known contamination. The effective barrier is defined as the asphalt layer. Surface water controls must be implemented both during and after construction of the barrier. Groundwater surveillance monitoring would be coordinated with the existing groundwater monitoring programs. The present network of groundwater monitoring wells and sampling schedule are assumed to be adequate for the monitoring of impacts to the groundwater. Deed restrictions are provided for the area containing the barrier, and groundwater that may be impacted by the wastes remaining at the site is monitored.

The remedial action objectives are met by (1) reducing the potential for settling, (2) immobilizing the waste through encapsulation, (3) eliminating the exposure pathways by constructing a physical barrier that prevents receptor contact, and (4) reducing water infiltration.

Alternative SS-8B is appropriate for pipeline sites that meet the following applicability criteria (Table 4-2):

- Contaminant concentrations exceed the preliminary remediation goals

- Contaminant concentrations do not exceed levels that may impact groundwater under the reduced infiltration scenario

- No breaches or plugs occur in the piping that would prevent grouting.

4.2.5.3 Alternative SW-7, Compaction. Alternative SW-7 is applicable only to solid waste sites and is similar to Alternative SW-3 with the addition of an in situ treatment technology. The alternative involves the following technologies:

- Dynamic compaction (Section 4.1.4.2)
- Surface barrier (Section 4.1.3.1)
- Surface water controls (Section 4.1.3.2)
- Groundwater surveillance monitoring (Section 4.1.1.1)
- Deed restrictions (Section 4.1.1.2).

As originally proposed in DOE-RL (1993a), this alternative also included vibration-aided grout injection. Vibration-aided grout injection has been eliminated for the following reasons:

- Dynamic compaction in itself is an effective technology for compaction and stabilization of buried wastes. The surface barrier over the compacted wastes will limit the production of leachate, so grouting will provide little added protection.

- The application of the vibration-aided grout injection technology directly conflicts with the application of dynamic compaction. If grout is applied before dynamic compaction, the grout may make the compaction process ineffective. If grout is applied after compaction, the densified ground will be less amenable to grouting and grouting may be ineffective.

- The success of the grouting program will be difficult to determine. Success depends on intrusive testing, which may be inconclusive in heterogeneous environments such as the burial grounds.

Alternative SW-7 stabilizes the waste site by using dynamic compaction. A test should be performed to optimize the design of the weight, drop pattern, and dropping parameters. For the purposes of this study, the parameters are assumed to be the same as those used at the DOE Savannah River Site (Section 4.1.4.2). After dynamic compaction, the technologies of Alternative SW-3 are implemented (Section 4.2.3).

The remedial action objectives are met by eliminating the exposure pathways by constructing a surface barrier that inhibits receptor contact. The surface barrier also protects the groundwater by minimizing the spread of contamination by erosion, leaching, or mobilization by biotic activity. Dynamic compaction increases long-term effectiveness by lowering the leachability of the waste and by reducing the potential for settling and subsequent failure of the barrier.

Alternative SW-7 is appropriate at solid waste sites if the following applicability criteria are met before implementation:

- Contaminant concentrations exceed the preliminary remediation goals

- Contaminant concentrations do not exceed levels that may impact groundwater under the reduced infiltration scenario.

No enhancements have been identified for the in situ treatment alternatives.

4.2.6 Removal/Treatment/Disposal General Response: Alternatives SS-10 and SW-9

The removal/treatment/disposal alternatives vary considerably depending on the waste site group being considered. The following sections will discuss each alternative separately.

4.2.6.1 Alternative SS-10. Alternative SS-10 is applicable to soil waste sites. This alternative includes the following technologies:

- Removal (Section 4.1.2)
- Thermal desorption (Section 4.1.5.1)
- Soil washing (Section 4.1.5.3)
- Disposal (Section 4.1.6.1).

Alternative SS-10 always includes soil washing, but will include thermal desorption only if organic contaminants are present. Thermal desorption, therefore, is considered an enhancement of this alternative.

As originally proposed in DOE-RL (1993a), this alternative included ex situ vitrification of treatment residuals. Ex situ vitrification has been eliminated for the following reasons:

- Vitrification of residuals from thermal desorption will not reduce the risks of handling those wastes, and would increase the complexity and costs involved in the overall treatment. The residuals from thermal desorption can be effectively disposed at the waste disposal site without further treatment.

- Likewise, vitrification of soil washing residuals would increase the complexity and cost of the overall treatment process, but would not significantly reduce the risk associated with the eventual fate of those wastes. The soil washing residuals can be contained at a disposal facility, and that containment will effectively reduce the risks without the added effort of vitrification.

Figure 4-8 is a flow diagram showing the major components that can be included in this alternative. Generally, soils are excavated then separated into organically contaminated soils and soils contaminated only with inorganic and radionuclide contaminants. Organically contaminated soils, if present, are treated by thermal desorption, then recombined with the remaining contaminated soil for contaminant removal by soil washing. Clean soil from the treatment process is used to backfill the site, while contaminated soil is transported to the disposal facility. All mixed waste is transported to the Environmental Restoration Disposal Facility.

Soil washing by physical separation includes a series of treatment operations. Initially, soils are separated by particle size fraction using a grizzly (large mesh screen), a vibrating screen assembly, a classifier tank, and a spiral classifier. This process results in soil fractions in the >13.5-mm (0.486-in.) range, the 13.5 to 2-mm (0.486 to 0.078-in.) range, the 2- to 0.25-mm (0.078- to 0.01-in.) range, and the <0.25-mm (0.01-in.) range. The two larger fractions are removed and stockpiled for use as backfill if they are clean. If they are contaminated they are transported to the disposal facility. The soil washing process can be terminated after the screening phase, if the contaminants are present primarily in one or two of the size fractions. In this case the clean size fractions would be used for fill and the contaminated size fractions would be transported to the disposal facility.

The sands resulting from the initial screening process (the 2- to 0.25-mm [0.078- to 0.01-in.] range) can be fed into a four-cell attrition scrubber and washed with an electrolyte solution. The fines generated from the attrition scrubbing are removed by screening, and the sand fraction is fed into a second attrition scrubber where it once again is scrubbed with an electrolyte solution. The clean sands resulting from the attrition scrubbing are dewatered and stockpiled for use as backfill. The contaminated fines generated from the various soil washing steps, estimated to be approximately 5 to 15% of the total soil mass, will be transported to the disposal facility. Wastewater generated during washing is transported to a clarifier to promote gravity settling of the solids. A combination of flocculent and polymers are added to enhance separation. The combination of flocculent and polymers was chosen to be consistent with the field scale treatability study currently planned for the 100 Area and will be evaluated further in the detailed design phase. Contaminated sediment and suspended fines are dewatered and removed for disposal. Wastewater is not expected to contain radionuclides and will therefore be recycled for reuse in the washing process. Contaminated residues from thermal desorption offgas treatment and fines from soil washing are transported to the disposal facility.

Soil washing by physical separation and attrition scrubbing will be effective only when most of the radionuclide activity is associated with the sand-sized and fine material (<2.0-mm [0.078 in.] fraction) and the fines are a minor fraction of the entire soil volume. Also, if cesium-137 is present, attrition scrubbing is effective only for contaminated sands with cesium-137 activity less than twice the preliminary remediation goal (based on treatability tests DOE-RL 1993e). Further, for soil washing it was assumed that cobbles and gravels do not contain cesium-137 activities above the preliminary remediation goals, and therefore, autogenous grinding was not included. Before implementation, a treatability study on soil washing and thermal desorption should be performed to verify assumptions and assist in remedial design.

The remedial action objectives are met by separating and removing the contaminated material that exceeds the preliminary remediation goals. Risk to human and ecological receptors are eliminated by removing the contaminants from the site soil, excavating to a depth required to remove contaminants exceeding preliminary remediation goals. Additional benefits are realized from the mass reduction of contaminants due to the treatment options. This Removal/Treatment/Disposal Alternative (SS-10) for soil waste sites is appropriate for those waste sites where contaminant concentrations exceed the preliminary remediation goals.

Thermal desorption and attrition scrubbing are two components of the soil washing alternative that may not be used at some sites. As previously discussed, thermal desorption will be used only when organic contaminants are present. The treatment residuals from the thermal desorption process are assumed to contain inorganic and/or radionuclide contaminants, and are fed into the physical separation (screening) process (Section 4.1.5.1).

Attrition scrubbing is effective in removing contaminants from soil if those contaminants are present primarily on the surface of the sand/soil particles. Based on treatability studies (Sections 4.1.5.3.2 and 4.1.5.3.3), attrition scrubbing may not remove adequate quantities of the contaminants if cesium-137 concentrations in the soils exceed twice the cesium-137 preliminary remediation goal. Site characterization data at the waste site groups indicate that the cesium-137 concentrations in most or all of the soils at the process effluent trench sites exceed twice the preliminary remediation goal. Therefore, attrition scrubbing would not be used at this waste site group. However, cesium-137 concentrations are generally less than twice the preliminary remediation goal in about two-thirds of the soils at the retention basins and sludge trenches, and in all soils at the pluto crib and fuel storage basin trenches; therefore, attrition scrubbing is appropriate for those waste site groups.

Soil washing, using one or several treatment technologies, is applicable for 6 of the 10 waste site groups (Table 4-2).

4.2.6.2 Alternative SW-9. Alternative SW-9 is applicable only to the solid waste sites. The alternative involves the following technologies:

- Removal (Section 4.1.2)
- Thermal desorption (Section 4.1.5.1)
- Compaction (Section 4.1.5.5)
- Disposal at the Environmental Restoration Disposal Facility (Section 4.1.6.1.2).

As originally proposed, this alternative also included cement stabilization of "noncompactable" wastes and treatment residues. Cement stabilization has been eliminated for the following reasons:

- The only noncompactable wastes that may be found at the solid waste sites are large pieces of equipment. Cement stabilization of these items is not feasible.

- Stabilization of thermal desorber residues before disposal does not reduce the risk at the disposal site. These residues can be managed effectively by placement (containment) at the Environmental Restoration Disposal Facility.

To implement this alternative, the contaminated materials are excavated from the site. During excavation, field detection instruments are used to ensure that the contaminated materials are properly characterized and segregated. This approach may require the designation of waste based on existing data, followed by field screening to ensure that the wastes actually fit that designation. The materials are initially separated into the following categories:

- Clean soil
- Containerized waste
- Compactable waste
- Solid wastes (waste that is neither compactable nor organically contaminated).

Clean soil is stockpiled for use as backfill material at the waste site. Solid wastes are assumed to be contaminated only with inorganic chemicals and radionuclides, and are transported to the Environmental Restoration Disposal Facility for disposal.

Containerized waste is inspected and placed into one of the other categories if possible. If the containerized waste does not require compaction or thermal treatment, it is placed in the solid waste category.

Containerized and compactable wastes that contain organic contaminants are treated by thermal desorption to remove the organic chemicals. The treatment residuals from the thermal treatment process are then handled as compactable wastes. While organic contamination is not expected in the 100 Area burial grounds, there is a potential for organic contamination. It is assumed, therefore, that 5% of all waste from the burial grounds is contaminated with organic constituents.

Compactable wastes are compacted into bales using the technology described in Section 4.1.5.5, and disposed at the appropriate disposal facility.

All mixed waste is transported to the Environmental Restoration Disposal Facility for treatment.

The treatment residuals from the above processes (compacted waste, thermally desorbed waste, and offgas treated waste), and the untreated waste (solids) are then disposed at the disposal facility. Both the available capacity at the disposal site and the waste acceptance criteria must be evaluated to determine which disposal site will be used.

The remedial action objectives are met by removing the contaminated material that exceeds the preliminary remediation goals. Risk to human and ecological receptors is eliminated by removing the contaminants from the site. Soil excavation is performed to the depth required to remove contaminants exceeding concentrations protective of groundwater. Additional benefits are gathered from the mass reduction and immobilization of contaminants because of the treatment options.

This Removal/Treatment/Disposal Alternative for solid waste sites (SW-9) is appropriate for sites where the contaminant concentrations exceed the preliminary remediation goals. As shown in Table 4-2, this alternative is appropriate only for the burial grounds.

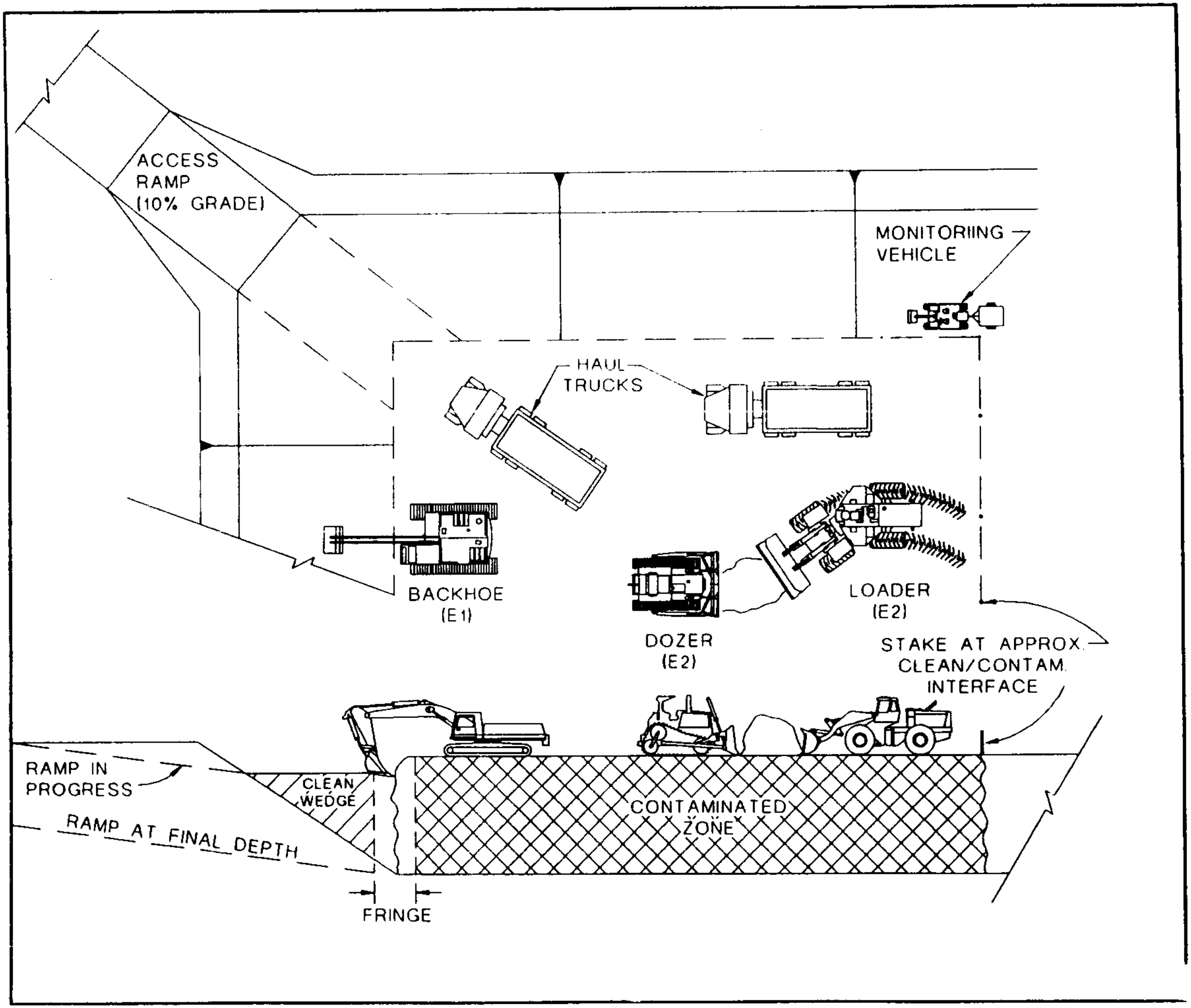


Figure 4-1. Large Site Excavation.

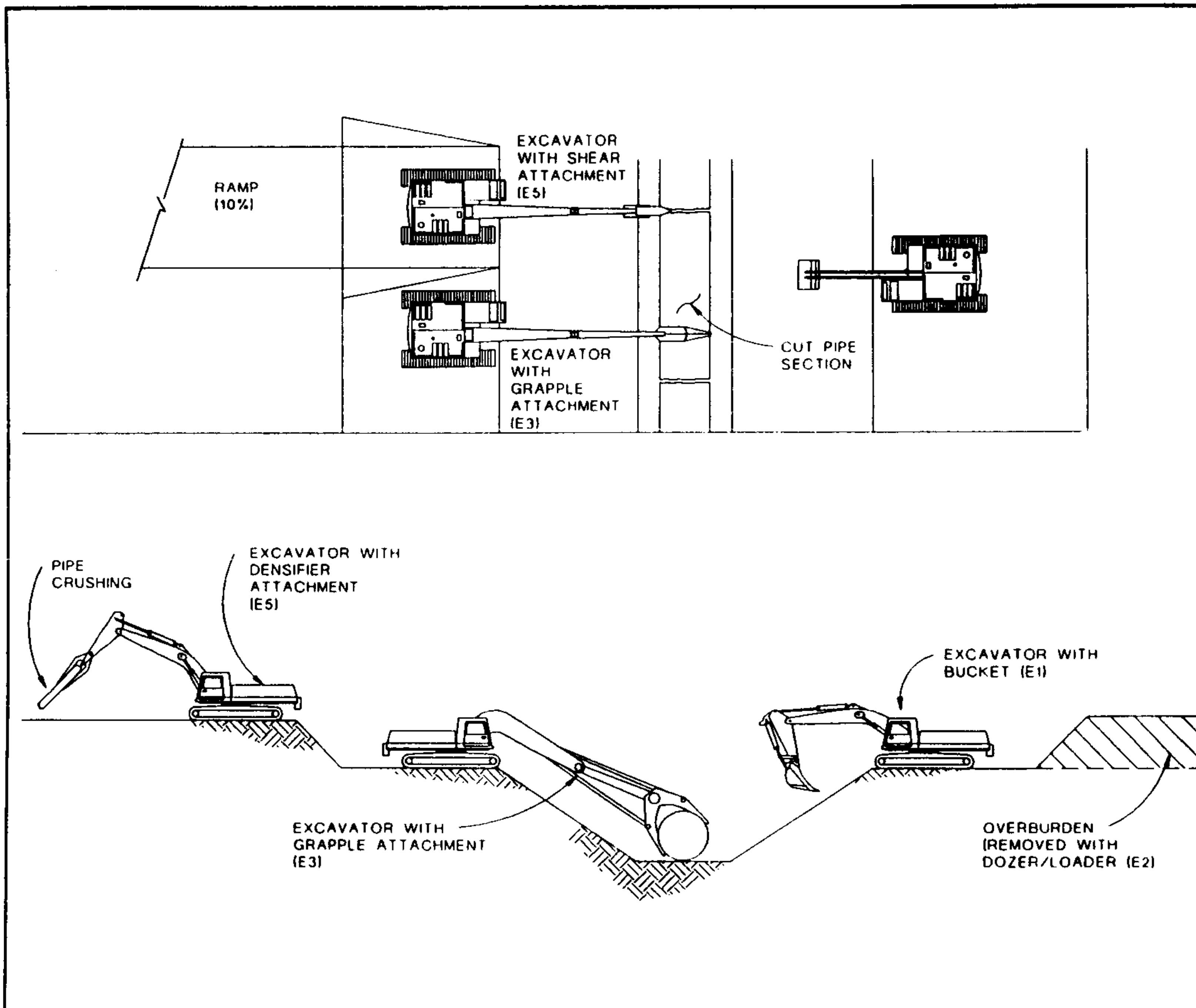


Figure 4-2. Pipeline Removal.

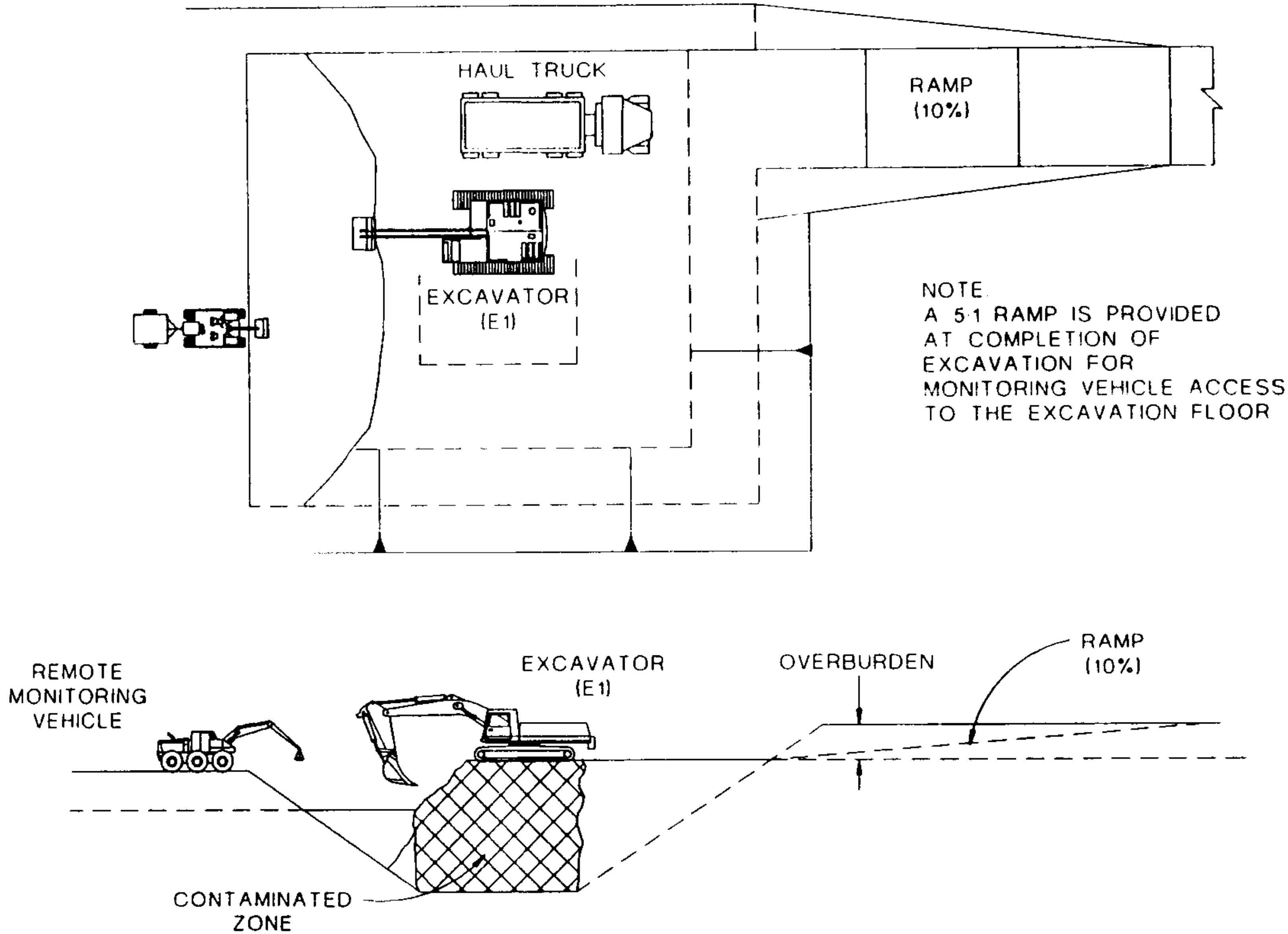


Figure 4-3. Small Site Excavation.

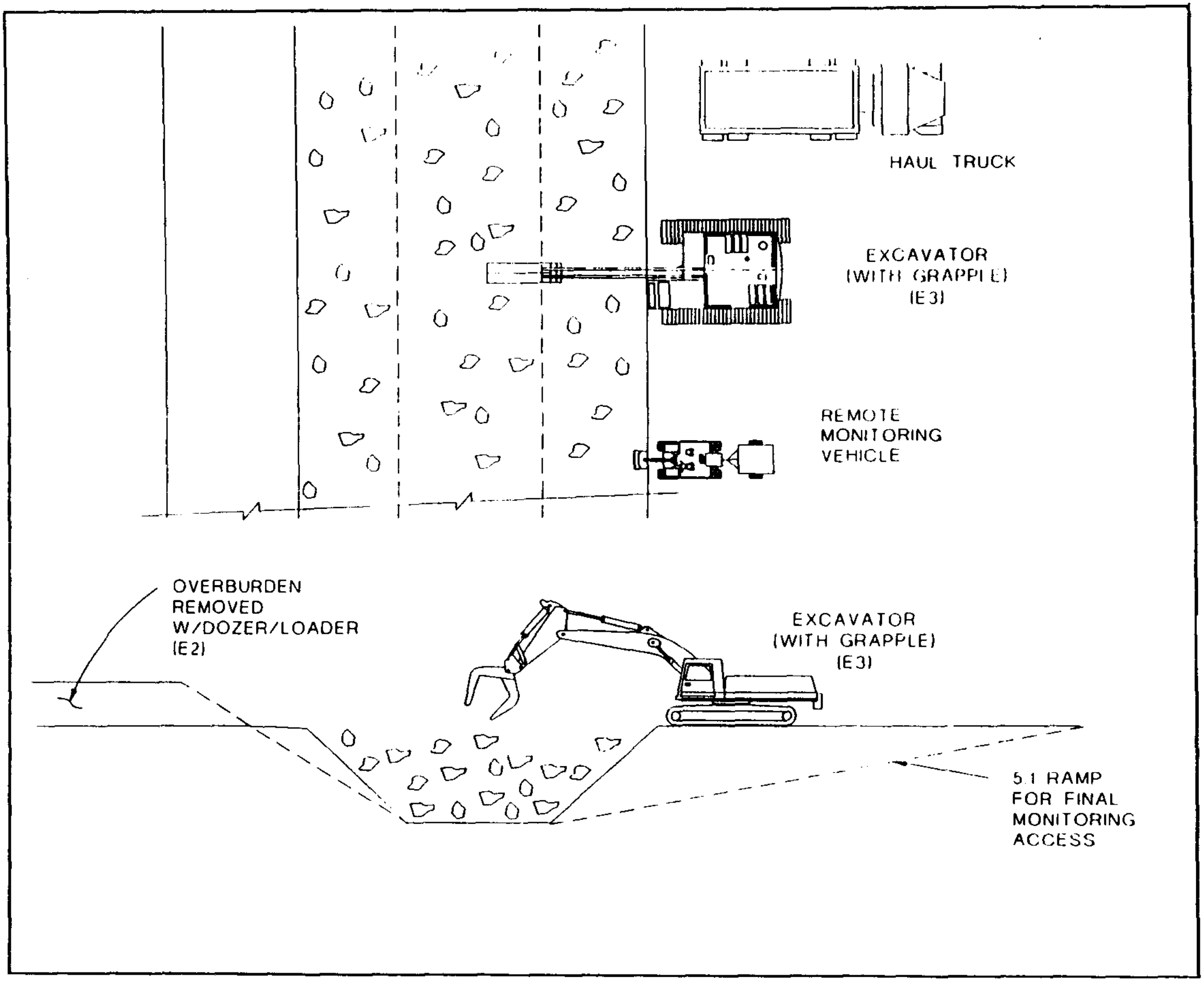


Figure 4-4. Buried Waste Excavation.

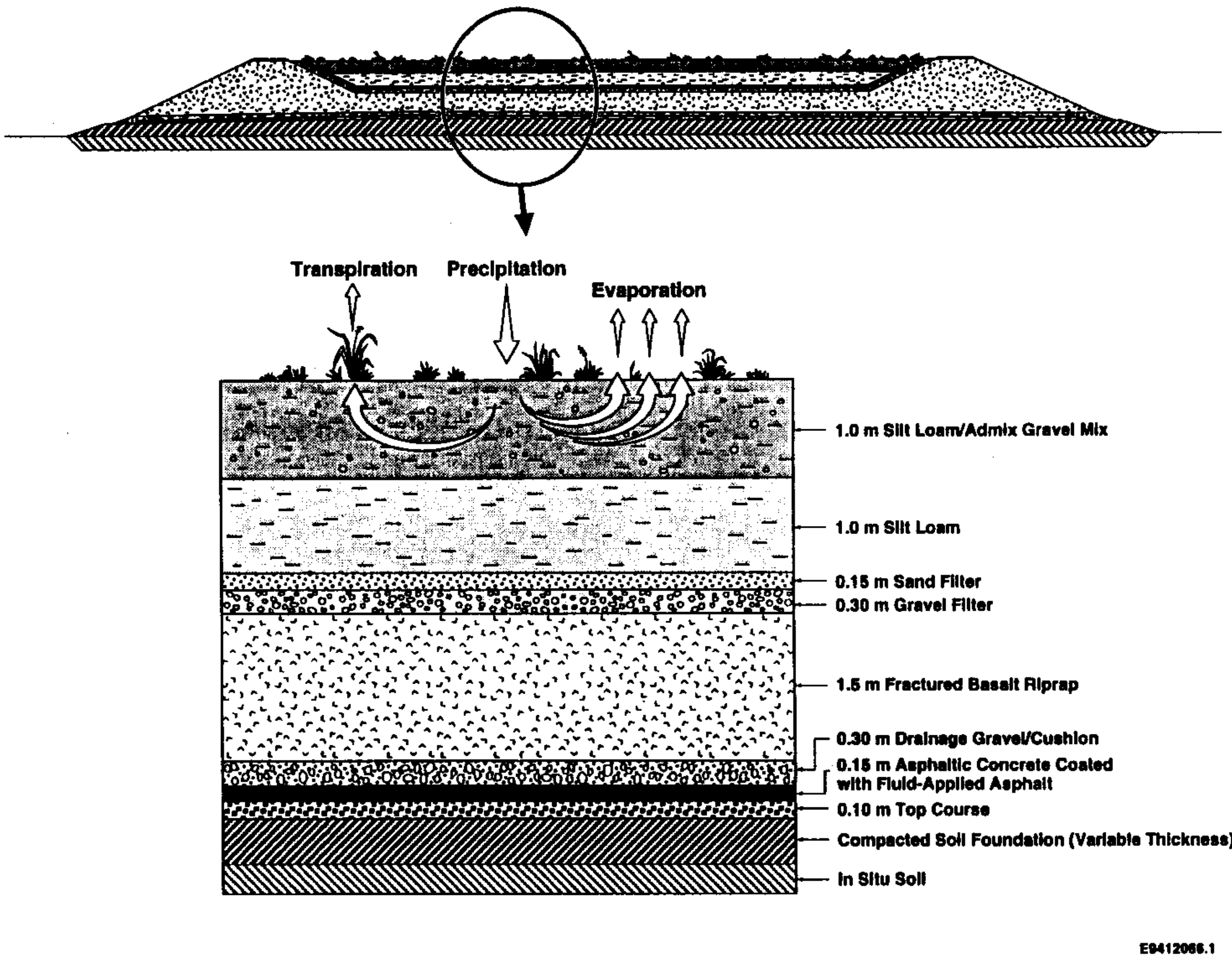
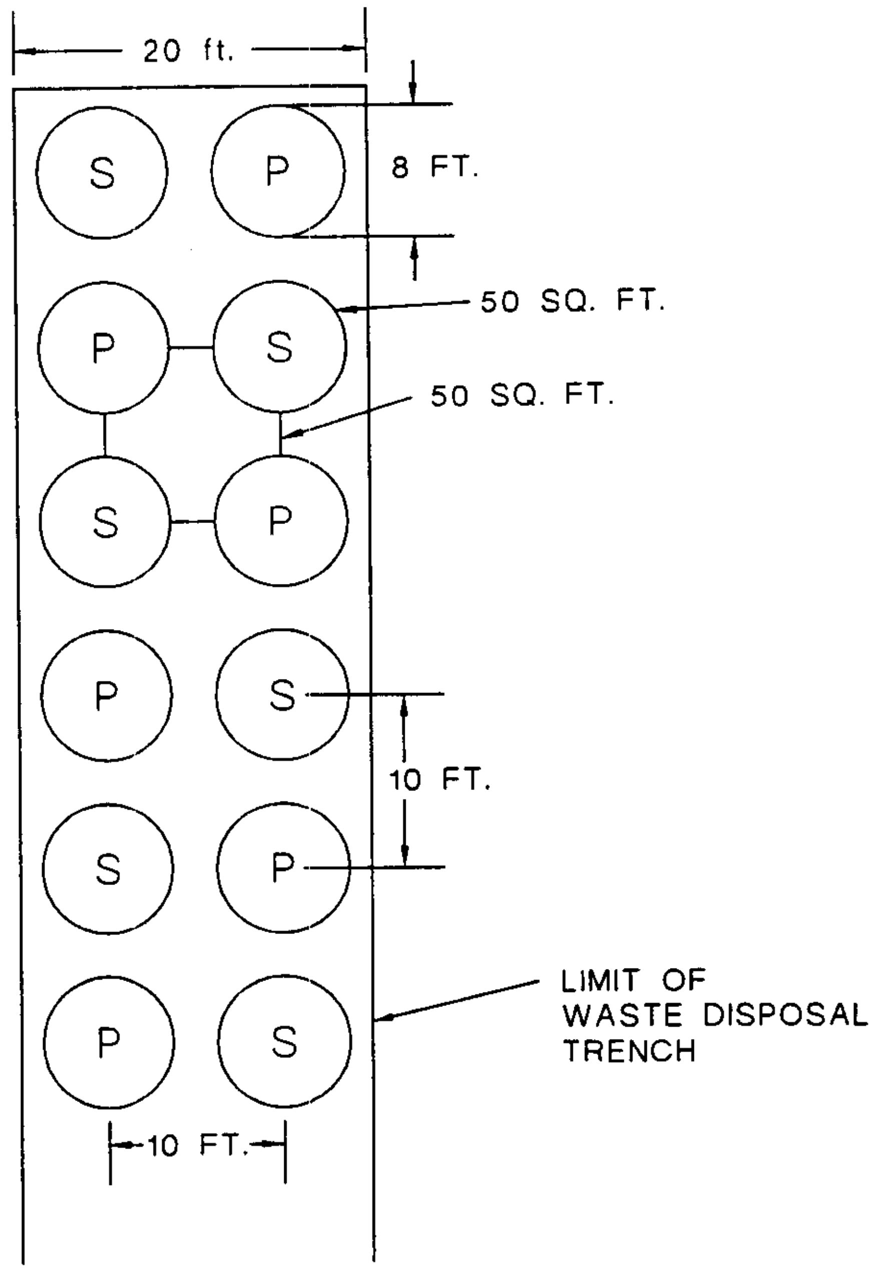


Figure 4-5. Hanford Barrier Concept.

Figure 4-6. Dynamic Compaction Pattern.



Grid pattern per specifications:
P = Primary drop points
S = Secondary drop points

409-02-8 5/19/94

Figure 4-7. Compaction Press (Baler).

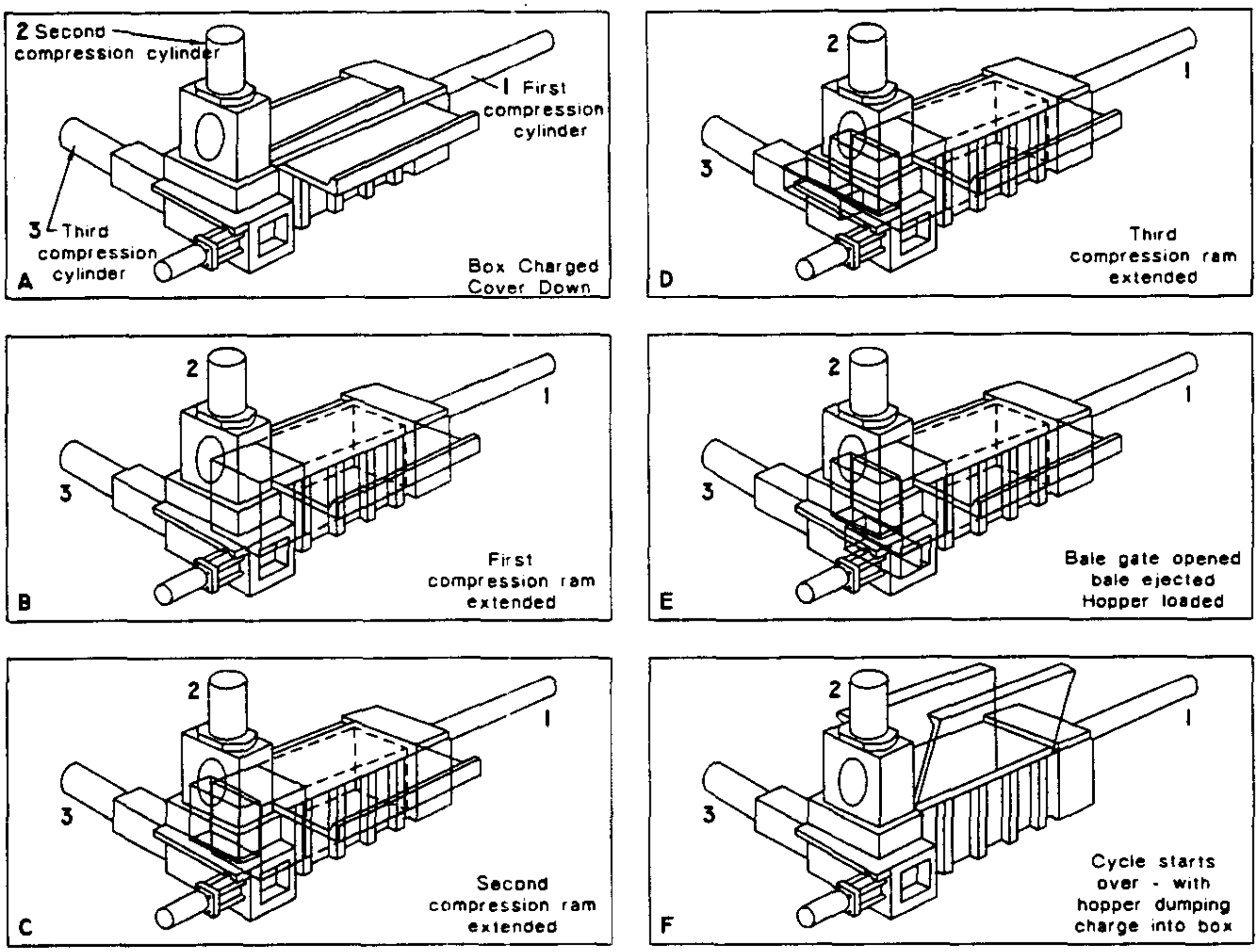


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Figure 4-8. SS-10: Removal/Treatment/Disposal Flow Diagram.

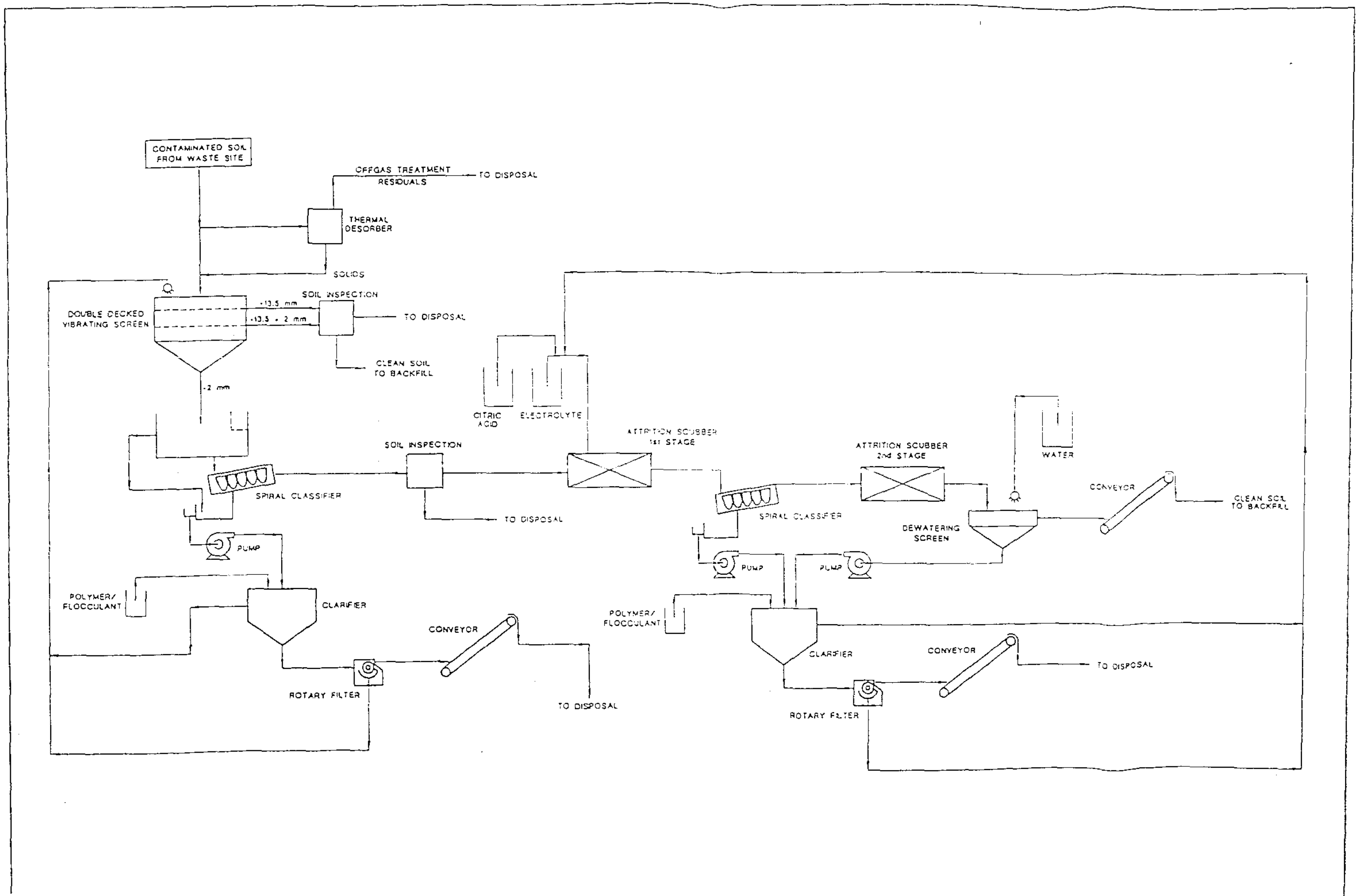

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Table 4-1. Remedial Alternatives and Technologies for Soil and Solid Waste Site Group.

Alternatives		Technologies Included in the Alternative	Waste Site Group									
			Retention Basins	Sludge Trenches	Fuel Storage Basin Trenches	Process Effluent Trenches	Pluto Cribs	Decon Cribs/ French Drains	Seal Pit Cribs	Pipelines	Burial Grounds	D&D Facilities
No Action	SS-1[1]	None										X
	SW-1								X			
Institutional Controls	SS-2	Deed Restrictions										
	SW-2	Groundwater Monitoring										
Containment	SS-3	Surface Water Controls						X		X	X	
	SW-3	Surface Barrier						X		X	X	
		Deed Restrictions						X		X	X	
		Groundwater Monitoring						X		X	X	
Removal, Disposal	SS-4	Removal	X	X	X	X	X	X		X	X	
	SW-4	Disposal	X	X	X	X	X	X		X	X	
In Situ Treatment	SS-8A	Surface Water Controls		X		X	X	X				
		In Situ Vitrification		X		X	X	X				
•Vitrification		Groundwater monitoring		X		X	X	X				
		Deed restrictions		X		X	X	X				
•Void Grouting	SS-8B	Void Grouting								X		
		Surface Barrier								X		
		Surface Water Controls								X		
		Deed Restrictions								X		
		Groundwater Monitoring								X		
•Dynamic Compaction	SW-7	Dynamic Compaction									X	
		Barrier									X	
		Surface Water Controls									X	
		Groundwater Monitoring									X	
		Deed Restrictions									X	
Removal, Treatment, Disposal	SS-10	Removal	X	X	X	X	X	X		X		
		Thermal Desorption										
•Soil Washing		Soil Washing	X	X	X	X	X	X		X		
		Disposal	X	X	X	X	X	X		X		
•Compaction	SW-9	Removal									X	
		Thermal Desorption									X	
		Compaction									X	
		ERDF Disposal									X	

X - Technology applies to this Waste Site Group
blank - Technology does not apply to this Waste Site Group
D&D - Decontaminated and Decommissioned
RCRA - Resource Conservation and Recovery Act
ERDF - Environmental Restoration Disposal Facility

[1]These remedial alternatives are described in detail in DOE-RL (1995a).

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Table 4-2. Comparison of Waste Site Groups to Remedial Alternatives.

Remedial Alternatives	Applicability Criteria	WASTE SITE GROUPS: Retention Basins	Sludge Trenches	Fuel Storage Basin Trenches	Process Effluent Trenches	Pluto Cribs	Decon Cribs and French Drains	Seal Pit Cribs	Pipeline	Burial Grounds	D&D Facilities
		Are Applicability Criteria and Enhancements Met?									
No Action											
SS-1, SW-1	Criterion: • Contaminant concentrations less than PRGs.	No	No	No	No	No	No	Yes	No	No	Yes
Institutional Controls											
SS-2, SW-2	Criteria: • Natural attenuation of radionuclides will reduce human health and ecological risks to safe levels prior to releasing DOE control of the site. • Organic and inorganic contaminant concentrations are less than PRGs.	No No	No No	No No	No No	No No	No No	NA NA	No No	No No	NA NA
Containment											
SS-3, SW-3	Criteria: • Contaminant concentrations greater than PRGs. • Contaminant concentrations are below levels that would impact groundwater based on the reduced infiltration scenario.	Yes No	Yes No	Yes No	Yes No	Yes No	Yes Yes	NA NA	Yes Yes	Yes Yes	NA NA
Removal/Disposal											
SS-4, SW-4	Criterion: • Contaminant concentrations greater than PRG.	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	Yes	NA
In Situ Treatment											
SS-8A (Vitrification)	Criteria: • Contaminant concentrations greater than PRGs. • Zone of contamination is no greater than 5.8 m (19 ft) thick.	Yes No	Yes Yes	Yes No	Yes Yes	Yes Yes	Yes Yes	NA NA	NA NA	NA NA	NA NA
SS-8B (Void Grouting)	Criteria: • Contaminant concentrations greater than PRGs. • Contaminant concentrations are below levels that would impact groundwater based on the reduced infiltration scenario. • No breaches or plugs occur in the piping that would prevent grouting.	NA NA NA	NA NA NA	NA NA NA	NA NA NA	NA NA NA	NA NA NA	NA NA NA	Yes Yes Yes	NA NA NA	NA NA NA
SW-7 Dynamic (Compaction)	Criteria: • Contaminant concentrations greater than PRGs. • Contaminant concentrations are below levels that would impact groundwater based on the reduced infiltration scenario.	NA NA	NA NA	NA NA	NA NA	NA NA	NA NA	NA NA	NA NA	Yes Yes	NA NA
Removal/Treatment/Disposal											
SS-10 (Soil Washing)	Criteria: • Contaminant concentrations greater than PRGs.	Yes	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA	NA
SW-9 (Compaction)	Criteria: • Contaminant concentrations greater than PRGs.	NA	NA	NA	NA	NA	NA	NA	NA	Yes	NA

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5.0 DETAILED ANALYSIS

This section evaluates the advantages and disadvantages of implementing the Remedial Alternatives described in Section 4.0, using CERCLA criteria (e.g., long term effectiveness and implementability) and considering potential impacts on various resources and human values.

This section evaluates the expected performance of each alternative in terms of evaluation criteria defined in EPAs *Guidance for Conducting Feasibility Studies at CERCLA Sites* (EPA 1988). The CERCLA criteria are described in Section 5.1, and the detailed analyses of the Remedial Alternatives are presented in Section 5.3. Nine different Remedial Alternatives were developed to provide an appropriate variety of remedial actions for addressing the contaminants found at the 10 different waste site groups located within the 100 Area (Table 4-2). These alternatives range from no action, to containment, to removal with subsequent treatment and disposal.

Some alternatives such as in situ compaction are appropriate for only a single waste site group, while other alternatives such as removal/disposal may be effective at most of the waste site groups. The applicability criteria described in Section 4.2 are the criteria used to determine which alternatives can be used at a particular waste site group to effectively remediate the contaminants known to occur at that waste site group. The applicability criteria also consider the capability of the remedial technologies (within the alternative) with respect to the physical and chemical characteristics of the site and the presence of structures, such as pipelines or retention basins. Table 4-1 summarizes the analysis conducted in Section 4.2 and shows which Remedial Alternatives (and technologies) are appropriate at each of the 10 waste site groups. Table 4-2 provides more detail and lists the applicability criteria for each of the Remedial Alternatives. These tables show that the Containment Alternative is applicable for three waste site groups, the Removal/Disposal Alternative may be appropriate at eight waste site groups, the removal/soil washing/disposal alternative is applicable at seven waste site groups, and In Situ Vitrification may be considered at four of the waste site groups. Most other alternatives are applicable at only one of the waste site groups.

Section 5.2 also evaluates the potential influence that the remedial actions may have on the natural, cultural, and physical resources at the waste sites. The information on potential resource impacts is used, in concert with the nine CERCLA evaluation criteria, to evaluate each alternative. This information can also be used to develop mitigation plans to avoid or minimize impacts. Section 5.2 also discusses issues such as irreversible and irretrievable commitment of resources and cumulative impacts.

5.1 EVALUATION CRITERIA DESCRIPTION

Nine CERCLA evaluation criteria have been developed by the EPA to address the statutory requirements and the technical and policy considerations important for selection of Remedial Alternatives. These evaluation criteria serve as the basis for conducting the detailed analysis during the FFS and for the subsequent selecting of an appropriate remedial action.

The nine CERCLA evaluation criteria are as follows:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Cost
- Regulatory acceptance
- Community acceptance.

The first two criteria, overall protection of human health and the environment and compliance with ARARs, are termed threshold criteria. Alternatives that do not protect human health and the environment or that do not comply with ARARs (or justify a waiver) do not meet statutory requirements for selection of a remedy; and, therefore, are eliminated from further consideration. The next five criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; and cost) are balancing criteria upon which the remedy selection is based. The CERCLA guidance for conducting feasibility studies lists appropriate questions to be answered when evaluating an alternative against the balancing criteria (EPA 1988). These questions are addressed during the detailed analysis process in Section 5.3 to provide a consistent basis for the evaluation of each alternative. The final two criteria, state and community acceptance, are evaluated following comment on this Process Document, the site-specific FFS, and the subsequent proposed plan.

The CERCLA evaluation criteria are described as follows:

1. Overall Protection of Human Health and the Environment: This evaluation criterion determines whether each alternative provides adequate protection of human health and the environment. Protection includes reduction of risk to acceptable levels (either by reduction of concentrations or the elimination of potential routes for exposure) and minimization of exposure threats (introduced by actions during remediation). As indicated in EPA guidance, there is overlap between this protection evaluation criterion and the criteria for compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness (EPA 1988). This first criterion is a threshold requirement and the primary objective of the remedial program.

2. Compliance with ARARs: Each alternative is assessed for attainment of federal and state ARARs. When an ARAR is not met, the basis for justifying

a waiver must be presented. Each of the following compliances are addressed for each alternative during the detailed analysis of ARARs:

- Compliance with chemical-specific ARARs, such as MTCA cleanup levels

- Compliance with location-specific ARARs, such as wetland regulations

- Compliance with action-specific ARARs, such as closure and post-closure cap requirements.

3. Long-term Effectiveness and Permanence: This criterion addresses the results of a remedial action concerning risks remaining at the site after remedial action objectives are met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. The following components of the criterion are addressed for each alternative:

   - Magnitude of Residual Risk: This factor assesses the residual risk remaining from untreated waste or treatment residuals after remedial activities are completed. The characteristics of the residual wastes are considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bio-accumulate.

   - Adequacy and Reliability of Controls: This factor assesses the adequacy and suitability of controls that are used to manage treatment residuals or untreated waste that remain at the site. It also assesses the long-term reliability of management controls for providing continued protection from residuals and includes an assessment of potential needs for replacement of technical components of the alternative.

4. Reduction of Toxicity, Mobility, or Volume: This criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances as their principal element. Permanent and significant reduction can be achieved through destruction of toxic contaminants, reduction of total mass, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media. This criterion focuses on the following specific factors for each of the alternatives:

   - The treatment processes used and the materials they treat

   - The amount of hazardous materials destroyed or treated, including how the principal threat(s) are addressed

- The degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction

- The degree to which the treatment is irreversible

- The type and quantity of treatment residuals that remain following treatment

- Whether the alternative satisfies the statutory preference for treatment as a principal element.

5. Short-term Effectiveness: Under this criterion, alternatives are evaluated regarding their potential effects on human health and the environment during the construction and implementation phases of the remedial action. The following factors are addressed for each alternative:

   - Protection of the community during remedial actions. Specifically, to address any risk that results from implementation, such as fugitive dust, transportation of hazardous materials, or air quality impacts from offgas emission.

   - Health and safety of remediation workers and reliability of protective measures taken.

   - Environmental impacts that may result from the construction and implementation of the remedial action.

   - The amount of time until the remedial action objectives are met.

   Human health short-term impacts are closely related to exposure duration, specifically, the amount of time a person may be exposed to hazards associated with the waste itself or the removal of the waste. The greater the exposure time, the greater the potential risk. The remedial action durations were determined by utilizing a computer cost model developed by Westinghouse Hanford Company (WHC 1994d). The durations are based on such things as depth, area, analytical requirements, excavation production rates, and worker schedule.

   Short-term environmental impacts are related primarily to the extent of physical disturbance of habitat. Risks may also be associated with the potential disturbance of sensitive species (such as the bald eagles) because of increased human activity in the area.

   The evaluation of short-term risks can range from qualitative to quantitative (DOE-RL 1994a). A qualitative assessment of short-term risk is appropriate for this Process Document because the risk associated with contamination at the waste sites is based on qualitative risk assessments.

Furthermore, the sites evaluated in this Process Document are high-priority waste sites that have been identified as needing action soon. Because a qualitative evaluation provides a sufficient differentiation between alternatives relative to short-term risks, there is no need to quantify short-term health risks. A general qualitative estimation of short-term risks is shown below for both human and ecological receptors. A more detailed evaluation of short-term risks to human health is presented in Section 5.2.2.5.

Remedial Alternative	Qualitative Short-Term Risks	
	Human (Worker)	Ecological
Institutional controls	low	low
Containment	medium	medium
In situ treatment	medium	medium
Removal/treatment/disposal	high	medium to high
Removal/disposal	high	medium to high

6. Implementability: The implementability criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of the required services and materials. The following factors are considered during the implementability analysis:

- Technical Feasibility:
  - Technical difficulties in constructing and operating the alternative
  - Likelihood of technical problems associated with implementation of the technology leading to schedule delays
  - Ease of implementing and interfacing additional remedial actions, if necessary
  - Ability to monitor the effectiveness of the remedy.
- Administrative Feasibility:
  - Ability to coordinate activities with other offices and agencies.
  - Potential for regulatory constraints to develop (for example, uncovering buried cultural resources or encountering endangered species)

- Availability of Services and Materials:

  - Availability of adequate offsite treatment, storage capacity, and disposal services, if necessary

  - Availability of necessary equipment and specialists and provisions to ensure any necessary additional resources

  - Availability of services and materials

  - Availability of prospective technologies.

7. Cost: The detailed cost analysis of alternatives involves estimating the expenditures required to complete each measure for capital and operation and maintenance costs. Once these values have been identified and a present worth calculated for each alternative (5% discount rate), a comparative evaluation can be made.

   The cost estimates presented in this section are based on conceptual designs prepared for the alternative and do not include detailed engineering data. An estimate of this type, according to EPA guidance, is usually expected to be accurate within +50 and -30%.

   The cost estimates are presented in 1994 dollars and prepared from information available at the time of this study. The actual cost of the project will depend on the final scope and design of the selected remedial action, the schedule of implementation, competitive market conditions, and other variables. However, most of these factors are not expected to affect the relative cost differences between alternatives.

8. Regulatory Acceptance: This assessment evaluates the technical and administrative issues and concerns the state of Washington may have regarding each of the alternatives. This criterion will be addressed following the agency review of this document and the proposed plan.

9. Community Acceptance: This assessment evaluates the issues and concerns the public may have regarding each of the alternatives. This criterion will be addressed following public review of this document and the proposed plan.

Once the alternatives have been described and individually assessed against the CERCLA evaluation criteria, a comparative analysis is conducted on a group-specific basis to evaluate the relative performance of each alternative in relation to each specific evaluation criterion. This is in contrast to the preceding analysis where each alternative was analyzed independently without consideration of other alternatives. The comparative analysis is presented in Section 6.0.

5.2 COMMON EVALUATION CONSIDERATIONS

In addition to the nine CERCLA criteria, specific environmental resources (such as air quality) and NEPA issues (such as cumulative impacts) are considered during the selection of Remedial Alternatives. Consideration of environmental resources and NEPA issues are required to meet the DOE Secretarial Policy on NEPA, and provide a complete evaluation of the Remedial Alternatives. Several of the CERCLA evaluation criteria involve consideration of environmental resources, but the emphasis is frequently directed at the potential effects of chemical contaminants on living organisms. Environmental resources in the NEPA context also includes consideration of potential effects on resources, such as transportation, air quality, socioeconomic, and visual resources. Also, the NEPA process involves consideration of several issues, such as indirect and cumulative impacts, the irreversible and irretrievable commitment of resources, and the actions that may be taken to avoid or mitigate environmental impacts. The NEPA-related resources and issues are described in Section 5.2.1 and 5.2.2 below.

5.2.1 Resources

5.2.1.1 Transportation Impacts. The proposed Remedial Alternatives are not expected to create any long-term negative transportation impacts. If adverse impacts to transportation are detected, remedial activities will be modified or stopped until the problem is mitigated.

The No Action and Institutional Control Alternatives will not affect transportation. These alternatives will not require the transport of any equipment, construction materials or waste. Commuter traffic flow would not increase or decrease.

The Containment, Removal/Disposal, In Situ Treatment, and Removal/Treatment/ Disposal Alternatives will require transport of equipment, construction materials and solid waste that could result in transportation impacts. The construction-related and commuter (worker) traffic flow for the Removal/Disposal and Removal/Treatment/Disposal Alternatives would be higher than for the containment and In Situ Treatment Alternatives.

5.2.1.2 Ecological Impacts. The No Action and Institutional Control Alternatives would not affect existing natural resource conditions. However, these alternatives do not include revegetation or other habitat enhancement actions. Without revegetation or other habitat enhancement efforts, most sites would not be restored to a native condition.

The Containment, Removal/Disposal, In Situ Treatment, and Removal/Treatment/ Disposal Alternatives would destroy existing vegetation at a waste site. In most cases, this is a minor impact because most waste sites in the 100 Area have already been severely disturbed. Contaminant removal or onsite containment, followed by revegetation and restoration efforts would benefit natural resources in the long term.

5.2.1.3 Air Quality Impacts. Hanford Site air quality is generally good. The proposed remediation alternatives are not expected to cause long-term negative impacts to existing air quality. Site restoration and revegetation efforts will preclude long-term wind erosion problems due to remediation activities.

The No Action and Institutional Control Alternatives would not affect short-term air quality. However, the Containment, Removal/Disposal, In Situ Treatment, and Removal/Treatment/Disposal Alternatives will generate fugitive dust. Dust controls and other mitigative measures will be used as needed to ensure that short-term impacts on air quality are minimized.

5.2.1.4 Cultural Resource Impacts. For 100 Area waste sites where cultural resources are present, mitigative measures will be implemented to ensure that cultural resource concerns are properly addressed.

The No Action and Institutional Control Alternatives are not expected to disturb cultural resources. However, if cultural resources are contaminated or legitimate access to cultural resources is denied due to contamination levels, these alternatives may not be appropriate.

The Containment and In Situ Treatment Alternatives would contain or treat the wastes in place, and therefore would also leave any existing cultural resources in place. However, cultural resources are not expected to occur at waste sites that have already been disturbed. The alternatives would generally result in the protection of cultural resources adjacent to the waste site because remedial activities would be confined primarily within the boundary of the waste site.

The potential for the Removal/Disposal and Removal/Treatment/Disposal Alternatives to disturb cultural resources would be high. Actions to mitigate adverse impacts to significant cultural resources would be required before initiating these alternatives.

5.2.1.5 Socioeconomic Impacts. The outlook for the Tri-Cities economy is uncertain. The local economy could decline or grow in the next 30 years depending on economic activity not directly related to DOE and the Hanford Site. Near-term reductions in the Hanford Site work force will probably have a negative impact on the local economy.

If the No Action and Institutional Control Alternatives are implemented, activities in the 100 Area would be limited to maintenance, security and routine monitoring. These alternatives fail to achieve the principles adopted by the Hanford Advisory Board Work Group for cultural/socioeconomic impacts. There would be no transition of the work force to provide economic stability. These alternatives would do little to provide economic diversification because of the minimum employment levels. The demand for recreational services, social services, facilities, and activities exerted by the few employees associated with the 100 Area and their families would be minimal.

The socioeconomic impacts of the Containment and In Situ Treatment Alternatives would be relatively minimal. Workers would be employed for several years to perform the work associated with these alternatives. These alternatives meet the principles established by the Hanford Advisory Board Work Group for cultural/socioeconomic impacts. These alternatives allow for work force transition from scientific/engineering to the excavation and construction trades. Effects on social services and recreation would probably be imperceptible because of the few employees involved. The effects on public services such as water supplies and waste water treatment facilities would be minimal.

If the Removal/Disposal and Removal/Treatment/Disposal Alternatives are implemented, workers would be employed to remove contaminated material, perform site restoration, and transport contaminated materials to a disposal site. The number of employees involved in these activities would be higher than employment levels for the containment and the In Situ Treatment Alternatives. Nonetheless, the impact would be minor compared to the overall Tri-City area employment. The growth in the local government tax base associated with increases in housing and commercial activity resulting from these alternatives would be insignificant. These alternatives achieve the principles adopted by the Hanford Advisory Board Working Group for cultural and socioeconomic impacts. The demand for recreation, social services, and public services caused by employees and families associated with these alternatives would be many times that exerted by the No Action Alternative and about three times greater than the Containment Alternative. Nevertheless, the demand would still have only a very small effect on the Tri-Cities capacity to accommodate these needs.

5.2.1.6 Noise and Visual Resources Impacts. No long-term noise or visual resource impacts are anticipated from any of the Remedial Alternatives under consideration. The installation of above-grade barriers could potentially impact visual resources. Noise increases in the 100 Area would return to background levels following remediation. Visual impacts will be mitigated through site revegetation and habitat restoration actions.

If the DOE relinquishes control of the 100 Area, long-term impacts are anticipated for noise and visual resources for all the alternatives, except the No Action Alternative. The anticipated impacts would be from increased noise levels and/or impacts to visual resources from developments (e.g., housing, agriculture) of the 100 Area.

No adverse short-term impacts to noise or visual resources are anticipated for the No Action or Institutional Control Alternatives. Sporadic and temporary short-term impacts to noise levels would occur because of transportation and construction activities under any of the action alternatives. Short-term visual resource impacts are anticipated during site remediation. These short-term impacts could be mitigated by minimizing the footprint of the remediation zone to the extent possible. The Containment, Removal/Disposal, In Situ Treatment, and Removal/Treatment/Disposal Alternatives are expected to affect short-term noise levels in the 100 Area. Noise mitigation would be instituted to minimize short-term impacts. All equipment and vehicles would be equipped with mufflers or other noise-reduction devices.

5.2.2 Issues

5.2.2.1 Mitigation Measures. The primary objective of mitigation is avoidance. If adverse impacts cannot be avoided, remedial action planning should minimize adverse impacts to the extent practicable through implementation of mitigation measures. Mitigation measures may also include restoring or protecting other areas within the Hanford Site or off site to compensate for damages that may be incurred during the cleanup effort.

Natural resources, for the purposes of mitigation, are considered to be physical resources such as land, water, and air; biological resources such as wildlife habitat or plants and animals; human resources such as remedial workers, and cultural resources such as Indian artifacts or historical sites. Studies have been conducted at the operable units within the 100 Area to characterize these resources. There are current ongoing and planned studies to complete the characterization of these resources where necessary. With this information, the natural resources will be fully described before developing the conceptual designs for remedial action.

This Process Document presents information on general mitigation approaches and actions. However, because the Process Document deals with waste site groups rather than specific waste sites, and the Remedial Alternative has not been selected yet, this report does not present specific mitigation plans. The completion of detailed mitigation plans will occur during the conceptual and preliminary design of the selected Remedial Alternative.

Natural resources can be impacted in a variety of ways during implementation of remedial actions. For example, excavation, treatment, and construction activities can unnecessarily destroy wildlife habitat; disrupt normal breeding, nesting, or feeding activities of animals; increase wind and water erosion; or unearth native Indian artifacts. Final mitigation measures, to either eliminate or reduce the adverse consequences of the remedial activities, will be developed as an integral component of the remedial design. The mitigation plans will be incorporated into the design specifications, and also made part of the contractual obligations for remedial contractors working on the site. In that way, mitigation becomes an integral component of the remedial activities.

The following general mitigation measures are examples of actions that may be taken to protect the physical, biological, human, and cultural resources that occur in the 100 Area:

<u>Physical Resources</u>

- Stockpile topsoil when possible.

- Minimize the width of construction corridors, the size of equipment yards and parking lots, and the amount of cut and fill required.

- Place equipment yards, treatment systems, and support services in formerly disturbed areas when possible.

- Develop and implement erosion control plans.

- Curtail or halt operations during high wind periods.

- Suppress fugitive dust with water, commercial suppressants, or temporary mulches.

- Prevent runoff and sediment transport to wetlands and the Columbia River.

Biological Resources

- Avoid wetlands, riparian habitats, and other sensitive areas when possible.
- Restrict the removal or destruction of trees.
- Use native species for revegetation or, when possible, plan for successional replacement of temporary ground cover with native species.
- Comply with the bald eagle management plan.
- Schedule construction activities to avoid breeding, nesting, winter roosting, and other sensitive seasonal activities.
- Prepare biological resource management plans.
- Work with DOE, the U.S. Fish and Wildlife Service, and the U.S. Army Corps of Engineers to mitigate impacts to wetlands.
- When possible, rectify impacts that cannot be avoided or minimized.

Human Resources

- Develop health and safety plans to protect onsite workers.
- Implement rigorous health and safety protocols.
- Minimize exposure to contaminants.
- Minimize generation of fugitive dust.
- Monitor air quality.
- Practice ALARA.

Cultural Resources

- Complete cultural resource surveys of areas to be remediated before implementing any action.
- Complete data recovery and analysis plans, have these approved by the State Historic Preservation Office, and conduct data recovery and analysis before initiating remedial actions.
- Develop cultural resource action plans for each reactor area.
- Train construction workers to recognize and report potential cultural resources.
- Work with the Indian nations to identify traditional use sites, prepare cultural resource mitigation plans, and evaluate the sensitivity of each waste site area.

5.2.2.2 Irreversible and Irretrievable Commitment of Resources. The alternatives that leave contaminated material in an operable unit would result in commitment of land-to-waste management, institutional controls, and monitoring. Although contamination left in place could be removed in the future, such removal would waste money spent on a surface barrier or in situ treatment, and would be more expensive than immediate removal. Selection of an alternative that leaves contamination in the operable unit should be considered an irreversible and irretrievable commitment of land-to-waste management.

Remediation of the 100 Area will require the irreversible commitment of millions of federal dollars. Depending on the Remedial Alternative, other irreversible commitments of resources include importing soil and rock for barriers and using consumables such as fuel, electricity, chemicals, and disposable protective equipment.

If sensitive habitats or cultural resources are involved in remedial actions, mitigation measures will be taken to minimize impacts. However, irreversible damage could occur to habitats, flora, and fauna during remediation. It is also possible that cultural resources could be destroyed during the remedial action.

5.2.2.3 Indirect and Cumulative Impacts. Based on improvements to the overall protection of human health and the environment, the net cumulative impact of the remedial actions is expected to be positive. Remedial actions will remove or isolate the contaminants, make land in the 100 Area available for other uses, and generally restore natural resources. Negative impacts from remediating the operable units within the 100 Area, as discussed in Sections 5.0 and 6.0, are expected to be minor and short term. However, there is potential for indirect and cumulative impacts as a result of remediating any one operable unit within the 100 Area.

Remedial activities at any one of the Operable Units in the 100 Area may potentially involve cumulative impacts due to interactions with other projects within the 100 Area, as well as interactions with other projects within the Hanford Site or along the Columbia River. For the purposes of this Source Operable Unit FFS, it was assumed that interactions with projects outside the Hanford Site, except for the Columbia River, would be insignificant because of the remote location of the 100 Area relative to the Tri-Cities and major agricultural operations in the region.

The potential indirect and cumulative impacts of remedial actions and other activities within the 100 Area will be dependent upon the scheduling of the remedial action at one site relative to the remedial actions at the other numerous operable units, and the scheduling of other activities within the 100 Area. Indirect and cumulative impacts may result from the interaction of activities at:

- Other source operable units
- Groundwater operable units
- D&D activities
- Treatability studies
- Expedited response actions

Cumulative and indirect impacts in the 100 Area will be greater if remedial activities at several operable units occur at the same time. Conversely, if the work can be properly sequenced cumulative impacts can be reduced or avoided. Because most of the above remedial actions and activities are still in the planning stage, coordination during the planning and initial implementation of the various projects will be necessary to reduce indirect and cumulative impacts.

Indirect and cumulative impacts may also occur because of interactions with projects outside of the 100 Area. Remedial actions, treatability studies, and D&D work are also occurring in the 200 and 300 Areas, and other portions of the Hanford Site. Also, there are two central disposal facilities (located within the 200 Area) that are currently being developed to accept wastes from most of the waste sites (if disposal is a component of the remedial action). Likewise, clean fill materials needed to remediate many of the waste sites may come from a limited number of borrow pits. The schedules, demands on labor and equipment resources, requirements for disposal volume and fill material, and budget needs must all be considered under the issue of cumulative impacts. The indirect effects of these numerous projects on transportation, restoration of natural resources, and future land use must also be considered.

Remediation of the 100 Area operable units should lead to long-term cumulative benefits to natural resources as a result of removing or controlling contaminants, revegetating currently disturbed and denuded areas, and restoring natural habitats. The Columbia River and the riparian ecosystem along the river should also benefit from the cumulative actions at the 100 Area and other portions of the Hanford Site.

5.2.2.4 Environmental Justice. The Environmental Justice Executive Order (E.O. 12898, February 1994) states:

> "Each federal agency shall make achieving environmental justice part of its mission by identifying and addressing as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations."

Low-income and minority populations involved in Hanford Site remedial actions include members of the Native American groups and local agricultural employees. The proposed alternatives have been assessed for potential disproportionate impacts to these low-income and/or minority populations.

The objectives of the Environmental Justice Executive Order may not be met by the No Action and Institutional Control Alternatives. Native American groups that use the Columbia River for fishing and wildlife recreation are concerned about potential adverse human health effects from contaminants located on the Hanford Site. Compared to other alternatives, the No Action and Institutional Control Alternatives represent a low risk of inadvertent excavation of Native American cultural resources.

The Containment, Removal/Disposal, In Situ Treatment, and Removal/Treatment/ Disposal Alternatives comply with the objectives of the Environmental Justice Executive Order. Construction activities would provide employment for the low-income workers, including a small number of new general labor (unskilled) jobs. However, excavation always poses the risk of unearthing Native American burials. Consequently, the risk of an adverse impact on Native Americans is disproportionately large compared to other segments of the population. The containment or removal alternatives, however, reduce or preclude the possibility of long-term lateral migration of contaminants from current locations to the Columbia River. These alternatives, with appropriate mitigation actions, will generally address Native American concerns.

5.2.2.5 Short-term Impacts to Human Health. Short-term impacts to human health during implementation of a remedial action can be grouped either as potential impacts to workers performing the remedial action or potential impacts to the community. Potential impacts to workers include physical hazards associated with construction activities, and exposures to chemical or radionuclide contaminants. Physical hazards to workers include slip, trip and falls, operation of heavy equipment, excavation and trenching, sharp objects, operation of motor vehicles, lifting hazards, heat and cold stress and noise. Contaminant exposure hazards include incidental ingestion of soil, inhalation of fugitive dust generated during remedial action and external exposure to radionuclides. Potential impacts to the community would largely be associated with inhalation of fugitive dust generated during remedial action.

Physical and contaminant exposure hazards to workers will vary with the magnitude of contamination in soil and the type of remedial action to be performed at a site. In general, potential hazards to workers will be lower for Remedial Alternatives that do not involve extensive contact with contaminated soils and wastes. The relative risks to workers potentially associated with the different Remedial Alternatives were evaluated with an activity hazard analysis. Remedial Alternatives assessed in the activity hazard analysis were as follows:

- Institutional Controls, which include security and monitoring
- Containment, which includes RCRA barrier construction, surface runoff control, groundwater monitoring and deed restrictions
- In Situ Treatment, which includes grout injection, compaction, or vitrification
- Removal and Disposal, which includes site preparation, excavation, possible demolition, and transport to an approved disposal facility
- Removal, Ex Situ Treatment, and Disposal, which includes site preparation, excavation, treatment, and disposal of residuals.

Specific work activities were identified for each Remedial Alternative, based on FFS-level information. Each work activity was evaluated to determine which of the following hazards could be associated with that activity.

- Slip, trips, and falls
- Heat and cold stress
- Heavy equipment operation
- Excavation and trenching
- Sharp objects
- Vehicular operation
- Lifting and materials handling
- Noise
- Contaminant exposure.

The severity of these potential hazards were evaluated qualitatively by review of the anticipated work activities for each alternative. For example, alternatives involving removal could involve greater hazards associated with heavy equipment and vehicular operation because of the excavation and transport of wastes to treatment and disposal facilities. Alternatives involving removal also have hazards associated with excavation, that are not likely to be present with other Remedial Alternatives. Finally, each alternative other than institutional controls are associated with potential contaminant exposure hazards by bringing workers into proximity with contaminated soils and wastes. Potential exposures of workers in proximity to radionuclides in soil at site 116-C-5 were evaluated using the RESRAD model. The modeling results indicate that potential exposures from external exposure at this site could exceed the DOE standard for worker exposure of 5 rem/year. These estimated exposures are less likely to be associated with the Institutional Control Alternative, because work activities for this alternative do not bring workers into proximity with contaminated soils and wastes.

The ranking of risks to workers associated with each Remedial Alternative, based on the activity hazard analysis, is summarized in Table 5-1.

As discussed previously, potential impacts to the surrounding communities are associated with emissions of airborne contaminants, either in fugitive dust generated during remedial action, or during treatment activities. Information developed in the *Hanford Emergency Response Plan* indicates that the closest residents are located 3 miles from the Hanford Site. A small portion of a sparsely populated area of southern Grant County represents the community closest to the 100 Area. Potential airborne contaminant exposures to offsite residents were evaluated for contaminants at site 116-C-5, assuming that remedial action produces a continuous concentration of 0.2 mg/m^3 of dust in air. This dust concentration, based on assumptions presented in the RESRAD model (Yu et al. 1993), accounts for relatively short periods of time of high dust emissions to the air (such as during excavation) along with lower levels of dust emissions associated with other work activities and windblown dust. Dust emissions were assumed to occur entirely from contaminated soils. The results from this analysis indicate that onsite concentrations of radionuclides in air were less than 1% of the DOE standards for protection of the offsite public. Concentrations at offsite locations are likely to be lower because of dilution in air. Therefore, airborne contaminants associated with remedial actions are not likely to represent an impact to offsite communities.

5.3 DETAILED ANALYSIS OF ALTERNATIVES

The group profiles, defined in Section 3.0, are compared against the applicability criteria and enhancements for each alternative defined in Section 4.0. Tables 4-1 and 4-2 show the results of this comparison and summarize applicable alternatives for each waste site group. In this section, each alternative is then evaluated in terms of the CERCLA threshold and balancing criteria (EPA 1988) (Tables 5-2 through 5-10).

A cost estimate is prepared for each waste site group based on a representative waste site. Appendix B includes a summary of the cost estimates for each waste site group, a table indicating the present worth calculations, and a graph presenting the effect of disposal cost on the alternative cost. The cost models created for the 100 Area FFS are presented in *100 Area Source Operable Unit Focused Feasibility Study Cost Models* (WHC 1994d).

5.3.1 No Action

The applicability criteria defined in Section 4.2.1 and shown in Table 4-2 must be met before implementing the No Action Alternative. The only waste site groups that meet the applicability criteria are the seal pit cribs and the D&D facilities.

Based on the discussion concerning D&D facilities presented in Section 3.1.7, and the existing data on seal pit cribs, it is assumed that there is no current threat warranting an interim action. Therefore, the CERCLA threshold criteria are met because current contamination levels are assumed to be at acceptable levels. Table 5-2 presents the analysis of the No Action Alternative for the seal pit cribs and D&D facilities. Because none of the other waste site groups meet the applicability criteria for no action, implementing no action would leave levels of contaminants at the waste site that may pose human health or environmental risks, and may not comply with ARARs. No action, in this case, would not provide long-term protection, and would not reduce mobility, toxicity, or the volume of the wastes.

5.3.2 Institutional Controls

The applicability criteria defined in Section 4.2.2 and shown in Table 4-2 must be met before implementing the institutional controls alternative. No waste site groups meet the applicability criteria; therefore, this alternative is not evaluated any further in this Process Document. If a specific waste site meets the applicability criteria for institutional controls based on information in an operable unit specific FFS, then this alternative will be analyzed in that FFS.

5.3.3 Containment

The applicability criteria defined in Section 4.2.3 and shown in Table 4-2 must be met before implementing the Containment Alternative. The waste site groups that meet the applicability criteria are as follows:

- Dummy decontamination cribs/french drains

- Pipelines
- Burial grounds.

The detailed analyses for the soil and solid waste site groups that can be remediated using containment are shown in Tables 5-3 and 5-4. The CERCLA evaluation criteria are evaluated for all waste site groups as a whole, with specific details being noted separately for an individual waste site group as necessary.

5.3.4 Removal/Disposal

The applicability criteria defined in Section 4.2.4 and shown in Table 4-2 must be met before implementing the Removal/Disposal Alternative. The waste site groups that meet the applicability criteria are as follows:

- Retention basins
- Sludge trenches
- Fuel storage basin trenches
- Process effluent trenches
- Pluto cribs
- Dummy decontamination cribs/french drains
- Pipelines
- Burial grounds.

The detailed analyses for the soil and solid waste site groups that can be remediated using this alternative are shown in Tables 5-5 and 5-6. The CERCLA evaluation criteria are evaluated for all waste site groups as a whole, with specific details being noted separately for an individual group as necessary.

5.3.5 In Situ Treatment

The applicability criteria defined in Section 4.2.5 and shown in Table 4-2 must be met before implementing the In Situ Treatment Alternative. The waste site groups that meet the applicability criteria are as follows:

- Sludge trenches
- Process effluent trenches
- Pluto cribs
- Dummy decontamination cribs/french drains
- Pipelines
- Burial grounds.

The detailed analyses for soil and solid waste site groups that can be remediated using in situ treatment are shown in Tables 5-7 and 5-8. The CERCLA evaluation criteria are evaluated for all waste site groups as a whole, with specific details being noted separately for an individual group as necessary.

5.3.6 Removal/Treatment/Disposal

The applicability criteria defined in Section 4.2.6 and shown in Table 4-2 must be met before implementing the Removal/Treatment/Disposal Alternative. The waste site groups that meet the applicability criteria are as follows:

- Retention basins
- Sludge trenches
- Fuel storage basin trenches
- Process effluent trenches
- Pluto cribs
- Dummy decontamination cribs/french drains
- Pipelines
- Burial grounds.

The detailed analyses for soil and solid waste site groups that can be remediated using this alternative are shown in Tables 5-9 and 5-10. The CERCLA evaluation criteria are evaluated for all waste site groups as a whole, with specific details being noted separately for an individual group as necessary. The reduced volume achieved through treatment will decrease the burden on the capacity of the disposal facility.

Table 5-1. Relative Risks to Workers Associated with Remedial Alternatives.

Remedial Alternative	Contaminant Exposure Hazards	Physical Hazards	Comments
Institutional Controls	Low	Low	Alternative unlikely to bring workers into proximity with contaminants; alternative involves limited operation of heavy equipment or vehicles
Containment	Medium	Medium	Contaminant exposures may be lower than removal alternatives for sites with high concentrations in subsurface soil; alternative involves heavy equipment operation, but limited excavation, if any
In situ Treatment	Medium	Medium	Contaminant exposures may be of concern for sites with high concentrations of external emitters (i.e., Cs-137) in shallow soils; alternative involves heavy equipment operation, but limited excavation, if any
Removal/Disposal	High	High	Alternative brings workers into proximity with contaminants in soil and wastes; alternative involves substantial heavy equipment and vehicular operation and excavation
Removal/Treatment/ Disposal	High	High	Alternative brings workers into proximity with contaminants in soil and wastes; alternative involves substantial heavy equipment and vehicular operation and excavation; additional contaminant exposure hazards are associated with treatment plant operations

Table 5-2. Detailed Analysis of the No Action Alternative (SS-1/SW-1).
(Applicable to seal pit cribs and decontaminatio and decommissioned facilities.) (Page 1 of 4)

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Will risk be at acceptable levels?	Yes. No contaminants remain above levels that would pose a risk to human health and the environment.
Timeframe to achieve acceptable levels?	Acceptable levels already exist.
Will the alternative pose any unacceptable short-term or cross-media impacts?	No adverse impacts will occur because no action is proposed.
Will the alternative impact natural resources?	The site will be left in its current condition. Many sites have been physically disturbed and are currently poor habitat for wildlife.
What restoration actions may be necessary?	No restoration is proposed.
Will residual contamination (following remediation) be a potential problem?	No contamination above acceptable levels exists at the site.
COMPLIANCE WITH ARARs	
What are the potential ARARs?	1. Chemical-specific ARARs are listed in Appendix C. 2. Location-specific ARARs are listed in Appendix C. 3. Action-specific ARARs are listed in Appendix C.
Will the potential ARARs be met?	1. Chemical-specific ARARs will be met because contaminants are already at acceptable levels. 2. Location-specific ARARs should be met because no action will be taken to disturb the area proximate to the waste site. 3. Action-specific ARARs do not apply because no action is taken.
Basis for waivers?	If waivers are necessary they will be determined in the ROD.
What are the potential TBC?	1. Chemical-specific "to be considered" requirements are listed in Appendix C. 2. Location-specific "to be considered" requirements are listed in Appendix C. 3. Action-specific "to be considered" requirements are listed in Appendix C.
Is the alternative consistent with the TBC?	1. Chemical-specific "to be considered" requirements will be met because contaminants are already at acceptable levels. 2. Location-specific "to be considered" requirements should be met because no action will be taken to disturb the area proximate to the waste site. 3. Action-specific "to be considered" requirements do not apply because no action is taken.
Will implementation of the alternative comply with ARARs regarding protection, restoration, and enhancement of natural resources and protection of cultural resources?	1. Chemical-specific ARARs are met by existing conditions. 2. Location-specific ARARs should be met with regards to impacts on the environment because no action is taken. However, the alternative does not include enhancement or restoration activities. 3. Action-specific ARARs will be met because no action is proposed. Cultural resources will not be disturbed because no action is proposed.
What difficulties may be associated with compliance to ARARs?	Chemical-specific ARARs will be complied with and action-specific ARARs do not apply because no action is proposed. No action may or may not comply with location-specific ARARs.

Table 5-2. Detailed Analysis of the No Action Alternative (SS-1/SW-1).
(Applicable to seal pit cribs and decontamination and decommissioned facilities.) (Page 2 of 4)

LONG-TERM EFFECTIVENESS AND PERMANENCE	
What is the magnitude of the remaining risk?	Remaining risks are equal to preremediation risks because no action is taken. The remaining risks would be at acceptable levels.
What remaining sources of risk can be identified?	None.
What is the likelihood that the technologies will meet performance needs?	Not applicable.
What type, degree, and requirement of long-term management is required?	No long-term management required.
What O&M functions must be performed?	No O&M requirements are planned under no action.
What difficulties may be associated with long-term O&M?	Not applicable.
What is the potential need for replacement of technical components?	Not applicable.
What is the magnitude of risk should the remedial action need replacement?	Not applicable.
What is the degree of confidence that controls can adequately handle potential problems?	Not applicable.
What are the uncertainties associated with land disposal of residuals and untreated wastes?	Not applicable.
Will the alternative provide long-term protection of natural resources?	No. No contamination above acceptable levels currently exists, but the alternative provides no restoration or environmental enhancements.
Will terrestrial habitats be degraded or enhanced?	There will be no change from current terrestrial habitat quality. Current quality is considered substandard.
How will the remedial action affect the overall quality of the ecosystem?	Because no action is taken, the quality of the ecosystem will remain in its current state, which is considered poor from an ecological standpoint.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Does the treatment process address the principal threats?	No treatment proposed.
Are there any special requirements for the treatment process?	No treatment proposed.
What portion of the contaminated material is treated/destroyed?	No contaminants are treated or destroyed.
To what extent is the total mass of toxic contaminants reduced?	No contaminants above acceptable levels are present.
To what extent is the mobility of contaminants reduced?	No treatment proposed.

Table 5-2. Detailed Analysis of the No Action Alternative (SS-1/SW-1).
(Applicable to seal pit cribs and decontamination and decommissioned facilities. (Page 3 of 4)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
To what extent is the volume of contaminated media reduced?	No treatment proposed.
To what extent are the effects of the treatment irreversible?	No treatment proposed.
What are the quantities of residuals and characteristics of the residual risk?	No residuals are present.
What risks do treatment of residuals pose?	No treatment proposed.
Is treatment used to reduce inherent hazards posed by principal threats at the site?	No treatment proposed.
How does the proposed treatment impact natural resources?	No treatment proposed.
Does the alternative result in a gain or loss of quality at the site for natural resources?	No change would result, leaving the site at its current low quality with respect to natural resources.
Will implementation of the alternative result in short-term impacts to natural resources (e.g., exposure of ecological receptors to physical or chemical impacts, noise, intrusion to habitat and special breeding areas, temporary displacement, seasonal restrictions on habitat use)?	No impact because no action is proposed.
Will the natural resource restoration activities associated with this alternative be easily implemented?	No restoration proposed.
Will long-term maintenance and monitoring of mitigation/restoration efforts and activities be necessary?	No mitigation/restoration proposed.
SHORT-TERM EFFECTIVENESS	
What are the risks to the community during remedial actions, and how will they be mitigated?	No risks to community associated with implementation of the No Action Alternative.
What risks remain to the community that cannot be readily controlled?	Not applicable.
What are the risks to the workers, and how will they be mitigated?	Not applicable.
What risks remain to the workers that cannot be readily controlled?	Not applicable.
What environmental impacts are expected with the construction and implementation of the alternative?	Not applicable.
What are the impacts that cannot be avoided should the alternative be implemented?	Not applicable.
How long until remedial response objectives are achieved?	Remedial action objectives are already achieved.

Table 5-2. Detailed Analysis of the No Action Alternative (SS-1/SW-1).
(Applicable to seal pit cribs and decontamination and decommissioned facilities. (Page 4 of 4)

IMPLEMENTABILITY	
What difficulties and uncertainties are associated with construction?	Not applicable.
What is the likelihood that technical problems will lead to schedule delays?	Not applicable.
What likely future remedial actions are anticipated?	Because risks are at acceptable levels, no future actions are anticipated. However, the release of the site from all controls will be reevaluated during the final RI/FS activities.
What risks of exposure exist should monitoring be insufficient to detect failure?	No monitoring is required.
What activities are proposed that require coordination with other agencies?	Not applicable.
Are adequate treatment, storage capacity, and disposal services available?	Not applicable.
Are necessary equipment and specialists available?	Not applicable.
Are technologies under consideration generally available and sufficiently demonstrated or will they require further development before they can be applied at the site?	Not applicable.
Will more than one vendor be available to provide a competitive bid?	Not applicable.

COST	CAPITAL	O&M	PRESENT WORTH
No costs associated with the alternative, because no action will be taken.	Not applicable.	Not applicable.	Not applicable.

ARAR - applicable or relevant and appropriate requirement
O&M - operation and maintenance
RAO - remedial action objectives
PRG - preliminary remediation goals
TBC - to be considered

Table 5-3. Detailed Analysis of the Containment Alternative (SS-3/SW-3).

(Applicable to the dummy decontamination cribs/french drains, pipelines, and burial grounds waste site groups) (page 1 of 4)

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Will human health risk be at acceptable levels?	Yes. Risk is at acceptable levels by elimination of potential pathways through installation of an engineered barrier. The engineered barrier limits direct exposure pathways to human receptors. SS-3: Constituent concentrations are below levels that could impact groundwater under the reduced infiltration allowed by the barrier based on evaluation of constituent concentrations. SW-3: Constituent concentrations are assumed to be below levels that could impact groundwater under the reduced infiltration allowed by the barrier.
Timeframe to achieve acceptable levels?	Acceptable risk levels are achieved at the completion of the remedial action. The duration of the remedial action is estimated, based on the representative site for a given group, as follows: dummy decontamination cribs/french drains: 0.1 yr pipelines: 2.4 yr burial grounds: 0.1 yr
Will the alternative pose any unacceptable short-term impacts to humans?	No cross-media impacts will be introduced by the alternative. Workers will not be exposed to the contaminants during implementation. Risks to workers during implementation can be minimized through engineering controls and proper health and safety protocols. Short-term risks to humans is low to medium.
Will the alternative impact natural resources?	This alternative will remove/destroy existing vegetation at the waste site. However, most waste sites have already been extensively disturbed. Cultural and natural resource impacts to adjacent areas can be minimized because no excavation or transportation of wastes is required. Long-term benefits outweigh the significant short-term effects because any site restoration and/or revegetation efforts will benefit natural resources over the long-term.
What restoration actions may be necessary?	Revegetation of above-grade barrier is required. Restoration of above-grade barrier provides opportunity to increase habitat diversity. Revegetation techniques are well established.
Will residual contamination (following remediation) be a potential problem?	Wastes will be left on site; a barrier will reduce exposure of plants and animals to contaminants. Plant roots and burrowing animals may impact integrity of the cap over time. Maintenance will be required. Long-term potential risk is medium.

COMPLIANCE WITH ARARs	
Will the potential ARARs be met?	1. Yes. Chemical-specific ARARs (listed in Appendix C) will be met to the extent practicable by meeting RAO and eliminating exposure pathways. 2. Yes. Location-specific ARARs (listed in Appendix C) can be met to the extent practicable through proper planning and scheduling. 3. Yes. Action-specific ARARs (listed in Appendix C) are met to the extent practicable through appropriate design and operation. The actions will be designed and operated to be compliant with the ARAR.
Basis for waivers?	If waivers are necessary, they will be determined in the ROD.
Is the alternative consistent with the "to be considered" requirements?	1. Yes. Alternative is consistent with chemical specific "to be considered" requirement (listed in Appendix C). The PRG are developed to comply with "to be considered" requirement. 2. Yes. Alternative is consistent with location specific "to be considered" requirement (listed in Appendix C). 3. Yes. Action-specific "to be considered" requirement (listed in Appendix C) are consistent with action. The actions will be designed and operated to be compliant with the "to be considered" requirement.

Table 5-3. Detailed Analysis of the Containment Alternative (SS-3/SW-3).

(Applicable to the dummy decontamination cribs/french drains, pipelines, and burial grounds waste site groups) (page 2 of 4)

COMPLIANCE WITH ARAR (cont'd)	
Will implementation of the alternative comply with ARARs regarding protection, restoration, and enhancement of natural resources and protection of cultural resources?	1. Chemical-specific ARARs will be met to the extent practicable by implementing the alternative. 2. Location-specific ARARs should be met to the extent practicable with proper design, planning, and scheduling. Sensitive and critical habitats and cultural resources will be avoided. Construction activities will be scheduled to avoid human intrusion on nesting, breeding, and foraging activities. 3. Action-specific ARARs will be met to the extent practicable through proper design, construction, and operation of the remedial action.
What difficulties may be associated with compliance to ARARs?	Containment requires construction of cap over buried wastes, plus groundwater monitoring and maintenance of the site. ARARs relatively easy to meet. Borrow material from off site needed for cap.

LONG-TERM EFFECTIVENESS AND PERMANENCE	
What is the magnitude of the remaining risk?	Direct exposure pathways are significantly reduced, thereby limiting any potential risk.
What remaining sources of risk can be identified?	All sources remain. However, all potential direct exposure pathways are significantly eliminated.
What is the likelihood that the technologies will meet performance needs?	Barrier tests indicate that it is very unlikely that long-term performance criteria will be met.
What type, degree, and requirement of long-term management is required?	Long-term post closure monitoring of the barrier is required. In addition, groundwater surveillance monitoring may be conducted.
What O&M functions must be performed?	Repair and maintenance of the engineered barrier.
What difficulties may be associated with long-term O&M?	Minor.
What is the potential need for replacement of technical components?	Routine inspections and barrier maintenance should keep this potential at a minimum. Barrier is designed for long-term integrity.
What is the magnitude of risk should the remedial action need replacement?	Minimal, because there is no direct exposure to the contaminated waste.
What is the degree of confidence that controls can adequately handle potential problems?	Control technologies implemented under this alternative are judged to be highly reliable.
What are the uncertainties associated with land disposal of residuals and untreated wastes?	Not applicable.
Will the alternative provide long-term protection of natural resources?	The barrier will limit the direct exposure pathways to plants and animals; revegetation will stabilize the surface and allow development of a stable habitat. Maintenance may be required to retain the integrity of the cap. Wastes will be left in place. Risk is mitigated by the action.
Will terrestrial habitats be degraded or enhanced?	Most waste sites currently have no vegetation or support only marginal cover. Revegetation of the cap will enhance terrestrial habitat and attract wildlife. Sensitive habitats adjacent to the site will be avoided as much as possible. Future changes in barrier integrity should have only limited influence of the terrestrial ecosystem.
How will the remedial action effect overall quality of the ecosystem?	Revegetation and increased use of the site by wildlife will improve the overall quality of the ecosystem. Enhanced habitats on the site will also improve the stability and quality of the terrestrial ecosystem in the area. Presence of residual wastes on site will limit the overall quality to some extent.

Table 5-3. Detailed Analysis of the Containment Alternative (SS-3/SW-3).

(Applicable to the dummy decontamination cribs/french drains, pipelines, and burial grounds waste site groups) (page 3 of 4)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Does the treatment process address the principal threats?	No treatment proposed. However, an engineered barrier addresses the principal threats to human health, ecosystems, and groundwater by limiting potential direct exposure pathways.
Are there any special requirements for the treatment process?	No treatment proposed.
What portion of the contaminated material is treated/destroyed?	No contaminants are treated or destroyed.
To what extent is the total mass of toxic contaminants reduced?	Long-term reduction caused by natural degradation of radionuclides.
To what extent is the mobility of contaminants reduced?	Contaminants are effectively immobilized through reduction in hydraulic infiltration.
To what extent is the volume of contaminated media reduced?	None. No treatment proposed.
To what extent are the effects of the treatment irreversible?	No treatment proposed.
What are the quantities of residuals and characteristics of the residual risk?	No change in waste quantity However, direct exposure pathways are significantly reduced.
What risks do treatment of residuals pose?	None. No treatment is proposed.
Is treatment used to reduce inherent hazards posed by principal threats at the site?	No treatment proposed.
How does the proposed treatment impact natural resources?	Construction activities would have an immediate detrimental effect on natural resources, but would be compensated by long-term gains in natural resource quality.
Does the alternative result in a gain or loss of quality at the site for natural resources?	New habitat would be formed and species diversity would increase.
Will implementation of the alternative result in short-term impacts to natural resources (e.g. exposure of ecological receptors to physical or chemical impacts, noise, intrusion to habitat and special breeding areas, temporary displacement, seasonal restrictions on habitat use)?	At the present time, the majority of the waste sites are severely disturbed, therefore, short-term impacts would be minimal. Impacts to adjacent habitats will not outweigh the long-term benefits of restoration efforts. Mitigation efforts will include scheduling activities to reduce intrusion during sensitive life stages, controlling fugitive dust, and establishing buffer zones if needed.
Will the natural resource restoration activities associated with this alternative be easily implemented?	Successful revegetation and/or restoration procedures are available, but more effort is required for this alternative because the cap is above grade and is more susceptible to such things as wind and water erosion, slope effects, and animal intrusion.
Will long-term maintenance and monitoring of mitigation/restoration efforts and activities be necessary?	Yes, long-term maintenance and monitoring will be required to ensure that revegetation and restoration efforts are successful.

Table 5-3. Detailed Analysis of the Containment Alternative (SS-3/SW-3).

(Applicable to the dummy decontamination cribs/french drains, pipelines, and burial grounds waste site groups) (page 4 of 4)

SHORT-TERM EFFECTIVENESS	
What are the risks to the community during remedial actions, and how will they be mitigated?	Potential for release of fugitive dust. Appropriate engineering controls and contingency plans will be developed and implemented during the barrier installation. No contaminated material will be exposed during installation. Community risks will be negligible.
What risks remain to the community that cannot be readily controlled?	None.
What are the risks to the workers, and how will they be mitigated?	Risks due to exposure or accident. Potential for release of fugitive dust during barrier construction. Workers are not exposed to contaminated materials during implementation. Risks can be minimized by implementing appropriate engineering controls and health and safety procedures. Short-term risk is low to medium.
What risks remain to the workers that cannot be readily controlled?	Minimal. Increased traffic will occur at some localities.
What environmental impacts are expected with the construction and implementation of the alternative?	Fugitive dust releases could possibly affect outlying environment, but can be controlled through proper operating procedures. Remedial activities can be scheduled to accommodate nesting or roosting species. Soil excavation may impact terrestrial species, and activities near the river may impact aquatic and wetland habitats and/or species. Short-term impacts are high.
What are the impacts that cannot be avoided should the alternative be implemented?	None.
How long until remedial response objectives are achieved?	All RAOs are met upon completion of barrier installation.

IMPLEMENTABILITY	
What difficulties and uncertainties are associated with construction?	Location confidence is low for some sites. Investigations may be required to locate and plan extent of barrier.
What is the likelihood that technical problems will lead to schedule delays?	Minimal. Proper planning can prevent schedule delays that may be encountered if location investigation is necessary.
What likely future remedial actions are anticipated?	None.
What risks of exposure exist should monitoring be insufficient to detect failure?	Barrier failure could result in hydraulic infiltration through the site. Direct human and ecosystem exposure is unlikely.
What activities are proposed which require coordination with other agencies?	Long-term deed restrictions will require coordination with state groundwater agencies and with local zoning authorities.
Are adequate treatment, storage capacity, and disposal services available?	Not applicable.
Are necessary equipment and specialists available?	Yes. General earthwork construction equipment and barrier materials are required and are readily available. Most construction materials can be obtained from onsite sources. Barrier design and construction specialists are available.
Are technologies under consideration generally available and sufficiently demonstrated or will they require further development before they can be applied at the site?	Deed restrictions and groundwater surveillance monitoring have been effective at other locations. The results of field and laboratory tests provide a technically defensible foundation on which barrier designs can be based. Hanford-specific designs are currently being implemented at the 200-BP-1 Operable Unit.
Will more than one vendor be available to provide a competitive bid?	Yes. Several general earthwork and barrier construction contractors exist locally.

ARAR - applicable, relevant and appropriate requirements
O&M - operation and maintenance
RAO - remedial action objectives
PRG - preliminary remediation goals

Table 5-4. Estimated Cost - Containment Alternative (SS-3/SW-3).

COST	CAPITAL	OPERATION AND MAINTENANCE	PRESENT WORTH
Dummy decontamination cribs/french drains 116-B4 100-BC length 1.2 m (4 ft) width 1.2 m (4 ft) area 1.48 m^2 (16 ft^2)	$3,225,000 •Includes: Installation of an engineered barrier.	$217,000 •Includes: Maintenance and repair of the engineered barrier	**$3,194,000**
Pipelines 100-BC	$101,051,000 •Includes: Installation of an engineered barrier.	$44,069,000 •Includes: Maintenance and repair of the engineered barrier	**$109,645,000**
burial grounds 118-4A, 100-DR 118-4A 100-DR length 57.9 m (190 ft) width 18.2 m (60 ft) area 1,060.2 m^2 (11,400 ft^2)	$4,238,000 •Includes: Installation of an engineered barrier.	$672,000 •Includes: Maintenance and repair of the engineered barrier	**$4,292,000**

Cost: Costs for implementing any alternative will be operable unit specific regarding any proposed mitigation/restoration measures and protection of natural resources. All alternatives will include costs for mitigative measures. These costs will be determined on an operable unit specific basis. In cases where remedial work can impact threatened and/or endangered species or sensitive habitat, costs may be increased by necessity to avoid certain areas or halt work during certain time periods (seasons).

Table 5-5. Detailed Analysis of the Removal/Disposal Alternative (SS-4/SW-4).

(Applicable to the retention basins, sludge trenches, fuel storage basin trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial grounds waste site groups) (page 1 of 5)

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Will human health risk be at acceptable levels?	Yes. Risk is at acceptable levels through removal of the contaminated material from the site (i.e., elimination of the source). Human health and ecological exposure pathways are eliminated by excavation. Impact to groundwater is eliminated by removal of contaminated material exceeding PRG. Contaminated material is transferred to a common disposal facility (i.e., ERDF or W-025).
Timeframe to achieve acceptable levels?	Acceptable risk levels will be achieved at the completion of the remedial action. The duration of the remedial action is estimated, based on the representative site for a given group, as follows: retention basins: 1.4 yr sludge trenches: 0.1 yr fuel storage basin trenches: 0.2 yr process effluent trenches: 0.5 yr pluto cribs: 0.1 yr dummy decontamination crib/french drain: 0.1 yr pipelines: 2.4 yr burial grounds: 0.1 yr
Will the alternative pose any unacceptable short-term impacts to humans?	No cross-media impacts are introduced by the alternative. Worker exposure to the contaminants can be controlled during excavation through development and implementation of appropriate engineering controls and proper health and safety protocols. Short-term impacts adjacent habitat is outweighed by the long-term benefits. Short-term risks to humans is medium.
Will the alternative impact natural resources?	This alternative will remove/destroy existing vegetation at the waste site. However, most waste sites have already been extensively disturbed. Excavation and transportation activities may present short-term impacts on cultural and natural resources in adjacent areas. Long-term benefits outweigh the significant short-term effects because any site restoration and/or revegetation efforts will benefit natural resources over the long-term.
What restoration actions may be necessary?	Restoration actions would include revegetation and stabilization.
Will residual contamination (following remediation) be a potential problem?	There will be no residual wastes left at the operable unit. Wastes will be transported to a disposal facility. No long-term risks at the operable unit.

Table 5-5. Detailed Analysis of the Removal/Disposal Alternative (SS-4/SW-4).

(Applicable to the retention basins, sludge trenches, fuel storage basin trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial grounds waste site groups) (page 2 of 5)

COMPLIANCE WITH ARARs	
Will the potential ARARs be met?	1. Yes. Chemical-specific ARARs (listed in Appendix C) will be met to the extent practicable. No constituents will be present in soil that exceed PRG. The PRG are developed to comply with ARARs. 2. Yes. Location-specific ARARs (listed in Appendix C) can be met to the extent practicable through proper planning and scheduling. 3. Yes. Action-specific ARARs (listed in Appendix C) are met to the extent practicable through appropriate design and operation. The actions will be designed and operated to be compliant with the ARARs to the extent practicable.
Basis for waivers?	If waivers are necessary, they will be determined in the ROD.
Is the alternative consistent with the "to be considered" requirements?	1. Yes. Alternative is consistent with chemical-specific "to be considered" requirements (listed in Appendix C). No constituents will be present in soil that exceed PRG. The PRG are developed to comply with "to be considered" requirements. 2. Yes. Alternative is consistent with location specific "to be considered" requirements (listed in Appendix C). 3. Yes. Action-specific "to be considered" requirements (listed in Appendix C) are consistent with action.
Will implementation of the alternative comply with ARARs regarding protection, restoration, and enhancement of natural resources and protection of cultural resources?	1. Chemical-specific ARARs will be met to the extent practicable by implementing the alternative. 2. Location-specific ARARs should be met to the extent practicable with proper design, planning, and scheduling. Sensitive and critical habitats and cultural resources will be avoided. Construction activities will be scheduled to avoid human intrusion on nesting, breeding, and foraging activities. 3. Action-specific ARARs will be met to the extent practicable through proper design, construction, and operation of the remedial action.
What difficulties may be associated with compliance to ARARs?	This alternative includes excavation, transportation of wastes, and placement of clean fill. Borrow material needed for fill. No site maintenance required. ARAR compliance moderately difficult.

Table 5-5. Detailed Analysis of the Removal/Disposal Alternative (SS-4/SW-4).

(Applicable to the retention basins, sludge trenches, fuel storage basin trenches, process effluent trenches, pluto cribs,dummy decontamination cribs/french drains, pipelines, and burial grounds waste site groups) (page 3 of 5)

LONG-TERM EFFECTIVENESS AND PERMANENCE	
What is the magnitude of the remaining risk?	None. Contaminated material exceeding PRG are removed and disposed, therefore, eliminating source at the waste site.
What remaining sources of risk can be identified?	None.
What is the likelihood that the technologies will meet performance needs?	Excavation and disposal are established technologies that meet or exceed performance requirements.
What type, degree, and requirement of long-term management is required?	None necessary at the excavation site. All long-term management is associated with the disposal facility.
What O&M functions must be performed?	None necessary at the excavation site. All long-term O&M is associated with the disposal facility.
What difficulties may be associated with long-term O&M?	Not applicable.
What is the potential need for replacement of technical components?	Not applicable.
What is the magnitude of risk should the remedial action need replacement?	Not applicable.
What is the degree of confidence that controls can adequately handle potential problems?	Not applicable.
What are the uncertainties associated with land disposal of residuals and untreated wastes.	The contaminated material is transferred to the disposal facility. Waste acceptance criteria and design of the facility is being developed in consideration of receiving Hanford Site contaminated material.
Will the alternative provide long-term protection of natural resources?	Removal of the wastes from the site and revegetation will allow for reestablishment of a near-natural or natural environment. Maintenance will be required short-term to ensure successful revegetation, but long-term maintenance should not be required. Potential for success of long-term development of natural ecosystem is good.
Will terrestrial habitats be degraded or enhanced?	Most waste sites currently have no vegetation or support only marginal cover. Removal of wastes and revegetation of the clean fill will enhance terrestrial habitat and attract wildlife. Sensitive habitats adjacent to the site will be avoided as much as possible. Absence of wastes at the site should allow the development of an improved (compared to present conditions) or near-natural ecosystem.
How will the remedial action effect overall quality of the ecosystem?	Revegetation and increased use of the site by wildlife will improve the overall quality of the ecosystem. Habitat enhancement at some sites will improve the stability and quality of the terrestrial ecosystem in the area. Removal of wastes from the site should provide for development of a natural ecosystem.

Table 5-5. Detailed Analysis of the Removal/Disposal Alternative (SS-4/SW-4).

(Applicable to the retention basins, sludge trenches, fuel storage basin trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial grounds waste site groups) (page 4 of 5)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Does the treatment process address the principal threats?	No treatment proposed.
Are there any special requirements for the treatment process?	No treatment proposed.
What portion of the contaminated material is treated/destroyed?	None; all contaminants are removed and disposed at a common disposal facility.
To what extent is the total mass of toxic contaminants reduced?	Long-term reduction occurs by natural degradation of radionuclides.
To what extent is the mobility of contaminants reduced?	No reduction in mobility of toxic contaminants.
To what extent is the volume of contaminated media reduced?	No reduction in volume of contaminated media.
To what extent are the effects of the treatment irreversible?	No treatment proposed.
What are the quantities of residuals and characteristics of the residual risk?	None. No residuals exceeding risk levels are left within the operable unit.
What risks do treatment of residuals pose?	None. No treatment proposed.
Is treatment used to reduce inherent hazards posed by principal threats at the site?	No treatment proposed.
How does the proposed treatment impact natural resources?	Construction activities would have an immediate detrimental effect on natural resources, but would be compensated by mitigating short-term effects and by long-term gains in natural resource quality.
Does the alternative result in a gain or loss of quality at the site for natural resources?	The effect would improve natural resource quality.
Will implementation of the alternative result in short-term impacts to natural resources (e.g., exposure of ecological receptors to physical or chemical impacts, noise, intrusion to habitat and special breeding areas, temporary displacement, seasonal restrictions on habitat use)?	At the present time, the majority of the waste sites are severely disturbed, therefore, short-term impacts would be minimal. Impacts to adjacent habitats will not outweigh the long-term benefits of restoration efforts. Mitigation efforts will include scheduling activities to reduce intrusion during sensitive life stages, controlling fugitive dust, and establishing buffer zones if needed.
Will the natural resource restoration activities associated with this alternative be easily implemented?	Revegetation and restoration techniques are available and can be implemented.
Will long-term maintenance and monitoring of mitigation/restoration efforts and activities be necessary?	Yes, long-term maintenance and monitoring will be required to ensure that revegetation and restoration efforts are successful

Table 5-5. Detailed Analysis of the Removal/Disposal Alternative (SS-4/SW-4).

(Applicable to the retention basins, sludge trenches, fuel storage basin trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial grounds waste site groups) (page 5 of 5)

SHORT-TERM EFFECTIVENESS	
What are the risks to the community during remedial actions, and how will they be mitigated?	Potential for release of fugitive dust during excavation. Appropriate engineering controls and contingency plans can be developed and implemented during the excavation and disposal.
What risks remain to the community that cannot be readily controlled?	None.
What are the risks to the workers, and how will they be mitigated?	Risks due to exposure or accident. Potential for releases of fugitive dusts during excavation. Risks can be controlled by implementing appropriate engineering controls and health and safety procedures. Short-term risk is high.
What risks remain to the workers that cannot be readily controlled?	Minimal. Increased traffic will occur at some locations. SS-4: None. Contaminants are known and will be mitigated through excavation of the contaminated material. SW-4: None.
What environmental impacts are expected with the construction and implementation of the alternative?	Fugitive dust releases could possibly affect outlying environment, but can be controlled through proper operating procedures. Remedial activities can be scheduled to accommodate nesting or roosting species. Soil excavation will impact terrestrial species and activities near the river may impact aquatic and wetland species. Short-term risk is medium.
What are the impacts that cannot be avoided should the alternative be implemented?	None.
How long until remedial response objectives are achieved?	All RAO are met upon completion of Remedial Alternative.

IMPLEMENTABILITY	
What difficulties and uncertainties are associated with construction?	The extent of contamination is uncertain, but will be delineated during excavation. SW-4: Uncertainties exist concerning the nature of buried wastes and the problems with encountering unexpected materials.
What is the likelihood that technical problems will lead to schedule delays?	Delays not likely. No adaptations to excavation technology are expected. There is some uncertainty on availability of disposal facilities at certain times.
What likely future remedial actions are anticipated?	None.
What risks of exposure exist should monitoring be insufficient to detect failure?	Removal does not require postclosure monitoring.
What activities are proposed that require coordination with other agencies?	None.
Are adequate treatment, storage capacity, and disposal services available?	Yes. Maximum capacity, currently available, at the W-025 facility is 25,000 yd^3. The ERDF capacity is 4.3 million yd^3, available in 1996. Remedial action will not be implemented until disposal is available.
Are necessary equipment and specialists available?	Yes. General earthwork construction equipment is required and is readily available. Excavation and analytical specialists are required and are available. Specialized analytical equipment may be required and is available.
Are technologies under consideration generally available and sufficiently demonstrated or will they require further development before they can be applied at the site?	Removal and disposal are developed technologies. Excavation of the 116-F-4 pluto crib has been completed demonstrating many of the technologies to be used. Excavation of the 118-B-1 burial ground will be conducted in March 1995 to demonstrate the ability to excavate buried waste.
Will more than one vendor be available to provide a competitive bid?	Yes. Several general earthwork contractors exist locally. Many vendors are also available to supply monitoring equipment.

PRG - preliminary remediation goals
RAO - remedial action objective
ARAR - applicable or relevant and appropriate requirement
ERDF - Environmental Restoration Disposal Facility
O&M - operations and maintenance
W-025 - W-025 Radioactive Mixed Waste Land Disposal Facility

Table 5-6. Estimated Cost - Removal/Disposal Alternative (SS-4/SW-4). (page 1 of 2)

COST	CAPITAL	OPERATION AND MAINTENANCE	PRESENT WORTH
Retention basins	$102,000,000 •Includes: Removal of the contaminated material and site restoration Transportation of the contaminated material to a common disposal facility	$0 •Includes: None	**$96,000,000**
Sludge trenches	$1,750,000 •Includes: Removal of the contaminated material and site restoration Transportation of the contaminated material to a common disposal facility	$0 •Includes: None	**$1,670,000**
Fuel storage basin trenches	$4,690,000 •Includes: Removal of the contaminated material and site restoration Transportation of the contaminated material to a common disposal facility	$0 •Includes: None	**$4,470,000**
Process effluent trenches	$16,500,000 •Includes: Removal of the contaminated material and site restoration Transportation of the contaminated material to a common disposal facility	$0 •Includes: None	**$15,700,000**
Pluto cribs	$277,000 •Includes: Removal of the contaminated material and site restoration Transportation of the contaminated material to a common disposal facility	$0 •Includes: None	**$267,000**
Dummy decontamination crib/french drain	$295,000 •Includes: Removal of the contaminated material and site restoration Transportation of the contaminated material to a common disposal facility	$0 •Includes: None	**$283,000**

Table 5-6. Estimated Cost - Removal/Disposal Alternative (SS-4/SW-4). (page 2 of 2)

COST	CAPITAL	OPERATION AND MAINTENANCE	PRESENT WORTH
Pipelines	$36,100,000 •Includes: Removal of the contaminated material and site restoration Transportation of the contaminated material to a common disposal facility	$0 •Includes: None	**$32,900,000**
Burial grounds	$2,500,000 •Includes: Removal of the contaminated material and site restoration Transportation of the contaminated material to a common disposal facility	$0 •Includes: None	**$2,380,000**

Cost: Costs for implementing any alternative will be operable unit specific regarding any proposed mitigation/restoration measures and protection of natural resources. All alternatives will include costs for mitigative measures. These costs will be determined on an operable unit specific basis. In cases where remedial work can impact threatened and/or endangered species or sensitive habitat, costs may be increased by necessity to avoid certain areas or halt work during certain time periods (seasons).

Table 5-7. Detailed Analysis - In Situ Treatment Alternative (SS-8A/SS-8B/SW-7).

(Applicable to the sludge trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups)
(page 1 of 10)

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Will human health risk be at acceptable levels?	Yes. Risk is at acceptable levels by limiting potential direct pathways through in situ treatment (i.e., vitrification). SS-8A: Yes. Risk is at acceptable levels by limiting human health and ecological exposure pathways. In Situ Vitrification of the contaminated material that is overlain by 1 m of clean fill limits direct exposure pathways to human and ecological receptors. Constituent concentrations are at levels that are protective of groundwater. SS-8B: Yes. Risk is at acceptable levels by limiting potential direct exposure pathways through installation of an engineered barrier over areas that have contaminated material. Grouting of the effluent pipeline effectively immobilizes any contaminated sludge that may be present. Constituent concentrations are below levels that would impact groundwater under the reduced infiltration allowed by the engineered barrier based on evaluation of constituent concentrations. SW-7: Yes. Risk is at acceptable levels by limiting potential direct exposure pathways through installation of an engineered barrier over areas that have contaminated material. Constituent concentrations are assumed to be below levels that would impact groundwater because the barrier would adequately reduce infiltration rates. Additional benefits are gathered from mobility reduction of contaminants because of dynamic compaction.
Timeframe to achieve acceptable levels?	Acceptable risk levels will be achieved at the completion of the remedial action. The duration of the remedial action is estimated, based on the representative site for a given group, as follows: sludge trenches: 0.4 yr process effluent trenches: 3.8 yr pluto cribs: 0.1 yr dummy decontamination crib/french drain: 0.1 yr pipelines: 0.2 yr burial grounds: 0.1 yr
Will the alternative pose any unacceptable short-term impacts?	No cross-media impacts are introduced by the alternative. Workers will not be exposed to the contaminants during implementation. Risks to workers during implementation can be minimized through engineering controls and proper health and safety protocols. Short-term impacts on adjacent habitat is outweighed by the long-term benefits. Short-term risk to humans is low to medium.
Will the alternative impact natural resources?	SS-8A: This alternative will remove/destroy existing vegetation at the waste site because uncontaminated surface material will be removed before vitrification. However, most waste sites have already been extensively disturbed. Impacts to adjacent areas can be minimized because no excavation or transportation of wastes is required. Long-term benefits outweigh the significant short-term effects because any site restoration and/or revegetation efforts will benefit natural resources over the long-term. SS-8B: This alternative will remove/destroy existing vegetation at the waste site during placement of the barrier. However, most waste sites have already been extensively disturbed. Impacts to adjacent areas can be minimized because no excavation or transportation of wastes is required. Long-term benefits outweigh the significant short-term effects because any site restoration and/or revegetation efforts will benefit natural resources over the long-term. SW-7: This alternative will destroy existing vegetation at the waste site during compaction. However, most waste sites have already been extensively disturbed. Impacts to adjacent areas can be minimized because no excavation or transportation of wastes is required. Long-term benefits outweigh the significant short-term effects because any site restoration and/or revegetation efforts will benefit natural resources over the long-term.

Table 5-7. Detailed Analysis - In Situ Treatment Alternative (SS-8A/SS-8B/SW-7).

(Applicable to the sludge trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups)
(page 2 of 10)

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
What restoration actions may be necessary?	SS-8A: Revegetation over vitrified wastes is required. Revegetation techniques are available, but depth of soil and subgrade may be shallow at some sites. SS-8B: Revegetation of above-grade barrier is required. Restoration of above-grade barrier provides opportunity to increase habitat diversity. Revegetation techniques are available. SW-7: Revegetation of above-grade barrier is required. Restoration of above-grade barrier provides opportunity to increase habitat diversity. Revegetation techniques are available.
Will residual contamination (following remediation) be a potential problem?	SS-8A: Wastes will be converted to a glassy immobile material. Potential leaching will be eliminated. Minimal maintenance will be required. Long-term risk is low. SS-8B: Wastes will be converted to an immobile grout material. Potential leaching will be eliminated. Minimal maintenance will be required. Long-term risk is low. SW-7: Wastes will be compacted, which will reduce potential transport of contaminants, at least short term. A barrier will reduce exposure of plants and animals to contaminants. However, plant roots and burrowing animals may impact the integrity of the barrier over time. Maintenance will be required. Long-term risk is medium.

COMPLIANCE WITH ARARs	
Will the potential ARARs be met?	1. Yes. Chemical specific ARARs (listed in Appendix C) will be met to the extent practicable by meeting RAO and eliminating exposure pathways. 2. Yes. Location-specific ARARs (listed in Appendix C) can be met to the extent practicable through proper planning and scheduling. 3. Yes. Action-specific ARARs (listed in Appendix C) are met to the extent practicable through appropriate design and operation. The actions will be designed and operated to be compliant with the ARARs.
Basis for waivers?	If waivers are necessary they will be determined in the ROD.
Is the alternative consistent with the "to be considered" requirements?	1. Yes. Alternative is consistent with chemical-specific "to be considered" requirements (listed in Appendix C). No constituents will be present in soil which exceed PRG. The PRG are developed to comply with "to be considered" requirements. 2. Yes. Alternative is consistent with location-specific "to be considered" requirements (listed in Appendix C). 3. Yes. Action-specific "to be considered" requirements (listed in Appendix C) are consistent with action.

Table 5-7. Detailed Analysis - In Situ Treatment Alternative (SS-8A/SS-8B/SW-7).

(Applicable to the sludge trenches, process effluent trenches,pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups) (page 3 of 10)

COMPLIANCE WITH ARAR	
Will implementation of the alternative comply with ARARs regarding protection, restoration, and enhancement of natural resources and protection of cultural resources?	1. Chemical-specific ARARs will be met to the extent practicable by implementing the alternative. 2. Location-specific ARARs should be met to the extent practicable with proper design, planning, and scheduling. Sensitive and critical habitats and cultural resources will be avoided. Construction activities will be scheduled to avoid human intrusion on nesting, breeding, and foraging activities. 3. Action-specific ARARs will be met to the extent practicable through proper design, construction, and operation of the remedial action.
What difficulties may be associated with compliance to ARARs?	SS-8A: Vitrification requires removal of clean overburden before vitrification and placement of clean fill over vitrified mass. Offgas controls required during vitrification. Limited maintenance and groundwater monitoring required. ARAR compliance relatively easy. SS-8B: This alternative requires onsite grouting and construction of an above-grade barrier. Borrow material needed for cap. Maintenance and groundwater monitoring will be required. ARAR compliance relatively easy. SW-7: This alternative requires heavy equipment for compaction, and placement of an at-grade barrier. Borrow material needed for cap. Maintenance and groundwater monitoring will be required. ARAR compliance relatively easy.

LONG-TERM EFFECTIVENESS AND PERMANENCE	
What is the magnitude of the remaining risk?	Direct exposure pathways are eliminated, therefore, reducing potential risk.
What remaining sources of risk can be identified?	All sources remain. However, all exposure pathways are eliminated. Waste is immobilized.
What is the likelihood that the technologies will meet performance needs?	SS-8A: In Situ Vitrification is an innovative technology that should be effective in meeting performance requirements. SS-8B: Void grouting and installation of an engineered barrier is expected to meet or exceed performance requirements. SW-7: An engineered barrier is expected to meet or exceed performance requirements. Dynamic compaction involves a demonstrated technology capable of meeting performance requirements.
What type, degree, and requirement of long-term management is required?	Long-term deed restrictions is required. In addition, groundwater surveillance monitoring will be conducted. SS-8B: Long-term postclosure monitoring of the engineered barrier is required. SW-7: Long-term postclosure monitoring of the engineered barrier is required.
What O&M functions must be performed?	SS-8A: Maintenance of soil cover overlying the vitrified material (for shielding to provide long-term protection of human health and the environment by limiting external radiation exposure caused by radionuclides left in situ) and operation and maintenance of the In Situ Vitrification system. SS-8B and SW-7: Repair and maintenance of the engineered barrier.

Table 5-7. Detailed Analysis - In Situ Treatment Alternative (SS-8A/SS-8B/SW-7).

(Applicable to the sludge trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups)
(page 4 of 10)

LONG-TERM EFFECTIVENESS AND PERMANENCE	
What difficulties may be associated with long-term O&M?	None.
What is the potential need for replacement of technical components?	SS-8B and SW-7: Routine inspections and barrier maintenance should keep replacement at a minimum.
What is the magnitude of risk should the remedial action need replacement?	Minimal, because there is no exposure to the contaminated material.
What is the degree of confidence that controls can adequately handle potential problems?	Control technologies implemented under this alternative are judged to be highly reliable.
What are the uncertainties associated with land disposal of residuals and untreated wastes.	Not applicable.
Will the alternative provide long-term protection of natural resources?	SS-8A: Vitrifying the wastes will preclude the transport of wastes into the ecosystem, and the clean fill cover will allow revegetation. The fill may have limited depth, partly preventing the establishment of a completely natural ecosystem. The vitrified mass may decrease success of deep-rooted plants and deeper burrowing animals. Long-term maintenance will be minimal. Potential success of long-term development of natural ecosystem is low. SS-8B: Void grouting will physically stabilize the wastes, and the barrier will limit the direct exposure pathways to plants and animals. Revegetation will stabilize the surface and allow development of a stable habitat. Maintenance will be required to retain the integrity of the cap. Wastes will be left in place; risk is mitigated by the action. Potential success of long-term development of natural ecosystem is medium. SW-7: Dynamic compaction will physically stabilize the wastes, and the barrier will limit the direct exposure pathways to plants and animals. Revegetation will stabilize the surface and allow development of a stable habitat. Maintenance will be required to retain the integrity of the cap. Long-term risk should be minimal. Potential success of long-term development of natural ecosystem is medium.

Table 5-7. Detailed Analysis - In Situ Treatment Alternative (SS-8A/SS-8B/SW-7).

(Applicable to the sludge trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups)
(page 5 of 10)

LONG-TERM EFFECTIVENESS AND PERMANENCE	
Will terrestrial habitats be degraded or enhanced?	SS-8A: Most waste sites currently have no vegetation or support only marginal cover. Vitrifying wastes will significantly reduce mobility of contaminants, and clean fill over the wastes will allow appropriate revegetation. Continued presence of a glassy mass will preclude development of a completely natural ecosystem. SS-8B: Most waste sites currently have no vegetation or support only marginal cover. In situ grout wastes will significantly reduce mobility of contaminants, and clean fill over the wastes will allow appropriate revegetation. Continued presence of grout will preclude development of a completely natural ecosystem. SW-7: Most waste sites currently have no vegetation or support only marginal cover. Compacted wastes will significantly reduce mobility of contaminants, and clean fill over the wastes will allow appropriate revegetation. Continued presence of compacted wastes will preclude development of a completely natural ecosystem.
How will the remedial action effect overall quality of the ecosystem?	SS-8A: Revegetation and increased use of the site by wildlife will improve the overall quality of the ecosystem. Revegetation of the clean fill over the vitrified wastes will improve the quality of the terrestrial ecosystem. Presence of the vitrified mass, however, will prevent the development of deep rooted vegetation and use of the area by certain animals. SS-8B: Revegetation and increased use of the site by wildlife will improve the overall quality of the ecosystem. Revegetation over the grouted wastes will improve the quality of the terrestrial ecosystem. Presence of the grout mass, however, will prevent the development of deep rooted vegetation and use of the are by certain animals. SW-7: Revegetation and increased use of the site by wildlife will improve the overall quality of the ecosystem. Revegetation over the compacted wastes will improve the quality of the terrestrial ecosystem. Presence of the compacted wastes, however, will prevent the development of deep rooted vegetation and use of the are by certain animals.

Table 5-7. Detailed Analysis - In Situ Treatment Alternative (SS-8A/SS-8B/SW-7).

(Applicable to the sludge trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups)
(page 6 of 10)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Does the treatment process address the principal threats?	SS-8A: Yes. Contaminants are immobilized and principle exposure pathways are eliminated. SS-8B: Yes. Grouting of pipelines reduces mobilization and leachability of wastes. Principle exposure pathways are eliminated through installation of the engineered barrier. SW-7: Yes. Dynamic compaction enhances the barrier effectiveness and reduces mobility of wastes. Principle exposure pathways are eliminated through installation of the engineered barrier.
Are there any special requirements for the treatment process?	SS-8A: A treatability study performed at the 116-B-6A crib area encountered a depth limitation of 4.3 m (14 ft), possibly from the presence of a cobble layer. The EPA documentation states that In Situ Vitrification is effective to a maximum depth of 5.8 m (19 ft). Also, 4,000 Amps of electricity are required at the beginning of the melt. SS-8B: Video survey of lines should be conducted before grouting. SW-7: Delineation of the extent of buried wastes required to verify assumptions. Verification that dynamic compaction is effective for the type and extent of wastes found at a particular site is also required.
What portion of the contaminated material is treated/destroyed?	SS-8A: All of the material to the maximum melt depth is treated, however, only organics are destroyed. SS-8B: Sludges within the pipelines will be treated through stabilization; no material is destroyed. SW-7: All material is compacted, none of the material is destroyed.
To what extent is the total mass of toxic contaminants reduced?	Long-term reduction of radionuclides will occur by natural degradation.
To what extent is the mobility of contaminants reduced?	SS-8A: Contaminants are effectively immobilized by stabilizing the contaminants in the glass melt. Hydraulic infiltration is temporarily reduced and mobilization is eliminated. SS-8B: Contaminants are effectively immobilized through void grouting and hydraulic infiltration is reduced in contaminated soil areas where the engineered barrier is installed. SW-7: Contaminants are effectively immobilized through reduction in hydraulic infiltration by compaction and installation of the engineered barrier.
To what extent is the volume of contaminated media reduced?	SS-8A: In Situ Vitrification reduces volume by 30%. SS-8B: Void grouting will not reduce volume. SW-7: Dynamic compaction has been shown to reduce contaminated volume by approximately 10 to 15%.
To what extent are the effects of the treatment irreversible?	SS-8A: In Situ Vitrification is an irreversible process. SS-8B: Grouting can be reversed with mechanical methods. An engineered barrier can be removed. SW-7: Dynamic compaction can be reversed with mechanical methods. An engineered barrier can be removed.
What are the quantities of residuals and characteristics of the residual risk?	SS-8A: Minimal quantities of residuals from offgas treatment, including condensate and contaminated filters. SS-8B and SW-7: No treatment residuals are produced.
What risks do treatment of residuals pose?	SS-8A: None. Residuals will be disposed at a common disposal facility. SS-8B and SW-7: None. No residuals are produced.
Is treatment used to reduce inherent hazards posed by principal threats at the site?	Yes. The principle exposure pathways are eliminated.

Table 5-7. Detailed Analysis - In Situ Treatment Alternative (SS-8A/SS-8B/SW-7).

(Applicable to the sludge trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups)
(page 7 of 10)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
How does the proposed treatment impact natural resources?	SS-8A: Of all the options, this treatment has the most negative effects in regards to natural resources because the subsurface soils has been vitrified and will never return to a natural condition. SS-8B: Construction activities would have an immediate detrimental effect on natural resources, but would be compensated by long-term gains in natural resource quality. SW-7: Construction activities would have an immediate detrimental effect on natural resources, but would be compensated by long-term gains in natural resource quality.
Does the alternative result in a gain or loss of quality at the site for natural resources?	SS-8A: A small gain in natural resource quality would be realized. SS-8B: New habitat would be formed and species diversity would increase. SW-7: New habitat would be formed and species diversity would increase.
Will implementation of the alternative result in short-term impacts to natural resources (e.g., exposure of ecological receptors to physical or chemical impacts, noise, intrusion to habitat and special breeding areas, temporary displacement, seasonal restrictions on habitat use)?	SS-8A: At the present time, the majority of the waste sites are severely disturbed, therefore, short-term impacts would be minimal. Impacts to adjacent habitats will be outweighed by the long-term benefits of restoration efforts. Mitigation efforts will include scheduling activities to reduce intrusion during sensitive life stages, controlling fugitive dust, and establishing buffer zones if needed. SS-8B: At the present time, the majority of the waste sites are severely disturbed, therefore, short-term impacts would be minimal. Impacts to adjacent habitats will be outweighed by the long-term benefits of restoration efforts. Mitigation efforts will include scheduling activities to reduce intrusion during sensitive life stages, controlling fugitive dust, and establishing buffer zones if needed. SW-7: At the present time, the majority of the waste sites are severely disturbed, therefore, short-term impacts would be minimal. Impacts to adjacent habitats will be outweighed by the long-term benefits of restoration efforts. Mitigation efforts will include scheduling activities to reduce intrusion during sensitive life stages, controlling fugitive dust, and establishing buffer zones if needed.
Will the natural resource restoration activities associated with this alternative be easily implemented?	SS-8A: Revegetation and restoration efforts for this alternative are easy to implement. SS-8B: Successful revegetation and/or restoration procedures are available. More effort is required for this alternative because the cap is above grade and is more susceptible to wind and water erosion, slope effects, and animal intrusion. SW-7: Successful revegetation and/or restoration procedures are available, but more effort is required for this alternative because the cap is above grade and is more susceptible to wind and water erosion, slope effects, and animal intrusion.

Table 5-7. Detailed Analysis - In Situ Treatment Alternative (SS-8A/SS-8B/SW-7).

(Applicable to the sludge trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups)
(page 8 of 10)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Will long-term maintenance and monitoring of mitigation/restoration efforts and activities be necessary?	SS-8A: Yes, long-term maintenance and monitoring will be required to ensure that revegetation and restoration efforts are successful. SS-8B: Yes, long-term maintenance and monitoring will be required to ensure that revegetation and restoration efforts are successful. SW-7: Yes, long-term maintenance and monitoring will be required to ensure that revegetation and restoration efforts are successful.

SHORT-TERM EFFECTIVENESS	
What are the risks to the community during remedial actions, and how will they be mitigated?	SS-8A: Potential for release of fugitive dust and gases during treatment. Appropriate engineering controls and contingency plans will be developed and implemented. SS-8B and SW-7: Potential for release of fugitive dust during treatment. Appropriate engineering controls and contingency plans will be developed and implemented.
What risks remain to the community that cannot be readily controlled?	None.
What are the risks to the workers, and how will they be mitigated?	Risks due to exposure or accident. Potential for release of fugitive dust during Remedial Alternative. Risks can be minimized by implementing appropriate engineering controls and health and safety procedures. Short-term risks are low to medium.
What risks remain to the workers that cannot be readily controlled?	SS-8A: Some uncertainty with respect to offgas emissions. SS-8B: None SW-7: Contaminants are unknown; therefore, a potential for risk exists because of this uncertainty.
What environmental impacts are expected with the construction and implementation of the alternative?	Fugitive dust releases could possibly affect outlying environment, but can be controlled through proper operating procedures. Remedial activities can be scheduled to accommodate nesting or roosting species. Soil excavation will impact terrestrial species and activities near the river may impact aquatic and wetland species. Short-term risk is medium.
What are the impacts that cannot be avoided should the alternative be implemented?	None.
How long until remedial response objectives are achieved?	All RAO are met upon completion of the remedial action.

Table 5-7. Detailed Analysis - In Situ Treatment Alternative (SS-8A/SS-8B/SW-7).

(Applicable to the sludge trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups)
(page 9 of 10)

IMPLEMENTABILITY	
What difficulties and uncertainties are associated with construction?	SS-8A: Investigation(s) may be required to locate the area proposed for In Situ Vitrification. In addition, soil particle sizes may vary from site to site. Existence of cobble layers and structural members may interfere with performance. The presence of excessive moisture or groundwater can limit the economic practicality of In Situ Vitrification because of the time and energy required to drive off the water. Soils with low alkaline content may not effectively carry a charge and thereby diminish the applicability of In Situ Vitrification (EPA 1992). Large quantities of combustible liquids or solids may increase the gas production rate beyond the capacity of the offgas system. In addition, the presence of metals in the soil can result in a conductive path that would lead to electrical shorting between electrodes. SS-8B: Investigation(s) may be required to locate and plan the extent of the barrier. The integrity (groutability) of the pipelines is uncertain and should be confirmed by investigation. SW-7: Dynamic compaction has been successful at other sites. Uncertainties exist because of variations in type of waste and unknown burial ground contents. Investigation(s) may be required to locate and plan the extent of the barrier.
What is the likelihood that technical problems will lead to schedule delays?	SS-8A: Adaptations to vitrification technology may be necessary to enable different waste site types to be treated. SS-8B: Minimal. Void grouting and a barrier are proven technology. Proper planning can prevent schedule delays that may be encountered if investigation is necessary. SW-7: Minimal. Dynamic compaction and a barrier are proven technology. Proper planning can prevent schedule delays that may be encountered if waste investigation is necessary.
What likely future remedial actions are anticipated?	None.
What risks of exposure exist should monitoring be insufficient to detect failure?	SS-8A: Human and ecological exposure may occur through undetected failure of the soil cover. The stability of the glass matrix should be very effective in minimizing contaminant risks to human health and the environment. SS-8B and SW-7: Failure of the engineered barrier could result in hydraulic infiltration through the site.
What activities are proposed that require coordination with other agencies?	Long-term deed restrictions will require coordination with state groundwater agencies and with local zoning authorities.
Are adequate treatment, storage capacity, and disposal services available?	Not applicable.
Are necessary equipment and specialists available?	SS-8A: Yes. All necessary equipment and specialists are readily available. SS-8B: Yes. General earthwork construction equipment and barrier materials are required and are readily available. Grouting and barrier construction specialists are required and available. SW-7: Yes. General earthwork construction equipment and barrier materials are required and are readily available. A specialized tamper may need to be constructed. Dynamic compaction and barrier design and construction specialists are required and available.

Table 5-7. Detailed Analysis - In Situ Treatment Alternative (SS-8A/SS-8B/SW-7).

(Applicable to the sludge trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups)
(page 10 of 10)

IMPLEMENTABILITY	
Are technologies under consideration generally available and sufficiently demonstrated or will they require further development before they can be applied at the site?	Deed restrictions and groundwater surveillance monitoring have been effective at other locations. SS-8A: In Situ Vitrification is an innovative technology, but has been effectively demonstrated at a number of sites to immobilize contaminants and effectively reduce leaching. SS-8B: Grouting has been successfully implemented at construction sites. Modifications may be needed to apply the technology at pipeline sites. Surface barriers are established technologies. Hanford-specific designs are currently being implemented at the 200-BP-1 Operable Unit. SW-7: Dynamic compaction has been successfully implemented at other sites and tested at the Hanford Site. Modifications may be needed to apply the technology at burial ground sites. Surface barriers are established technologies. Hanford-specific designs are currently being implemented at the 200-BP-1 Operable Unit.
Will more than one vendor be available to provide a competitive bid?	SS-8A: Geosafe has been the exclusive vendor for DOE; however, other vendors can supply ISV to DOE if available. SS-8B: Yes. Grouting, general earthwork, and barrier construction contractors exist locally. SW-7: Yes. Compaction, general earthwork, and barrier construction contractors exist locally.

ARAR - applicable or relevant and appropriate requirement
ISV - In Situ Vitrification
O&M - operation and maintenance
RAO - remedial action objectives
PRG - preliminary remediation goals

Table 5-8. Estimated Cost - In Situ Treatment Alternative (SS-8A/SS-8B/SW-7).

COST	CAPITAL	OPERATION AND MAINTENANCE	PRESENT WORTH
Sludge trenches	$3,610,000 •Includes: In Situ Vitrification equipment and installation	$2,290,000 •Includes: Maintenance of the soil cover Operation of In Situ Vitrification system	**$5,630,000**
Process effluent trenches	$33,900,000 •Includes: In Situ Vitrification equipment and installation	$27,700,000 •Includes: Maintenance of the soil cover Operation of In Situ Vitrification system	**$54,800,000**
Pluto cribs	$598,000 •Includes: In Situ Vitrification equipment and installation	$89,600 •Includes: Maintenance of the soil cover Operation of In Situ Vitrification system	**$661,000**
Dummy decontamination crib/french drain	$632,000 •Includes: In Situ Vitrification equipment and installation	$113,000 •Includes: Maintenance of the soil cover Operation of In Situ Vitrification system	**$715,000**
Pipelines	$11,492,000 •Includes: Installation of an engineered barrier Grouting of the pipeline	$1,121,000 •Includes: Maintenance and repair of the engineered barrier	**$11,574,000**
Burial grounds	$4,238,000 •Includes: Installation of an engineered barrier Dynamic soil compaction	$699,000 •Includes: Maintenance and repair of the engineered barrier	**$4,430,000**

Cost: Costs for implementing any alternative will be operable unit specific regarding any proposed mitigation/restoration measures and protection of natural resources. All alternatives will include costs for mitigative measures. These costs will be determined on an operable unit specific basis. In cases where remedial work can impact threatened and/or endangered species or sensitive habitat, costs may be increased by necessity to avoid certain areas or halt work during certain time periods (seasons).

Table 5-9. Detailed Analysis of the Removal/Treatment/Disposal Alternative (SS-10/SW-9).

(Applicable to the retention basins, sludge trenches, fuel storage basin trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups) (page 1 of 7)

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Will human health risk be at acceptable levels?	Yes. Risk is reduced to acceptable levels through removal of the contaminated material from the site (i.e., elimination of the source). Human health and ecological exposure pathways are eliminated by excavation. Impact to groundwater eliminated by removal of contaminated material exceeding PRG. Contaminated material is transferred to a common disposal facility (i.e., ERDF or W-025). SS-10: Additional benefits result from the mass and volume reduction of contaminants by soil washing. SW-9: Additional benefits are realized by reducing mass, mobility, and volume of contaminants because of thermal desorption and compaction.
Timeframe to achieve acceptable levels?	Acceptable risk levels are achieved at the completion of the remedial action. The duration of the remedial action is estimated, based on the representative site for a given group, as follows: retention basins: 3.2 yr sludge trenches: 0.1 yr fuel storage basin trenches: 0.3 yr process effluent trenches: 0.6 yr pluto cribs: 0.1 yr dummy decontamination crib/french drain: 0.1 yr pipelines: 2.5 yr burial grounds: 0.1 yr
Will the alternative pose any unacceptable short-term impacts?	No cross-media impacts are introduced by the alternative. Worker exposure to the contaminants can be controlled during excavation through development and implementation of appropriate engineering controls and proper health and safety protocols. Short-term risk to humans is high.
Will the alternative impact natural resources?	This alternative will remove/destroy existing vegetation at the waste site. However, most waste sites have already been extensively disturbed. Impacts to adjacent areas will result from excavation and transportation, operation of treatment facilities, and disposal site requirements. Long-term benefits outweigh the significant short-term effects because any site restoration and/or revegetation efforts will benefit natural resources over the long-term.
What restoration actions may be necessary?	Revegetation of at-grade barrier required. Initial revegetation may include uniform dryland grasses. Revegetation techniques are well established.

Table 5-9. Detailed Analysis of the Removal/Treatment/Disposal Alternative (SS-10/SW-9).

(Applicable to the retention basins, sludge trenches, fuel storage basin trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups) (page 2 of 7)

COMPLIANCE WITH ARARs	
Will the potential ARARs be met?	1. Yes. Chemical-specific ARARs (listed in Appendix C) will be met to the extent practicable. No constituents will be present in soil which exceed PRG. The PRG are developed to comply with ARARs. 2. Yes. Location-specific ARARs (listed in Appendix C) can be met to the extent practicable through proper planning and scheduling. 3. Yes. Action-specific ARARs (listed in Appendix C) are met to the extent practicable through appropriate design and operation. The actions will be designed and operated to be compliant with the ARARs.
Basis for waivers?	If waivers are necessary, they will be determined in the ROD.
Is the alternative consistent with the "to be considered" requirements?	1. Yes. Alternative is consistent with chemical-specific "to be considered" requirements (listed in Appendix C). No constituents will be present in soil which exceed PRG. The PRG are developed to comply with "to be considered" requirements. 2. Yes. Alternative is consistent with location-specific to be considered" requirements (listed in Appendix C). 3. Yes. Action-specific "to be considered" requirements (listed in Appendix C) are consistent with action.
Will implementation of the alternative comply with ARARs regarding protection, restoration, and enhancement of natural resources and protection of cultural resources?	1. Chemical-specific ARARs will be met to the extent practicable by implementing the alternative. 2. Location-specific ARARs should be met with proper design, planning, and scheduling. Sensitive and critical habitats and cultural resources will be avoided. Construction activities will be scheduled to avoid human intrusion on nesting, breeding, and foraging activities. 3. Action-specific ARARs will be met to the extent practicable through proper design, construction, and operation of the remedial action.
What difficulties may be associated with compliance to ARARs?	This alternative requires excavation, treatment of wastes, and transportation of wastes and treatment residuals. Several ARARs are associated with just the treatment activities. Borrow material needed for fill. No site maintenance required. ARAR compliance difficult.

Table 5-9. Detailed Analysis of the Removal/Treatment/Disposal Alternative (SS-10/SW-9).

(Applicable to the retention basins, sludge trenches, fuel storage basin trenches, process effluent trenches, pluto cribs, dummy contamination cribs/french drains, pipelines, and burial ground waste site groups) (page 3 of 7)

LONG-TERM EFFECTIVENESS AND PERMANENCE	
What is the magnitude of the remaining risk?	None. Contaminated material exceeding PRG are removed, treated, and disposed, therefore, eliminating the source at the waste site.
What remaining sources of risk can be identified?	None.
What is the likelihood that the technologies will meet performance needs?	Excavation, treatment, and disposal are established technologies that meet or exceed performance requirements. SS-10: Soil washing is an established technology, but less proven than excavation. However, it meets performance requirements under favorable circumstances. SW-9: Thermal desorption and compaction are established technologies that meet performance requirements.
What type, degree, and requirement of long-term management is required?	Treatment (i.e., soil washing or thermal desorption) of the contaminated material will occur near the excavation site. The treatment areas will be restored. All additional long-term management is associated with the disposal facility.
What O&M functions must be performed?	Treatment (i.e., soil washing or thermal desorption) of the contaminated material will occur near the excavation site. The treatment areas will be restored. All additional long-term O&M is associated with the disposal facility.
What difficulties may be associated with long-term O&M?	Not applicable.
What is the potential need for replacement of technical components?	Not applicable.
What is the magnitude of risk should the remedial action need replacement?	Not applicable.
What is the degree of confidence that controls can adequately handle potential problems?	Not applicable.
What are the uncertainties associated with land disposal of residuals and untreated wastes.	The contaminated material is transferred to a common disposal facility. Waste acceptance criteria and design of the facility is being developed in consideration of receiving Hanford Site contaminated material.
Will the alternative provide long-term protection of natural resources?	Removal of the wastes from the site and revegetation will allow for reestablishment of a near-natural or natural environment. Maintenance will be required short-term to ensure successful revegetation, but long-term maintenance will not be required on site. Offsite disposal of treatment residuals may require limited offsite management of wastes. Potential success of long-term development of natural ecosystem is high.
Will terrestrial habitats be degraded or enhanced?	Most waste sites currently have no vegetation or support only marginal cover. Removal of wastes and revegetation of the clean fill will enhance terrestrial habitat and attract wildlife. Sensitive habitats adjacent to the site will be avoided as much as possible. Absence of wastes at the site should allow the development of an improved (compared to the present condition) or near-natural ecosystem.
How will the remedial action effect overall quality of the ecosystem?	Revegetation and increased use of the site by wildlife will improve the overall quality of the ecosystem. Habitat enhancement at some sites will improve the stability and quality of the terrestrial ecosystem in the area. Removal of wastes from the site should provide for development of a natural ecosystem.

Table 5-9. Detailed Analysis of the Removal/Treatment/Disposal Alternative (SS-10/SW-9).

(Applicable to the retention basins, sludge trenches, fuel storage basin trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups) (page 4 of 7)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Does the treatment process address the principal threats?	Yes. SS-10: Soil washing reduces the threats at sites where little or no cesium-137 is associated with the cobbles or gravels, and at sandy sites where cesium-137 exists at levels that are treatable. SW-9: Thermal desorption reduces threats associated with volatile and semivolatile organic compounds. Compaction reduces volume and leachability of remaining wastes.
Are there any special requirements for the treatment process?	Yes. SS-10: Cesium-137 concentrations must be below PRG in the gravels or cobbles, and the cesium-137 concentrations in the sand fraction cannot exceed twice the PRG for effective reduction in the two-stage attrition scrubber. SW-9: Waste must be appropriately sized for the thermal desorption process and segregated for compaction.
What portion of the contaminated material is treated/destroyed?	SS-10: The soil washing includes size separation and a two-stage attrition scrubber. A fraction of the contaminated materials can be treated by the two-stage attrition scrubber. Contaminated but untreated cobbles are transported directly to the disposal facility. SW-9: Approximately 5% of contaminated materials are assumed to be treatable by thermal desorption and about 50% of desorbed organic constituents are destroyed. Approximately 90% of wastes are assumed to be treatable by compaction, but none of the compacted constituents are destroyed.
To what extent is the total mass of toxic contaminants reduced?	Long-term reduction occurs by natural degradation of radionuclides. The mass reduction at the disposal facility is discussed below. SS-10: Reduction of radionuclide concentrations in washed soil fines (2 to 0.25 mm in size) is achieved, reducing the total mass of contaminated media. SW-9: Nearly all of the volatile and semivolatile organic contaminants within the wastes are reduced. No reduction in mass of inorganic contaminants is achieved.
To what extent is the mobility of contaminants reduced?	Mobility of constituents is eliminated at the waste site by removal. The mobility reduction at the disposal facility is achieved as follows: SW-9: Nearly all of the volatile and semivolatile organic contaminants are rendered immobile. Mobility (leachability) of inorganic constituents are reduced by compaction.

Table 5-9. Detailed Analysis of the Removal/Treatment/Disposal Alternative (SS-10/SW-9).

(Applicable to the retention basins, sludge trenches, fuel storage basin trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups) (page 5 of 7)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
To what extent is the volume of contaminated media reduced?	The percentage suitable for soil washing was determined based on an evaluation of cesium-137 concentrations with respect to depth and treatment limitations. Based on the extent of cesium-137 contamination relative to total extent of contamination, the percentage was estimated. At the retention basins, sludge trenches, and dummy decontamination cribs/french drains; 67% of the contaminated soil is suitable for two-stage attrition scrubbing based on the cesium-137 concentration profile in the waste site; 49% of the total volume of contaminated soil can be successfully treated and returned to the site. At the fuel storage basin trenches and pluto cribs; 100% of the contaminated soil is suitable for two-stage attrition scrubbing based on the cesium-137 concentration profile in the waste site; 61% of the total volume of contaminated material can be successfully treated and returned to the site. At the process effluent trenches and pipelines; none of the contaminated soil is suitable for two-stage attrition scrubbing based on the cesium-137 concentration profile in the waste site, but 23% of the total volume of contaminated material can be successfully treated by segregating clean cobbles and gravels and returning these to the site. Future soil sites where 33% of the contaminated soil is suitable for two-stage attrition scrubbing based on the cesium-137 concentration profile in the waste site; 36% of the total volume of contaminated material can be successfully treated and returned to the site. SW-9: 90% of the contaminated material can be compacted by a factor of 50% of its original volume. The volume of waste in sites contaminated only with volatile and semivolatile organic constituents may be reduced completely.
To what extent are the effects of the treatment irreversible?	SS-10: Soil washing is irreversible. SW-9: Thermal desorption is irreversible. Compaction may be reversed with mechanical methods.
What are the quantities of residuals and characteristics of the residual risk?	SS-10: Soil washing will produce residuals that will be transferred to the disposal facility. SW-9: Thermal desorption will produce small amounts of residuals that are transferred to the disposal facility.
What risks do treatment of residuals pose?	None. No treatment proposed for residuals.
Is treatment used to reduce inherent hazards posed by principal threats at the site?	Treatment is used to reduce potential hazards at the disposal facility.

Table 5-9. Detailed Analysis of the Removal/Treatment/Disposal Alternative (SS-10/SW-9).

(Applicable to the retention basins, sludge trenches, fuel storage basin trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial ground waste site groups) (page 6 of 7)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
How does the proposed treatment impact natural resources?	Construction activities would have an immediate detrimental effect on natural resources, but would be compensated by long-term gains in natural resource quality. This alternative has the potential for more negative effects on natural resources because treatment facilities will be operated and residuals will be disposed.
Does the alternative result in a gain or loss of quality at the site for natural resources?	The long-term effect of this alternative would be an improvement in natural resource quality at the operable unit.
Will implementation of the alternative result in short-term impacts to natural resources (e.g., exposure of ecological receptors to physical or chemical impacts, noise, intrusion to habitat and special breeding areas, temporary displacement, seasonal restrictions on habitat use)?	At the present time, the majority of the waste sites are severely disturbed, therefore, short-term impacts would be minimal. Short-term impacts to adjacent habitats will be outweighed by long-term benefits of restoration. Mitigation efforts will include scheduling activities to reduce intrusion during sensitive life stages, controlling fugitive dust, and establishing buffer zones if needed.
Will the natural resource restoration activities associated with this alternative be easily implemented?	Revegetation and restoration efforts for this alternative are relatively easy to implement.
Will long-term maintenance and monitoring of mitigation/restoration efforts and activities be necessary?	Yes, long-term maintenance and monitoring will be required to ensure that revegetation and restoration efforts are successful.

SHORT-TERM EFFECTIVENESS	
What are the risks to the community during remedial actions, and how will they be mitigated?	Potential for release of fugitive dust during excavation and treatment. Appropriate engineering controls and contingency plans will be developed and implemented during excavation and disposal.
What risks remain to the community that cannot be readily controlled?	None.
What are the risks to the workers, and how will they be mitigated?	Risks due to exposure or accident. Potential for release of fugitive dust during excavation and treatment. Risks can be controlled by implementing appropriate engineering controls and health and safety procedures. Short-term risk is high.
What risks remain to the workers that cannot be readily controlled?	SS-10: Minimal uncertainty, therefore, all risks will be mitigated. SW-9: Unmitigated risks due to unknown buried wastes.
What environmental impacts are expected with the construction and implementation of the alternative?	Fugitive dust releases could possibly affect outlying environment, but can be controlled through proper operating procedures. Remedial activities can be scheduled to accommodate nesting or roosting species. Short-term risk is medium. Soil excavation may impact terrestrial species, and activities near the river may impact aquatic species and wetlands.
What are the impacts that cannot be avoided should the alternative be implemented?	None.
How long until remedial response objectives are achieved?	All RAO are met upon completion of Remedial Alternative.

Table 5-9. Detailed Analysis of the Removal/Treatment/Disposal Alternative (SS-10/SW-9).

(Applicable to the retention basins, sludge trenches, fuel storage basin trenches, process effluent trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines, and burial grounds waste site groups) (page 7 of 7)

IMPLEMENTABILITY	
What difficulties and uncertainties are associated with construction?	The extent of contamination is uncertain, but will be delineated during excavation. SS-10: Two-stage attrition scrubbing may be effective if the cesium-137 concentrations do not exceed twice the PRG. SW-9: Uncertainty exists concerning the nature of buried wastes and the problems with encountering unexpected materials.
What is the likelihood that technical problems will lead to schedule delays?	Delays not likely. No adaptations to excavation technology are expected. There is some uncertainty on availability of the disposal facilities at certain times. SS-10: Soil washing performed off-line and has little potential to impact the schedule. SW-9: Compaction and thermal desorption are performed off-line and have little potential to impact the schedule.
What likely future remedial actions are anticipated?	None.
What risks of exposure exist should monitoring be insufficient to detect failure?	Removal does not require post closure monitoring.
What activities are proposed that require coordination with other agencies?	None.
Are adequate treatment, storage capacity, and disposal services available?	Yes. Maximum capacity at the W-025 facility is 25,000 yd^3, available in 1994. The ERDF capacity is 4.3 million yd^3, available in 1996. Remedial action will not be implemented until disposal is available.
Are necessary equipment and specialists available?	Yes. General earthwork construction equipment is required and is readily available. Excavation and analytical specialists are required and are available. Specialized analytical equipment may be required and is available. Excavation, analytical, and treatment equipment and specialists are required and are available.
Are technologies under consideration generally available and sufficiently demonstrated or will they require further development before they can be applied at the site?	Yes. Removal and disposal are developed technologies. SS-10: Excavation of the 116-F-4 pluto crib has been completed demonstrating many of the technologies to be used. Particle separation of cobbles and gravels from sands and fines is a demonstrated technology. Bench scale tests have shown attrition scrubbing to be fairly effective in treating sands contaminated when levels of cesium-137 that do not exceed two times the PRG. However, a field scale soil washing study is scheduled for late 1994 to verify the results of the bench scale study. SW-9: Excavation of the 118-B-1 burial ground will be conducted in 1995 to demonstrate the ability to excavate buried waste. Thermal desorption and compaction are developed technologies.
Will more than one vendor be available to provide a competitive bid?	Yes. Several general earthwork contractors exist locally. Many vendors are also available to supply monitoring, compaction, thermal desorption, and soil washing equipment

ARAR - applicable or relevant and appropriate requirement
O&M - operation and maintenance
RAO - remedial action objectives
PRG - preliminary remediation goals
ERDF - Environmental Restoration Disposal Facility
W-025 - W-025 Radioactive Mixed Waste Land Disposal Facility

Table 5-10. Estimated Cost - Removal/Treatment/Disposal Alternative (SS-10/SW-9). (page 1 of 2)

COST	CAPITAL	OPERATION AND MAINTENANCE	PRESENT WORTH
Retention basins	$102,000,000 •Includes Removal of the contaminated material and site restoration Transportation of the excavated material to a common disposal facility	$24,500,000 •Includes Treatment of the contaminated material (i.e., soil washing)	**$114,000,000**
sludge trenches	$2,130,000 •Includes Removal of the contaminated material and site restoration Transportation of the excavated material to a common disposal facility	$277,000 •Includes Treatment of the contaminated material (i.e., soil washing)	**$2,300,000**
Fuel storage basin trenches	$4,880,000 •Includes Removal of the contaminated material and site restoration Transportation of the excavated material to a common disposal facility	$950,000 •Includes Treatment of the contaminated material (i.e., soil washing)	**$5,570,000**
Process effluent trenches	$17,300,000 •Includes Removal of the contaminated material and site restoration Transportation of the excavated material to a common disposal facility	$1,450,000 •Includes Treatment of the contaminated material (i.e., soil washing)	**$17,900,000**
Pluto cribs	$708,000 •Includes Removal of the contaminated material and site restoration Transportation of the excavated material to a common disposal facility	$9,240 •Includes Treatment of the contaminated material (i.e., soil washing)	**$692,000**
Dummy decontamination cribs/french drains	$721,000 •Includes: Removal of the contaminated material and site restoration Transportation of the excavated material to a common disposal facility	$114,000 •Includes: Treatment of the contaminated material (i.e., soil washing)	**$707,000**

Table 5-10. Estimated Cost - Removal/Treatment/Disposal Alternative (SS-10/SW-9). (page 2 of 2)

COST	CAPITAL	OPERATION AND MAINTENANCE	PRESENT WORTH
Pipelines	$38,100,000 •Includes: Removal of the contaminated material and site restoration Transportation of the excavated material to a common disposal facility	$5,780,000 •Includes: Treatment of the contaminated material (i.e., soil washing)	**$40,000,000**
Burial grounds	$2,510,000 •Includes: Removal of the contaminated material and site restoration Transportation of the excavated material to a common disposal facility	$137,000 •Includes: Treatment of the contaminated material (i.e., compaction and thermal desorption)	**$2,530,000**

Cost: Costs for implementing any alternative will be operable unit specific regarding any proposed mitigation/restoration measures and protection of natural resources. All alternatives will include costs for mitigative measures. These costs will be determined on an operable unit specific basis. In cases where remedial work can impact threatened and/or endangered species or sensitive habitat, costs may be increased by necessity to avoid certain areas or halt work during certain time periods (seasons).

6.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents the rationale and results for a comparison of Remedial Alternatives for each waste site group. The basis for this comparison was established by using the nine CERCLA criteria (EPA 1988) discussed in Section 5.0. Key discriminators were selected within the evaluation criteria to obtain an overall ranking that could be used to compare various Remedial Alternatives for each waste site group. This comparative analysis identifies the relative advantages and disadvantages of each alternative, providing a basis for selecting a Remedial Alternative.

The alternatives are compared for each waste site group except D&D sites and seal pit cribs. There is only one appropriate alternative for each of these two waste site groups; the No Action Alternative (Section 4.2 and Tables 4-1 and 4-2). Therefore, no comparison of alternatives is performed for these two waste site groups because the only alternative considered is No Action.

For the waste site groups other than seal pit cribs and decommissioned and decontaminated facilities, the No Action Alternative is included only to provide for the comparison. This is because the detailed analysis presented in Section 5.0 concludes that the No Action Alternative does not satisfy the threshold criteria for the retention basins, process effluent trenches, fuel storage basin trenches, sludge trenches, pluto cribs, dummy decontamination cribs/french drains, pipelines or burial grounds. By not satisfying the threshold criteria, the No Action Alternative is not considered a viable alternative.

6.1 EVALUATION CRITERIA AND KEY DISCRIMINATORS

To facilitate the evaluation of Remedial Alternatives, CERCLA has identified nine specific evaluation criteria (EPA 1988):

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance.

The first two criteria, overall protection of human health and the environment and compliance with ARARs, are threshold criteria because the Remedial Alternative either meets or does not meet the criteria. Remedial Alternatives must be protective of human health and the environment to be considered a viable Remedial Alternative. Additionally, all alternatives selected for consideration in a feasibility study must meet ARARs to the extent practicable unless a waiver can be justified. Thus, these two threshold criteria are not factored into the quantitative comparative analysis presented in this section. The last two criteria, state and community acceptance, cannot be evaluated until after the proposed plan has been issued and therefore are not used in the quantitative evaluation presented below.

The NEPA values, such as transportation and natural resource impacts, are integrated into the short-term and long-term effectiveness criteria for the purposes of this evaluation.

Based on the CERCLA evaluation criteria and current knowledge of the 100 Area sites, key discriminators were identified within the following five evaluation criteria.

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost.

Sections 6.1.1 through 6.1.5 discuss the five evaluation criteria and associated key discriminators.

6.1.1 Long-term Effectiveness and Permanence

The main consideration in this criteria is the long-term consequence of the Remedial Alternative. Key discriminators for this criteria, and an example of significant alternative differences and how they were emphasized during the comparative analysis, include the following:

- Residual risk (e.g., removal of the source contaminants eliminates site risk, while capping wastes in place results in residual risk requiring monitoring).

- Adequacy and reliability of controls (e.g., the Containment Alternative needs to address the reliability of the containment barrier and the Removal/Disposal Alternative needs to address the reliability of the engineered disposal site).

- Long-term natural resource/environmental consequences (includes indirect and cumulative effects, and irreversible and irretrievable commitment of resources).

6.1.2 Reduction of Toxicity, Mobility, or Volume through Treatment

The key consideration in this criteria is the ability to reduce the mobility, toxicity, or volume of contaminants. Almost all of the alternatives considered will decrease contaminant mobility using containment or treatment technologies, but the effectiveness of the alternatives differ. Some Remedial Alternatives will also reduce waste volume, using physical separation processes to segregate clean material from contaminated material. Only a few of the remedial technologies can reduce toxicity. Therefore, the key discriminators for this comparative evaluation are:

- Reduction in mobility of contaminants
- Reduction in volume of wastes.

6.1.3 Short-term Effectiveness

EPA (1988) includes several discriminators (risk to the community, risk to the worker and risk to the environment) in the short-term effectiveness criteria. There are also NEPA values that relate to short-term effectiveness including potential impacts to cultural resources, natural resources, socioeconomics, and transportation. The health risk to the community is considered insignificant for this evaluation because the remote location of the 100 Area. Socioeconomics was not considered a key discriminator because there probably would not be much difference in the impacts of the Remedial Alternatives being considered at the regional level. The risk to the environment will vary at each waste site. The vegetation and natural habitats at many of the waste sites have been previously disturbed so these impacts may be minor. However, impacts to protected or sensitive species may be critical. Thus, the key discriminators for this criteria are:

- Risk to workers
- Transportation impacts
- Risks to natural and cultural resources.

6.1.4 Implementability

Technical feasibility, administrative feasibility, and availability of services and materials are discriminators for implementability (EPA 1988). Technical feasibility is important because it takes into account technical aspects of implementing a remedial action. Administrative feasibility considers how consistent the remedial action is with the final action. Since final land use is unknown, the interim remedial actions considered were based on the assumption of unrestricted land use in the future. Administrative feasibility is also significant because it includes coordination with other agencies and parties (agencies, trustees, tribes). Availability of services and materials is significant when considering waste removal and disposal, In Situ Treatment, capping, and sources of fill material.

The key discriminators are as follows:

- Technical feasibility
- Administrative feasibility
- Availability of services and materials.

6.1.5 Cost

The estimated cost of each alternative is considered in all evaluations. The estimated costs available at this time should only be used to compare relative differences between Remedial Alternatives. It is not intended to be an accurate estimate of actual complete costs to remediate the sites.

6.2 WASTE SITE GROUPS AND REMEDIATION ALTERNATIVES

Tables 4-1 and 4-2 indicate which Remedial Alternatives are appropriate for each waste site group. The specific waste site groups and remediation alternatives available for each group are summarized in Table 6-1.

6.3 SCORING AND WEIGHTING RATIONALE

6.3.1 Scoring and Weighting

Based on the key discriminators for each of the five evaluation criteria, waste site groups were scored to obtain an overall ranking that could be used to quantitatively compare Remedial Alternatives. Criteria scoring was done on a 1 to 10 scale as described in Table 6-2. Odd number scores (1,3,5,7,9) were primarily used to differentiate the criteria. In situations where it was difficult to give a score using odd numbers, even numbers were used. For example, if a Remedial Alternative was not as good as a five but better than a three a score of four was given.

Costs were scored on a 1 to 10 scale. To provide relative comparisons, cost estimates were normalized to achieve comparable scores. By doing this, the Remedial Alternative with the lowest cost received a score of 10 and the other Remedial Alternative costs were scored proportionately. An example of how scores were achieved is provided in Table 6-3.

6.3.1.1 Weighting. Each of the five criteria were assigned a weight between zero and one. For interim action, some criteria were considered more important than others. Long-term effectiveness, implementability, and cost criteria were equally weighted as one (1.0). Short-term effectiveness and reduction in toxicity, mobility, and volume were given a one-half (0.5) weight because their importance for evaluating interim action was considered lower than the other three criteria.

Each of the five evaluation criteria for each waste site group and associated Remedial Alternative were scored. The weighting factors were multiplied by the score and summed to achieve an overall ranking.

6.4 COMPARISON OF REMEDIAL ALTERNATIVES

This section provides the results, rationale, and considerations that reflect the comparative evaluation of Remedial Alternatives. Tables 6-4 through 6-11 present the results of the scoring and ranking process for each waste site group. Costs for all Remedial Alternatives are shown in Table 6-12.

6.4.1 Retention Basins

The Removal/Disposal and Removal/Treatment/Disposal Alternatives are appropriate for remediating the retention basins (Sections 4.0 and 5.0). Based on the scoring/weighing process described in Section 6.3, the Removal/Disposal Alternative is the best (Table 6-4).

6.4.1.1 Long-term Effectiveness and Permanence. The Removal/Treatment/Disposal Alternative received the highest score for long-term effectiveness and permanence for remediation of the retention basins (Table 6-4). This alternative would remove all contaminated soils and concrete from the waste site, treat all or a portion of the soils, and dispose of the treatment residuals at a central disposal facility. There would be no long-term restrictions on land use at the waste site following remediation. There would be a commitment of land at the central waste disposal facility to manage the treatment residuals from the retention basins. However, because the treatment component of this alternative would reduce the volume of wastes in comparison to the Removal/Disposal Alternative, less space will be needed at the central disposal facility. Also, because the clean soils resulting from the treatment process can be used as clean fill at the waste site, the Removal/Treatment/Disposal Alternative would require less importing of clean soil from offsite (outside the operable unit) borrow areas. Long-term negative impacts of the Removal/Treatment/Disposal and Removal/Disposal Alternatives include the requirement for continuous waste management.

The Removal/Disposal Alternative would have the same long-term benefits as the Removal/Treatment/Disposal Alternative. The Removal/Disposal Alternative would remove all of the contaminated soil from the waste site, and the land would be available for many different uses. There would be no need for land use controls. The wastes would be managed at a central disposal facility specifically designed for that purpose. All of the contaminated soil from the retention basins would be taken to the central disposal facility. The Removal/Disposal Alternative would, therefore, require more disposal volume than the Removal/Treatment/Disposal Alternative. Also, the Removal/Disposal Alternative would require more clean fill from offsite borrow areas because there is no treatment component to clean some of the contaminated onsite soils.

6.4.1.2 Reduction in Toxicity, Mobility, or Volume. Both the Removal/Disposal and Removal/Treatment/Disposal Alternatives would, to some extent, reduce the mobility of the contaminants at the retention basins. The Removal/Disposal Alternative would place all wastes within a central disposal facility. This would reduce mobility, but would not change the toxicity or the volume of the wastes. The Removal/Treatment/Disposal Alternative, however, would treat some of the wastes and thereby reduce the volume of contaminated soils in some cases by about 50%. Because the contaminants at the retention basins are radionuclides and metals and the treatment processes are essentially physical separation and washing technologies, this alternative would not reduce the toxicity of the contaminants. The treatment residuals (remaining contaminated soils) would be disposed at the central disposal facility and, therefore, the mobility of the contaminants would be reduced the same as for the Removal/Disposal Alternative. The Removal/Treatment/Disposal Alternative was ranked the best for reduction of mobility, toxicity, and volume (Table 6-4) because it would reduce both the volume and mobility of the remaining wastes.

6.4.1.3 Short-term Effectiveness. The Removal/Disposal Alternative was ranked better than the Removal/Treatment/Disposal Alternative for short-term effectiveness (Table 6-4). Short-term effectiveness was evaluated by considering risks to workers doing the remediation, potential risks to cultural and natural resources resulting from the remedial activities, duration of the remedial action, and transportation requirements (hauling wastes from the operable unit, hauling equipment and supplies to the site, and hauling clean fill to the operable unit for restoration).

The Removal/Disposal Alternative requires excavation and transportation of the wastes to a central disposal facility. This could potentially expose workers to the contaminated soil. However, the remedial action would require only routine excavation and hauling activities, and these actions could be implemented using effective controls to protect workers. The Removal/Disposal Alternative would have some short-term effects on vegetation and wildlife, but most of these short-term impacts could be avoided or reduced by proper implementation of the alternative. If there are cultural resources present, they would be identified during excavation and addressed according to the cultural resources action plan.

The Removal/Disposal Alternative would take less time to implement than the Removal/Treatment/Disposal Alternative.

The Removal/Treatment/Disposal Alternative would disturb more land area than the Removal/Disposal Alternative because of the need to set up treatment facilities, potentially causing greater impacts to natural and cultural resources. Workers would be exposed to soil contaminants during treatment, in addition to excavation and hauling. Workers would potentially be exposed to treatment solutions, air emissions, and water effluent associated with the treatment operations. The Removal/Treatment/Disposal Alternative would reduce the volume of wastes to be hauled to the central disposal facility, and also reduce the volume of clean fill needed from offsite borrow areas. Finally, the Removal/Treatment/Disposal Alternative would present the highest potential for accidental releases of substances associated with the remedial activities, which includes fuels and lubricants, and contaminated water.

6.4.1.4 Implementability. For technical and administrative feasibility reasons, the Removal/Disposal Alternative is easier to implement than the Removal/Treatment/Disposal Alternative. The technical aspects of excavation and hauling are routine. The Removal/Treatment/Disposal Alternative includes treatment technologies as well as excavation and hauling, and is technically more difficult to implement than the Removal/Disposal Alternative.

Interagency coordination and regulatory compliance associated for the Removal/Disposal Alternative would be easier to accomplish than for the Removal/Treatment/Disposal Alternative, primarily because the treatment aspects of the Removal/Treatment/Disposal Alternative add ARARs.

6.4.1.5 Costs. Costs for the Removal/Disposal Alternative are less than for the Removal/Treatment/Disposal Alternative (Table 6-12).

6.4.2 Fuel Storage Basin Trenches

The Removal/Disposal and Removal/Treatment/Disposal Alternatives are the appropriate Remedial Alternatives for the fuel storage basin trenches. The Removal/Disposal Alternative ranked slightly higher than the Removal/Treatment/Disposal Alternative (Table 6-5).

6.4.2.1 Long-term Effectiveness and Permanence. The Removal/Treatment/Disposal Alternative received a higher score than the Removal/Disposal Alternative for long-term effectiveness. This alternative would remove all contaminated soils from the waste site, treat all or a portion of the soils, and place the treatment residuals in the central waste disposal facility where they would be managed along with wastes from other waste sites. There would be no long-term restrictions on land use at the waste site. There would be a commitment of land at the central waste disposal facility to manage the treatment residuals from the fuel basin trenches. However, because the treatment component of this alternative would reduce the volume of wastes in comparison to the Removal/Disposal Alternative, less space will be needed at the central disposal facility. Also, because the clean soils resulting from the treatment process can be used as clean fill at the waste site, the Removal/Treatment/Disposal Alternative would require less importing of clean soil from offsite (outside the operable unit) borrow areas. Long-term negative impacts of the

Removal/Treatment/Disposal and Removal/Disposal Alternatives include the requirement for continuous waste management.

The Removal/Disposal Alternative would have the same long-term benefits as the Removal/Treatment/Disposal Alternative. The Removal/Disposal Alternative would remove all of the contaminated soil from the waste site, and the land would be available for many different uses. There would be no need for land use controls. The wastes would be managed at a central disposal facility specifically designed for that purpose. All of the contaminated soil fuel storage basin trenches would be taken to the central disposal facility. The Removal/Disposal Alternative would, therefore, require more disposal volume than the Removal/Treatment/Disposal Alternative. Also, the Removal/Disposal Alternative would require more clean fill from offsite borrow areas because there is no treatment component to clean some of the contaminated onsite soils.

6.4.2.2 Reduction in Toxicity, Mobility, or Volume. Both the Removal/Disposal and the Removal/Treatment/Disposal Alternatives reduce the mobility of the contaminants by placing the contaminants in a central disposal facility. However, the Removal/Treatment/Disposal Alternative scored higher in this category because the volume of contaminated soil is reduced through treatment, reducing the amount of contaminated soil taken to a central disposal facility.

6.4.2.3 Short-term Effectiveness. The Removal/Disposal Alternative scored higher than the Removal/Treatment/Disposal Alternative for short-term effectiveness. Using the Removal/Treatment/Disposal Alternative, the short-term impacts to land, worker safety, and natural resources would be greater because soil treatment results in more handling of the contaminated soils, increased worker exposure to contaminants, and a greater overall land disturbance. Transportation between the treatment facility and the waste site, and the handling of the contaminated soils at the treatment facility, results in greater exposure to workers and a higher potential for spills, fugitive dust, noise, and air impacts. Treatment results in a longer schedule and would, therefore, increase exposure time for workers and wildlife.

6.4.2.4 Implementability. The Removal/Disposal Alternative is easier to accomplish than the Removal/Treatment/Disposal Alternative because the latter alternative requires a treatment facility. The Removal/Treatment/Disposal Alternative scored lower for implementability because implementation is more complex, time schedules are longer, and regulatory requirements are more numerous. Administrative actions would be easier to accomplish using the Removal/Disposal Alternative and fewer services and materials are required using the Removal/Disposal Alternative.

6.4.2.5 Costs. Costs for the Removal/Disposal Alternative are less than for the Removal/Treatment/Disposal Alternative (Table 6-12).

6.4.3 Process Effluent Trenches

The three appropriate alternatives to remediate the process effluent trenches are (1) Removal/disposal, (2) In Situ Vitrification, and (3) Removal/Treatment/Disposal (Sections 4.0 and 5.0). The Removal/Disposal Alternative ranked the highest followed by the Removal/Treatment/Disposal Alternative and the In Situ Vitrification Alternative (Table 6-6).

6.4.3.1 Long-term Effectiveness and Permanence. The best alternative for remediation of the process effluent trenches for long-term effectiveness and permanence is the Removal/Treatment/Disposal Alternative followed by the Removal/Disposal Alternative and then the In Situ Vitrification Alternative (Table 6-6). The Removal/Treatment/Disposal Alternative would remove all contaminated soils from the waste site, treat all or a portion of the soils, and place the treatment residuals in the central waste disposal facility where they would be managed along with wastes from other waste sites. There would be no long-term restrictions on land use at the waste site. There would be a commitment of land at the central waste disposal facility to manage the treatment residuals from the process effluent trenches. However, because the treatment component of this alternative would reduce the volume of wastes in comparison to the Removal/Disposal Alternative, less space will be needed at the central disposal facility. Also, because the clean soils resulting from the treatment process can be used as clean fill at the waste site, the Removal/Treatment/Disposal Alternative would require less importing of clean soil from offsite (outside the operable unit) borrow areas. Long-term negative impacts of the Removal/Treatment/Disposal and Removal/Disposal Alternatives include the requirement for continuous waste management.

The Removal/Disposal Alternative would have the same long-term benefits as the Removal/Treatment/Disposal Alternative. The Removal/Disposal Alternative would remove all of the contaminated soil from the waste site, and there would be no need for land use controls. The wastes would be managed at a central disposal facility specifically designed for that purpose. All of the contaminated soil from the process effluent trenches would be taken to the central disposal facility. The Removal/Disposal Alternative would, therefore, require more disposal volume than the Removal/Treatment/Disposal Alternative. Also, the Removal/Disposal Alternative would require more clean fill from offsite borrow areas because there is no treatment component to clean some of the contaminated onsite soils.

In Situ Vitrification of the soils at the process effluent trenches would effectively immobilize the wastes by incorporating the contaminants into a glassy matrix. The vitrified wastes would be covered by at least one meter of clean soil/fill. The land surface of the operable unit could then be released for limited long-term use; but because of the subsurface vitrified wastes, some deed restrictions or other land use controls would be required. The In Situ Vitrification Alternative, however, does not require transport of wastes to, and use of an offsite disposal facility.

In Situ Vitrification is an innovative technology used at several hazardous waste sites. The In Situ Vitrification Alternative would require groundwater monitoring at the operable unit to monitor for the potential migration of contaminants because the vitrification process may not treat all of the wastes. The presence of the subsurface glassy mass caused by the vitrification process would preclude some wildlife use of the area (burrowing animals and their prey) and prevent reestablishment of deep rooted vegetation. Although it is unlikely that cultural resources exist in or adjacent to the process effluent trenches (because of prior industrial use/disturbance), In Situ Vitrification would incorporate resources present at the site into the glassy matrix. In Situ Vitrification was given the lowest score for long-term effectiveness and permanence primarily because it would require land use restrictions and the uncertainties associated with possible future contaminant migration from the waste site.

6.4.3.2 Reduction in Mobility, Toxicity, or Volume. The Removal/Disposal, In Situ Vitrification, and Removal/Treatment/Disposal Alternatives would reduce the mobility of the contaminants to some extent. The Removal/Disposal Alternative would place all wastes within the central disposal facility. This would reduce mobility, but not change the toxicity or the amount of the wastes. In Situ Vitrification would immobilize the wastes within a vitrified matrix and leave the wastes at the operable unit. In the long term, In Situ Vitrification would be more effective in reducing the mobility of the contaminants than the Removal/ Disposal Alternative, but the in situ treatment would not reduce the toxicity or the volume of the wastes (same for the Removal/Disposal Alternative). The Removal/Treatment/ Disposal Alternative would treat some of the wastes and reduce the volume of contaminated soils. However, because the contaminants at the process effluent trenches are radionuclides and metals, and the treatment processes are essentially physical separation and washing technologies, this alternative would not reduce the toxicity of the contaminants. The treatment residuals (remaining contaminated soils) would be disposed at the central disposal facility and, therefore, the mobility of the contaminants would be reduced the same as for the Removal/Disposal Alternative. For the reduction of mobility, toxicity, and volume category, the Removal/Disposal Alternative scored lowest, the In Situ Vitrification Alternative scored highest, and the Removal/Treatment/Disposal Alternative scored between these two alternatives.

6.4.3.3 Short-term Effectiveness. The Removal/Disposal and In Situ Vitrification Alternatives are rated high (for different reasons) for short-term effectiveness (Table 6-6). The Removal/Treatment/Disposal Alternative received the lowest score.

The In Situ Vitrification Alternative does not require transporting wastes to the central disposal facility, and requires less clean fill and topsoil than the Removal/Disposal and Removal/Treatment/Disposal Alternatives. The Removal/Treatment/Disposal Alternative would require the most equipment and supplies. The In Situ Alternative would not expose the workers directly to the contaminants because the wastes would be left in place. There is, however, a potential for worker exposure to treatment off-gases. The In Situ Alternative would cause the least land disturbance and require the least onsite activities, and therefore is the least likely of the three alternatives to impact natural and cultural resources in the short term. However, if there are cultural resources present, the in situ treatment process would result in the irretrievable loss of those resources.

The Removal/Disposal Alternative requires excavation and transportation of the wastes to a central disposal facility. The excavation could potentially expose workers directly to the contaminated soil. However, this remedial action would require only routine excavation and hauling activities, and these actions could be implemented with effective controls to protect workers. The Remove/Disposal Alternative would have some short-term effects on vegetation and wildlife, but most of these short-term impacts could be avoided or reduced by proper implementation of the alternative. If there are cultural resources present, they would be identified during excavation and addressed according to the cultural resources action plan.

The Removal/Treatment/Disposal Alternative would disturb more land area than the Removal/Disposal and In Situ Vitrification Alternatives, potentially causing greater impacts to natural and cultural resources. Workers would be potentially exposed to the soil contaminants during excavation, treatment, and hauling operations. Workers would also be potentially exposed to treatment solutions, air emissions, and water effluents associated with the treatment actions. The Removal/Treatment/Disposal Alternative would reduce the volume of wastes to be hauled to the central disposal facility, and would also reduce the volume of clean fill needed from offsite borrow areas. The Removal/Treatment/Disposal Alternative could also present the highest potential for accidental releases of substances associated with the remedial activities, such as fuels and lubricants, and contaminated water.

6.4.3.4 Implementability. The Removal/Disposal Alternative is easier to implement than the In Situ Vitrification and Removal/Treatment/Disposal Alternatives for technical and administrative feasibility. The technical aspects of excavation and hauling are routine, but In Situ Vitrification is an innovative technology requiring field investigations and field process testing before full implementation. Site-specific geologic and contaminant conditions may enhance or degrade the expected performance of In Situ Vitrification and postremedy monitoring would also be required because of the uncertainty regarding the complete vitrification of all the wastes and the long-term stability of the vitrified material. The Removal/Treatment/Disposal Alternative includes treatment technologies as well as excavation and hauling and is, therefore, technically more difficult to implement than the Removal/Disposal Alternative.

The anticipated interagency coordination associated with the Removal/Disposal Alternative would be easier to accomplish than for the In Situ Vitrification Alternative or the Removal/Treatment/Disposal Alternative. In Situ Vitrification requires a specialty contractor and may cause procurement delays. Vitrification requires additional contaminant characterization to define the contaminant zone to be vitrified. Also, vitrification may not be consistent with the intended final remedial action at the waste site. The treatment process for the Removal/Treatment/Disposal Alternative adds ARARs to this alternative. The scores for the three alternatives are shown in Table 6-6.

6.4.3.5 Costs. Costs for the Removal/Disposal Alternative are less than costs for the Removal/Treatment/Disposal and In Situ Vitrification Alternatives (Table 6-12).

6.4.4 Sludge Trenches

The three appropriate alternatives for remediating the sludge trenches are (1) removal/disposal, (2) In Situ Vitrification, and (3) removal/treatment/disposal (Sections 4.0 and 5.0). The Removal/Disposal Alternative received the highest ranking followed by the Removal/Treatment/Disposal Alternative and then the In Situ Vitrification Alternative (Table 6-7).

6.4.4.1 Long-term Effectiveness and Permanence. The best alternative for remediating the sludge trenches for long-term effectiveness is the Removal/Treatment/Disposal Alternative. This alternative would remove all contaminated soils from the waste site, treat all or a portion of the soils, and place the treatment residuals in the central waste disposal facility where they would be managed along with wastes from other waste sites. There would be no long-term restrictions on land use at the waste site. There would be a commitment of land at the central waste disposal facility to manage the treatment residuals from the sludge trenches. However, because the treatment component of this alternative would reduce the volume of wastes in comparison to the Removal/Disposal Alternative, less space will be needed at the central disposal facility. Also, because the clean soils resulting from the treatment process can be used as clean fill at the waste site, the Removal/Treatment/Disposal Alternative would require less importing of clean soil from offsite (outside the operable unit) borrow areas. Long-term negative impacts of the Removal/Treatment/Disposal and Removal/Disposal Alternatives include the requirement for continuous waste management.

The Removal/Disposal Alternative would have the same long-term benefits as the Removal/Treatment/Disposal Alternative. The Removal/Disposal Alternative would remove all of the contaminated soil from the waste site, and there would be no need for land use controls. The wastes would be managed at a central disposal facility specifically designed for that purpose. All of the contaminated soil from the sludge trenches would be taken to the central disposal facility. The Removal/Disposal Alternative would, therefore, require more disposal volume than the Removal/Treatment/Disposal Alternative. Also, the Removal/Disposal Alternative would require more clean fill from offsite borrow areas because there is no treatment component to clean some of the contaminated onsite soils.

In Situ Vitrification of the soils at the sludge trenches would effectively immobilize the wastes by incorporating the contaminants into a glassy matrix. The vitrified wastes would be covered by at least one meter of clean soil/fill. The land surface of the operable unit could then be released for limited long-term use. However, because of the subsurface vitrified wastes some deed restrictions or other land use controls would be required. The In Situ Vitrification Alternative does not require transportation of wastes to, and use of an offsite disposal facility.

In Situ Vitrification is an innovative technology used at several hazardous waste sites. In Situ Vitrification would require groundwater monitoring at the operable unit to monitor for the potential migration of contaminants because the vitrification process may not treat all of the wastes. The presence of the subsurface glassy mass would preclude some wildlife use of the area (burrowing animals and their prey) and prevent reestablishment of deep rooted vegetation. Although it is unlikely that cultural resources exist in or adjacent to the process effluent trenches (because of prior industrial use/disturbance), In Situ Vitrification would incorporate any resources present at the site into the glassy matrix. In Situ Vitrification was given the lowest score for long-term effectiveness and permanence primarily because it would require land use restrictions and the uncertainties associated with possible future contaminant migration from the waste site.

6.4.4.2 Reduction in Mobility, Toxicity, or Volume. The Remedial Alternatives (removal/disposal, removal/treatment/disposal, and In Situ Vitrification) that could be used at the sludge trenches would reduce the mobility of the contaminants to some extent, but none of these alternatives will reduce the toxicity. The mobility of the wastes would be reduced by containment at the central waste disposal facility or conversion of the waste to a glassy matrix. The Removal/Treatment/Disposal Alternative is the only alternative that would reduce the volume of wastes. For the reduction of mobility, toxicity, and volume category, the Removal/Disposal Alternative was considered the worst, In Situ Vitrification was considered the best, and the Removal/Treatment/Disposal Alternative scored between these two alternatives.

6.4.4.3 Short-term Effectiveness. Both the Removal/Disposal and In Situ Vitrification Alternatives rated high. The Removal/Treatment/Disposal Alternative scored low because the treatment component increases (1) the time required to complete the action, (2) the risk to workers, and (3) the potential risk to natural and cultural resources. The transportation impacts of the Removal/Treatment/Disposal and the Removal/Disposal Alternatives would be about the same, while the In Situ Vitrification Alternative would have the least transportation impact.

The In Situ Vitrification Alternative would pose fewer risks to workers than the Removal/Disposal and Removal/Treatment/Disposal Alternatives because the wastes would be left in place. The Removal/Treatment/Disposal Alternative would pose the greatest risk to workers. In addition to the excavation and hauling activities, the treatment of the waste would expose the workers directly to the contaminated sludges and to hazardous materials associated with the treatment process. Physical hazards would also be present during treatment. The Removal/Treatment/Disposal Alternative will disturb a larger land area than the Removal/Disposal and In Situ Vitrification Alternatives, potentially causing more impacts to natural and cultural resources. In Situ Vitrification may result in the irretrievable loss of cultural resources.

6.4.4.4 Implementability. The Removal/Disposal Alternative is easier to implement than the In Situ Vitrification and Removal/Treatment/Disposal Alternatives for technical and administrative feasibility. The technical aspects of excavation and hauling are routine, but In Situ Vitrification is an innovative technology requiring field investigations and field process testing before full implementation. Site-specific geologic and contaminant conditions may enhance or degrade the expected performance of In Situ Vitrification and postremedy monitoring would also be required because of the uncertainty regarding the complete vitrification of all the wastes and the long-term stability of the vitrified material. The Removal/Treatment/Disposal Alternative includes treatment technologies as well as excavation and hauling and is, therefore, technically more difficult to implement than the Removal/Disposal Alternative.

The anticipated interagency coordination associated with the Removal/Disposal Alternative would be easier to accomplish than for the In Situ Vitrification Alternative or the Removal/Treatment/Disposal Alternative. In Situ Vitrification requires a specialty contractor and may cause procurement delays. Vitrification requires additional contaminant characterization to define the contaminant zone to be vitrified. Also, vitrification may not be consistent with the intended final remedial action at the waste site. The treatment process for the Removal/Treatment/Disposal Alternative adds ARARs to this alternative. The scores for the three alternatives are shown in Table 6-6.

6.4.4.5 Costs. Costs for the Removal/Disposal Alternative are less than for the Removal/Treatment/Disposal and In Situ Vitrification Alternatives (Table 6-12).

6.4.5 Pluto Cribs

Removal/Disposal, In Situ Vitrification, and Removal/Treatment/Disposal are the appropriate alternatives for remediating the pluto cribs. The Removal/Disposal Alternative received the highest ranking followed by the Removal/Treatment/Disposal and In Situ Vitrification Alternatives (Table 6-8).

6.4.5.1 Long-term Effectiveness and Permanence. The Removal/Treatment/Disposal Alternative is the best alternative for remediating the pluto cribs for long-term effectiveness and permanence. The Removal/Treatment/Disposal Alternative would remove all contaminated soils from the waste site, segregate the wooden timbers from the soil, treat the soils, and dispose of the treatment residuals at a central disposal facility. There would be no long-term restrictions on land use at the waste site. There would be a commitment of land at the central waste disposal facility to manage the treatment residuals from the pluto cribs. However, because the treatment component of this alternative would reduce the volume of wastes in comparison to the Removal/Disposal Alternative, less space will be needed at the central disposal facility. Also, because the clean soils resulting from the treatment process can be used as clean fill at the waste site, the Removal/Treatment/Disposal Alternative would require less importing of clean soil from offsite (outside the operable unit) borrow areas. Long-term negative impacts of the Removal/Treatment/Disposal and Removal/Disposal Alternatives include the requirement for continuous waste management.

The Removal/Disposal Alternative would have the same long-term benefits as the Removal/Treatment/Disposal Alternative. The Removal/Disposal Alternative would remove all of the contaminated soil from the waste site, and there would be no need for land use controls. The wastes would be managed at a central disposal facility specifically designed for that purpose. All of the contaminated soil from the pluto cribs would be taken to the central disposal facility. The Removal/Disposal Alternative would, therefore, require more disposal volume than the Removal/Treatment/Disposal Alternative. Also, the Removal/Disposal Alternative would require more clean fill from offsite borrow areas because there is no treatment component to clean some of the contaminated onsite soils.

In Situ Vitrification of the soils and wooden timbers in the pluto cribs would effectively immobilize the wastes by incorporating the contaminants into a glassy matrix. The vitrified wastes would be covered by at least one meter of clean soil/fill. The land surface of the operable unit could then be released for limited long-term use. However, because of the subsurface vitrified wastes some deed restrictions or other land use controls would be required. The In Situ Vitrification Alternative does not require transportation of wastes to, and use of an offsite disposal facility.

In Situ Vitrification is an innovative technology used at several hazardous waste sites. In Situ Vitrification would require groundwater monitoring at the operable unit to monitor for the potential migration of contaminants because the vitrification process may not treat all of the wastes. The presence of the subsurface glassy mass would preclude some wildlife use of the area (burrowing animals and their prey) and prevent reestablishment of deep rooted vegetation. Although it is unlikely that cultural resources exist in or adjacent to the process effluent trenches (because of prior industrial use/disturbance), In Situ Vitrification would incorporate any resources present at the site into the glassy matrix. In Situ Vitrification was given the lowest score for long-term effectiveness and permanence primarily because it would require land use restrictions and the uncertainties associated with possible future contaminant migration from the waste site.

6.4.5.2 Reduction in Mobility, Toxicity, or Volume. The three Remedial Alternatives (Removal/Disposal, Removal/Treatment/Disposal, and In Situ Vitrification) that could be used at the pluto cribs would reduce the mobility of the contaminants to some extent, but none of these alternatives would reduce the toxicity. The mobility of the wastes would be reduced by containment at the central waste disposal facility or conversion of the waste to a glassy matrix. The Removal/Treatment/Disposal Alternative is the only alternative that would reduce the volume of wastes. The Removal/Disposal Alternative received the lowest score for reduction of mobility, toxicity, and volume; the In Situ Vitrification Alternative received the highest score and the Removal/Treatment/Disposal Alternative scored between these two alternatives (Table 6-8).

6.4.5.3 Short-term Effectiveness. The Removal/Disposal and In Situ Vitrification Alternatives were rated high (Table 6-8). The Removal/Treatment/Disposal Alternative scored low because the treatment component of this alternative increases (1) the time required to complete the action, (2) the risk to workers, and (3) the potential risk to natural and cultural resources. The transportation impacts of the Removal/Treatment/Disposal and the Removal/Disposal Alternatives would be about the same, while the In Situ Vitrification Alternative would have the least impact for transportation.

The In Situ Vitrification Alternative would pose fewer risks to workers than the Removal/Disposal and Removal/Treatment/Disposal Alternatives because the wastes would be left in place. The Removal/Treatment/Disposal Alternative would pose the most risk to workers. In addition to the excavation and hauling activities, the treatment of the waste would expose the workers directly to contaminated soils, contaminated wood, and to hazardous materials associated with the treatment process. Physical hazards would also be present during treatment.

The Removal/Treatment/Disposal Alternative would disturb more land area than the Removal/Disposal and In Situ Vitrification Alternatives and, therefore, would probably cause greater impacts to natural and cultural resources.

6.4.5.4 Implementability. The Removal/Disposal Alternative is easier to implement than the In Situ Vitrification and Removal/Treatment/Disposal Alternatives for technical and administrative feasibility. The technical aspects of excavation and hauling are routine, but In Situ Vitrification is an innovative technology requiring field investigations and field process testing before full implementation. Site-specific geologic and contaminant conditions may enhance or degrade the expected performance of In Situ Vitrification and postremedy monitoring would also be required because of the uncertainty regarding the complete vitrification of all the wastes and the long-term stability of the vitrified material. The Removal/Treatment/Disposal Alternative includes treatment technologies as well as excavation and hauling and is, therefore, technically more difficult to implement than the Removal/Disposal Alternative.

The anticipated interagency coordination associated with the Removal/Disposal Alternative would be easier to accomplish than for the In Situ Vitrification Alternative or the Removal/Treatment/Disposal Alternative. In Situ Vitrification requires a specialty contractor and may cause procurement delays. Vitrification requires additional contaminant characterization to define the contaminant zone to be vitrified. Also, vitrification may not be consistent with the intended final remedial action at the waste site. The treatment process for the Removal/Treatment/Disposal Alternative adds ARARs to this alternative. The scores for the three alternatives are shown in Table 6-6.

6.4.5.5 Costs. Costs for the Removal/Disposal Alternative are less than for the Removal/Treatment/Disposal and In Situ Vitrification Alternatives (Table 6-12).

6.4.6 Dummy Decontamination Cribs and French Drains

Removal/Disposal, Removal/Treatment/Disposal, Containment, and In Situ Vitrification are the four appropriate alternatives for remediating the dummy decontamination cribs and french drains (see Sections 4.0 and 5.0). Based on the scoring/weighing process described in Section 6.4, the Removal/Disposal and Removal/Treatment/Disposal Alternatives received the highest scores followed by the Containment and In Situ Vitrification Alternatives (Table 6-9).

6.4.6.1 Long-term Effectiveness and Permanence. The Removal/Treatment/Disposal Alternative is the best alternative for remediating the dummy decontamination cribs and french drains for long-term effectiveness. This alternative would remove all contaminated soils from the waste site, treat all or a portion of the soils, and place the treatment residuals in the central waste disposal facility. There would be no long-term restrictions on land use at the waste site. There would be a commitment of land at the central waste disposal facility to manage the treatment residuals from the cribs and french drains. However, because the treatment component of this alternative would reduce the volume of wastes in comparison to the Removal/Disposal Alternative, less space will be needed at the central disposal facility. Also, because the clean soils resulting from the treatment process can be used as clean fill at the waste site, the Removal/Treatment/Disposal Alternative would require less importing of clean soil from offsite (outside the operable unit) borrow areas. Long-term negative impacts for all four alternatives include the requirement for continuous waste management.

The Removal/Disposal Alternative would have the same long-term benefits as the Removal/Treatment/Disposal Alternative. The Removal/Disposal Alternative would remove all of the contaminated soil from the waste site, and there would be no need for land use controls. The wastes would be managed at a central disposal facility specifically designed for that purpose. All of the contaminated soil from the dummy decontamination cribs and french drains would be taken to the central disposal facility. The Removal/Disposal Alternative would, therefore, require more disposal volume than the Removal/Treatment/Disposal Alternative. Also, the Removal/Disposal Alternative would require more clean fill from offsite borrow areas because there is no treatment component to clean some of the contaminated onsite soils.

In Situ Vitrification of the soils at the dummy decontamination cribs and french drains would effectively immobilize the wastes by incorporating the contaminants into a glassy matrix. None of the wastes would be transported off the waste site. The vitrified wastes would be covered by at least 1 m (3.28 ft) of clean fill or soil. The surface of the waste site would be available for limited uses in the long term, but some deed restrictions or other land use controls would be necessary to maintain the integrity of the subsurface vitrified mass.

The vitrification process will not necessarily treat all of the wastes, so there is a potential for wastes migrating from the site. Groundwater monitoring, therefore, would be required. The presence of the subsurface vitrified mass would preclude some wildlife use of the area (burrowing animals and their prey) and the reestablishment of deep rooted vegetation. Although it is unlikely that cultural resources may exist in or adjacent to the decontamination cribs and french drains (because of prior industrial use/disturbance), In Situ Vitrification would incorporate any resources present at the site into the glassy matrix.

The Containment Alternative would leave the contaminated soils in place and construct an engineered barrier over the wastes. The barrier would reduce the mobility of the contaminants by reducing infiltration into and through the waste site, and would effectively sever the exposure pathway between the contaminants in the wastes and the potential receptors (humans, plants, and animals).

The negative aspects of the Containment Alternative are similar to the In Situ Vitrification Alternative. Waste will be left by the Containment and In Situ Vitrification Alternatives, requiring deed restrictions or some other form of institutional control. These controls are needed to protect the integrity of the barrier and preclude activities that would intrude into the wastes. Because the integrity of the engineered barrier may deteriorate over time, groundwater monitoring and barrier maintenance activities would be required over time at the waste site. The engineered barrier would require several types of fill material, from basalt rock to topsoil and, therefore, would require the excavation and transport of this material from offsite borrow areas.

6.4.6.2 Reduction in Toxicity, Mobility, or Volume. All four of the Remedial Alternatives (removal/disposal, removal/treatment/disposal, containment, and In Situ Vitrification) that could be used at the dummy decontamination cribs and french drains would reduce the mobility of the contaminants to some extent, but only the Removal/Treatment/Disposal Alternative would reduce the volume of the wastes. The Removal/Treatment/Disposal Alternative would treat the wastes using primarily physical separation technologies, and thereby would reduce the volume of the contaminated soils by separating clean soils from the wastes. The treatment residuals would be placed in the central disposal facility.

The Removal/Disposal, Containment, and In Situ Vitrification Alternatives immobilize the wastes using different technologies, but none of these alternatives would reduce the volume. The Removal/Disposal Alternative reduces the mobility of the contaminants by placing them in a central disposal facility while the Containment Alternative reduces the mobility by placing an engineered barrier over wastes left in place at the waste site. The In Situ Vitrification Alternative would preclude mobility by vitrifying the wastes into a solid mass. The Containment Alternative is the least effective of these three alternatives in reducing mobility over the long term, while the In Situ Vitrification Alternative is the best. None of the four alternatives would reduce the toxicity of the contaminants. The treatment technologies used in the Removal/Treatment/Disposal Alternative are physical separation techniques, and because the contaminants at the decontamination cribs and french drains are limited to radionuclides and inorganic chemicals, there is no chemical treatment process that will reduce toxicity.

6.4.6.3 Short-term Effectiveness. The Containment and Removal/Disposal Alternatives are rated high for short-term effectiveness. The Removal/Treatment/Disposal Alternative received the lowest score of the four alternatives, primarily because of the increased risk and added time of the treatment component. Short-term effectiveness was evaluated based on risks to workers doing the remediation, potential risks to cultural and natural resources resulting from the remedial activities, duration of the remedial action, and transportation requirements (hauling wastes from the site, hauling equipment and supplies to the site, and hauling clean fill to the waste site for restoration).

The Containment Alternative would leave the wastes in place so workers would not be directly exposed to the contaminants. Material would have to be brought to the waste site for constructing the engineered barrier so there will be physical hazards associated with excavation (at the offsite borrow areas) and hauling. Physical hazards would also be associated with the construction of the onsite barrier, but these activities are routine construction operations. The only area at the waste site that will be disturbed is the area directly over the wastes (these areas have already been disturbed) and access roads. Potential impacts to cultural and natural resources would, therefore, be minimal. The duration of the remedial action would be relatively short.

The Removal/Disposal Alternative requires excavation and transportation of the wastes to the central disposal facility and, therefore, could potentially expose the workers directly to the contaminated soil. However, the remedial actions would require only routine excavation and hauling activities so these actions could be implemented with effective controls to protect workers. The Removal/Disposal Alternative would have some short-term effects on vegetation and wildlife, but most of these short-term impacts could be avoided or reduced by mitigation measures. If there are cultural resources present, they would be identified during excavation and addressed according to the cultural resources action plan. The Removal/Disposal Alternative would take less time to implement than the Removal/Treatment/Disposal Alternative, but more time to implement than the Containment and In Situ Vitrification Alternatives.

The In Situ Vitrification Alternative does not require transporting wastes to the central disposal facility, and requires less clean fill and topsoil than the other three alternatives. Equipment and supplies would be needed at the waste site for all four alternatives, but the In Situ Vitrification and Removal/Treatment/Disposal Alternatives will require the most. The In Situ Vitrification would not expose the workers directly to the contaminants because the wastes will be left in place. There is, however, a potential for worker exposure to treatment off-gases. In Situ Vitrification and Containment Alternatives would cause the least land disturbance and require the least onsite activities, and therefore are the least likely to impact natural and cultural resources. However, if there are cultural resources present, the In Situ Vitrification treatment process would result in the irretrievable loss of those resources. Because the wastes will be left in place, the In Situ Vitrification and Containment Alternatives provide no opportunity to acquire additional waste characterization data during the remedial action.

The Removal/Treatment/Disposal Alternative would disturb the largest land area, and would probably cause more impacts to natural and cultural resources. Workers would be exposed to soil contaminants during excavation and hauling, and would be exposed to treatment solutions, air emissions, and water effluent associated with the treatment operations. The Removal/Treatment/Disposal Alternative would reduce the volume of wastes to be hauled to the central disposal facility, and would also reduce the volume of clean fill needed from offsite borrow areas. Finally, the Removal/Treatment/Disposal Alternative would present the highest potential for accidental releases of substances associated with the remedial activities, such as fuels and lubricants, solvents, and contaminated water.

6.4.6.4 Implementability. The Removal/Disposal Alternative is the easiest of the four alternatives to implement for both technical and administrative feasibility. The excavation and hauling activities required in the Removal/Disposal Alternative are routine technologies and all contractors have those technical capabilities. The administrative aspects are also routine.

The Containment Alternative is also easy to implement from a technical perspective. Engineered barriers are used routinely at hazardous waste sites. The Containment Alternative requires no excavation or transportation of wastes. From an administrative aspect, this action may not be consistent with the long-term goal of future unrestricted use of the site. The Containment Alternative requires large amounts of soil and rock material for construction of the engineered barrier, and this material would come from offsite borrow areas.

The In Situ Vitrification Alternative is a relatively new technology with implementation uncertainties. This alternative requires a specialty contractor with vitrification experience. Field investigations would be required before implementing the vitrification process to determine the extent of the contaminants within the waste site and document the site specific conditions that can influence the success of this technology. Post-remedy monitoring would also be required because of the uncertainty regarding the complete vitrification of all the wastes and the long-term stability of the vitrified material.

The Removal/Treatment/Disposal Alternative includes treatment technologies as well as excavation and hauling and is, therefore, technically difficult to implement. The technical aspects of the treatment technologies planned for this alternative are routine, but treatment by any technology would increase technical difficulties. The regulatory aspects and anticipated interagency coordination associated with the Removal/Treatment/Disposal Alternative will be more difficult to accomplish than for the Removal/Disposal Alternative. The treatment aspects of the Removal/Treatment/Disposal Alternative add ARARs because of the onsite treatment operations, control of air emissions and wastewater effluent, and the potential effects of the treatment activities on natural and cultural resources.

6.4.6.5 Costs. Costs for the Removal/Disposal Alternative are less than for the Removal/ Treatment/Disposal, In Situ Vitrification and Containment Alternatives (Table 6-12).

6.4.7 Pipelines

There are four appropriate Remedial Alternatives for pipelines (removal/disposal, removal/treatment/disposal, in situ grouting, and containment). After the scoring was applied, the Removal/Treatment/Disposal and Removal/Disposal Alternatives ranked the highest followed by containment and in situ grouting (Table 6-10). When discussing the Removal/Treatment/Disposal Alternative in relation to pipelines, the treatment portion of this alternative would consist of treating the associated contaminated soil by soil washing techniques (Section 4.1.5.3). The excavated pipes would be removed and disposed of in a central disposal facility.

6.4.7.1 Long-term Effectiveness and Permanence. The Removal/Treatment/Disposal and Removal/Disposal Alternatives received the highest scores for long-term effectiveness and permanence and the In Situ Grouting and Containment Alternatives received lower scores (Table 6-10). The Removal/Disposal and the Removal/Treatment/Disposal Alternatives would remove all contaminated soils associated with the pipelines, and place the soils or treatment residuals in the central waste disposal facility where they would be managed along with wastes from other waste sites. There would be no long-term restrictions on land use at the waste site. There would be a commitment of land at the central waste disposal facility to manage the soils or treatment residuals. The treatment component of the Removal/ Treatment/Disposal Alternative would reduce the volume of wastes in comparison to the Removal/Disposal Alternative, requiring less space at the central disposal facility. Also, because the clean soils resulting from the treatment process can be used as clean fill at the waste site, the Removal/Treatment/Disposal Alternative would require less importing of clean soil from offsite (outside the operable unit) borrow areas. Long-term negative impacts of the Removal/Treatment/Disposal and Removal/Disposal Alternatives include the requirement for continuous waste management.

The Removal/Disposal Alternative would have the same long-term benefits as the Removal/Treatment/Disposal Alternative. Both alternatives would remove all of the contaminated soil associated with the pipelines, and there would be no need for land use controls. The wastes would be managed at a central disposal facility specifically designed for that purpose. For the Removal/Disposal Alternative, all of the contaminated soil associated with the pipelines would be taken to the central disposal facility. The Removal/Disposal Alternative would, therefore, require more disposal volume than the Removal/Treatment/ Disposal Alternative. Also, the Removal/Disposal Alternative would require more clean fill from offsite borrow areas because there is no treatment component to clean some of the contaminated onsite soils.

In situ grouting received the third lowest score for long-term effectiveness and permanence. In situ grouting would immobilize residual waste in the pipelines, but none of the wastes would be removed. Grouting would not necessarily treat 100% of the waste and any contaminated soil associated with the pipelines would not be treated or removed. Soil contaminants resulting from prior leaks would not be treated.

The Containment Alternative would leave the contaminated pipelines and soils in place and construct an engineered barrier over the wastes. The barrier would reduce the mobility of the contaminants by reducing infiltration into and through the waste site, and would effectively sever the exposure pathway between the contaminants in the wastes and the potential receptors (humans, plants, and animals).

Negative aspects of the Containment Alternative are similar to those of the In Situ Grouting Alternative. For the Containment Alternative, the wastes would be left onsite so deed restrictions or some other form of institutional control would be needed to protect the integrity of the barrier and preclude activities that would intrude into the wastes. Because the integrity of the engineered barrier may deteriorate over time, groundwater monitoring would be required at the waste site along with barrier maintenance activities. The presence of the barrier would limit vegetation to shallow rooting plants, and would preclude full use of the site by wildlife. The engineered barrier would require several types of fill material, from basalt rock to topsoil and, therefore, would require the excavation and transport of this material from offsite borrow areas.

6.4.7.2 Reduction in Toxicity, Mobility, or Volume. The Removal/Treatment/Disposal and Removal/Disposal Alternatives received the highest scores to in situ routing and containment (Table 6-10). Under these alternatives, there would be a reduction in contaminant mobility at the waste site and at the central disposal facility. The Removal/Disposal, Containment, and In Situ Grouting alternatives would contain the waste using different technologies, but none would reduce the volume.

The Removal/Disposal Alternative would reduce the mobility of the contaminants by placing them in a central disposal facility, while the Containment Alternative would reduce the mobility by placing an engineered barrier over wastes left in place at the waste site. The Containment Alternative would reduce the water infiltration exposure pathway but long-term barrier performance is unknown. The In Situ Grouting Alternative would reduce mobility by grouting the wastes in the pipelines. The Containment Alternative is the least effective of the alternatives for reducing long-term mobility.

None of the four alternatives would reduce the toxicity of the contaminants. The treatment technologies used in the Removal/Treatment/Disposal Alternative are essentially physical separation techniques to separate contaminated from clean soils, and therefore don't change the toxicity.

6.4.7.3 Short-term Effectiveness. The Containment and In Situ Grouting alternatives received the highest scores compared to the Removal/Dispose and Removal/Treatment/ Disposal Alternative for short-term effectiveness. For the Containment and In Situ Grouting alternatives, there is a lower exposure risk to workers and less environmental impacts from dust and noise. Cultural resources would be left in place.

The Removal/Treatment/Disposal Alternative received the lowest score (Table 6-10) because the treatment component of this alternative increases (1) the time required to complete the action, (2) the risk to workers, and (3) the potential risk to natural and cultural resources. The transportation impacts of the Removal/Treatment/Disposal and the Removal/Disposal Alternatives would be about the same, while the In Situ Grouting

Alternative would have the least impact on transportation. The Removal/Treatment/Disposal Alternative would disturb a larger land area than the Removal/Disposal and In Situ Grouting alternatives and, therefore, would probably cause more impacts to natural and cultural resources.

The Removal/Disposal Alternative received a lower score than the Containment and In Situ Grouting alternatives because the Removal/Disposal Alternative increases the potential for impacts to cultural and natural resources.

The Containment Alternative would leave the wastes in place, and workers would not be exposed directly to the contaminants. Material would have to be brought to the waste site for constructing the engineered barrier so there would be physical hazards associated with excavation (at the offsite borrow areas) and hauling. Physical hazards would also be associated with the construction of the onsite barrier, but these activities are routine construction operations. The only area at the waste site that would be disturbed is the area directly over the wastes (these areas have already been disturbed) and access roads. Potential impacts to cultural and natural resources would be minimal. The duration of the remedial action would be relatively short.

6.4.7.4 Implementability. The Removal/Disposal Alternative received the highest score for implementability followed by the Removal/Treatment/Disposal Alternative. The Removal/Disposal Alternative would be the easiest of the four alternatives to implement, for both technical and administrative feasibility. The excavation and hauling activities required in the Removal/Disposal Alternative are routine technologies. The administrative aspects are also routine.

The In Situ Grouting and Containment Alternatives received the lowest scores because they may not be consistent with final action. The Containment Alternative is technically easier to achieve than the In Situ Grouting.

6.4.7.5 Costs. Costs for the Removal/Disposal Alternative are less than for the Removal/Treatment/Disposal, In Situ Grouting and Containment Alternatives (Table 6-12).

6.4.8 Burial Grounds

There are four appropriate Remedial Alternatives for burial grounds, (removal/disposal, removal/treatment/disposal, in situ compaction, and containment). The Removal/Treatment/ Disposal and Removal/Disposal Alternatives received almost identical ranks followed closely by the Containment and In Situ Compaction alternatives (Table 6-11).

6.4.8.1 Long-term Effectiveness and Permanence. The Removal/Treatment/Disposal and Removal/Disposal Alternatives received the highest scores for long-term effectiveness and permanence (Table 6-11). These alternatives would remove all contaminated soils associated with the burial grounds, and place the contaminated soils or treatment residuals in the central waste disposal facility where they would be managed along with wastes from other waste sites. There would be no long-term restrictions on land use at the waste site. There would be a commitment of land at the central waste disposal facility to manage the contaminated soils or treatment residuals. However, because the treatment component of the Removal/Treatment/Disposal Alternative would reduce the volume of wastes in comparison to the Removal/Disposal Alternative, less space will be needed at the central disposal facility. Also, because the clean soils resulting from the treatment process can be used as clean fill at the waste site, the Removal/Treatment/Disposal Alternative would require less importing of clean soil from offsite (outside the operable unit) borrow areas. Long-term negative impacts of the Removal/Treatment/Disposal and Removal/Disposal Alternatives include the requirement for continuous waste management.

The Removal/Disposal Alternative would have the same long-term benefits as the Removal/Treatment/Disposal Alternative. Both alternatives would remove all of the contaminated soil associated with the burial grounds from the waste site, and there would be no need for land use controls. The wastes would be managed at a central disposal facility specifically designed for that purpose.

Both the In Situ Compaction and Containment Alternatives include constructing an engineered barrier over the wastes, designing surface water controls, maintaining groundwater monitoring, and implementing deed restrictions or other land-use controls. In addition to these, the In Situ Compaction Alternative includes dynamic compaction of the buried wastes to increase stability and reduce the permeability of the wastes that are left in place. The barrier by itself would reduce the mobility of the contaminants by reducing infiltration into the burial grounds, and effectively sever the exposure pathway between the contaminated wastes and the human, plant, and animal receptors. The addition of the dynamic compaction technology increases the long-term integrity of the surface barrier by reducing the potential for future subsidence, but would also increase short-term risks and costs, as compared to the Containment Alternative.

Negative aspects of the Containment and In Situ Compaction Alternatives are similar. The wastes would be left onsite so deed restrictions or some other form of institutional control would be needed to protect the integrity of the barrier and preclude activities that would intrude into the wastes. Because the integrity of the engineered barrier may deteriorate over time, groundwater monitoring would be maintained at the waste site along with barrier maintenance activities. The presence of the barrier would limit vegetation to shallow rooting plants, and would preclude full use of the site by wildlife. The engineered barrier would require several types of fill material, from basalt rock to topsoil and, therefore, would require the excavation and transport of this material from offsite borrow areas. Finally, both alternatives would potentially cause long-term environmental impacts to soil borrow areas and basalt quarries.

6.4.8.2 Reduction in Toxicity, Mobility, or Volume. In Situ Compaction, Containment, and the Removal/Disposal Alternatives received the lowest scores in this category because there would be only a minimal reduction in mobility and no reduction in toxicity and volume. The In Situ Compaction and Containment Alternatives do not remove the contaminants from the waste site. The water infiltration exposure pathway would be reduced under the In Situ Compaction and Containment Alternatives, but long-term barrier performance may degrade.

The Removal/Treatment/Disposal Alternative received the highest score for this criteria. Under this alternative, there is a reduction in contaminant mobility and volume. The Removal/Treatment/Disposal Alternative would reduce material transport to the central disposal facility because of onsite treatment.

6.4.8.3 Short-term Effectiveness. The Containment and In Situ Compaction Alternatives received the highest scores for short-term effectiveness. These alternatives would result in a lower contaminant exposure risk to workers and the environmental impacts from dust and noise would be low. Cultural resources, if present, would be left in place.

The Removal/Treatment/Disposal Alternative scored low for short-term effectiveness because the treatment component of this alternative increases (1) the time required to complete the action, (2) the risk to workers, and (3) the potential risk to natural and cultural resources. The transportation impacts of the Removal/Treatment/Disposal and the Removal/Disposal Alternatives would be about the same, while the In Situ Compaction Alternative would have the least impact for transportation. The Removal/Treatment/Disposal Alternative would disturb a larger land area than the Removal/Disposal In Situ, Compaction, and Containment Alternatives and, therefore, would probably cause more impacts to natural and cultural resources.

6.4.8.4 Implementability. The Removal/Disposal and Containment Alternatives received higher (and identical) scores for implementability than the Removal/Treatment/Disposal and In Situ Compaction Alternatives.

The Removal/Disposal Alternative would be the easiest of the four alternatives to implement for both technical and administrative feasibility. The excavation and hauling activities required in the Removal/Disposal Alternative are routine technologies. The administrative aspects are also routine.

The Containment Alternative is also easy to implement from a technical perspective. Engineered barriers are used routinely at hazardous waste sites and containment requires no excavation or transportation of wastes. From an administrative aspect, this action would not be consistent with the long-term goal of future unrestricted use of the site. The Containment Alternative requires large amounts of soil and rock material for construction of the engineered barrier and this material would come from offsite borrow areas.

The In Situ Compaction and Removal/Treatment/Disposal Alternatives received the lowest scores for implementability. The In Situ Compaction Alternative is easier to achieve technically than the Removal/Treatment/Disposal Alternative, but there are many uncertainties regarding the effectiveness of compaction techniques.

The Removal/Treatment/Disposal Alternative is technically more difficult to achieve because of waste handling and treatment concerns. The Removal/Treatment/Disposal Alternative includes treatment technologies in addition to excavation and hauling and is, therefore, technically more difficult to implement. The technical aspects of the treatment technologies that are planned for this alternative are fairly routine, but treatment by any technology would increase the technical difficulties. The regulatory aspects and anticipated interagency coordination associated with the Removal/Treatment/Disposal Alternative would be more difficult to accomplish than for the Removal/Disposal Alternative. The treatment aspects of the Removal/Treatment/Disposal Alternative add ARARs because of the onsite treatment operations, control of air emissions and wastewater effluent, and the potential effects of the treatment activities on natural and cultural resources.

6.4.8.5 Costs. Costs for the Removal/Disposal Alternative are less than for the Removal/Treatment/Disposal, In Situ Compaction, and Containment Alternatives (Table 6-12).

Table 6-1. Waste Site Groups and Associated Remedial Alternatives.

Waste Site Group	Remediation Alternatives
GROUP A	
Retention Basins Fuel Storage Basin Trenches	Removal/Disposal, Removal/Treatment/Disposal
GROUP B	
Process Effluent Trenches Sludge Trenches Pluto Cribs	Removal/Disposal, Removal/Treatment/Disposal, In Situ Vitrification
GROUP C	
Dummy Decontamination Cribs and French Drains Pipelines Burial Grounds	Removal/Disposal, Removal/Treatment/Disposal, In Situ Treatment (Vitrification, Grouting,Compaction), Containment

Table 6-2. Description of Scores for Each Waste Site Group and Associated Remedial Alternatives. (Page 1 of 2)

Score	Description
1	**Long-term effectiveness**: high residual risk, monitoring required, high degree of uncertainty associated with adequacy of controls, high degree of long term impacts to natural resources
	Reduction of toxicity, mobility, and volume: no reduction in toxicity, mobility, or volume of contaminants
	Short-term Effectiveness: high risk to workers, high transportation impacts, high impact to cultural and/or natural resources
	Implementability: not technically or administratively feasible, poor availability of services and materials
3	**Long-term effectiveness**: above average residual risk, monitoring required, some degree of uncertainty associated with adequacy of controls, below average impacts to natural resources
	Reduction of toxicity, mobility, and volume: very little reduction in mobility, or volume of contaminants
	Short-term effectiveness: above average risk to workers, some transportation impacts, above average impacts to cultural and/or natural resources
	Implementability: not technically and/or administratively feasible, below average availability of services and materials
5	**Long-term effectiveness**: average residual risk, some monitoring may be required, average degree of uncertainty associated with adequacy of controls, average impacts to natural resources
	Reduction of toxicity, mobility, and volume: average reduction in mobility, or volume of contaminants
	Short-term effectiveness: average risk to workers, some transportation impacts, average impacts to cultural and/or natural resources
	Implementability: technically and/or administratively feasible, average availability of services and materials
7	**Long-term effectiveness**: below average residual risk, monitoring may not be required, low degree of uncertainty associated with adequacy of controls, below average impacts to natural resources
	Reduction of toxicity, mobility and volume: above average reduction in mobility, or volume of contaminants
	Short-term effectiveness: below average risk to workers, few transportation impacts, below average impacts to cultural and/or natural resources
	Implementability: technically and administratively feasible, above average availability of services and materials

Table 6-2. Description of Scores for Each Waste Site Group and Associated Remedial Alternatives. (Page 2 of 2)

Score	Description
9	**Long-term effectiveness**: little or no residual risk, monitoring not required, no uncertainty associated with adequacy of controls, little or no impact to natural resources
	Reduction of toxicity, mobility and volume: large reduction in mobility or volume of contaminants relative to other remedial alternatives
	Short-term Effectiveness: little or no risk to workers, little or no transportation impacts, little or no impacts to cultural and/or natural resources
	Implementability: technically and administratively feasible, ready availability of services and materials

Table 6-3. Example of How Costs Were Normalized to Achieve a Score.

Normalization Procedure	Alternative #1	Alternative #2	Alternative #3
1. Cost	23M	28M	46M
2. Divide by lowest cost (23)	1	1.22	2.0
3. Invert the above number	1	0.82	0.5
4. Multiply by 10 to get relative scores	10	8.2	5.0
5. Final score (round off)	10	8	5

Table 6-4. Quantitative Comparison of Evaluation Criteria for Retention Basins.

CERCLA Evaluation Criteria	Remedial Alternatives					
	Removal/Disposal			Removal/Treatment/Disposal		
	Weight	Score	Rank[a]	Weight	Score	Rank[a]
Long-term Effectiveness	1.00	7.00	7.00	1.00	9.00	9.00
Reduction of Mobility or Volume	0.50	4.00	2.00	0.50	5.00	2.5
Short-term Effectiveness	0.50	6.00	3.00	0.50	3.00	1.50
Implementability	1.00	9.00	9.00	1.00	5.00	5.00
Cost	1.00	10.00	10.00	1.00	8.00	8.00
Total Rank[b]			31.0			26.0

[a]Rank = weight x score
[b]Total Rank = sum of individual rankings

Table 6-5. Quantitative Comparison of Evaluation Criteria for Fuel Storage Basin Trenches.

CERCLA Evaluation Criteria	Remedial Alternatives					
	Removal/Disposal			Removal/Treatment/Disposal		
	Weight	Score	Rank[a]	Weight	Score	Rank[a]
Long-term Effectiveness	1.00	7.00	7.00	1.00	9.00	9.00
Reduction of Mobility or Volume	0.50	3.00	1.5	0.50	5.00	2.5
Short-term Effectiveness	0.50	7.00	3.50	0.50	5.00	2.50
Implementability	1.00	7.00	7.00	1.00	5.00	5.00
Cost	1.00	10.00	10.00	1.00	8.00	8.00
Total Rank[b]			29.0			27.0

[a]Rank = weight x score
[b]Total Rank = sum of individual rankings

Table 6-6. Quantitative Comparison of Evaluation Criteria for Process Effluent Trenches.

CERCLA Evaluation Criteria	Remedial Alternatives								
	Removal/Disposal			In Situ Vitrification			Removal/Treatment/ Disposal		
	Weight	Score	Rank[a]	Weight	Score	Rank[a]	Weight	Score	Rank[a]
Long-term Effectiveness	1.00	7.00	7.00	1.00	4.00	4.00	1.00	9.00	9.00
Reduction of Mobility or Volume	0.50	3.00	1.5	0.50	7.00	3.5	0.50	5.00	2.5
Short-term Effectiveness	0.50	7.00	3.50	0.50	7.00	3.50	0.50	3.00	1.50
Implementability	1.00	7.00	7.00	1.00	2.00	2.00	1.00	5.00	5.00
Cost	1.00	10.00	10.00	1.00	3.00	3.00	1.00	9.00	9.00
Total Rank[b]			29.0			16.0			27.0

[a]Rank = weight x score
[b]Total Rank = sum of individual rankings

Table 6-7. Quantitative Comparison of Evaluation Criteria for Sludge Trenches.

CERCLA Evaluation Criteria	Remedial Alternatives								
	Removal/Disposal			In Situ Vitrification			Removal/Treatment/ Disposal		
	Weight	Score	Rank[a]	Weight	Score	Rank[a]	Weight	Score	Rank[a]
Long-term Effectiveness	1.00	7.00	7.00	1.00	4.00	4.00	1.00	9.00	9.00
Reduction of Mobility or Volume	0.50	3.00	1.5	0.50	7.00	3.5	0.50	5.00	2.5
Short-term Effectiveness	0.50	7.00	3.50	0.50	7.00	3.50	0.50	5.00	2.50
Implementability	1.00	7.00	7.00	1.00	3.00	3.00	1.00	5.00	5.00
Cost	1.00	10.00	10.00	1.00	3.00	3.00	1.00	7.00	7.00
Total Rank[b]			29.0			17.0			26.0

[a]Rank = weight x score
[b]Total Rank = sum of individual rankings

Table 6-8. Quantitative Comparison of Evaluation Criteria for Pluto Cribs.

CERCLA Evaluation Criteria	Remedial Alternatives								
	Removal/Disposal			In Situ Vitrification			Removal/Treatment/ Disposal		
	Weight	Score	Rank[a]	Weight	Score	Rank[a]	Weight	Score	Rank[a]
Long-term Effectiveness	1.00	7.00	7.00	1.00	4.00	4.00	1.00	9.00	9.00
Reduction of Mobility or Volume	0.50	3.00	1.5	0.50	7.00	3.5	0.50	5.00	2.5
Short-term Effectiveness	0.50	8.00	4.00	0.50	7.00	3.50	0.50	6.00	3.00
Implementability	1.00	8.00	8.00	1.00	4.00	4.00	1.00	6.00	6.00
Cost	1.00	10.00	10.00	1.00	4.00	4.00	1.00	4.00	4.00
Total Rank[b]			30.5			19.0			24.5

[a]Rank = weight x score
[b]Total Rank = sum of individual rankings

Table 6-9. Quantitative Comparison of Evaluation Criteria for Dummy Decontamination Cribs and French Drains.

CERCLA Evaluation Criteria	Remedial Alternatives											
	Containment			Removal/Disposal			In Situ Vitrification			Removal/Treatment/Disposal		
	Weight	Score	Rank[a]	Weight	Score	Rank[a]	Weight	Score	Rank[a]	Weight	Score	Rank[a]
Long-term Effectiveness	1.00	3.00	3.00	1.00	7.00	7.00	1.00	4.00	4.00	1.00	9.00	9.00
Reduction of Mobility or Volume	0.50	2.00	1.0	0.50	3.00	1.5	0.50	7.00	3.5	0.50	5.00	2.50
Short-term Effectiveness	0.50	9.00	4.50	0.50	8.00	4.00	0.50	7.00	3.50	0.50	6.00	3.00
Implementability	1.00	6.00	6.00	1.00	8.00	8.00	1.00	3.00	3.00	1.00	6.00	6.00
Cost	1.00	1.00	1.00	1.00	10.00	10.00	1.00	4.00	4.00	1.00	4.00	4.00
Total Rank[b] Score			15.5			30.5			18.0			24.5

[a]Rank = weight x score
[b]Total Rank = sum of individual rankings

Table 6-10. Quantitative Comparison of Evaluation Criteria for Pipelines.

CERCLA Evaluation Criteria	Remedial Alternatives											
	Containment			Removal/Disposal			In Situ Grouting			Removal/Treatment/Disposal		
	Weight	Score	Rank[a]	Weight	Score	Rank[a]	Weight	Score	Rank[a]	Weight	Score	Rank[a]
Long-term Effectiveness	1.00	2.00	2.00	1.00	7.00	7.00	1.00	3.00	3.00	1.00	9.00	9.00
Reduction of Mobility or Volume	0.50	1.00	0.50	0.50	3.00	1.50	0.50	2.00	1.0	0.50	5.00	2.5
Short-term Effectiveness	0.50	7.00	3.50	0.50	6.00	3.00	0.50	6.00	3.00	0.50	4.00	2.00
Implementability	1.00	3.00	3.00	1.00	7.00	7.00	1.00	2.00	2.00	1.00	5.00	5.00
Cost	1.00	1.00	1.00	1.00	4.00	4.00	1.00	10.00	10.00	1.00	3.00	3.00
Total Rank[b]			10.0			22.5			19.0			21.5

[a]Rank = weight x score
[b]Total Rank = sum of individual rankings

Table 6-11. Quantitative Comparison of Evaluation Criteria for Burial Grounds.

CERCLA Evaluation Criteria	Remedial Alternatives											
	Containment			Removal/Disposal			In Situ Compaction			Removal/Treatment/Disposal		
	Weight	Score	Rank[a]	Weight	Score	Rank[a]	Weight	Score	Rank[a]	Weight	Score	Rank[a]
Long-term Effectiveness	1.00	3.00	3.00	1.00	7.00	7.00	1.00	4.00	4.00	1.00	9.00	9.00
Reduction of Mobility or Volume	0.50	2.00	1.0	0.50	3.00	1.5	0.50	2.00	1.0	0.50	5.00	2.5
Short-term Effectiveness	0.50	9.00	4.50	0.50	3.00	1.50	0.50	7.00	3.50	0.50	2.00	1.00
Implementability	1.00	5.00	5.00	1.00	5.00	5.00	1.00	4.00	4.00	1.00	3.00	3.00
Cost	1.00	6.00	6.00	1.00	10.00	10.00	1.00	6.00	6.00	1.00	9.00	9.00
Total Rank[b]			19.5			25.0			18.5			24.5

[a]Rank = weight x score
[b]Total Rank = sum of individual rankings

Table 6-12. Cost Comparisons for all Waste Site Groups and Associated Remedial Alternatives.

Waste Site Group	Remedial Alternatives Estimated Cost (Thousands of $$) Removal/Disposal	Removal/ Treatment/ Disposal	In Situ Treatment	Containment
GROUP A				
Retention Basins	96,000	114,000	---	---
Fuel Storage Basin Trenches	4,470	5,570	---	---
GROUP B				
Process Effluent Trenches	15,700	17,900	54,800	---
Sludge Trenches	1,670	2,300	5,630	---
Pluto Cribs	267	692	661	---
GROUP C				
Dummy Decontamination Cribs and French Drains	283	707	715	3,194
Pipelines	32,900	40,000	11,492	109,645
Burial Grounds	2,380	2,530	4,238	4,292

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APPENDIX A

DEVELOPMENT OF PRELIMINARY REMEDIATION GOALS

1.0 PURPOSE AND OBJECTIVE

This appendix describes the procedures used to develop the preliminary remediation goals for the 100 Area source operable unit FFSs. The preliminary remediation goals are numeric expressions of the remedial action objectives presented in Section 2.4 of the Process Document. (The term "Process Document" refers to the main text of this report, Sections 1.0 through 6.0, and Appendices A, B, and C.) The preliminary remediation goals are concentrations in soil, for each contaminant of concern, that are considered protective of human health and the environment, assuming an occasional-use exposure scenario, as described in Section 2.3 of the Process Document. The preliminary remediation goals are used to estimate the amount of soil that requires remediation to meet the remedial action objectives. The preliminary remediation goals are also used to assess the performance of the Remedial Alternatives by describing a numeric goal to be achieved by the treatment technologies.

The preliminary remediation goals are intended to protect human health, protect plant and animal populations, and attain ARARs. The ARARs are discussed in Section 2.6 of the Process Document, and are listed in the tables in Appendix C. The preliminary remediation goals protective of human health were calculated so they represented soil concentrations that would not exceed an increased cancer risk of 1×10^{-6} (for carcinogenic or radioactive contaminants) or a noncancer hazard quotient of 0.1 (for noncarcinogenic contaminants). The hazard quotient for noncarcinogenic chemicals is set at 0.1, rather than 1.0, to accommodate the potential additive or synergistic effect of several chemical stressors acting on a receptor at the same time. The 1×10^{-6} increased cancer risk also accommodates for potential additive or synergistic effects.

This appendix includes four sections, including this Section 1.0. Section 2.0 discusses the human and biological receptors and exposure pathways that were used to calculate the preliminary remediation goals. Section 2.0 also describes the zones of contact that represent the locations where the receptors come in contact with the contaminants. Section 3.0 presents the remedial action objectives for the 100 Area source operable units, then presents the formulas used to derive the human health, environmental, and protection of groundwater-based preliminary remediation goals. Section 4.0 discusses the application of the preliminary remediation goals.

2.0 RECEPTORS AND EXPOSURE PATHWAYS

This section presents a conceptual exposure model for the 100 Area. The model illustrates how the receptors come in contact with the contaminants in the 100 Area. This section also defines which receptors and exposure pathways are used in the Process Document to calculate the preliminary remediation goals. The conceptual exposure model is based on an occasional-use exposure scenario as discussed in Sections 2.2 and 2.3 of the Process Document.

2.1 CONCEPTUAL EXPOSURE MODEL

The conceptual exposure model for the 100 Area (used for the Process Document) is illustrated in Figure A-1. The source of the contaminants is the contaminated soils and solid wastes within the 100 Area operable units. These contaminants are assumed to remain in place or be transported from their original location by wind erosion and by water infiltrating through the vadose zone toward the groundwater system. Surface water erosion is assumed to be a minor transport mechanism for contaminants in the 100 Area because of the arid weather and porous nature of the soils. The human, animal, and plant receptors are exposed to the contaminants by direct contact with soils, by inhaling air containing contaminated particulates (dust), by ingesting contaminated foods or soil, and by being exposed to external radiation from radionuclides.

The principal receptors under the occasional use exposure scenario are assumed to be as follows:

- Visitors to the area
- The Great Basin pocket mouse
- Plants in general.

2.2 RECEPTORS

The human visitors refer to those people visiting and recreating in the area after remedial action has been completed. The site visitor is considered a long-term receptor. The primary exposure routes to humans are considered to be inhalation of particulates or vapors in air, ingestion of soil, and exposure to external radiation from radioactive contaminants in the soils (Figure A-1). Because the preliminary remediation goals define the soil concentrations that will be left at the site after remediation has been completed, they do not apply to the workers that will be involved in the actual remedial work. Short-term risks to workers involved in the remediation itself are discussed in Section 5.2.2.5 of the Process Document.

The Great Basin pocket mouse was selected as representative of the animals that could be exposed to site contaminants. Although there are numerous species of animals in the 100 Area, the pocket mouse was selected as the representative species because it is common in the area and lives in underground burrows. The mouse, therefore, is in direct contact with the contaminated soils. The home range of the pocket mouse is approximately the same size as many of the individual waste sites. It was assumed, for the purposes of estimating exposure, that the mouse lives entirely within the waste site. The principal exposure route to the mouse was assumed to be by ingestion of plants (primarily seeds) growing in the contaminated soils. External radiation dose to wildlife has been shown to be a minor contributor to total dose (Poston and Soldat 1992), and the relatively short life span precludes the development of significant harmful cancer effects. The external radiation exposure route, therefore, was not included in the calculation of the preliminary remediation goals for wildlife.

For plants, a species native to the 100 Area was not selected because the information available on phytotoxicity of contaminants to plants is based primarily on domestic species. Therefore, the preliminary remediation goals addressed plants as a generic, rather than species-specific, receptor. The principal exposure route for plants was considered to be the uptake of contaminants from the soil.

2.3 ZONES OF CONTACT/POINTS OF COMPLIANCE

Humans, animals, and plants may come in contact with the site contaminants at different depths within the soil strata. All three receptors (using the occasional-use exposure scenario) are exposed to contaminants at the surface, but animals and plants in a natural setting will be exposed to contaminants at deeper depths than humans. Because the principal source of the contaminants is soil (i.e., the Process Document addresses only the source operable units), the depth of the contaminants in the soil strata must be considered.

Under the occasional-use exposure scenario, assuming no excavation for construction of houses or other structures, humans will be exposed only to contaminants near the ground surface. Radionuclides that are deeper than 1 m (3 ft) are not used to calculate external radiation exposure because 1 m (3 ft) of soil is considered adequate for shielding humans from eaningful radiation from the radioactive contaminants at the 100 Area (WHC 1994c). The zone of contact for humans, therefore, is the 0 to 1 m (0 to 3 ft) strata. This may also be referred to as the point of compliance for regulatory purposes.

Burrowing animals, such as the pocket mouse, live in underground burrows that may be about 2 m (6 ft) deep (WHC 1994b). These animals are also exposed to external radiation emanating from radionuclides that are deeper than 2 m (6 ft). Also, the pocket mouse and other animals that eat plants take up contaminants from the plants. This means that the depth of the plant roots must be considered because the contaminants in the soil are taken up by the plant roots, and the plant in turn is eaten by the mouse. Several plant species common at the Hanford Site have roots that penetrate to 3 m (9 ft) (Klepper et al. 1985). The zone of contact for animals and plants, therefore, is assumed to be the 0 to 3 m (10 ft) strata.

For the purposes of developing preliminary remediation goals, groundwater is considered a receptor because one of the remedial action objectives is to protect groundwater for beneficial uses. Because contaminants from any depth can leach out of the soil and be transported to the groundwater, the zone of contact or point of compliance for protection of groundwater is from the surface to the top of the water table.

Table A-1 illustrates the zones of contact for humans, plants, animals, and groundwater protection. The preliminary remediation goals based on human health risks are applicable at the 0 to 1 m (0 to 3 ft) strata. Preliminary remediation goals based on animal or plant risks would apply to the 0 to 3 m (0 to 10 ft) strata. However, as discussed in Section 2.5 of the Process Document, human health-based remediation goals are used in the Process Document to establish soil concentrations protective of animals and plants. This means that the human health-based preliminary remediation goals are applicable throughout the 0 to 3 m (0 to 10 ft) strata. Finally, protection of groundwater remediation goals are applied to the 0 to 3 m (0 to 10 ft) strata and the depth strata of more than 3 m (10 ft).

The preliminary remediation goals represent the soil concentrations that are considered nonhazardous to the receptors. Therefore, to remediate a particular waste site in the 100 Area, the soils that exceed the preliminary remediation goals must be remediated. The human health-based preliminary remediation goals must be met within the 0 to 3 m (0 to 10 ft) strata, and the protection of groundwater preliminary remediation goals must be met within both the 0 to 3 m (0 to 10 ft) strata and within the soil strata greater than 3 m (0 to 10 ft). This means that the most restrictive of the two goals must be met within the 0 to 3 m (0 to 10 ft) strata. For the purpose of applying the preliminary remediation goals, the 0 to 3 m (0 to 10 ft) strata is referred to as Zone 1, and the greater than 3 m (10 ft) strata is referred to as Zone 2.

Table A-2 presents the preliminary remediation goals for each contaminant of concern in the 100 Area. It also indicates which of the remediation goals are applied to Zone 1 and Zone 2, and indicates when the preliminary remediation goals are less than Hanford Site background soil concentrations or the laboratory analytical detection limits (or laboratory quantification limits). As discussed in Section 2.5 of the Process Document, when the preliminary remediation goals are below (more restrictive) soil background levels or laboratory detection limits, the background concentrations or the detection limits are used in lieu of the remediation goals. This approach precludes trying to remediate the site to levels lower than natural soil conditions, or to concentrations that cannot be reliably and consistently measured.

3.0 PRELIMINARY REMEDIATION GOALS

The remedial action objectives are statements indicating what the remediation is expected to accomplish. These objectives specify the receptor that will be protected, the media or exposure pathway involved, and the level of protection that should be afforded by the remedial action. The remedial action objectives are defined below.

- For Human Health
  - Limit exposure of human receptors to contaminated surface and subsurface soils to limit increased risk in the range of 1×10^{-4} to 1×10^{-6} for carcinogenic and radioactive contaminants, and at or below a noncancer hazard quotient of 0.1 for the noncarcinogenic contaminants.
  - Limit future impacts to groundwater by ensuring that contamination remaining in the vadose zone will result in concentrations in groundwater below groundwater protection standards.
  - Comply with ARARs.

- For Environmental Protection:
  - Limit exposure of ecological receptors to contaminants.
  - Avoid or minimize destruction of habitat and disruption of natural animal activities to the extent possible.
  - Comply with ARARs.

Final remediation objectives will be determined by the signatories to the Tri-Party Agreement during the record of decision process.

A number of factors must be considered while developing preliminary remediation goals to satisfy the remedial action objectives listed above. In addition to considering contaminant concentrations that are protective of human health, ecological resources, and groundwater, several other factors must be considered. These factors include the background concentrations of natural soil constituents that might also be site contaminants (e.g., chromium and uranium), the limits of detection that analytical laboratories can achieve, and the federal and state regulatory limits for levels of contamination in soil, air, and water. For example, if a human health preliminary remediation goal is lower than the naturally-occurring background concentration, then the background concentration would be used as the remediation goal. Similarly, if a human health preliminary remediation goal is lower than a level that can be routinely or reliably quantified by an analytical laboratory, the laboratory quantification limit would be the remediation goal. The primary factors used to develop preliminary remediation goals are discussed below, and the specific soil concentrations used as preliminary remediation goals for each contaminant are identified in Table A-2. As shown in Table A-2, the preliminary remediation goals for Zones 1 and 2 may be based on any of the factors discussed above.

3.1 HUMAN HEALTH

Risks to human health are potentially associated with carcinogenic and noncarcinogenic effects. Radionuclides and some chemicals can induce carcinogenic effects in humans, and some chemicals and radionuclides pose noncarcinogenic risk as well. The following subsections (3.1.1 and 3.1.2) define the carcinogenic and noncarcinogenic preliminary remediation goals for protection of human health.

3.1.1 Carcinogenic Constituents

Preliminary remediation goals, which are calculated from a target increased cancer risk level, define carcinogenic contaminant concentrations in soil that are protective of human health. Table A-2 identifies preliminary remediation goals for constituents considered to be carcinogenic.

Preliminary remediation goals for carcinogenic contaminants are estimated from a target increased cancer risk level using equations presented in the *Hanford Site Risk*

Assessment Methodology (DOE-RL 1995), and intake factors and assumptions that correspond to an occasional-use scenario. An increased cancer risk level of 1×10^{-6} has been selected as a point of departure for calculating preliminary remediation goals for individual carcinogenic contaminants. For radionuclides, the preliminary remediation goals corresponding to 1×10^{-6} are based on the assumption that the site is not available for use until the year 2018, which has been selected as the earliest possible date for release of sites. Thus, radioactive decay occurring from 1994 to 2018 is considered in developing the preliminary remediation goals for radionuclides. The following sections describe the calculation of preliminary remediation goals for carcinogenic contaminants that are protective of human health.

The target risk of 1×10^{-6} is the sum of the risks from all exposure pathways considered in the occasional-use scenario. The exposure pathways associated with the occasional-use scenario, for purposes of preliminary remediation goals development, are soil ingestion, inhalation of fugitive dust and organic vapors, and external exposure to radionuclides. Therefore, the target risk is the sum of the risks from these three exposure pathways, as follows:

$$TR = Risk_{si} + Risk_{inh} + Risk_{ext} \qquad (1)$$

where

TR	=	Target risk, or 1×10^{-6}
$Risk_{si}$	=	Increased cancer risk from soil ingestion
$Risk_{inh}$	=	Increased cancer risk from inhalation
$Risk_{ext}$	=	Increased cancer risk from external exposure

Increased cancer risk is calculated as the product of contaminant intake and a slope factor; therefore, the target risk can be calculated as follows:

$$TR = \sum (Intake \times SF)_i \qquad (2)$$

where

i	=	Ingestion, inhalation or external exposure pathways
Intake	=	Contaminant intake (mg/kg-day or pCi)
SF	=	Carcinogenic slope factor $(mg/kg\text{-}day)^{-1}$ or $(pCi)^{-1}$ (EPA 1992)

Contaminant intake is calculated as the product of contaminant concentration in soil and an intake factor, the intake factor represents assumptions concerning rate of contact with the contaminated medial, exposure frequency, duration, body weight, and other assumptions. Intake factors used to develop preliminary remediation goals for carcinogenic contaminants were obtained from *Hanford Site Risk Assessment Methodology*. Using the contaminant concentration in soil and intake factors, target risk can be calculated as follows:

$$TR = \sum (IF \times SC \times SF)_i \qquad (3)$$

where SC is the concentration in soil (mg/kg or pCi/g). Because SC is the same for all pathways, it can be brought out of the summation, as follows:

$$TR = SC \times \sum (IF \times SF)_i \qquad (4)$$

Equation 4 can be rearranged to solve for concentration in soil:

$$SC = \frac{TR}{\sum (IF \times SF)_i} \qquad (5)$$

Equation 5 is used to calculate preliminary remediation goals for chemical contaminants (i.e., not radionuclides). For radionuclides, a relationship is defined between the concentration in soil corresponding to 1 x 10^{-6} in the year 2018 (the year when sites would be released for use, as described previously) and the concentration in soil in 1994, which is used to estimate volumes of contaminated soil requiring remediation action. This relationship is defined as follows:

$$SC_t = SC_o \times DF \qquad (6)$$

where

SC_t	=	Concentration in soil at time t (nominally 2018)
SC_o	=	Concentration in soil at time 0 (assumed to be 1994)
DF	=	Decay factor = 0.5^{β}
β	=	Calculated as $(time_t - time_o)/T_{0.5}$
$T_{0.5}$	=	Radionuclide-specific half-life (EPA 1992)

Equation 5 can then be rearranged to incorporate radioactive decay as follows:

$$SC_o = \frac{TR}{[0.5^{\beta} \times \sum (IF \times SF)_i]} \qquad (7)$$

Equation 7 can then be used to calculate the concentration in soil in 1994 that achieves the target increased cancer risk level in 2018.

The intake factors listed in these equations (one each for inhalation, ingestion, and external radiation) for the occasional-use scenario were calculated using exposure assumptions from *Hanford Site Risk Assessment Methodology* (DOE-RL 1995). These intake factors are shown below:

	Carcinogenic	Radionuclide
Soil ingestion	$2.99 \times 10^{-8}\ d^{-1}$	25.2 g
Inhalation	$1.17 \times 10^{-10}\ d^{-1}$	0.21 g
External exposure	--	0.153 year

3.1.2 Noncarcinogenic Constituents

Preliminary remediation goals for noncarcinogenic contaminants is back-calculated from a target hazard quotient using intake factors and assumptions in the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995). Table A-2 identifies the noncarcinogenic preliminary remediation goals. A hazard quotient of 0.1 is used for individual constituents to account for possible synergistic and additive interactions between chemicals such that the sum of the hazard quotients for all the contaminants at the site does not exceed 1.0 (DOE-RL 1994a). Preliminary remediation goals were not calculated for noncarcinogenic effects of radionuclides. Carcinogenic effects of radionuclides are considered by EPA to be of greater concern than noncarcinogenic effects.

The preliminary remediation goals calculation methodology follows the equations outlined in the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995). Calculation of preliminary remediation goals for noncarcinogenic contaminants were based on the soil ingestion exposure pathway, using assumptions corresponding to an occasional-use scenario, and reference doses presented in a qualitative risk assessment. The soil ingestion exposure assumptions are based on the soil ingestion rate for a child, which is considered to be higher than an adult soil ingestion rate. The soil ingestion intake factor used in calculating the preliminary remediation goals for noncarcinogenic contaminants was $2.4 \times 10^{-7}\ d^{-1}$. Soil ingestion was the sole exposure pathway considered in developing preliminary remediation goals for noncarcinogenic contaminants, because inhalation reference doses are not available for most of the contaminants in soil.

3.2 ECOLOGICAL

Preliminary remediation goals are not calculated in the Process Document for the protection of ecological receptors because no standard methods currently exist for the derivation of preliminary remediation goals protective of animal or plant populations or natural ecosystems. The preliminary remediation goals protective of human health are used in lieu of ecological-based goals, and these human health-based goals are applied to the 0 to 3 m (0 to 10 ft) zone of contact where plants and animals can be exposed.

The human health preliminary remediation goals for radionuclide contaminants are likely adequate for protecting plant and animal populations (NAS 1972; ICRP 1977; EPA 1993), as discussed in Section 2.5 of the Process Document. For inorganic and organic contaminants, the preliminary remediation goals calculated to protect groundwater or human health were almost always more restrictive than some initial estimates of ecological-based remediation goals (see Section 2.5). Therefore, the human health or groundwater protection-based preliminary remediation goals for inorganics and organics were used in lieu of animal or plant-based goals. Section 2.5 of the Process Document discusses the uncertainties involved in trying to develop ecological-based preliminary remediation goals.

3.3 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Applicable or relevant and appropriate requirements are federal or state promulgated standards defining acceptable levels of constituents in water, air, or soil (or a method to determine an acceptable level) for the protection of human health or other beneficial use. The ARARs applicable to this FFS are discussed in Section 2.0 and listed in Appendix C. Of those ARARs and "to be considered" requirements, the only requirements with quantitative soil limits are the State of Washington's *Model Toxics Control Act* for chemicals and the DOE Orders for radionuclides. The *Model Toxics Control Act* has a standard method (Method B) to determine acceptable levels for nonradioactive constituents. The method uses a residential exposure-scenario with a target risk of 1×10^{-6}. The *Model Toxics Control Act* is listed in Appendix C as a potential ARAR for the 100 Area (if frequent-use scenario is deemed appropriate), and was also used for comparison purposes in the *Feasibility Study Report for the 200-BP-1 Operable Unit*[1] (DOE-RL 1993b). The *Model Toxics Control Act* Method B for estimating allowable contaminant concentrations in soil was evaluated in the Sensitivity Analysis Report (Appendix D). Several of the Method B allowable levels in soil are more stringent than human health preliminary remediation goals listed in Table A-2, but less stringent than the groundwater protection preliminary remediation goals.

The values defined by the *Model Toxics Control Act* will be more conservative than the risk-based calculations discussed in the Process Document because of different exposure scenarios. The *Model Toxics Control Act* values may be used in lieu of other sources of preliminary remediation goals.

The DOE Orders require limiting the dose from residual radioactivity to <100 mrem/yr. This is considered a "to be considered" requirement, because the DOE Orders are not promulgated at this time. However, the DOE Orders are the only available

[1]The 200-BP-1 Operable Unit FS (DOE-RL 1993b) is the most recent feasibility study conducted at the Hanford Site. It is considered in this FFS because the actions, location (i.e., Hanford), contaminants, available disposal facilities, and regulating agencies are all similar. Also, the 200-BP-1 feasibility study has been reviewed by the regulating agencies and meets their expectations.

source of soil limits, and DOE has the authority to regulate radionuclides on DOE sites (one of which is Hanford). The dose limit of 100 mrem/yr represents a cumulative dose from contaminants, and therefore, is not used to determine preliminary remediation goals for individual contaminants.

3.4 PROTECTION OF GROUNDWATER

Nonradionuclide groundwater maximum contaminant levels are derived from federally promulgated regulations, such as the *Safe Drinking Water Act* (40 CFR 141) and the RCRA groundwater standards (40 CFR 264). The State of Washington's *Model Toxics Control Act* groundwater maximum contaminant levels are used when a federal maximum contaminant level is not available. The *Model Toxics Control Act* defines default vadose zone concentrations that are protective of groundwater as 100x the groundwater maximum contaminant levels (WAC 173-340-740 (3)(A)). This default applies unless vadose zone modeling is employed to determine site-specific concentrations that protect groundwater.

Because the *Safe Drinking Water Act* and the *Model Toxics Control Act* do not contain a comprehensive list of maximum contaminant levels for radionuclides, the derived concentration guides from the DOE's *Radiation Protection of the Public and the Environment* (DOE 1993) for radionuclides in groundwater are used to determine acceptable soil concentrations for radionuclides. The derived concentration guides are based on a 100 mrem/yr dose to offsite individual (from beta/gamma radiation).

In place of the default *Model Toxics Control Act* 100x rule, this FFS uses the Summers Model, documented in *Determining Soil Response Action Levels Based on Potential Contaminant Migration to Ground Water; A Compendium of Examples* (EPA 1989a) to determine soil concentrations protective of groundwater. The Summers Model differs from the *Model Toxics Control Act* 100x rule because it uses site and contaminant specific information in addition to the groundwater maximum contaminant levels (derived concentration guides for radionuclides), to determine allowable soil contaminant concentration. Table A-3 lists the parameters used in the Summers Model. Because the Summers Model uses site- and contaminant-specific information, it is considered more representative than the *Model Toxics Control Act* 100x rule. Also, certain assumptions in the Summers Model provide conservatism in the calculations, such as assuming a uniform contaminant concentration throughout the vadose zone, and assuming that no groundwater mixing occurs between the site and the point of compliance. Further conservatism can be introduced, depending on the parameter values used in the model calculations.

The equation to calculate allowable constituent concentration in vadose soil is

$$C_s = K_d \bullet C_p \bullet \frac{1\ L}{1000\ ml} \qquad (8)$$

where C_s is the allowable constituent concentration in soil (pCi/g or mg/kg), C_p is the allowable leachate concentration (pCi/L or ug/L), and K_d is the soil-water distribution coefficient (ml/g). The allowable leachate concentration is calculated as

$$C_p = \frac{C_{gw}(Q_p + Q_{gw}) - Q_{gw} \bullet C_i}{Q_p} \qquad (9)$$

where c_{gw} is the allowable concentration in groundwater based on maximum contaminant levels or derived concentration guides (pCi/L or ug/L), Q_p is the infiltration flow rate (ft^3/day), Q_{gw} is the groundwater flow rate (ft^3/day), and C_i is the initial or background concentration in groundwater (pCi/L or ug/L). The infiltration flow rate (Q_p) equals the product of the recharge rate (ft/day) and the horizontal area of contamination (ft^2). The groundwater flow rate is calculated as

$$Q_{gw} = K \bullet i \bullet h \bullet w \qquad (10)$$

where K and i are the hydraulic conductivity in the aquifer (ft/day) and hydraulic gradient (ft/ft) in the aquifer, respectively, and h and w are the thickness (ft) and width (ft) of the zone of mixing in the aquifer, respectively.

If the soil-water distribution coefficient (K_d) is zero or unknown, the equation for calculating the allowable constituent concentration in soil becomes

$$C_s = Cp\frac{\theta_v}{P_b}\left(\frac{1\ mg}{1000\ ug}\ or\ \frac{1\ kg}{1000\ g}\right) \qquad (11)$$

where θ_v is the soil volumetric water content and p_b is the soil dry (bulk) density (kg/L). If the constituent is organic, the soil-water distribution coefficient is calculated as

$$K_d = K_{oc} \bullet C \qquad (12)$$

where K_{oc} is the organic carbon partition coefficient (ml/g) and C is the fractional organic carbon content of the soil (g/g).

The following assumptions are made when calculating acceptable soil concentrations:

1. The aquifer is the Hanford/Ringold Formation. Average hydraulic conductivity is assumed to be 30.4 m/day (100 ft/day) (DOE-RL 1993c).

2. The hydraulic gradient is estimated to be 0.09 cm/cm (0.003 ft/ft) (DOE-RL 1993c).

3. Initial concentration in groundwater is assumed to be zero for all constituents (this is accurate for most radionuclides except for naturally occurring constituents).

4. Zone of mixing is 9 m (30 ft) thick (Hartman and Lindsey 1993).

5. Recharge rate is 10 cm/yr (3.94 in./yr) (Gee 1987).

6. Allowable concentration in groundwater is the derived concentration guides for radionuclides; a combination of primary maximum contaminant levels, secondary maximum contaminant levels, and RCRA groundwater standards for nonradionuclides; and *Model Toxics Control Act* groundwater maximum contaminant levels when a federal standard is not available.

7. Distribution coefficients for radionuclides and inorganics are as documented in Ames and Serne (1991).

8. Soil moisture content averages about 5% (9% by volume) (DOE-RL 1994b).

9. Soil dry density is about 110 pcf (1.8 kg/l).

10. Organic carbon of Hanford Site soil is 0.1% by weight (Ames and Serne 1991).

11. Organic carbon partitioning coefficients for organics are as documented in EPA (1986).

12. Waste site area is assumed to be that of the 116-C-5 retention basins (243.8 x 243.8 m [800 x 800 ft]) or (59,457.95 m^2 [640,000 ft^2]).

Using the above stated assumptions, the allowable soil concentration for cesium-137 can be calculated as follows:

First calculate Cp;

Cgw = 1146 pCi/l

Qp = (800 ft * 0.0009 ft/day) = 575 ft^3/day
Qgw = (100 ft/day * 0.003) * 30 ft * 800 ft = 7200 ft^3/day
Ci * Qgw = 0

Cp = 1146 pCi/l * (575 + 7200 ft^3/day)/575 ft^3/day - 15,500 pCi/l

Then calculate Cs;

Kd = 50 ml/g
Cs = 50 ml/g * 15,500 pCi/l * 1.01/1000 ml = 775 pCi/g.

The Summers Model aids in delineating which sites require remedial action and how much action is required. If in situ general response actions change the environment such that certain parameters change, the calculated allowable soil contamination level may change accordingly. For example, the surface barrier evaluated in this FFS would reduce the amount of infiltration entering the contaminated vadose zone. Table A-4 presents the allowable soil contaminant concentrations, assuming the barrier reduces the infiltration rate from 10 cm (3.9 in.)/yr to 0.5 mm (0.0195 in.)/yr. If the soil contaminant levels exceed the values in Table A-4, then the barrier would not adequately protect the groundwater. In this report, the application of this approach is referred to as the "reduced infiltration scenario."

3.5 BACKGROUND

Background concentrations are considered the lowest practical levels for a cleanup action. Background investigations for nonradioactive constituents have been completed and are documented in *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analyses* (DOE-RL 1993d). The study has produced statistical distributions of background concentrations for nonradioactive constituents. The appropriate confidence limit for the distribution of background data for use in the interim remedial measure will be documented in the Interim Record of Decision (IROD). The 95% upper threshold limit for inorganic constituents is presented in Table A-5.

Characterization of radioactive constituents is in progress and values should be available at the time the IROD is written. Some preliminary radionuclide background values are presented in Table A-2. When considering the radionuclide background data presented in Table A-2, it should be noted that the data is very sparse for some isotopes, both in number and in geographic coverage. Most of the samples were collected on the Hanford Site, but a few are from distant locations, such as Moses Lake, Yakima, and Walla Walla.

3.6 CONTRACT REQUIRED QUANTITATION LIMITS OR CONTRACT REQUIRED DETECTION LIMITS

Contract required laboratory detection limits for each contaminant will be used in lieu of the human health or protection of groundwater preliminary remediation goals if the human health or groundwater preliminary remediation goals are below the required levels of detection (see Table A-2).

This is in agreement with the *Model Toxics Control Act* (WAC 173-340-700(3)(a)), which states that:

> "...cleanup levels for hazardous substances not addressed under applicable state and federal laws...are established at concentrations which do not exceed the natural background concentration or the practical quantitation limit for the substance in question."

Also, EPA's risk assessment guidance (EPA 1989b) states that contract required quantitation limits or contract required detection limits may be considered as cleanup criteria after the contaminants are verified as legitimate and the responsible parties have negotiated to obtain lower limits, such as using special analytical services before investigation. The contract required quantitation limits/contract required detection limits used in lieu of more restrictive remediation goals are:

- Based on contaminants of potential concern. The contaminants used in the FFS have been through data validation, screening in the qualitative risk assessment, and screening in the limited field investigation before being placed on the contaminants of potential concern list. Thus, they are legitimate contaminants.

- Taken from operable unit-specific work plans (see Table A-2). The Tri-Parties negotiated and approved the work plans that define CRQL/CRDL. These CRQL/CRDL are used, when appropriate, in the FFS as preliminary remediation goals.

4.0 APPLICATION OF PRELIMINARY REMEDIATION GOAL VALUES

Within each zone, there may be preliminary remediation goals values available for more than one receptor. In all cases, the most stringent value is used as the preliminary remediation goals for a given constituent in a given zone. It is understood, however, that the preliminary remediation goals value must not be below background concentrations and must be above detection limits. Table A-2 identifies the preliminary remediation goals for each constituent in each zone (note that background values are not represented because no single set of background concentrations has been identified for the 100 Area soils). This table will be reevaluated once final background values are established.

5.0 REFERENCES

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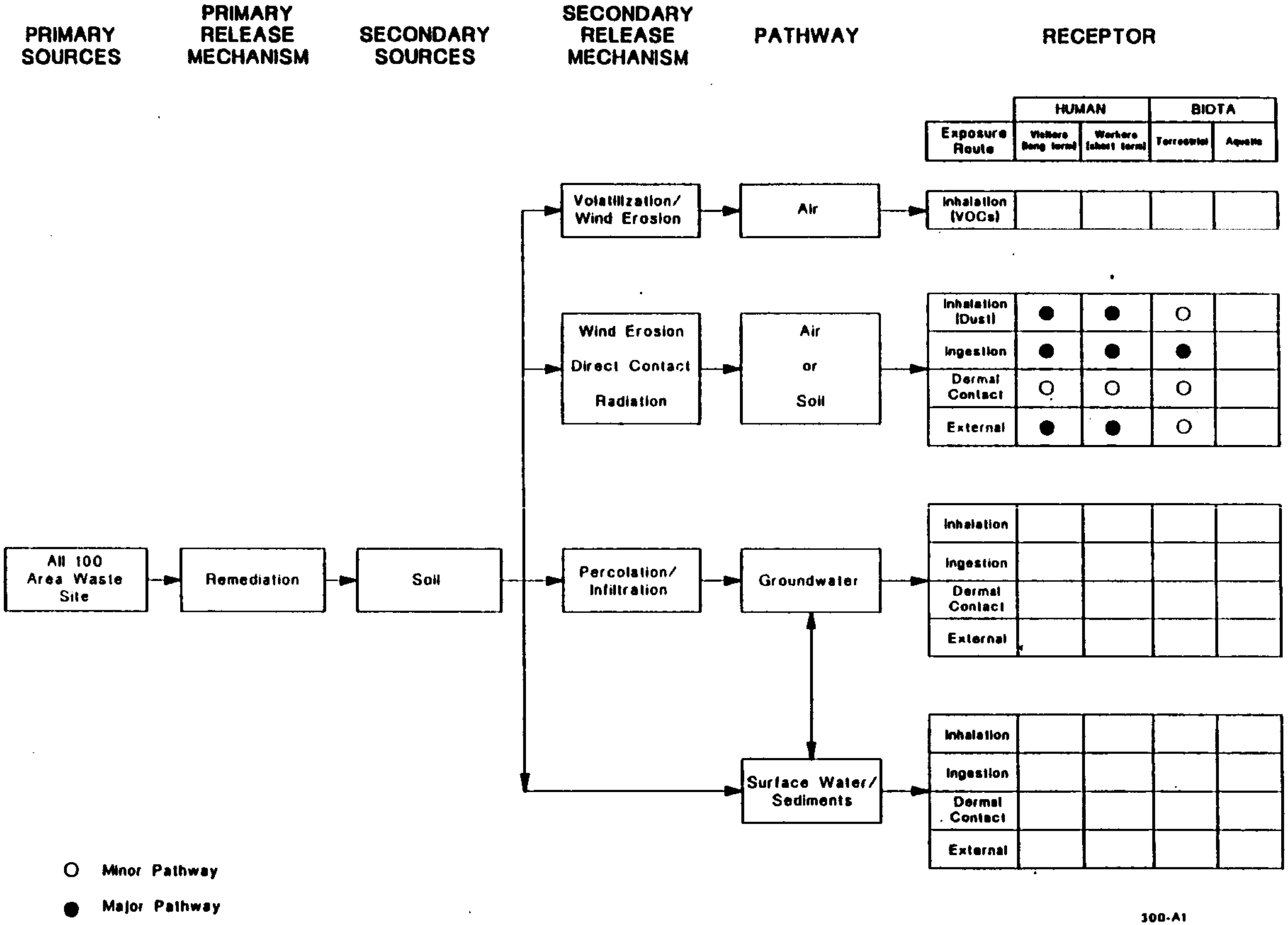

Figure A-1. 100 Area Source Operable Unit FFS Conceptual Exposure Pathway Model.

Table A-1. Zones of Contact Between Receptors and Contaminants in the 100 Area.

Zone	Depth (m)	Receptor	Exposure Pathway	Potential Preliminary Remediation Goals
1	0-3 m (0-10 ft)	Humans 0-1 m (0-3 ft)	ingestion, inhalation, and exposure to external radiation	Human health Plant-specific Animal-specific ARAR Protection of Groundwater
		Plants 0-3 m (0-10 ft)	uptake from soil into plant biomass	
		Animals 0-3 m (0-10 ft)	ingestion of plants	
2	All depths above groundwater	Protection of groundwater resource		Protection of Groundwater

ARARs - applicable or relevant, and appropriate requirements

Table A-2. Potential Preliminary Remediation Goals.

	HUMAN-HSRAM (a,b)		PROTECTION of GROUNDWATER (a,c)	BACKGROUND (d,e)	CRQL/CRDL (f)	ZONE SPECIFIC PRG	
	TR = 1E-06	HQ = 0.1				1 (g) 0-10 ft.	2 (h) >10 ft.
RADIONUCLIDES (pCi/g)							
Am-241	76.9	N/A	31	N/C	1	31	31
C-14	44,200	N/A	18	N/C	50	50	50
Cs-134	3,460	N/A	517	N/C	0.1	517	517
Cs-137	5.68	N/A	775	1.8	0.1	6	775
Co-60	17.5	N/A	1,292	N/C	0.05	18	1,292
Eu-152	5.96	N/A	20,667	N/C	0.1	6	20,667
Eu-154	10.6	N/A	20,667	N/C	0.1	11	20,667
Eu-155	3,080	N/A	103,000	N/C	0.1	3,080	103,000
H-3	2,900,000	N/A	517	N/C	400	517	517
K-40	12.1	N/A	145	19.7	4	19.7	145
Na-22	545	N/A	207	N/C	4 (i)	207	207
Ni-63	184,000	N/A	46,500	N/C	30	46,500	46,500
Pu-238	87.9	N/A	5	N/C	1	5	5
Pu-239/240	72.8	N/A	4	0.035	1	4	4
Ra-226	1.1	N/A	0.03	0.98	0.1	1	1
Sr-90	1,930	N/A	129	0.36	1	129	129
Tc-99	28,900	N/A	26	N/C	15	26	26
Th-228	7,260	N/A	0.1	N/C	1 (j)	1	1
Th-232	162	N/A	0.01	N/C	1	1	1
U-233/234	165	N/A	5	1.1	1	5	5
U-235	23.6	N/A	6	N/C	1	6	6
U-238 (k)	58.4	N/A	6	1.04	1	6	6
INORGANICS (mg/kg)							
Antimony	N/A	167	0.002	N/C	6	6	6
Arsenic	16.2	125	0.013	9	1	9	9
Barium	N/A	29,200	258	175	20	258	258
Cadmium	1,360	417	0.775	N/C	0.5	0.8	0.775
Chromium VI	204	2,086	0.026	28	1	28	28
Lead	N/C	N/C	8	14.9	0.3	14.9	14.9
Manganese	N/A	2,086	13	583	1.5	583	583
Mercury	N/A	125	0.31	1.3	0.02	1.3	1.3
Zinc	N/A	100,000	775	79	2	775	775
ORGANICS (mg/kg)							
Aroclor 1260 (PCB)	4.34	N/A	1.37	<0.033	0.033	1	1
Benzo(a)pyrene	5	N/A	5.68	<0.330	0.330	5	6
Chrysene	N/A	N/A	0.01	<0.330	0.330	0.330	0.330
Pentachlorophenol	300	N/A	0.27	<0.8	0.8	0.8	0.8

TR=Target Risk; HQ= Hazard Quotient; N/A=Not Applicable; N/C=Not calculated
(a) Risk-based numbers based on a 1E-06 increased cancer risk for carcinogens and radionuclides and a noncancer hazard quotient of 0.1 for noncarcinogens.
(b) Occasional Use Scenario
(c) Based on Summer's Model (EPA 1989b)
(d) Status Report, Hanford Site Background: Evaluation of Existing Soil Radionuclide Data (Letter #008106)
(e) Hanford Site Background: Part 1, Soil Background for Nonradioacitve Analytes, DOE/RL-92-24, Rev. 2.
(f) Based on 100-BC-5 OU Work Plan QAPP (DOE-RL 1992)
(g) PRGs are established to be protective of groundwater, human and ecological receptors.
(h) PRGs are established to be protective of groundwater.
(i) Based on gross beta analysis
(j) Detection limit assumed to be same as Th-232
(k) Includes total U if no other data exist
(l) Value calculated exceeds 1,000,000 ppm therefore use 100,000 ppm as default

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Table A-3. Kd Values Used in the Summer's Method.

Radionuclides	Kd (ml/g)	Inorganics	Kd (ml/g)	Organics	Kd (ml/g)
^{241}Am	200	Antimony	0.05	Aroclor 1260	530
^{14}C	0.05	Arsenic	0.05	Benzo(a)pyrene	5,500
^{134}Cs	50	Barium	25	Chrysene	200
^{137}Cs	50	Cadmium	30	Pentachlorophenol	53
^{60}Co	50	Chromium VI	0.05		
^{152}Eu	200	Lead	30		
^{154}Eu	200	Manganese	50		
^{155}Eu	200	Mercury	30		
^{3}H	0.05	Zinc	30		
^{40}K	4				
^{22}Na	4				
^{63}Ni	30				
^{238}Pu	25				
$^{239/240}Pu$	25				
^{226}Ra	0.05				
^{90}Sr	25				
^{99}Tc	0.05				
^{228}Th	0.05				
^{232}Th	0.05				
$^{233/234}U$	2				
^{235}U	2				
^{238}U	2				

Table A-4. Allowable Soil Concentration - Reduced Infiltration Scenario.

Analyte	Soil Concentration
RADIONUCLIDES	**pCi/g**
^{241}Am	5,012
^{14}C	2,924
^{134}Cs	83,539
^{137}Cs	125,309
^{60}Co	208,848
^{152}Eu	3,341,560
^{154}Eu	3,341,560
^{155}Eu	16,707,800
^{3}H	83,539
^{40}K	23,391
^{22}Na	33,416
^{63}Ni	7,518,510
^{238}Pu	835
$^{239/240}Pu$	627
^{226}Ra	4
^{90}Sr	20,885
^{99}Tc	4,177
^{228}Th	16.708
^{232}Th	2.088
$^{233/234}U$	835
^{235}U	1,002
^{238}U	1,002
INORGANICS	**mg/kg**
Antimony	0.251
Arsenic	2.088
Barium	41,770
Cadmium	125.309
Chromium (VI)	4.177
Lead	1,253
Manganese	2,088
Mercury	50.123
Zinc	125,309
ORGANICS	**mg/kg**
Aroclor 1260	221
Benzo(a)pyrene	919
Chrysene	2
Pentachlorophenol	44

Table A-5. Background Summary Statistics and Upper Threshold Limits for Inorganic Analytes.

Analyte	95% UTL[a](mg/kg)
Aluminum	15,600
Antimony	15.7[b]
Arsenic	8.92
Barium	171
Beryllium	1.77
Cadmium	0.66[b]
Calcium	23,920
Chromium	27.9
Cobalt	19.6
Copper	28.2
Iron	39,160
Lead	14.75
Magnesium	8,760
Manganese	612
Mercury	1.25
Nickel	25.3
Potassium	3,120
Selenium	5[b]
Silver	2.7
Sodium	1,290
Thallium	3.7[b]
Vanadium	111
Zinc	79
Molybdenum	1.4[b]
Titanium	3,570
Zirconium	57.3
Lithium	37.1
Ammonia	28.2
Alkalinity	23,300
Silicon	192
Fluoride	12
Chloride	763
Nitrite	21[b]
Nitrate	199
Ortho-phosphate	16
Sulfate	1,320

Source: DOE-RL 1993d, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, DOE/RL-92-24, Rev. 1 Draft, U.S. Department of Energy, Richland, Washington.
* NR = Not Reported
[a] 95% confidence limit of the 95th percentile of the data distribution
[b] Limit of detection

APPENDIX B

WASTE SITE GROUP COST ESTIMATES

1.0 COST ESTIMATE SUMMARIES

This appendix presents the methods used to develop the cost models in support of the source operable unit focused feasibility study reports. This appendix also applies the cost models to the Remedial Alternatives for each waste site group and presents them in summary form on the attached tables.

The cost models were developed using the environmental restoration cost models (1994 fiscal year planning baselines) as the starting point. These environmental restoration cost models were revised for the focused feasibility studies to include all costs associated with the Remedial Alternatives. These models are presented in detail in *100 Area Source Operable Unit Focused Feasibility Study Cost Models* (WHC 1994). The cost model document (WHC 1994) describes the work breakdown structure and general assumptions for each cost model.

The cost models were first used to support the cost estimates for the waste site groups discussed in this document. An estimate was made for each waste site group based on the applicable Remedial Alternatives. These estimates are presented in Tables B-1 through B-8. The corresponding Figures B-1 through B-8 graphically represent the estimates with a variation in the unit cost for disposal. The figures were developed using three data points for the disposal unit cost: \$70/cubic yard (the design point), \$700/yd^3 and \$7,000/yd^3. The design point (\$70/yd^3) is based on current estimates for initial construction, operations/maintenance, and anticipated expansion.

Waste Site Group	Cost Summary Table	Cost Summary Figure
Retention Basins	Table B-1	Figure B-1
Sludge Trenches	Table B-2	Figure B-2
Fuel Storage Basin Trenches	Table B-3	Figure B-3
Process Effluent Trenches	Table B-4	Figure B-4
Pluto Cribs	Table B-5	Figure B-5
Dummy Decontamination Cribs and French Drains	Table B-6	Figure B-6
Seal Pit Cribs	No Costs Associated	No Costs Associated
Pipelines	Table B-7	Figure B-7
Burial Grounds	Table B-8	Figure B-8
Decontaminated and Decommissioned Facilities	No Costs Associated	No Costs Associated

2.0 REFERENCES

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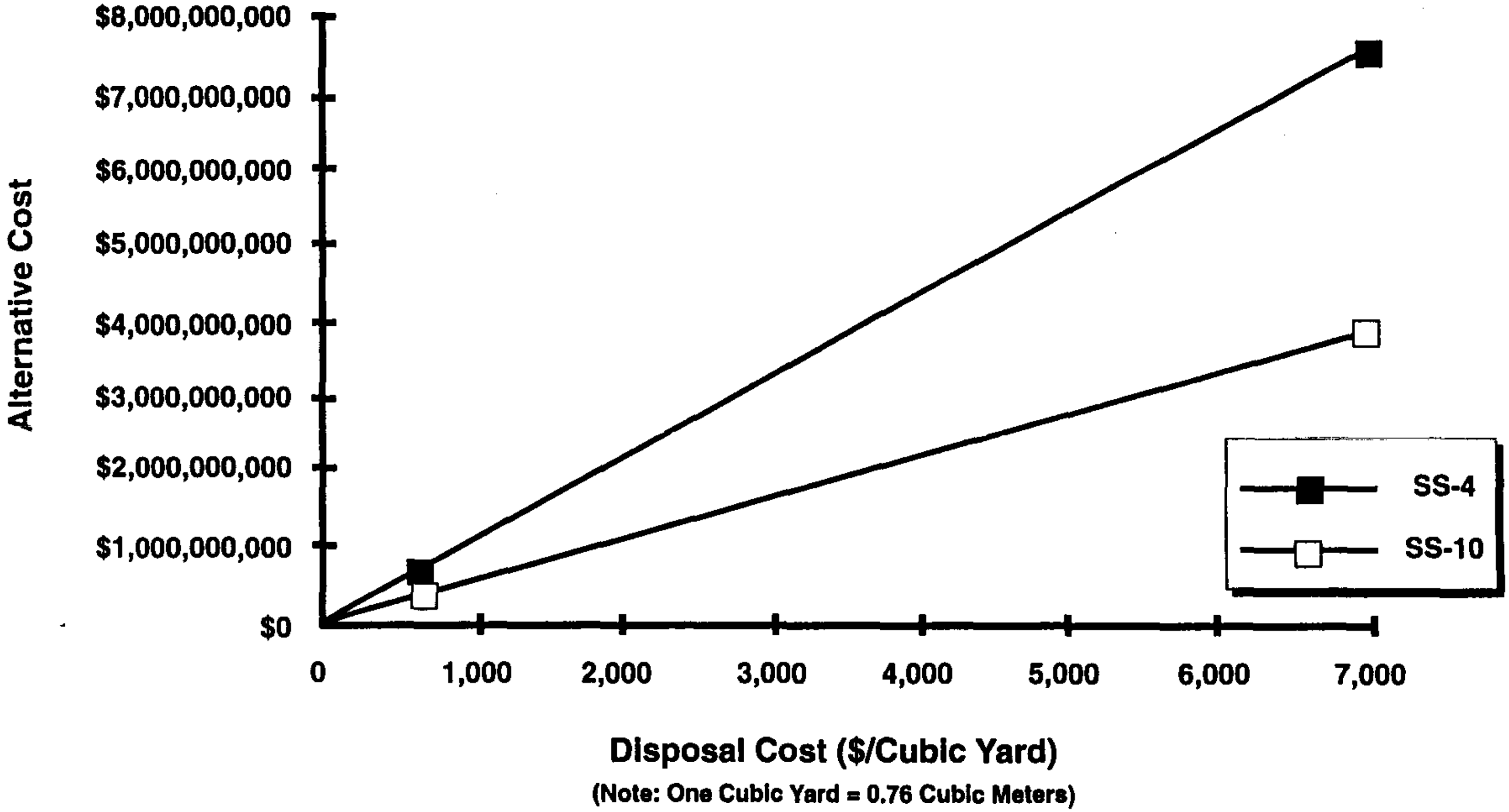


Figure B-1. Retention Basins Disposal Cost Comparison.

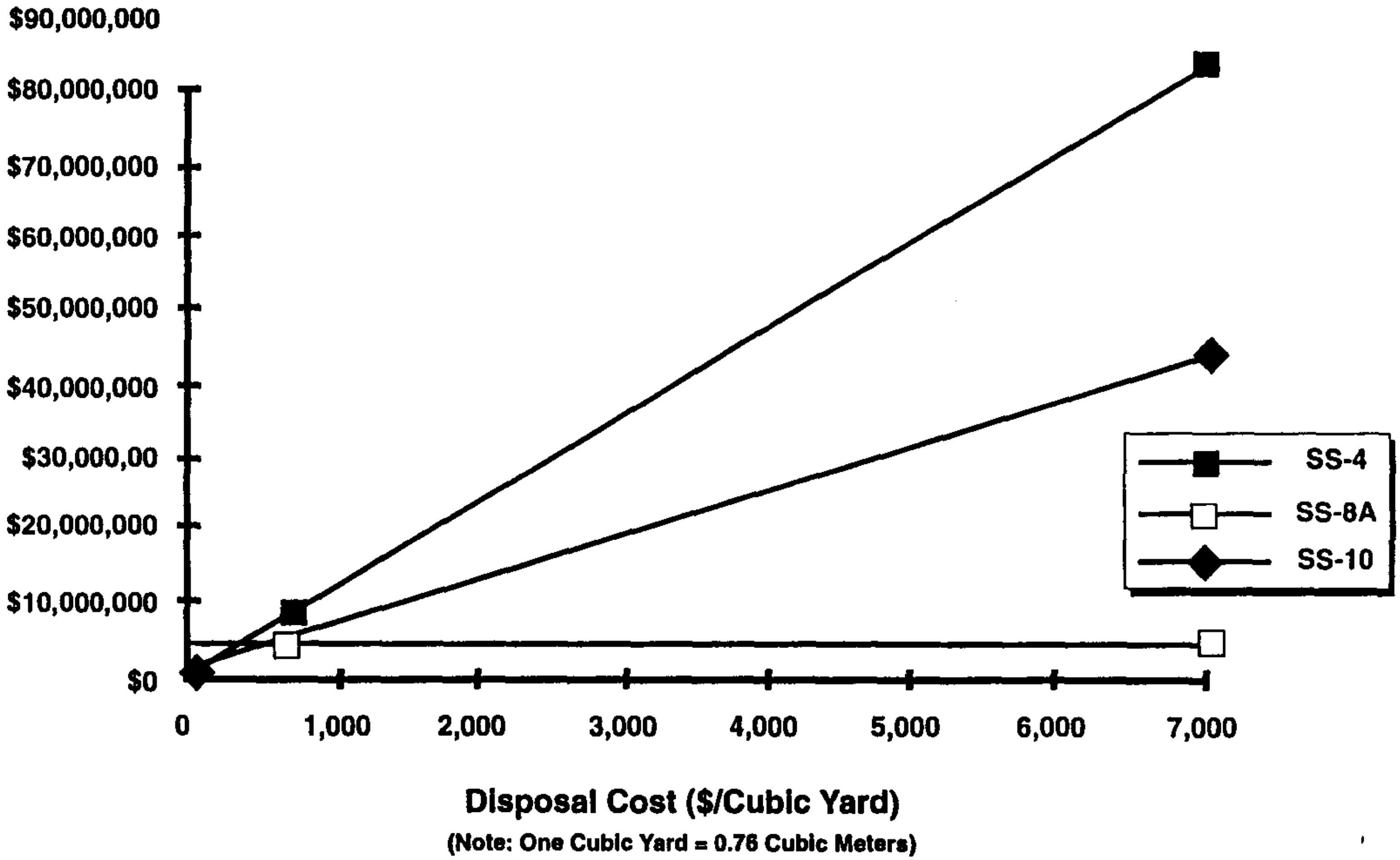


Figure B-2. Sludge Trenches Disposal Cost Comparison.

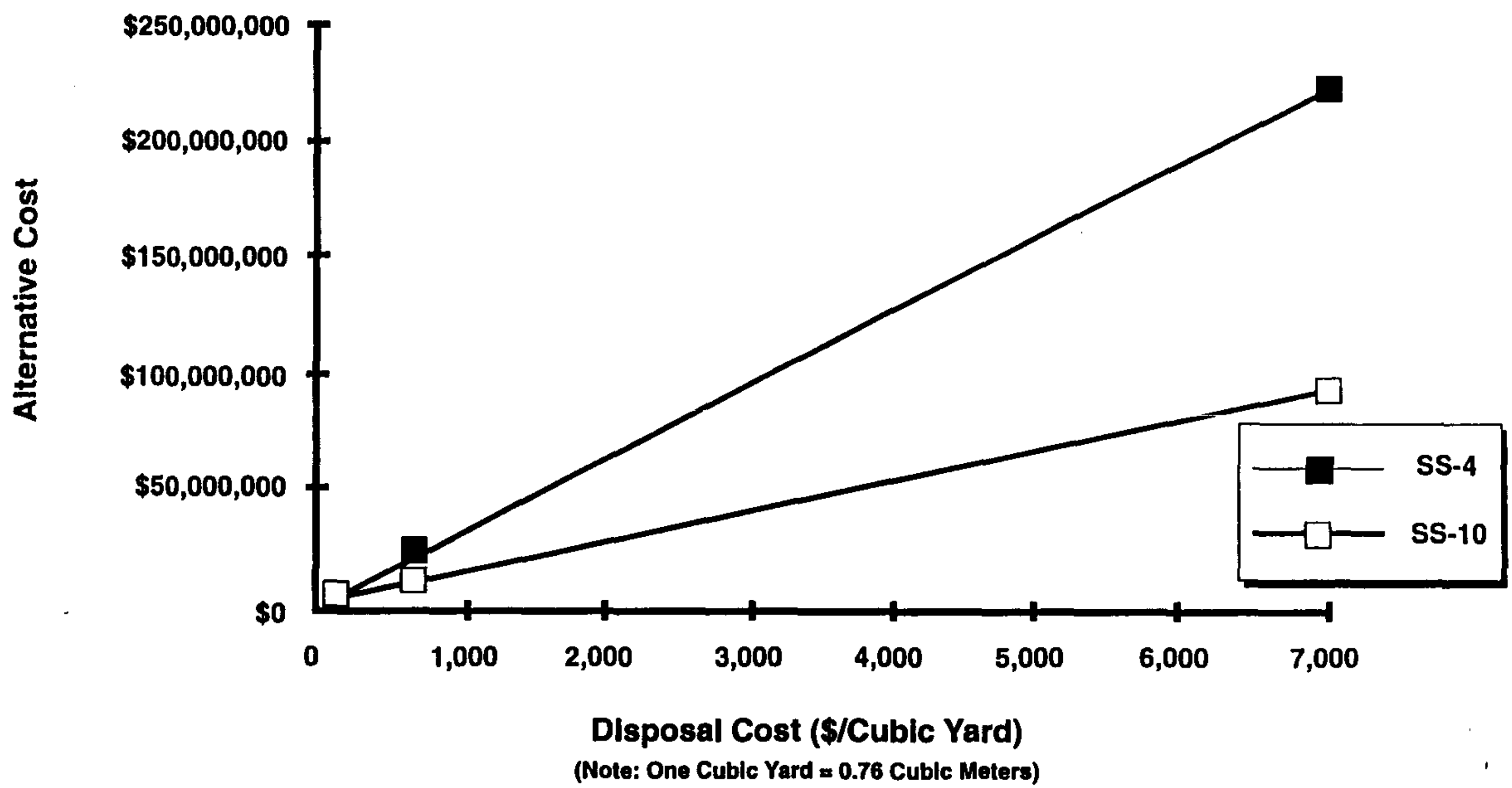


Figure B-3. Fuel Storage Basin Trenches Disposal Cost Comparison.

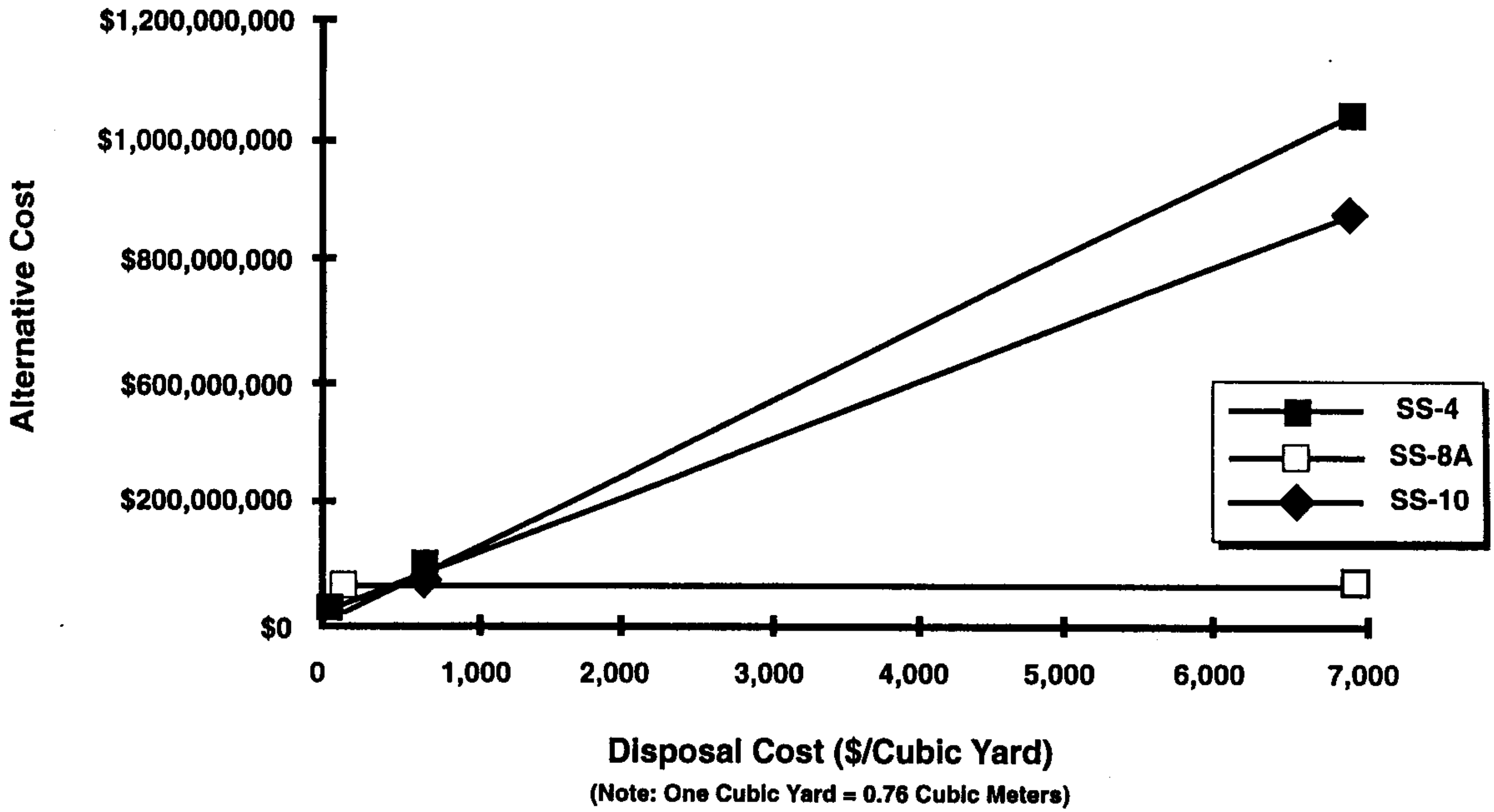


Figure B-4. Process Effluent Trenches Disposal Cost Comparison.

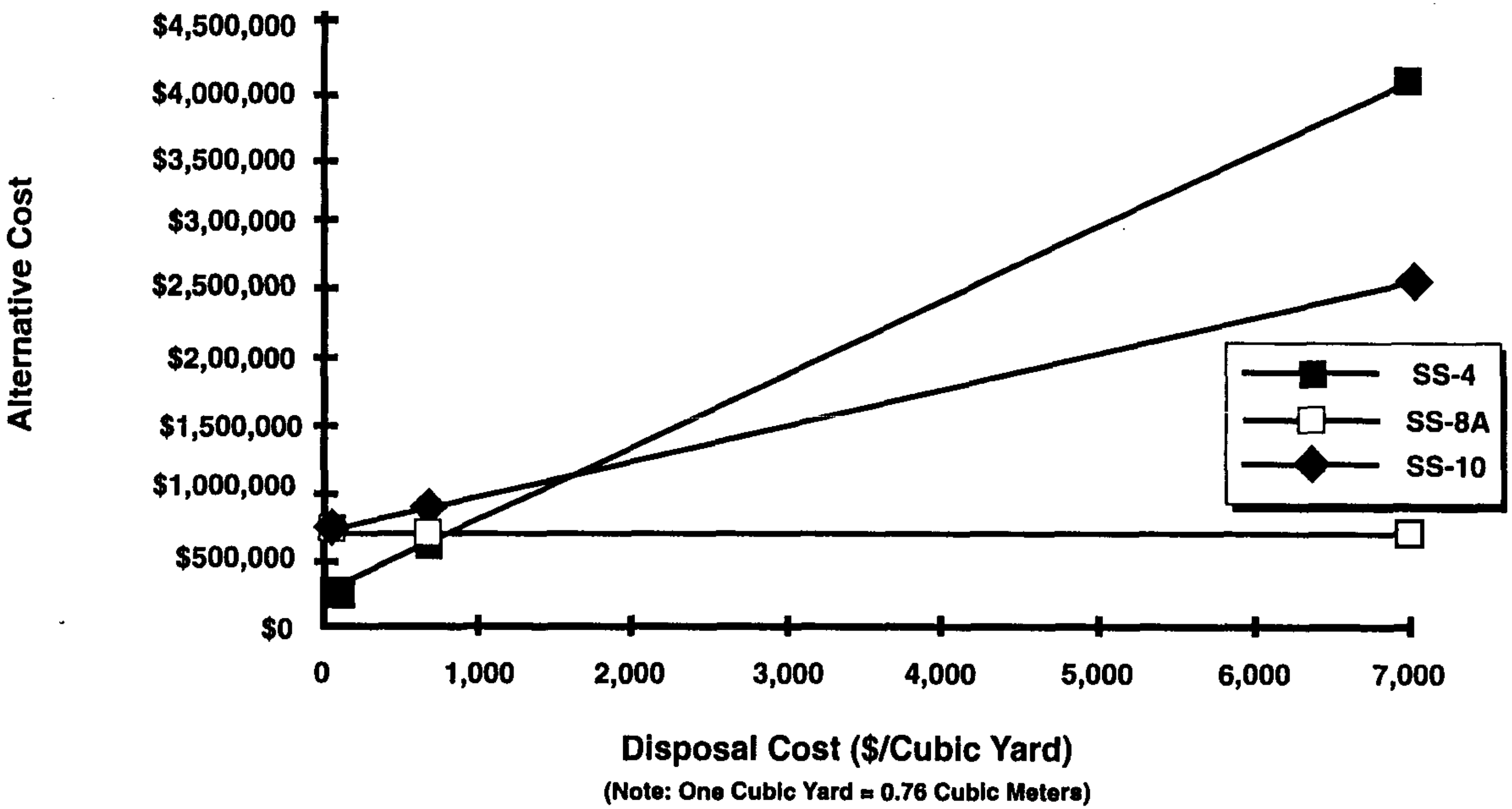


Figure B-5. Pluto Cribs Disposal Cost Comparison.

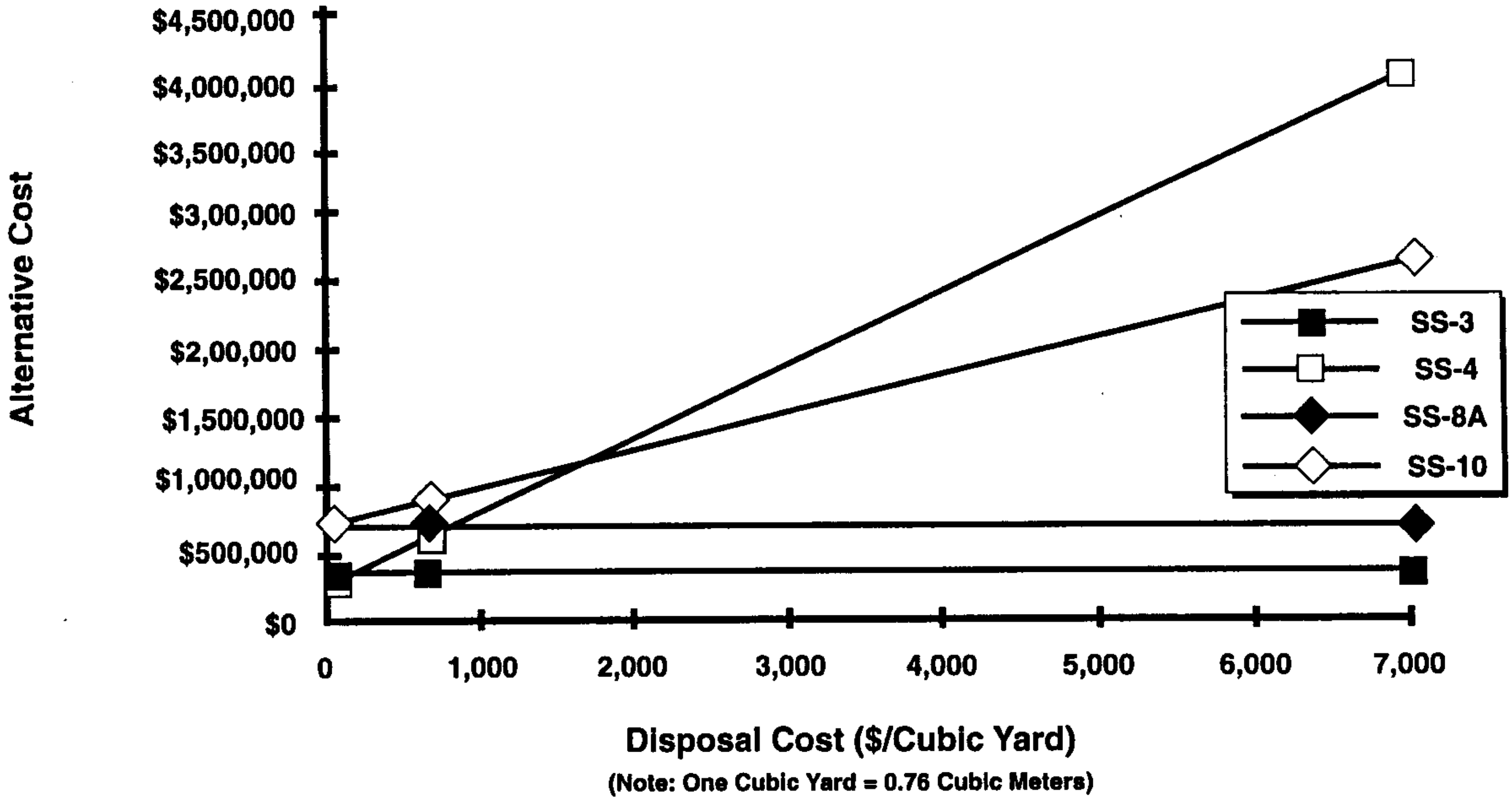


Figure B-6. Dummy Decontamination Cribs and French Drains Disposal Cost Comparison.

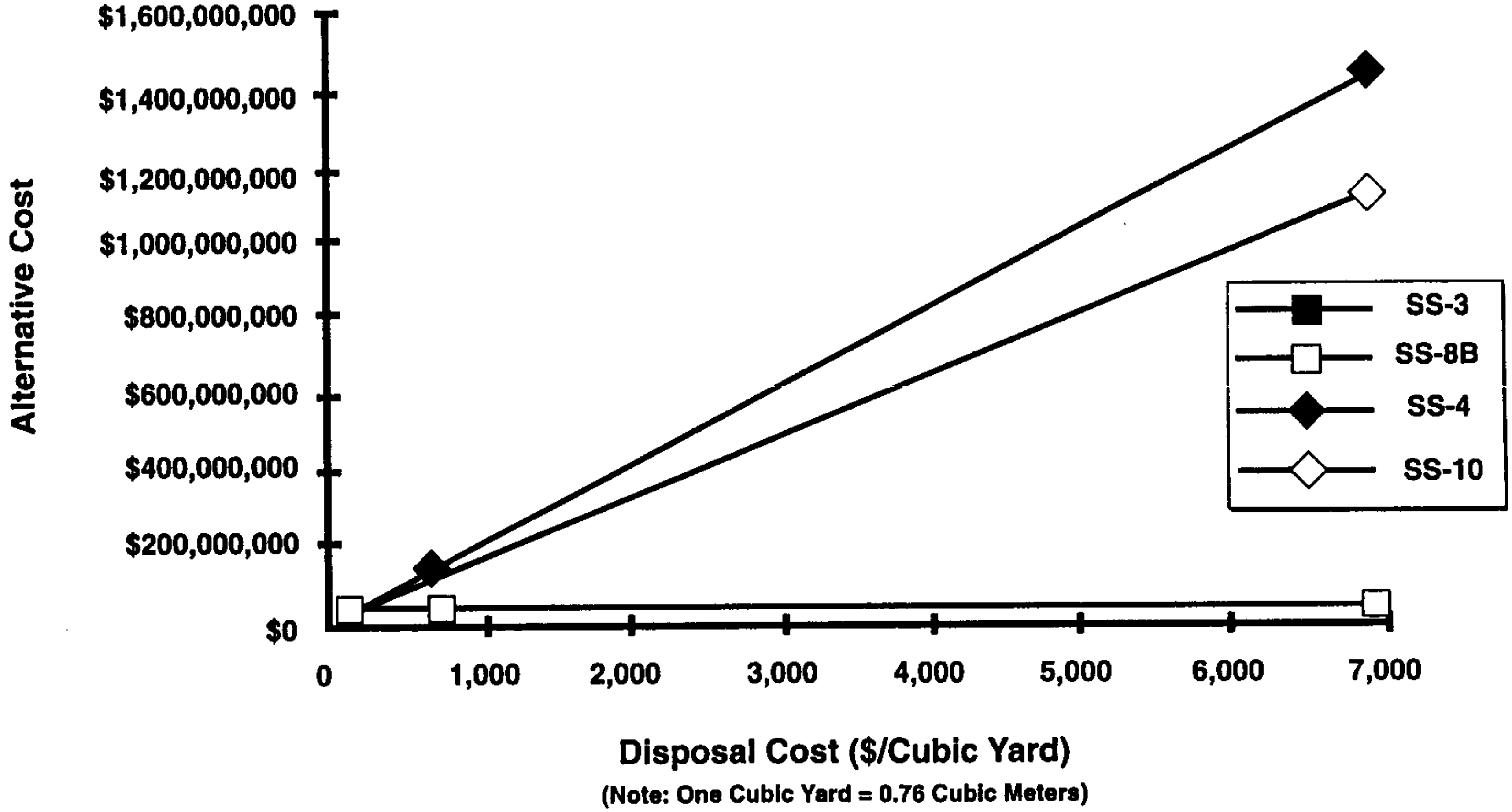


Figure B-7. Pipelines Disposal Cost Comparison.

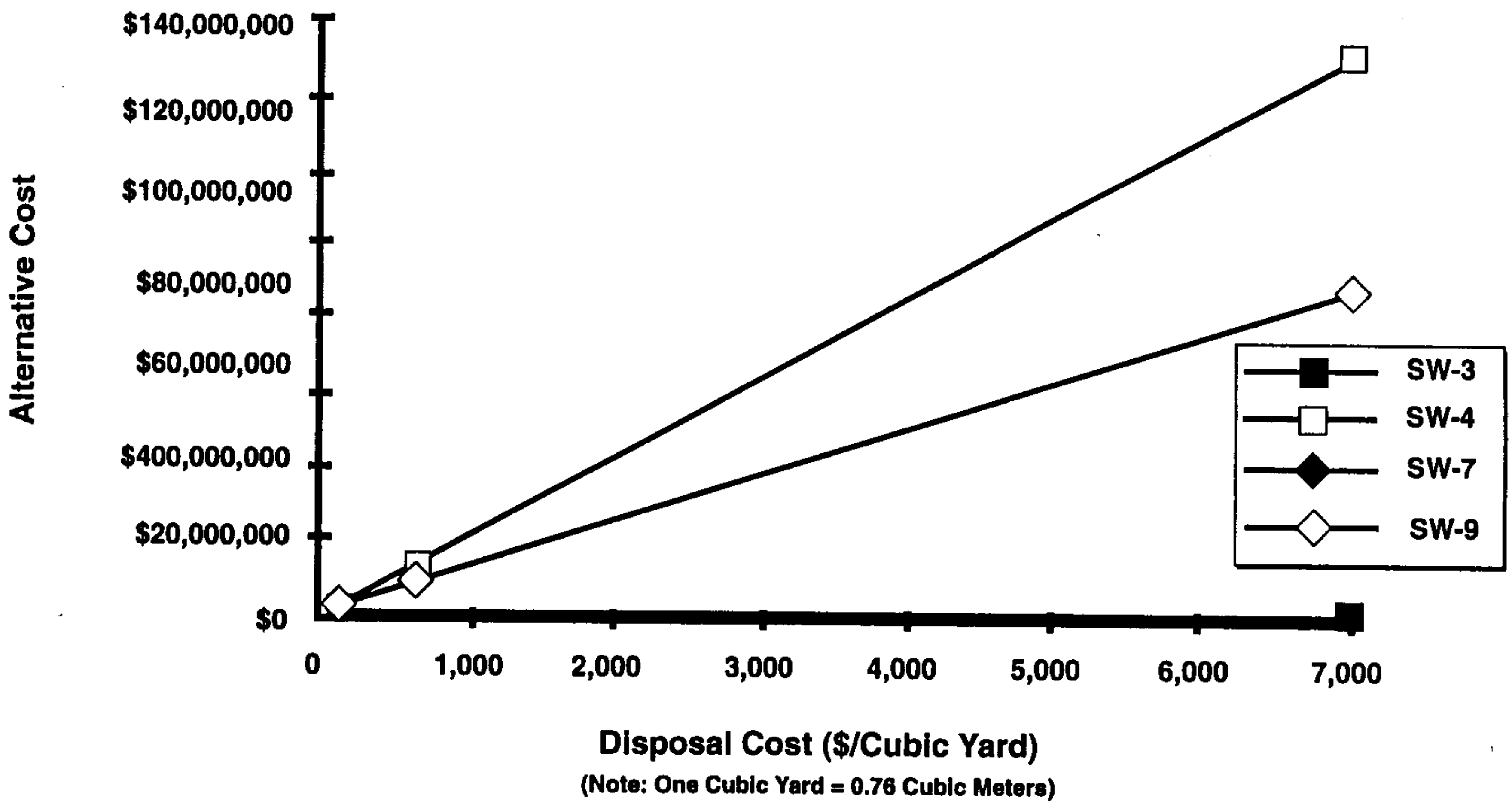


Figure B-8. Burial Grounds Disposal Cost Comparison.

Table B-1. Cost Model Work Breakdown Structure Discussion. (page 1 of 3)

ELEMENTS AND LEVELS	DESCRIPTION
ANA: Offsite Analytical Services	This element represents the offsite contractor performing laboratory analysis of samples.
ANA:02 Laboratory Analysis	This level includes the laboratory analysis of samples. 10% of routine samples and all quality control samples were assumed to be analyzed using level III and level V analysis. Site certification samples were assumed to be analyzed using level IV and V analysis.
SUB: Fixed Price Contractor	This element represents remedial activities performed by the fixed price contractor.
SUB:01 Mobilization & Preparatory	This level includes mobilization of personnel and equipment, preparation for temporary facilities, and construction of temporary facilities.
SUB:02 Sample Collection and Monitoring	This level includes in situ monitoring and field sample collection. Assumptions for sampling include one regular sample per 32 yd^3 removed (one per container) and one quality control sample per twenty regular samples. Site certification samples were assumed to be taken at one per 2,500 ft^2 of bottom area with a minimum of four samples. Additional activities included treatment process sampling, which was assumed to be at a rate of one sample per 1,000 yd^3 of feed material.
SUB:08 Solids Collection & Containment	This level includes excavation, capping, dynamic compaction, and personnel training. The excavation activity includes excavation of noncontaminated soil, excavation of contaminated soil, and demolition of solid waste materials. The capping activity includes all steps necessary to construct the appropriate cap layers. The dynamic compaction activity includes the physical compaction and dust suppression. Personnel training included the standard 40-hour course, a fundamentals of radiation safety course, and an 8-hour supervisor course.
SUB:13 Physical Treatment	This level includes both soil washing and solid waste compaction activities, such as mobilization/setup, personnel training, operation, system maintenance, demobilization, and pre and posttreatment plan submittals. Assumptions include a swell factor of 25% for the material being hauled from the excavation. 90% of the contaminated material was assumed to be compactible.

Table B-1. Cost Model Work Breakdown Structure Discussion. (page 2 of 3)

ELEMENTS AND LEVELS	DESCRIPTION
SUB:14 Thermal Treatment	This level includes thermal desorption mobilization/setup, personnel training, system operation, demobilization, and pre and posttreatment plan submittals. It is assumed that 5% of contaminated soil is organically contaminated and will be thermally treated should organics be present. An additional assumption includes a swell factor of 25% for the material being hauled from the excavation.
SUB:15 Stabilization/Fixation	This level includes In Situ Vitrification mobilization/setup, personnel training, system operation, demobilization, and pre and postconstruction submittals.
SUB:18 Disposal (Other than Commercial)	This level includes transport to the disposal facility and disposal fees/taxes. Assumptions include a 60% swell factor for demolition waste and a 25% swell factor for soils. Reduction in final volume is achieved and quantified based on specific treatment process. A disposal fee of $70/cubic yard was assumed based on current estimates for initial construction, operations/maintenance, and anticipated expansion of the environmental restoration disposal facility.
SUB:20 Site Restoration	This level includes activities, such as load/haul borrow materials, spread/compact borrow and stockpiled materials, revegetation, and irrigation. Assumptions include the availability of onsite borrow materials at no additional charge.
SUB:21 Demobilization	This level includes the demobilization of temporary facilities. Note: Because multiple sites will be cleaned up within an operable unit and a cost for mobilization between sites is already included, no allowance for demobilization is made. Only the cost to remove temporary utilities, fencing, and decontamination facilities are included.
ERC: Environmental Restoration Contractor	This element represents activities performed by the prime contractor.
ERC:02 Onsite Laboratory	This level includes mobile laboratory support, quality assurance/safety oversight, and health physics support. 90% of routine soil and solid waste samples were assumed to be analyzed using level III analysis. Routine sampling was assumed to occur at one sample per every 32 yd^3 removed (one per container.)
ERC:08 Solids Collection & Containment	This level includes personnel protection services, including equipment, maintenance, and laundry services.

Table B-1. Cost Model Work Breakdown Structure Discussion. (page 3 of 3)

ELEMENTS AND LEVELS	DESCRIPTION
Subcontractor Material Procurement Rate	The materials procurement rate reflects the activities associated with procurement or direct materials, inventories, and subcontracts.
Project Management/Construction Management	This cost accounts for project management, construction management, and office support personnel.
General & Administrative/Common Support Pool	The general and administrative costs consist of indirect costs of activities that benefit the company and cannot be identified to a specific end cost objective. The common support pool provides for site-wide services of which the company pays a proportional share.
Contingency	A contingency value is calculated for the various waste site groups based on an evaluation of the various levels, the relative importance of the factor to successful completion of the action, and the probability that the factor will change.
Total, Capital, Annual Operations and Maintenance	The total represents the costs associated with the remedial action. The total cost includes capital and operations and maintenance of a cap. These costs are accounted for through the year 2018.
Present Worth	Present worth is calculated using a 5% discount rate over the life of the activity.

Table B-2. Cost Summary for Retention Basins.

Cost Element		SS-4	SS-10
ANA: Offsite Analytical Services			
ANA:02	Laboratory Analysis	896,730	2,791,230
SUB: Fixed Price Contractor			
SUB:01	Mobilization and Preparatory	98,320	86,895
SUB:02	Sample Collection and Monitoring	655,060	1,687,645
SUB:08	Solids Collection and Containment	1,488,360	2,701,331
SUB:13	Physical Treatment		24,631,614
SUB:18	Disposal (Other than Commercial)	42,082,870	23,978,104
SUB:20	Site Restoration	5,429,140	4,582,906
SUB:21	Demobilization	19,930	17,686
ERC: Environmental Restoration Contractor			
ERC:02	Onsite Laboratory	1,138,810	3,252,496
ERC:08	Solids Collection and Containment	117,830	367,196
Subcontractor Materials Procurement Rate		497,740	576,862
Project Management/Construction Management		7,729,210	9,282,410
General and Admin./Common Support Pool		15,110,600	18,147,112
Contingency		27,095,250	34,078,290
Total		102,359,830	126,181,775
Capital		102,359,830	101,704,269
Annual Operations and Maintenance		0	7,649,221
Present Worth		95,988,999	113,522,862

SS-3/SW-3: Containment
SS-4/SW-4: Removal/Disposal
SS-8A/SS-8B/SW-7: In Situ Treatment
SS-10/SW-9: Removal/Treatment/Disposal

Table B-3. Cost Summary for Sludge Trenches.

Cost Element		SS-4	SS-8A	SS-10
ANA: Offsite Analytical Services				
ANA:02	Laboratory Analysis	54,730	-	84,200
SUB: Fixed Price Contractor				
SUB:01	Mobilization and Preparatory	52,930	50,880	58,720
SUB:02	Sample Collection and Monitoring	22,070	10,370	29,110
SUB:08	Solids Collection and Containment	49,220	30,350	54,230
SUB:13	Physical Treatment	-	-	436,620
SUB:14	Thermal Treatment	-	-	-
SUB:15	Stabilization/Fixation	-	2,425,230	-
SUB:18	Disposal (Other than Commercial)	476,830	-	270,280
SUB:20	Site Restoration	132,560	93,660	114,200
SUB:21	Demobilization	13,890	13,960	13,890
ERC: Environmental Restoration Contractor				
ERC:02	Onsite Laboratory	58,900	205,630	101,880
ERC:08	Solids Collection and Containment	4,220	31,650	8,790
Subcontractor Materials Procurement Rate		54,570	191,580	71,320
Project Management/Construction Management		129,780	458,000	173,850
General and Admin./Common Support Pool		253,710	895,380	339,880
Contingency		443,160	1,498,270	650,070
Total		1,746,550	5,904,950	2,407,030
Capital		1,746,550	3,614,830	2,130,290
Annual Operations and Maintenance		0	2,290,120	276,740
Present Worth		1,665,934	5,630,268	2,302,000

SS-3/SW-3: Containment
SS-4/SW-4: Removal/Disposal
SS-8A/SS-8B/SW-7: In Situ Treatment
SS-10/SW-9: Removal/Treatment/Disposal

Table B-4. Cost Summary for Fuel Storage Basin Trenches.

Cost Element		SS-4	SS-10
ANA: Offsite Analytical Services			
ANA:02	Laboratory Analysis	134,720	202,080
SUB: Fixed Price Contractor			
SUB:01	Mobilization and Preparatory	48,220	54,020
SUB:02	Sample Collection and Monitoring	90,500	109,850
SUB:08	Solids Collection and Containment	197,440	210,690
SUB:13	Physical Treatment	-	1,110,490
SUB:14	Thermal Treatment	-	-
SUB:15	Stabilization/Fixation	-	-
SUB:18	Disposal (Other than Commercial)	1,296,360	591,070
SUB:20	Site Restoration	327,910	265,790
SUB:21	Demobilization	13,220	13,210
ERC: Environmental Restoration Contractor			
ERC:02	Onsite Laboratory	195,830	261,770
ERC:08	Solids Collection and Containment	16,880	21,450
Subcontractor Materials Procurement Rate		144,080	171,920
Project Management/Construction Management		349,570	421,540
General and Admin./Common Support Pool		683,410	824,110
Contingency		1,189,370	1,575,460
Total		4,687.520	5,833,480
Capital		4,687,520	4,883,100
Annual Operations and Maintenance		0	950,380
Present Worth		4,466,689	5,565,137

SS-3/SW-3: Containment
SS-4/SW-4: Removal/Disposal
SS-8A/SS-8B/SW-7: In Situ Treatment
SS-10/SW-9: Removal/Treatment/Disposal

Table B-5. Cost Summary for Process Effluent Trenches.

Cost Element		SS-4	SS-8A	SS-10
ANA: Offsite Analytical Services				
ANA:02	Laboratory Analysis	298,910	-	564,140
SUB: Fixed Price Contractor				
SUB:01	Mobilization and Preparatory	69,430	68,250	75,120
SUB:02	Sample Collection and Monitoring	219,350	88,710	303,450
SUB:08	Solids Collection and Containment	456,380	233,580	525,740
SUB:13	Physical Treatment	-	-	1,611,480
SUB:14	Thermal Treatment	-	-	-
SUB:15	Stabilization/Fixation	-	27,873,720	-
SUB:18	Disposal (Other than Commercial)	5,895,520	-	4,750,350
SUB:20	Site Restoration	1,145,530	669,110	1,037,890
SUB:21	Demobilization	16,190	16,460	16,170
ERC: Environmental Restoration Contractor				
ERC:02	Onsite Laboratory	399,560	2,256,070	626,660
ERC:08	Solids Collection and Containment	39,740	370,950	61,200
Subcontractor Materials Procurement Rate		78,110	289,500	83,200
Project Management/Construction Management		1,249,330	4,779,950	1,363,690
General and Admin./Common Support Pool		2,442,430	9,344,810	2,666,010
Contingency		4,188,630	15,636,980	5,063,490
Total		16,508,130	61,628,090	18,748,610
Capital		16,508,130	33,886,890	17,295,880
Annual Operations and Maintenance		0	7,300,316	1,452,730
Present Worth		15,725,648	54,806,062	17,866,453

SS-3/SW-3: Containment
SS-4/SW-4: Removal/Disposal
SS-8A/SS-8B/SW-7: In Situ Treatment
SS-10/SW-9: Removal/Treatment/Disposal

Table B-6. Cost Summary for Pluto Cribs.

Cost Element		SS-4	SS-8A	SS-10
ANA: Offsite Analytical Services				
ANA:02	Laboratory Analysis	16,840	-	29,470
SUB: Fixed Price Contractor				
SUB:01	Mobilization and Preparatory	53,120	45,040	53,600
SUB:02	Sample Collection and Monitoring	1,540	960	1,670
SUB:08	Solids Collection and Containment	6,590	6,040	7,560
SUB:13	Physical Treatment	-	-	171,110
SUB:14	Thermal Treatment	-	-	-
SUB:15	Stabilization/Fixation	-	225,280	-
SUB:18	Disposal (Other than Commercial)	16,960	-	10,090
SUB:20	Site Restoration	19,870	18,640	19,480
SUB:21	Demobilization	13,110	13,120	13,210
ERC: Environmental Restoration Contractor				
ERC:02	Onsite Laboratory	10,030	22,110	41,410
ERC:08	Solids Collection and Containment	280	1,550	3,870
Subcontractor Materials Procurement Rate		8,120	22,560	20,200
Project Management/Construction Management		19,440	53,300	51,330
General and Admin./Common Support Pool		38,010	104,190	100,350
Contingency		73,410	174,350	193,640
Total		277,310	687,150	716,990
Capital		277,310	597,530	707,750
Annual Operations and Maintenance		0	89,620	9,240
Present Worth		266,639	660,573	692,246

SS-3/SW-3: Containment
SS-4/SW-4: Removal/Disposal
SS-8A/SS-8B/SW-7: In Situ Treatment
SS-10/SW-9: Removal/Treatment/Disposal

Table B-7. Cost Summary for Dummy Decontamination Cribs and French Drains.

Cost Element		SS-3	SS-4	SS-8A	SS-10
ANA: Offsite Analytical Services					
ANA:02	Laboratory Analysis	-	16,840	-	29,470
SUB: Fixed Price Contractor					
SUB:01	Mobilization and Preparatory	42,340	52,730	44,520	52,660
SUB:02	Sample Collection and Monitoring	-	2,680	1,840	2,780
SUB:08	Solids Collection and Containment	188,650	7,700	8,130	9,270
SUB:13	Physical Treatment	-	-	-	171,630
SUB:14	Thermal Treatment	-	-	-	-
SUB:15	Stabilization/Fixation	-	-	247,890	-
SUB:18	Disposal (Other than Commercial)	-	20,150	-	11,410
SUB:20	Site Restoration	1,295,270	21,100	19,480	20,340
SUB:21	Demobilization	12,770	13,060	13,030	13,020
ERC: Environmental Restoration Contractor					
ERC:02	Onsite Laboratory	15,790	12,060	23,970	44,080
ERC:08	Solids Collection and Containment	250	560	1,830	4,220
Subcontractor Materials Procurement Rate		112,350	8,570	24,450	20,520
Project Management/Construction Management		250,110	20,790	57,770	52,490
General and Admin./Common Support Pool		488,970	40,650	112,940	102,620
Contingency		818,210	78,080	188,990	197,770
Total		3,224,710	294,980	744,850	732,280
Capital		3,224,710	294,980	632,340	720,850
Annual Operations and Maintenance		216,959	0	112,510	11,430
Present Worth		3,194,406	283,449	715,494	706,693

SS-3/SW-3: Containment
SS-4/SW-4: Removal/Disposal
SS-8A/SS-8B/SW-7: In Situ Treatment
SS-10/SW-9: Removal/Treatment/Disposal

Table B-8. Cost Summary for Pipelines.

Cost Element		SS-3	SS-4	SS-8B	SS-10
ANA: Offsite Analytical Services					
ANA:02	Laboratory Analysis	-	412,580	-	766,220
SUB: Fixed Price Contractor					
SUB:01	Mobilization and Preparatory	706,870	47,282	52,270	47,280
SUB:02	Sample Collection and Monitoring	-	935,521	-	1,014,990
SUB:08	Solids Collection and Containment	46,388,220	2,793,691	4,025,580	2,812,350
SUB:13	Physical Treatment	-	-	-	5,933,280
SUB:14	Thermal Treatment	-	-	-	-
SUB:15	Stabilization/Fixation	-	-	-	-
SUB:18	Disposal (Other than Commercial)	-	7,994,662	-	5,912,960
SUB:20	Site Restoration	2,944,120	4,115,948	1,314,900	3,951,860
SUB:21	Demobilization	106,380	10,984	14,120	10,980
ERC: Environmental Restoration Contractor					
ERC:02	Onsite Laboratory	1,569,950	1,565,798	128,240	1,565,930
ERC:08	Solids Collection and Containment	34,220	219,825	12,310	216,660
Subcontractor Materials Procurement Rate		501,460	158,981	394,700	196,840
Project Management/Construction Management		7,837,680	2,676,404	891,320	3,249,470
General and Admin./Common Support Pool		15,322,670	5,232,369	1,742,530	6,352,710
Contingency		25,639,930	9,942,337	2,915,830	11,851,670
Total		101,051,500	36,106,381	11,491,800	43,883,200
Capital		101,051,500	36,106,381	11,491,800	38,108,100
Annual Operations and Maintenance		44,068,809	0	1,121,388	2,310,040
Present Worth		109,645,406	32,948,740	11,573,598	40,025,889

SS-3/SW-3: Containment
SS-4/SW-4: Removal/Disposal
SS-8A/SS-8B/SW-7: In Situ Treatment
SS-10/SW-9: Removal/Treatment/Disposal

Table B-9. Cost Summary for Burial Grounds.

Cost Element		SW-3	SW-4	SW-7	SW-9
ANA: Offsite Analytical Services					
ANA:02	Laboratory Analysis	-	12,630	-	12,630
SUB: Fixed Price Contractor					
SUB:01	Mobilization and Preparatory	47,460	53,490	60,210	60,410
SUB:02	Sample Collection and Monitoring	-	30,430	-	30,420
SUB:08	Solids Collection and Containment	584,440	75,620	608,090	75,610
SUB:13	Physical Treatment	-	-	-	87,220
SUB:14	Thermal Treatment	-	-	-	278,830
SUB:15	Stabilization/Fixation	-	-	-	-
SUB:18	Disposal (Other than Commercial)	-	767,640	-	446,340
SUB:20	Site Restoration	1,308,530	173,970	1,308,500	172,910
SUB:21	Demobilization	13,490	14,010	13,490	14,010
ERC: Environmental Restoration Contractor					
ERC:02	Onsite Laboratory	28,100	52,580	52,820	66,960
ERC:08	Solids Collection and Containment	490	6,330	3,170	11,400
Subcontractor Materials Procurement Rate		142,640	81,410	145,290	85,100
Project Management/Construction Management		328,740	188,320	318,780	199,380
General and Admin./Common Support Pool		623,210	368,170	624,680	389,790
Contingency		1,042,840	675,100	1,075,430	714,480
Total		4,110,010	2,499,700	4,238,450	2,645,500
Capital		4,110,010	2,499,700	4,238,450	2,508,630
Annual Operations and Maintenance		672,106	0	699,315	136,870
Present Worth		4,292,018	2,383,260	4,430,148	2,532,877

SS-3/SW-3: Containment
SS-4/SW-4: Removal/Disposal
SS-8A/SS-8B/SW-7: In Situ Treatment
SS-10/SW-9: Removal/Treatment/Disposal

APPENDIX C

ARAR TABLES

Table C-1 Potential Federal ARARs

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
***Atomic Energy Act of 1954*, as amended**	42 U.S.C. 2011 et seq.	Authorizes DOE to set standards and restrictions governing facilities used for research, development, and use of atomic energy.			
Department of Energy Occupational Radiation Protection (Final Rule)	10 CFR 835	Establishes occupational and visitor radiological exposure limits.	Adheres to DOE Radiological Control Manual DOE/EH-02561, which is encompassed within the Hanford Site Radiological Control Manual.	All	BC-1 DR-1 HR-1
Nuclear Regulatory Commission Standards for Protection Against Radiation	10 CFR Part 20 Subpart C	Sets occupational dose limits for adults. Total effect dose equivalent equal to 5 rem/year.	Occupational dose limits will be followed during remediation in radiological areas.	All	BC-1 DR-1 HR-1
Uranium Mill Tailings Radiation Control Act of 1978	Public Law 95-604, as amended				
Standards for Uranium and Thorium Mill Tailings	40 CFR 192	Establishes standards for control, cleanup, and management of radioactive materials from inactive uranium processing sites.	May be relevant and appropriate if any radium-226 is encountered.	All	BC-1 DR-1
Land Cleanup Standards	40 CFR 192.10-192.12	Requires remedial actions to provide reasonable assurance that, as a result of residual radioactive materials from any designated processing site, the concentration of radium-226 in land averaged over any area of 100 m^2 shall not exceed the background level by more than 5 pCi/g, averaged over the first 15 cm of soil below the surface and 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface. In any habitable building, a reasonable effort shall be made during remediation to achieve an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 Working Level (WL). In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL and the level of gamma radiation shall not exceed the background level by more than 20 microroentegens per hour.	May be relevant and appropriate if any radium-226 encountered during remediation. Radium-226 did not result from uranium processing; therefore, regulation is not applicable.	All	BC-1 DR-1
Implementation	40 CFR 192.20-192.23	Requires that when radionuclides other than radium-226 and its decay products are present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials, remedial action shall reduce other residual radioactivity to levels as low as reasonably achievable (ALARA).	May be relevant and appropriate if any radium-226 is encountered during remediation.	All	BC-1 DR-1

*No action and institutional control alternatives are not considered.

Table C-1. Potential Federal ARARs.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
Archaeological and Historical Preservation Act of 1974	16 U.S.C. 469	Requires action to recover and preserve artifacts in areas where activity may cause irreparable harm, loss, or destruction of significant artifacts.	Applicable when remedial action threatens significant scientific, prehistorical, historical, or archeological data.	All	BC-1 DR-1 HR-1
Archaeological Resources Protection Act of 1979	16 U.S.C. 470aa mm (1990)	Protects archaeological and traditional cultural properties associated with archaeological sites. Requires notification of Indian Tribes of possible harm to or destruction of sites having religious or cultural significance.	Applicable when remedial action threatens archaeological and traditional cultural properties.	All	BC-1 DR-1 HR-1
Protection of Archaeological Resources	43 CFR Part 7	Establishes procedures to be followed by federal land managers to protect archaeological resources on federal lands. Sets civil and criminal penalties for violations; protects confidentiality of archaeological resource information.	Applicable when remedial action threatens archaeological resources.	All	BC-1 DR-1 HR-1
American Indian Religious Freedom Act of 1978	42 U.S.C. 1996	Provides for access by Native Americans to religious sites and development of mitigation measures if actions will deny such access. Requires agency to consult with traditional religious leaders regarding activities that might affect religious sites.	Applicable when remedial action threatens Native American religious sites.	All	BC-1 DR-1 HR-1
The Religious Freedom Restoration Act of 1993	42 U.S.C. 2000bb; P.L. 103-141	Requires agency to demonstrate compelling need for a project that will deny the free exercise of religion by Native Americans. If activities threaten access to religious site, consultation with tribes will be necessary.	Applicable when remedial action threatens Native American religious sites.	All	BC-1 DR-1 HR-1
Antiquities Act of 1906	16 U.S.C. 431-433	Protects all historic and prehistoric ruins and objects of antiquity located on Federal lands. Provides for criminal sanctions against excavation, injury, or destruction of such resources.	Applicable when remedial action threatens historic or prehistoric ruins.	All	BC-1 DR-1 HR-1
Endangered Species Act of 1973	16 U.S.C. 1531 et seq.	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 zone surrounding threatened and endangered species, mitigation measures must be taken to protect this resource.	This law is applicable as threatened or endangered species have been identified with the 100 Area.	All	BC-1 DR-1 HR-1
Migratory Bird Treaty Act	16 U.S.C. 703 et seq. 50 CFR 10-24	Makes it illegal to pursue, hunt, take, capture, kill, possess, trade, or transport any migratory bird, part, nest, or egg included in the terms of the conventions between the U.S. and Great Britain, the U.S. and Mexico, and the U.S. and Japan. Although this Act does not require ecological assessments be done for federal agency projects, if a disturbance is expected in an area where migratory birds may be affected, such an assessment should be done to ensure the law's intent.	If remedial actions potentially impact migrating birds, this Act is applicable.	All	BC-1 DR-1 HR-1
Fish and Wildlife Services List of Endangered and Threatened Wildlife and Plants	50 CFR Parts 17, 222, 225, 226, 227, 402, 424	Requires identification of activities that may affect listed species. Actions must not threaten the continued existence of a listed species or destroy critical habitat. Requires consultation with the Fish and Wildlife Service to determine if threatened or endangered species could be impacted by activity.	This law is applicable as threatened or endangered species have been identified with the 100 Area.	All	BC-1 DR-1 HR-1
Historic Sites, Buildings, and Antiques Act	16 U.S.C. 461	Establishes requirements for preservation of historic sites, buildings, or objects of national significance. Undesirable impacts to such resources must be mitigated.	Applicable to properties listed in the National Register of Historic Places, or eligible for such listing.	All	BC-1 DR-1 HR-1

*No action and institutional control alternatives are not considered.

Table C-1. Potential Federal ARARs.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
National Historic Preservation Act of 1966, as amended.	16 U.S.C. 470 et seq.	Prohibits impacts on cultural resources. Where impacts are unavoidable, requires impact mitigation through design and data recovery.	Applicable to properties listed in the National Register of Historic Places, or eligible for such listing.	All	BC-1 DR-1 HR-1
Protection of Historic Properties	36 CFR 800	Sets criteria to assess effects, to develop mitigation measures to address unavoidable adverse impacts, and to address properties discovered during implementation of an undertaking.	Applicable when remedial action threaten a historic property discovered during remedial activity.	All	BC-1 DR-1 HR-1
Historic Sites Act of 1935	16 U.S.C. 461-467 36 CFR 65	Requires action to undertake the recovery, protection, and preservation of sites, buildings, objects, and antiquities of National significance.	Applicable when remedial action threatens sites, buildings, objects, and antiquities of National significance.	All	BC-1 DR-1 HR-1
Native American Graves Protection and Repatriation Act of 1990	25 U.S.C. 3001-3013 Public Law 101-601 (1993)	Requires action by federal agency when Native American human remains and associated funerary objects are inadvertently discovered during construction. Requires work stoppage, protection of items, and notification to appropriate Indian Tribes.	Applicable if, during remedial action, Native American human remains or burial objects are discovered. Construction activities may resume 30 days after certification that agency head and Indian Tribes have been notified.	All	BC-1 DR-1 HR-1
Floodplains/Wetlands Environmental Review	10 CFR Part 1022	Requires federal agencies to avoid, to the extent possible, adverse effects associated with the development of a floodplain or the destruction or loss of wetlands.	Applicable if remedial activities take place in a floodplain or wetlands.	All	BC-1 DR-1 HR-1

*No action and institutional control alternatives are not considered.

Table C-1. Potential Federal ARARs.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
***Clean Air Act*, as amended**	42 U.S.C. 7401 et seq.	A comprehensive environmental law designed to regulate any activities that affect air quality, providing the national framework for controlling air pollution.			
National Emissions Standards for Hazardous Air Pollutants (NESHAP)	40 CFR Part 61	Establishes numerical standards for hazardous air pollutants.			
Radionuclide Emissions from DOE Facilities (except Airborne Radon-222, and Radon-220)	40 CFR 61.92	Prohibits emissions of radionuclides to the ambient air exceeding an effective dose equivalent of 10 mrem/year.	Applicable to incinerators and other remedial technologies where air emission may occur.	SW-4,SW-7, SW-9,SS-4, SS-8,SS-10	BC-1 DR-1 HR-1
Emission Standards for Asbestos for Waste Disposal Operations for Demolition and Renovation	40 CFR 61.150	States there must either be no visible emissions to the outside air during the collection, processing (including incineration), packaging, or transporting of any asbestos-containing waste material generated by the source, or specified waste treatment methods must be used.	Applicable to recovery and handling of asbestos wastes.	SW-4,SW-7, SW-9	BC-1 DR-1 HR-1
Asbestos Standard for Active Waste Disposal Sites	40 CFR 61.154	States there must either be no visible emissions to the outside air during the collection, processing (including incineration), packaging, or transporting of any asbestos-containing waste material generated by the source, or specified waste treatment methods must be used.	Applicable to landfill disposal of asbestos.	SW-4,SW-9	BC-1 DR-1 HR-1
Protection of Stratospheric Ozone	40 CFR 82	Management of refrigerant systems.	Applicable to all buildings/facilities containing refrigerant systems.	All	BC-1 DR-1 HR-1
***Federal Water Pollution Control Act* (FWPCA), as amended by the *Clean Water Act of 1988* (CWA)**	33 U.S.C. 1251 et seq.	Creates the basic national framework for water pollution control and water quality management in the United States.	Applicable to discharges of pollutants to navigable waters.		
The National Pollutant Discharge Elimination System (NPDES)	40 CFR Part 122	Part 122 covers establishing technology-based limitations and standards, control of toxic pollutants, and monitoring of effluent to ensure limits are not exceeded.	Applicable if remediation includes wastewater discharge; also applies to storm water runoff associated with industrial activities. Effluent limitations established by EPA are included in NDPES permit.	SW-3,SW-4, SW-7,SW-9, SS-3,SS-4, SS-10	BC-1 DR-1 HR-1
NPDES Criteria and Standards	40 CFR 125.104	Best management practices program shall be developed in accordance with good engineering practices.	Applicable if remediation includes wastewater discharge; also applies to storm water runoff associated with industrial activities. Effluent limitations established by EPA are included in NDPES permit.	SW-3,SW-4, SW-7,SW-9, SS-3,SS-4, SS-10	BC-1 DR-1 HR-1
Discharge of Oil	40 CFR Part 110	Prohibits discharge of oil that violates applicable water quality standards or causes a sheen of oil on water surface. Runoff from site will need control for oily water discharge to waters of the United States.	Applicable if oily water is discharged or caused to run off during remedial action.	All	BC-1 DR-1 HR-1
***Solid Waste Disposal Act*, as amended by the *Resource Conservation and Recovery Act* (RCRA)**	40 U.S.C. 6901 et seq.	Establishes the basic framework for federal regulation of solid waste. Subpart C of RCRA control the generation, transportation, treatment, storage, and disposal of hazardous waste through a comprehensive "cradle to grave" system of hazardous waste management techniques and requirements.	Hazardous waste generated by site remediation activities must meet RCRA generator and treatment, storage, or disposal (TSD) substantive requirements. Applicable if hazardous waste is generated during remediation.		

*No action and institutional control alternatives are not considered.

Table C-1. Potential Federal ARARs.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
Identification and Listing of Hazardous Waste	40 CFR Part 261 [WAC 173-303-016]	Identifies by both listing and characterization, those solid wastes subject to regulation as hazardous wastes under Parts 261-265, 268, 270, 271, and 124.	Applicable if remediation techniques result in generation of hazardous wastes. Environmental media (e.g., soil and groundwater) contaminated with RCRA listed waste must be managed as RCRA listed waste unless the regulatory agencies determine that the media no longer contains the listed waste.	SW-4, SW-9, SS-4, SS-8, SS-10	BC-1 DR-1 HR-1
Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262 [WAC 173-303]	Describes regulatory requirements imposed on generators of hazardous wastes who treat, store, or dispose of the waste onsite.	Applicable if remediation techniques result in generation of hazardous waste.	All	BC-1 DR-1 HR-1
Designation & Determination of LDR Status	40 CFR 262.11 (WAC 173-303-070)	Requires generator to determine waste designation and LDR Status.	Applicable if remediation techniques result in generation of solid waste.	All	BC-1 DR-1 HR-1
Accumulation Time	40 CFR 262.34 [WAC 173-303-200]	Allows a generator to accumulate hazardous waste on site for 90 days or less without a permit, provided that all waste is containerized and labeled.	Hazardous waste removed from the 100-Area operable units, and waste treatment residues, are subject to the 90-day generator accumulation requirements if the waste is stored on site for 90 days or less. If hazardous waste is stored on site for more than 90 days, the substantive provisions of permitting standards for TSD facilities are applicable.	SW-4, SW-9, SS4, SS-8, SS-10	BC-1 DR-1 HR-1
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264 [WAC 173-303]	Establishes requirements for operating hazardous waste treatment, storage, and disposal facilities. Applies to facilities put in operation since November 19, 1980. Facilities in operation before that date and existing facilities handling newly regulated wastes must meet similar requirements in 40 CFR Part 265.	Applicable if remediation technique results in onsite treatment, storage, or disposal of hazardous waste.	SS-8A, SS-8B, SW-9, SS-10	BC-1 DR-1 HR-1
Closure	40 CFR 264.111-264.116 [WAC 173-303-610] Subpart G	Performance standard that controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, postclosure escape of chemicals, disposal or decontamination of equipment, structures, and soils. All contaminated equipment, structures, and soils must be properly disposed.	Substantive requirements may be relevant and appropriate during remediation activities.	SW-9, SS-8, SS-10	BC-1 DR-1 HR-1
Postclosure	40 CFR 264.117-264.120 [WAC 173-303-610] Subpart G	Postclosure care must begin after completion of closure and continue for 30 years. During this period, the owner or operator must comply with all postclosure requirements, including maintenance of cover, leachate monitoring, and groundwater monitoring.	Applicable to waste remaining in place after closure. Requires postclosure care and monitoring to ensure elimination of escape of hazardous constituents, leachate, and contaminated runoff.	SW-9, SS-8, SS-10	BC-1 DR-1 HR-1

*No action and institutional control alternatives are not considered.

Table C-1. Potential Federal ARARs.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
Container Storage	40 CFR 264.170-264-178 [WAC 173-303-160-173-303-161] Subpart I	Condition of containers, compatibility of waste with containers, container management, containment, special requirements for ignitable or reactive wastes.	May be applicable if container storage is to occur. Inspection requirements may be in potential conflict with ALARA requirements.	SW-4, SW-9, SS-4, SS-8, SS-10	BC-1 DR-1 HR-1
Miscellaneous Unit	40 CFR 264.600-603 (WAC 173-303-680) Subpart X	Requires general environmental performance standards for operations including monitoring and inspections.	May be applicable if miscellaneous units occur, i.e., thermal treatment is used.	SS-10, SW-9	BC-1 HR-1
Waste Piles	40 CFR 264.250-259 (WAC 173-303-660) Subpart L	Design in operating requirements: monitoring, leachate system and lines.	May be applicable if waste piles occur outside area of contamination.	All	BC-1 DR-1 HR-1
Tanks	40 CFR 264.190-199 (WAC 173-303-640) Subpart G	Design operating standards for tanks including secondary containment and leak detection systems; tank management; containment; special requirements for ignitable or reactive wastes.	May be applicable if tank storage is to occur. Inspection requirements may be potential conflict with ALARA requirements. May be applicable for soil washing process.	SS-10, SW-9	BC-1 DR-1 HR-1
Temporary Units	40 CFR 264-553 (WAC 173-3-3-646(7)	Establishes alternative performance standards for temporary tanks and containers used for treatment or storage of hazardous remediation wastes for up to one year.	Applicable if temporary unit is used.	SS-10, SW-9	BC-1 DR-1 HR-1
Land Disposal Restrictions (LDR)	40 CFR Part 268 [WAC 173-303-140-WAC 173-303-141]	Generally prohibits placement of restricted RCRA hazardous wastes in land-based units such as landfills, surface impoundments, and waste piles.	Applicable unless waste has been treated, treatment has been waived, a treatment variance has been set for the waste, an equivalent treatment method has been established, or waste qualifies for delisting.	All	BC-1 DR-1 HR-1
Dilution Prohibition	40 CFR 268.3 Subpart A	Requires remediation waste to be appropriately treated which does not include dilution. Generators are required to identify applicable treatment standards at the point of generation and prior to mixing with other remediation wastes.	Applicable if waste contains RCRA hazardous constituents.	All	BC-1 DR-1 HR-1
Debris Rule	40 CFR 268.45	Requires treatment of hazardous waste debris by specified technologies contained in 40 CFR 268.45, Table 1.	Applicable if waste contains RCRA hazardous constituents.	All	BC-1 DR-1 HR-1
Prohibition and Treatment Standards	40 CFR 268.30-268.46 [WAC 173-303-140]	Establishes treatment standards that must be met prior to land disposal.	Applicable if wastes contain RCRA hazardous constituents.	SW-4, SW-9, SS-4, SS-10	BC-1 DR-1 HR-1
Prohibition on Storage	40 CFR 268.50 [WAC 173-303-141]	The storage of nonradioactive hazardous waste restricted from land disposal under RCRA Section 3004 and 40 CFR 268, Subpart C, is prohibited unless wastes are stored in tanks and containers by a generator or the onsite operator of a TSD facility solely for the purpose of accumulation of such quantities as to facilitate proper treatment or disposal. TSD facility operators may store wastes for up to one year under these circumstances.	Applicable only to nonradioactive hazardous waste.	SW-4, SW-9, SS-4, SS-10	BC-1 DR-1 HR-1

*No action and institutional control alternatives are not considered.

Table C-1. Potential Federal ARARs.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
***Toxic Substances Control Act* (TSCA), as amended**	15 U.S.C. 2601 et seq.	Provides EPA with authority to regulate the production, use, distribution, and disposal of toxic substances.			
Regulation of Polychlorinated Biphenyls (PCBs)	40 CFR Part 761	For spills occurring after May 4, 1987, spillage or disposal must be reported to EPA. Unless otherwise approved, PCBs at concentrations of 50 ppm or greater must be treated in an incinerator. Spills that occurred before May 4, 1987 are to be decontaminated to requirements established at the discretion of the EPA.	The PCBs may have been disposed of in the landfill sites in electrical capacitors or transformers. If PCBs are found, this requirement would be applicable.	All	

*No action and institutional control alternatives are not considered.

Table C-2. Potential State ARARs.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
Model Toxics Control Act (MTCA)	70.105D RCW	Requires remedial actions to attain a degree of cleanup protective of human health and the environment.			
Cleanup Regulations	WAC 173-340	Establishes cleanup levels and prescribes methods to calculate cleanup levels for soils, groundwater, surface water, and air.	Applicable to remediation actions where hazardous substances have been released.	All	BC-1 DR-1 HR-1
Soil Cleanup Standards	WAC 173-340-700-760	Establishes cleanup standards for contaminated media. These levels must be protective of the groundwater if groundwater is considered a pathway of exposure.	Applicable to remediation actions where hazardous substances have been released. Levels will be calculated based on final land use decision. If airborne radionuclide emissions are anticipated during remediation at waste sites, emissions must be monitored and control technology developed during design phase.	All	BC-1 DR-1 HR-1
Radiation Protection--Air Emissions	WAC 246-247	Establishes procedures to monitor and control airborne radionuclide emissions.	Applicable if airborne radionuclide emissions are anticipated during remedial action.	All	BC-1 DR-1 HR-1
New and Modified Sources	WAC 246-247-070	Requires the use of best available radionuclide control technology (BARCT)	Applicable if airborne radionuclide emissions are anticipated during remedial action.	All	BC-1 DR-1 HR-1

*No action and institutional control alternatives are not considered.

Table C-2. Potential State ARARs.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
Habitat Buffer Zone for Bald Eagle Rules	RCW 77.12.655				
Bald Eagle Protection Rules	WAC 232-12-292	Prescribes action to protect bald eagle habitat, such as nesting or roost sites, through the development of a site management plan.	Applicable if the areas of remedial activities include bald eagle habitat.	All	BC-1 DR-1 HR-1
The Indian Graves and Records Act of the State of Washington	RCW 27.44	Prohibits the willful removal, mutilation, defacement, or destruction of any cairn, grave, or glyptic or painted record of any Native Indian or prehistoric people. Requires agency to consult with traditional religious leaders regarding activities that might affect religious sites.	There are Native American burial grounds and cultural areas within the 100 Area Operable Units; therefore, this is applicable.	All	BC-1 DR-1 HR-1
Department of Game State Environmental Policy Act	WAC 232-012	Requires management plans if endangered, or sensitive wildlife or habitat are affected. Washington State Department of Fish and Wildlife will be consulted to minimize ecological impacts.	Upon the determination of impacts to threatened, endangered, or sensitive species or habitat by the remedial actions, this may be applicable.	All	BC-1 DR-1 HR-1

*No action and institutional control alternatives are not considered.

Table C-2. Potential State ARARs.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
Department of Ecology	43.12A RCW	Vests the Washington Department of Ecology with the Authority to undertake the state air regulation and management program.			
Air Pollution Regulations	WAC 173-400	Establishes requirements to control and/or prevent the emission of air contaminants.	Applicable if emission sources are created during remedial action.	SW-3, SW-4, SW-7, SW-9, SS-3, SS-4, SS-8, SS-10	BC-1 DR-1 HR-1
Standards for Maximum Emissions	WAC 173-400-040	Requires best available control technology be used to control fugitive emissions of dust from materials handling, construction, demolition, or any other activities that are sources of fugitive emissions. Restricts emitted particulates from being deposited beyond the Hanford Site. Requires control of odors emitted from the source. Prohibits masking or concealing prohibited emissions. Requires measures to prevent fugitive dust from becoming airborne.	Applicable to dust emissions from cutting of concrete and metal and vehicular traffic during remediation.	SW-3, SW-4, SW-7, SW-9, SS-3, SS-4, SS-8, SS-10	BC-1 DR-1 HR-1
Emission Limits for Radionuclides	WAC 173-480	Controls air emissions of radionuclides from specific sources.	Applicable to remedial activities that result in air emissions.	SW-4, SW-7, SW-9, SS-4, SS-8, SS-10	BC-1 DR-1 HR-1
New and Modified Emission Units	WAC 173-480-060	Requires the best available radionuclide control technology be used in planning constructing, installing, or establishing a new emissions unit.	Applicable to remedial actions that result in air emissions.	SW-4, SW-7, SW-9, SS-4, SS-8, SS-10	BC-1 DR-1 HR-1
Washington Clean Air Act	RCW 70.94	Establishes a statewide framework for the planning, regulation control, and management of air pollution sources.			
Controls for New Sources of Toxic Air Pollutants	WAC 173-460	Establishes systematic control of new sources emitting toxic air pollutants.	Applicable if new sources emitting toxic air pollutants are established.	SW-4, SW-7, SW-9, SS-4, SS-8, SS-10	BC-1 DR-1 HR-1
Decontaminating Ambient Impact Compliance	WAC 173-460-080	Requires the owner or operator of a new source to complete an acceptable source impact level analysis using dispersion modeling to estimate maximum incremental ambient impact of each Class A or B toxic air pollutant. Establishes numerical limits for small quantity emission rates.	Applicable to remedial alternatives with the potential to release toxic air pollutants.	SW-4, SW-7, SW-9, SS-4, SS-8, SS-10	BC-1 DR-1 HR-1
***Hazardous Waste Management Act of 1976*, as amended in 1980 and 1983**	70.105 RCW	Establishes a statewide framework for the planning, regulation, control, and management of hazardous waste.			
Dangerous Waste Regulations	WAC 173-303	Establishes the design, operation, and monitoring requirements for management of hazardous waste. Includes requirements for generators of dangerous waste. Dangerous waste includes the full universe of wastes regulated by WAC 173-303, including extremely hazardous waste.	Applicable if dangerous or extremely hazardous waste is generated and/or managed during remedial action.	All	BC-1 DR-1 HR-1

*No action and institutional control alternatives are not considered.

Table C-2. Potential State ARARs.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
Waste Designation	WAC 173-303-070, 071, 080, 082, 090, 100, 110	Exceeds federal RCRA program by requiring designation of waste including additional parameters (i.e., toxicity, persistence, and carcinogenicity), additional listed wastes, and PCBs.	Applicable if remediation wastes, based on process knowledge/analysis exceed the parameters.	All	BC-1 DR-1 HR-1
Land Disposal Restrictions	WAC 173-303-140	State LDR requirements exceed the federal requirements for nonradiological extremely hazardous, organic/carbonaceous and solid acid wastes.	Applicable if remediation wastes meet additional categories.	All	BC-1 DR-1 HR-1
Model Toxics Control Act	70.105D RCW	Authorizes the state to investigate releases of hazardous substances, conduct remedial actions, carry out state programs authorized by federal cleanup laws, and take other actions.			
Hazardous Waste Cleanup Regulations	WAC 173-340	Addresses releases of hazardous substances caused by past activities and potential and ongoing releases from current activities.	Applicable to facilities where hazardous substances have been released, or there is a threatened release that may pose a threat to human health or the environment.	All	BC-1 DR-1 HR-1
Selection of Cleanup Actions	WAC 173-340-360(4)	Establishes hierarchy of consideration before selecting cleanup process.	Must be considered during comparative analysis of remedial alternatives.	All	BC-1 DR-1 HR-1
Cleanup Actions	WAC 173-340-400	Ensures that the cleanup action is designed, constructed, and operated in accordance with the cleanup plan and other specified requirements.	Cleanup must follow remedial design document and remedial action work plans.	All	BC-1 DR-1 HR-1
Institutional Controls	WAC 173-340-440	Requires physical measures, such as fences and signs, to limit interference with cleanup.	Physical measures may be applicable if institutional controls are used.	SW-2,SW-3, SW-4,SW-7, SW-9,SS-2, SS-3,SS-4, SS-8,S-10	BC-1 DR-1 HR-1
Solid Waste Management Act	70.95 RCW	Establishes a statewide program for solid waste handling, recovery, and/or recycling.			
Minimum Functional Standards for Solid Waste Handling	WAC 173-304	Establishes requirements to be met statewide to handle all solid waste.	Applicable if management of solid waste occurs during remediation. Solid waste controlled by this Act includes garbage, industrial waste, construction waste, ashes, and swill.	All	BC-1 DR-1 HR-1
Onsite Containerized Storage, Collection, and Transportation Standards	WAC 173-304-200	Sets requirements for containers and vehicles to be used on site.	Applicable if containers are used during remediation.	All	BC-1 DR-1 HR-1
Water Pollution Control Act	90.48 RCW	Prohibits discharge of polluting matter in waters.			
State Waste Discharge Permit Program	WAC 173-216	Requires the use of all known available and reasonable methods of prevention, control, and treatment.	Applicable for any discharges of liquids to the ground.	All	BC-1 DR-1 HR-1
Corrective Action Management Unit (CAMU)	173-303-646(4)	Authorizes designation of a corrective action management unit, which does not constitute land disposal of dangerous waste.	May be used if dangerous waste not meeting LDR standards is placed in the disposal/facility.	SS-4, SW-4, SS-10, SW-9	BC-1

*No action and institutional control alternatives are not considered.

Table C-2. Potential State ARARs.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
Water Well Construction Act	18.104 RCW				
Standards for Construction and Maintenance of Wells	WAC 173-160	Establishes 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.	Applicable if water supply wells, monitoring wells, or other wells are used during remediation.	SW-2, SW-3, SW-7, SS-2, SS-3, SS-8	BC-1 DR-1 HR-1

*No action and institutional control alternatives are not considered.

Table C-3. Potential To Be Considered Requirements.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
Benton Clean Air Authority	Regulation 1, Article 8	Establishes regulations relative to asbestos.	Must be considered if asbestos is found during remediation.	All	BC-1 DR-1 HR-1
A Guide on Remedial Actions at Superfund Sites with PCB Contamination	EPA Directive 9355-.4-01FS	Provides a general framework to determine cleanup levels, identify treatment options, and assess necessary management controls for residuals of PCBs.	Must be considered if PCBs are found during remediation.	All	
U.S. Department of Energy Orders		DOE Orders are mandatory contractor requirements at DOE facilities.			
Radiation Protection of the Public and the Environment	DOE 5400.5	Establishes radiation protection standards for the public and environment.	This Order will be replaced with 10 CFR 834 when it is promulgated.	All	BC-1 DR-1 HR-1
Radiation Dose Limit (All Pathways)	DOE 5400.5, Chapter II, Section 1a	The exposure of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an effective dose equivalent greater than 100 mrem from all exposure pathways, except under specified circumstances.	If remedial activities are considered "routine DOE activities," this order would be relevant and appropriate.	All	BC-1 DR-1 HR-1

*No action and institutional control alternatives are not considered.

Table C-3. Potential To Be Considered Requirements. (page 2 of 2)

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
Residual Radionuclides in Soil	DOE 5400.5 Chapter IV, Section 4a	Generic guidelines for radium-226 and radium-228 are as follows: • 5 pCi/g averaged over the first 15 cm of soil below the surface • 15 pCi/g averaged over 15-cm-thick layers of soil more than 15 cm below the surface. Guidelines for residual concentrations of radionuclides other than Radium-226 must be derived from the basic dose limits by an environmental pathway analysis using specific property data where available. Procedures for these deviations are given in "A Manual for Implementing Residual Radioactive material Guidelines" (DOE/CH-8901). In addition, residuals must also meet "authorized" limits that may (and undoubtedly will) be lower than the concentrations derived form the basic dose limits (DOE 5400.5 IV, Section 5.). Procedures for determination of "hot spots," "hot-spot cleanup limits," and residual concentration guidelines for mixtures are in DOE/CH-8901. Residual radioactive materials above the guidelines must be controlled to the required levels in 5400.5, Chapter II and Chapter IV.	Residual concentrations of radioactive material in soil are defined as those in excess of background concentrations averaged over an area of 100 m^2. This order must be considered for residual radionuclide in soils, dependent upon land use decisions.	All	BC-1 DR-1
NRC Draft Radiological Criteria for Decommissioning	10 CFR Part 20 (proposed revision)	This rule provides a clear and consistent regulatory basis to determine the extent to which lands and structures must be remediated before a site can be considered decommissioned. The primary goal is to return the site to levels approximately background. Indistinguishable from background is defined as no more than 3 mrem/year over background. The limit would be 15 mrem/year over background.	This will be applicable upon promulgation.	All	BC-1 DR-1 HR-1
Radioactive Waste Management	DOE Order 5820.2A	Defines waste designation for TRU, high- and low-level waste and establishes generator criteria.	This DOE Order is being extensively revised as 5820.2B	All	BC-1 DR-1 HR-1
Draft Department of Energy Radiation Protection of the Public and the Environment	10 CFR 834	Additional requirements above 5400.5 that are more prescriptive.	Will replace 5400.5.	All	BC-1 DR-1 HR-1

*No action and institutional control alternatives are not considered.

Table C-3. Potential To Be Considered Requirements.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
Hanford Reach Study Act	P.L. 100-605	Provides for a comprehensive river conservation study. Prohibits the construction of any dam, channel, or navigation project by a federal agency for 8 years after enactment. New federal and nonfederal projects and activities are required, to the extent practicable, to minimize direct and adverse effects on the values for which the river is under study and to use existing structures.	This law was enacted November 4, 1988.	All	BC-1 DR-1 HR-1
Wild and Scenic Rivers Act	16 U.S.C. 1271	Prohibits federal agencies from recommending authorization of any water resource project that would have a direct and adverse effect on the values for which a river was designated as a wild and scenic river or included as a study area.	The Hanford Reach of the Columbia River is under study for inclusion as a wild and scenic river.	SW-3, SW-4, SW-7, SW-9, SS-3, SS-4, SS-8, SS-10	BC-1 DR-1 HR-1

*No action and institutional control alternatives are not considered.

Table C-3. Potential To Be Considered Requirements.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
Benton Clean Air Authority	Regulation 1, Article 5	Establishes a regional program for open burning.	These county regulations are authorized by the state Clean Air Act.	All	BC-1 DR-1 HR-1
Residual Radioactive Material as Surface Contamination	U.S. NRC Regulatory Guide 1.86	Sets contamination guidelines release equipment and building components for unrestricted use, and if buildings are demolished, shall not be exceeded for contamination in the ground.	Dependent upon land use decisions, this guide may be considered.	D&D Facilities	BC-1 DR-1 HR-1
Fish and Wildlife Coordination Act	16 U.S.C. 661 et seq.	This Act ensures that wildlife conservation is given equal consideration with other values during the planning of activities that affect water resources. The Act authorizes the Secretary of the Interior to provide assistance to federal, state, and public or private agencies in the "development, protection, rearing, and stocking of all species of wildlife, resources thereof, and their habitat...". The Act also requires a consultation with the U.S. Fish and Wildlife Service (USFWS) when a federal agency plans to impound, or deepen, or otherwise modify a body of water.	While the recommendations by the USFWS are not legally binding, DOE is required to give them full consideration.	All	BC-1 DR-1 HR-1
Executive Orders Protection of Wetlands	EO 11990	This Executive Order requires that each federal agency "...take action to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; and (2) providing Federally undertaken, finance, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to, water and related land resources planning, regulating, and licensing activities."	Must be considered if action is taken that may impact wetland area.	All	BC-1 DR-1 HR-1
Floodplain Management	EO 11988	This Order requires federal agencies to take floodplain management into account when formulating or evaluating water or land use plans. The Order specifies that "...each agency shall...restore and reserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing Federally undertaken, financial, or assisted construction and improvements; and (3) conducing Federal activities and programs affecting land use, and licensing conducting activities.	Must be considered if actions are taken within a floodplain.	All	BC-1 DR-1 HR-1
Protection and Enhancement of the Cultural Environment	EO 11593	Provides direction to federal agencies to preserve, restore, and maintain cultural resources.	Pertains to sites, structures, and objects of historical, archeological, or architectural significance.	All	BC-1 DR-1 HR-1

*No action and institutional control alternatives are not considered.

Table C-3. Potential To Be Considered Requirements.

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected*	Operable Unit Affected
Exotic Organisms	EO 11987	This Order requires Federal agencies to restrict, to the extent possible, the introduction of exotic species into the lands or waters that they own, lease, or hold for purposes of administration. It also restricts the use of Federal funds and programs for importation and introduction of exotic species.	Must be considered during revegetation.	All	BC-1 DR-1 HR-1
U.S. Department of Energy Orders		DOE Orders are mandatory contractor requirements at DOE facilities.			
Discharge of Treatment System Effluent	DOE 5400.xy	Treatment systems shall be designed to allow operators to detect and quantify unplanned releases of radionuclides, consistent with the potential for off-property impact.	Required of all DOE-controlled facilities where radionuclides might be released as a consequence of an unplanned event.	SW-7, SW-9, SS-8, SS-10	BC-1 DR-1 HR-1
Safety Requirements for the Packaging of Fissle and Other Radioactive Materials	DOE 5480.3 Sections 7 and 8	Establishes requirements for packaging and transportation of radioactive materials for DOE facilities.	Requirements must be met if radioactive material is packaged and transported to disposal facility.	SW-4, SW-9, SS-4, SS-10	BC-1 DR-1 HR-1
Radioactive Waste Management	DOE 5820.2A Chapters III and IV	Establishes policies and guidelines by which DOE manages radioactive waste, waste byproducts, and radioactive contaminated surplus facilities. Disposal shall be on the site at which it was generated, if practical, or at another DOE facility. DOE waste containing byproduct material shall be stored, stabilized in place, and/or disposed of consistent with the requirements of the residual radioactive material guidelines contained in 40 CFR 192.	Must be met when managing radioactive waste created by remediation activities.	All	BC-1 DR-1 HR-1
Department of Ecology Liquid Effluent Consent Order	DE 91NM-177	Requires discharges of liquid effluent to the soil column to be eliminated, treated, or otherwise minimized.	Must be considered if discharges of liquid effluent to the soil column are part of the remedial alternative.	SW-9, SS-8, SS-10	BC-1 DR-1 HR-1
Tri-Party Agreement		Establishes requirements, guidelines, and schedules for the environmental restoration program at the Hanford Site.	Must be adhered to and complied with by all parties with regard to remedial actions at all operable units.	All	BC-1 DR-1 HR-1
Radiation Protection for Occupational Workers	DOE 5480.11	Establishes radiation worker protection from ionizing radiation at DOE and DOE contractor operations.	Required at DOE facilities and part of ALARA policy.	All	BC-1 DR-1 HR-1

*No action and institutional control alternatives are not considered.

APPENDIX D

SENSITIVITY ANALYSIS REPORT

EXECUTIVE SUMMARY

This Sensitivity Analysis is included as an appendix to the *100 Area Source Operable Unit Focused Feasibility Study* (FFS) (DOE/RL-1994), and was performed to determine how different potential future exposure scenarios might impact the baseline alternatives evaluations presented in the Process Document.

The remedial action objectives for the FFS were based on an assumed future exposure scenario described by remediation of soils to support occasional use (e.g., recreational use) of the land surface and frequent use of groundwater (i.e., *Safe Drinking Water Act* Maximum Contaminant Levels [MCL]). During review of the Process Document, the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) determined that additional exposure scenarios should be considered. The Sensitivity Analysis was performed to address this need, as well as two secondary issues. The Sensitivity Analysis objectives were as follows:

- Identify the impacts of other exposure scenarios on the baseline evaluation of alternatives presented in the Process Document
- Identify the impacts of changing the target risk for each scenario from 10^{-6} to 10^{-4}
- Evaluate the potential impacts of considering different exposure pathways in development of remediation goals for each exposure scenario.

During Tri-Party negotiations in January and February of 1995 (following preparation and review of the initial draft of this sensitivity analysis), a new land use and remediation scenario emerged and was developed by the Tri-Parties. The revised frequent-use scenario is intended to support unrestricted future land use. At the time this new concept was introduced, the majority of the FFS documentation had been developed and reviewed by the Tri-Parties. Consequently, consideration and analysis of the new scenario is addressed in a separate attachment to this document (Attachment 6).

ES.1 POTENTIAL FUTURE EXPOSURE SCENARIO ANALYSIS

Five exposure scenarios were addressed in the main body of the original Sensitivity Analysis:

- **Baseline** - remediation of soils to support occasional use of the land surface and frequent use of groundwater.
- **Occasional-use** - remediation of soils to support both occasional use of the land surface and groundwater.
- **Frequent-use** - remediation of soils to support both frequent use of the land surface and groundwater.

- **Modified frequent-use** - remediation of soils to support frequent-use of land surface with no use of groundwater.

- **Complete excavation** - near total removal to support frequent-use at all depths above groundwater.

The new remediation scenario is based on the Washington State Model Toxics Control Act (MTCA) Method B (WAC 173-340, 1992) residential cleanup levels for organic and inorganic contaminants, and the EPA/Nuclear Regulatory Commission proposed 15 mrem/yr dose above background for radionuclide contaminants. Because of the similarities with the frequent-use scenario, the new scenario will hereafter be referred to as the "revised frequent-use scenario".

With the exception of the revised frequent-use scenario, preliminary remediation goals (PRG) were developed for each of the exposure scenarios. Because of similarities that exist between waste sites in the 100 Area, four representative waste sites were selected to streamline the evaluation. The four waste site types chosen cover a range of sizes (based on projected lateral dimensions) from small to large. Waste volumes requiring remediation were computed for each of the four representative sites for each of the five original scenarios. Results were extrapolated to the entire 100 Area by grouping 100 Area waste sites based on which of the four representative waste sites they matched best. Based on the computed excavation, treatment, and disposal volumes, costs were estimated for each scenario (area-wide estimates). Estimated volumes and costs, and the analysis of the revised frequent-use scenario are presented in Attachment 6.

ES.2. SCENARIO EVALUATION

The results of the Sensitivity Analysis indicate that the selection of exposure scenario can have a considerable impact on total remediation volumes and costs. For summary purposes, the 100 Area-wide estimates of volumes and costs have been used in the discussion below.

The volumes and costs for the modified frequent-use scenario are assumed to represent the revised frequent-use scenario. The revised frequent-use scenario is based on an essentially residential land surface use scenario coupled with a revised groundwater model that potentially requires less excavation. A more detailed discussion is provided in Attachment 6.

The Sensitivity Analysis indicates that the occasional-use scenario results in the lowest CV, approximately 2,900,000 m^3 (10,200,000 ft^3). This CV is over 1,000,000 m^3 (3,500,000 ft^3) less (27%) than the baseline scenario, which had a CV of nearly 4,000,000 m^3 (141,000,000 ft^3). The exposure scenario, with the second lowest CV, is the modified frequent-use scenario (or revised frequent-use scenario), which results in over 600,000 m^3 (21,000,000 ft^3) less CV than the baseline scenario. The frequent-use scenario had only a slightly larger CV than the baseline scenario. The complete excavation scenario had the largest CV, nearly 4,900,000 m^3 (1,730,000,000 ft^3). Excavation volume is dependent on CV, and therefore, exhibits similar sensitivities to changes in the exposure scenario; however, the scenarios with the greatest extent of excavation (e.g., complete excavation) result in a disproportionate increase in excavation volume relative to contaminated soil volume. That is, the ratio of EV over contaminated soil volume increases as more conservative PRG are considered.

The cost analysis indicates that waste disposal is the primary component of both the RD and RTD costs. Because disposal cost is proportional to volume, the cost sensitivity was similar to the volume sensitivity. In addition, the RTD cost varied in a similar manner as the RD costs; therefore, the following discussion is based on only the RD costs. The exposure scenario resulting in the least cost was the occasional-use scenario, with an estimated total cost of nearly $1.7 billion. Although this cost was only 22% less than the base case baseline scenario, the cost difference amounts to nearly $500 million. The modified frequent-use scenario (and revised frequent-use scenario) had a cost slightly larger than the occasional-use scenario. The third ranked exposure scenario was the baseline scenario with an estimated cost of over $2.1 billion. The frequent-use scenario costs were slightly larger than the baseline scenario (approximately $70 million more). Similar to the volume comparison, the complete excavation scenario results in the highest remediation cost of over $3 billion. This estimated cost is $900 million more than the estimated cost of the baseline scenario and $1.4 billion more than the cost of the occasional-use scenario.

The 100 Area costs for the Containment Alternative were also estimated. The Containment Alternative was analyzed under the baseline and occasional-use scenarios because the alternative is generally inconsistent with unrestricted or frequent-type uses. Under the baseline scenario, the 100 Area costs for containment were nearly the same as for RD and were lest then the RTD Alternatives. Under the occasional-use scenario, the containment cost was significantly more than the RD and RTD Alternatives.

ES.3 TARGET RISK

The FFS, occasional-use, frequent-use, and modified frequent-use exposure scenarios were evaluated for changes in target risk levels (i.e., 10^{-4} versus 10^{-6}). (The complete excavation scenario was not evaluated for sensitivity to changes in target risk because this scenario was developed and analyzed as a bounding condition based on a target risk of 10^{-6}. The revised frequent-use scenario is based on remediation levels that are either prescribed or proposed by regulations. Therefore, changes in target risk were not analyzed.

For the FFS, occasional-use, and frequent-use scenarios, the protection of groundwater PRGs were the limiting criteria that define the depth of contamination removal. Because of this, these scenarios are unaffected by changes in target risk. Likewise, the 4.5 m (15 ft) maximum excavation limit associated with the modified frequent-use scenario minimizes the effect of changing target risk. The remediation costs and volumes for the four representative sites were not sensitive to changes in target risk.

ES.4 PATHWAY ASSESSMENT

The Process Document, 100 Area operable unit-specific FFSs, and related qualitative risk assessments rely on a subset of exposure pathways to assess risk and develop PRGs. This subset includes soil ingestion, inhalation of fugitive dust or volatiles, and external exposure from radionuclides in soil. A full baseline risk assessment usually considers additional exposure pathways, such as consumption of homegrown produce, ingestion of sediments, and dermal contact with water. This report includes an assessment of whether risk levels vary significantly when a full set of exposure pathways are considered in lieu of the selected subset of pathways.

The findings of the pathway assessment indicated that risk and human health PRG are generally not sensitive to the differences between a subset and a full set of exposure pathways. There are no significant differences between the pre or postremediation risks for the subset of pathways or full set of pathways. In those few cases where the full set of pathways indicate potential increases in preremediation risk, the risk is mitigated by remediation to the human health PRG derived from the subset of exposure pathways. Based on the findings of the pathway assessment, no change is recommended for the current exposure pathway approach used in the Process Document and the 100 Area operable unit-specific FFS documents.

The points of compliance for IRM and final remediation have not yet been established; therefore, assumptions were made in the Sensitivity Analysis for each exposure scenario. For example, all scenarios assume that ambient water quality criteria in the Columbia River (the assumed point of compliance) would not be exceeded. Another assumption for some scenarios is that groundwater is currently suitable for drinking water, and therefore, remediation of the soils should be based on protection of that pristine resource. In reality, the groundwater has already been impacted beneath most of the waste sites.

ACRONYMS

ABS	dermal absorption factor from soil
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirements
BCF	bioconcentration factor
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
COPC	contaminants of potential concern
CRDL	contract required detection limits
CRQL	contract required quantitation limits
CV	contamination volume
DOE	U.S. Department of Energy
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
EV	excavation volume
FFS	Focused Feasibility Study
HSRAM	Hanford Site Risk Assessment Methodology
ICR	incremental cancer risks
IRIS	Integrated Risk Information System
IRM	interim remedial measure
LDR	land disposal restrictions
LFI	Limited Field Investigation
MCACES	micro computer assisted cost estimating system
MCL	maximum contaminant level
MTCA	*State of Washington Model Toxics Control Act*
NEPA	*National Environmental Policy Act*
PRG	preliminary remediation goals
QRA	qualitative risk assessment
RA	remedial action
RAO	remedial action objective
RAPS	remedial action priority system
RD	Remove and Dispose
ROD	record of decision
RTD	Remove/Treat/Dispose
SIS	site insensitive scenario
TCV	total contaminated volume
TEV	total excavation volume
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
USLE	universal soil loss equation

CONTENTS

CONTENTS (continued)

ATTACHMENTS

CONTENTS (continued)

FIGURES

TABLES

1.0 INTRODUCTION

This report is one of the main elements of the *100 Area Source Operable Unit Focused Feasibility Study* (DOE-RL 1994b). As an appendix to DOE-RL 1994b, this report further develops the FFS analyses to show the potential impacts of additional exposure scenarios beyond the single scenario presented in the Process Document and the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Unit Specific appendices.

1.1 BACKGROUND

The Process Document and the operable unit-specific FFS reports are based on a single set of RAO. Remedial action objectives are media-specific or operable unit-specific objectives to protect human health and the environment. The RAO specified the COPC for the media of interest, exposure pathways, and PRG so that an appropriate range of waste site management options could be developed for analysis. Development of RAO was based on consideration of COPC, ARARs, and potential future uses of the 100 Area.

For the purposes of conducting the FFS, an exposure scenario that included occasional use of the land and frequent use of the groundwater was selected. The hypothetical receptors, exposure pathways, and points of compliance used in the Process Document were taken from those described in the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995). The pathways selected (ingestion, inhalation, and external radiation) are a subset of all the possible pathways identified in DOE-RL (1995) and are consistent with the Tri-Party Agreement instructions relative to pathway selection (DOE-RL 1995).

During the review period for the Process Document and operable unit-specific FFS appendices, the DOE, EPA, Ecology determined that additional exposure scenarios should be examined as part of the FFS for the 100 Area source operable units. The development of additional scenarios was deemed necessary for the following reasons:

- There is currently no future land use policy for the 100 Area. While residential use may be appropriately conservative, it is recognized that other scenarios should be considered pending development of a land use policy.
- The Hanford Future Site Uses Working Group, which represents a wide spectrum of public interests, has advocated cleanup criteria that would allow for generally "unrestricted use" of the 100 Area (DOE-RL 1992).

Selecting a specific exposure scenario implies commitments on specific land uses and groundwater uses (decisions that cannot be made at this time). Analyzing several exposure scenarios provides a basis to consider a range of remediation alternatives. The exposure scenario discussed in the Process Document provides a baseline for the assessment of these other exposure scenarios. This appendix looks at several exposure scenarios in order to provide a better understanding of the changes that may occur in interim remedial measures if the selected exposure scenario were changed. This report was prepared to present the potential impacts (especially remediation areas, volumes, and costs) associated with different exposure scenarios.

1.2 PURPOSE AND SCOPE

The general purpose of this report is to extend the scope of the Process Document to address additional exposure scenarios, representing potential future uses of the 100 Area. The primary objective of the sensitivity analysis is to identify the sensitivity of the analyses (especially volumes and costs) presented in the Process Document to:

- Changes in potential future exposure scenarios
- Changes in target risk
- Changes in the exposure pathways.

Each of these elements is introduced in the following paragraphs.

1.2.1 Exposure Scenarios

In addition to the baseline scenario, this report evaluates four other potential exposure scenarios. Each exposure scenario is defined by land surface use and groundwater use components. Land surface use provides a basis to establish RAO for soils so that potential risks associated with exposure to these soils (e.g., through direct contact, incidental ingestion, external radiation) are controlled. Groundwater use provides a basis for RAO so that potential risks associated with exposure to groundwater (e.g., through ingestion) are controlled. Groundwater use has a relationship to source operable units because vadose zone soils must be remediated to levels that do not result in unacceptable leaching of contaminants into groundwater. More detailed descriptions of each exposure scenario are included in Section 2.0. The five scenarios are summarized below:

- Baseline: Corresponds to the scenario applied as the basis of the FFS. Remediation of Remediation of soils to support occasional-use of land and frequent-use of groundwater.
- Occasional-Use: Corresponds to remediation of soils to support occasional-use of land and occasional-use of groundwater.
- Frequent-Use: Corresponds to remediation of soils to support frequent-use of land and frequent-use of groundwater.
- Modified Frequent-Use: Corresponds to frequent-use of land and obtaining drinking water from a source other than local groundwater.

- Complete Excavation: Corresponds to near total removal of contaminated soils based on 10^{-6} target risk frequent-use of all soils above water table. Protection of groundwater is not assumed because it is inherent in complete source removal.

The term "occasional-use" implies a limited duration exposure to the media of interest, such as seven 24-hour days of recreational type use per year. The term "frequent-use" implies a more unrestricted exposure to the media of interest, such as exposure to the media of interest 365 days out of the year.

This report assesses areas, volumes, costs, and other factors for each scenario, compares the scenarios, and finally presents results and conclusions.

1.2.2 Target Risk

The EPA has identified a target risk range of 10^{-4} to 10^{-6} for the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) program (40 CFR 300.430 (e)(2). The risk evaluation described in the Process Document and the operable unit-specific FFS are based on a target risk of 10^{-6}. This report includes an assessment of the impact of changing the target risk from 10^{-4} to 10^{-6} for the first four scenarios listed. This assessment was not performed for the complete excavation scenario because the remediation goal is based on frequent-use (10^{-6}) for all depths.

1.2.3 Pathway Assessment

This report includes an assessment of the various exposure pathways that contribute to overall risk, and compares the pathways to determine which have the most impact on increasing risk levels. The pathway assessment offers information for decision makers regarding the relative contribution to total risk of various exposure routes (e.g., ingestion, inhalation, and external radiation) versus the entire set of possible pathways described in the DOE-RL 1995.

1.3 APPROACH

This report expands on the analyses presented in the Process Document by showing the potential impacts of assuming other exposure scenarios. As such, and in keeping with standard CERCLA feasibility study methodology, the PRG developed and used in this report do not constitute final remediation goals. The development of ultimate cleanup levels was not addressed in this report. The final remediation goals for 100 Area IRMs will be developed by DOE, EPA, and Ecology in conjunction with development of IRM proposed plans, public comment on Proposed Plans, and RODs.

To achieve the scope and purpose of this report, four types of waste sites were selected as representative waste sites in the 100 Area. These representative sites were evaluated individually and in detail, and the results were extended across the 100 Area. This methodology allows this report to focus on specific objectives at a level of detail consistent with the level of site knowledge.

Each of the four representative waste sites was evaluated for Containment, RD, and RTD Alternatives developed in the Process Document. Because In Situ Treatment is applicable only at limited depths and the surface area requiring treatment is proportional to the surface area for the Containment Alternative, the analysis results from examining the Containment Alternative will be used to estimate the impacts to the In Situ Treatment Alternative.

The PRG developed in this report were calculated using the same methodology as in the Process Document. Exposure scenario specific PRG were developed for both land surface use and a groundwater use. Land surface use PRG were developed based on a 10^{-6} target risk. Groundwater use PRG were developed through application of the Summers Method Analytical Model using MCLs for drinking water as the target cleanup levels for groundwater. Appendix A of the Process Document contains a more detailed description of this analytical method.

1.4 ORGANIZATION OF REPORT

Below is a summary of Sections 2.0 through 5.0 of this report.

- Section 2.0, "Basis for Analysis," defines the exposure scenarios addressed in this report, documents the methodology for calculating the PRG for each scenario, and includes the results of the assessments of the relative importance of different exposure pathways and changing target risk level.
- Section 3.0, "Methodology and Results," describes the methodology to develop waste area and volume estimates and associated remediation costs, and describes the methodology for extension of the calculations to provide a 100 Area-wide assessment of the impacts of different exposure scenarios.
- Section 4.0, "Comparative Analysis of Exposure Scenarios," evaluates each exposure scenario against specific criteria relative to the baseline scenario.
- Section 5.0, "Conclusions," summarizes findings and makes recommendations.

2.0 BASIS FOR ANALYSIS

This section describes the exposure scenarios evaluated in this report, presents the PRG associated with each exposure scenario, summarizes the remediation alternatives, and summarizes the pathway and target risk assessment.

2.1 DEFINITION OF EXPOSURE SCENARIOS

The exposure scenarios discussed in this report were introduced briefly in Section 1.0. Table 2-1 and the following sections describe the scenarios in more detail. For convenience, the scenario analyzed in the Process Document and operable unit-specific FFS appendices is also summarized. The scenario descriptions reference the terms "occasional-use" and "frequent-use." The term "occasional-use" implies a limited duration exposure to the media of interest, such as seven 24-hour days of recreational type use per year. The term "frequent-use" implies a more unrestricted exposure to the media of interest, such as exposure to the media of interest 365 days out of the year.

Each potential 100 Area exposure scenario is defined by the following two components:

- Land Surface Use - Remedial action objectives established for soils in the vadose zone so that potential risks associated with exposure to these soils are controlled.

- Groundwater Use - Remedial action objectives established so that potential risks associated with exposure to groundwater and the future protection of groundwater resources are controlled. To protect groundwater, soils would be remediated to levels that do not result in unacceptable leaching of contaminants to groundwater.

2.1.1 Baseline Scenario

The baseline scenario currently serves as the basis for the Process Document and the operable unit-specific FFSs. The baseline scenario also serves as the "base case" scenario for the Sensitivity Analysis (i.e., in this report the effects of changing exposure scenarios are expressed relative to those associated with the baseline scenario).

The baseline scenario is based on the assumption that land surface use in the 100 Area would consist of occasional uses of the land in the depth zone of 0 to 3 m (0 to 10 ft). As discussed in Appendix A of the Process Document, three potential receptors in the 0 to 3 m (0 to 10 ft) zone are considered: humans in the first meter (3 ft); animals (pocket mouse) in the first two meters (6.5 ft); and plants in the first 3 m (10 ft). In the FFS, the protection of human health concentrations are used as substitutes for the ecological receptors in the 0 to 3 m (0-10 ft) depth range. A more detailed explanation is provided in Section 2.5.2 of the Process Document. The second component of this scenario, groundwater use, assumes that groundwater would be restored to levels consistent with the federal MCL (drinking water quality). The latter assumption was applied to all soils in the vadose zone (i.e., regardless of depth). This influences soil cleanup by requiring that contaminated soils be remediated to levels so that residual contaminants remaining in the soil do not leach downward causing an exceedance of drinking water standards.

2.1.2 Occasional-Use Scenario

The occasional-use scenario is based on the assumption that both land surface use and groundwater use in the 100 Area is consistent with occasional uses of the land and groundwater. The protection of land surface use is considered in the 0 to 3 m (0 to 10 ft) depth zone (as in the baseline scenario), and protection of groundwater use is considered in the entire vadose zone. The exposure pathways and exposure duration assumptions for land surface use are identical to those made for the baseline scenario. However, the soil concentrations calculated for protection of groundwater for the occasional-use scenario are different from the baseline scenario. Specifically, the soil concentrations required for protection of groundwater in the occasional-use scenario have been adjusted in proportion to the difference in exposure durations (intake factors) between a frequent-use and occasional-use scenario. In the baseline scenario, PRG in soil for protection of groundwater are based on the assumption that groundwater would be restored to MCL. The MCL is based on a drinking water intake rate of 2 L/day for 365 days/year. Protection of groundwater under an occasional-use scenario is based on an assumption of occasional-use of groundwater (with an exposure frequency of 7 days per year). The MCL is multiplied by a factor of 52 (365 days/7 days) to obtain concentrations in water providing protection of public health equivalent to MCL under an occasional-use scenario. This approach allows for consideration of an occasional groundwater use that is consistent with an occasional land surface use. It should be noted that application of this approach to calculating occasional-use of groundwater is unusual and could be in conflict with ARAR or other technical risk considerations. Regardless of these shortcomings, the scenario is carried forward as an intermediate scenario.

2.1.3 Frequent-Use Scenario

The frequent-use scenario is based on frequent use of both land surface and groundwater in the 100 Area. The land surface use is considered in the depth zone of 0 to 4.5 m (0 to 15 ft) (based on the MTCA guidance for residential land uses). The groundwater use is considered in the entire vadose zone. Under the frequent-use scenario, soils in the vadose zone would be remediated to a level that would allow frequent use of groundwater for drinking water. The soil concentrations (PRG) required for the protection of groundwater in the frequent-use scenario are identical to those in the baseline scenario. The frequent-use scenario demonstrates the impacts of adopting a residential-type use of the land.

2.1.4 Modified Frequent-Use Scenario

This modified frequent-use scenario differs from the scenario described in Section 2.1.3 in that drinking water and garden irrigation water is extracted from the Columbia River and that groundwater is not used as a source of untreated drinking water or for garden irrigation. The current point of compliance driving remediation of soils to protect groundwater are the "near-river" wells. The future point of compliance driving remediation of soils to protect groundwater is the Columbia River. This future point of compliance will be based on modeling of groundwater flow and contaminant transport. The surface land use is considered in the depth zone of 0 to 4.5 m (0 to 15 ft) (as in the frequent-use scenario). This report does not include contaminant transport modeling to demonstrate that contaminants left in place would not be transported to the Columbia River or "near-river" wells in concentrations that exceed ambient water quality criteria. For purposes of this report, it is assumed that sites remediated under the modified frequent-use scenario would not leave residual contamination in place that would result in an exceedance of ambient water quality criteria at the Columbia River. This scenario provides an assessment of a frequent use of the land with prohibitions against consumption or other uses of the groundwater.

2.1.5 Complete Excavation Scenario

The complete excavation scenario is based on removal of soil and waste in which contaminant concentrations exceed frequent-use PRG (10^{-6} target risk) at all depths above water table. This scenario is included as a bounding condition and represents the most comprehensive cleanup scenario. Protection of land surface use and groundwater use is achieved by excavating all soils that exceed the concentrations described above. All soils in the vadose zone are considered, but protection of groundwater values are not calculated because the protection of groundwater is inherent in source removal.

2.2 PRELIMINARY REMEDIATION GOALS

For the purposes of the FFS Process Document and this appendix, the exposure pathways used to calculate PRG include direct external exposure to radiation, ingestion of soil, and inhalation of dust. The PRG calculated for each exposure scenario are described in Table 2-1 using the following steps:

- Allowable contaminant levels are calculated based on pathways, exposure assumptions (e.g., duration of exposure), target risk (e.g., 10^{-6}), and an interim action completion date of 2018.

- For radionuclides, the 2018 allowable contaminant levels are then back-calculated from 2018 to 1992 using radioactivity decay equations. The year 1992 was chosen as the base date for PRG development because the majority of the LFI data corresponds to 1992. The Process Document, OU-specific FFSs, and this report follow the same approach.

- For nonradionuclides, the concentration data reported in the LFI and other characterization studies are unchanged. The concentration corresponding to a hazard quotient of 0.1 is then calculated as input to Table 2-1. A hazard quotient of 0.1, rather than 1.0, is used to account for the additive effects of individual nonradionuclides.

- The 1992 allowable contaminant levels are compared against the protection of groundwater limits derived from MCL and the Summers Model. The lower of the two values is then compared to the analytical detection limits. The lowest number of the latter comparison is then included as the appropriate PRG.

Five scenario-specific PRG tables are included in Attachment 2. A summary of the scenario-specific PRG is presented in Table 2-2.

2.3 REMEDIATION ALTERNATIVE SUMMARY

The alternatives developed in the Process Document were established by the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1993d). The phase 1 and 2 alternative screening defined potentially applicable general response actions for 100 Area waste sites. In the Process Document, alternatives consistent with the following general response actions were developed as remediation alternatives:

- No Action
- Institutional Controls
- Containment
- Remove/Dispose
- In Situ Treatment
- Remove/Treat/Dispose.

The No Action Alternative is not affected by changes in exposure scenario, and therefore, is not carried forward in this appendix. The Institutional Controls Alternative was found to be not applicable to any of the waste site groups in the Process Document, and therefore is not carried forward in this appendix.

The Containment Alternative is carried forward only for the baseline and occasional-use scenarios because a Hanford barrier is generally inconsistent with unrestricted or frequent-type uses. In an effort to limit the scope of the Sensitivity Analysis, the In Situ Treatment Alternative is not specifically carried forward. Like the Containment Alternative, In Situ Treatment is generally inconsistent with unrestricted or frequent-type uses. Like the RD and RTD Alternatives, In Situ Treatment is dependent on the depth and lateral extend of contamination. In this report, the Containment, RD, and RTD Alternatives are carried forward as surrogates for the In Situ Treatment Alternative. That is, the sensitivity analysis of the alternatives will be used to identify the general trends expected for In Situ Treatment as exposure scenarios are varied.

Both the RD and RTD Alternatives are carried forward and analyzed as applicable to all five exposure scenarios.

2.4 PATHWAY ASSESSMENT SUMMARY

The PRG developed in the 100 Area FFS documents are based on a specific subset of the total number of exposure pathways that could be considered in a risk assessment. This approach is consistent with DOE (1995) guidance and agreements between the Tri-Parties. However, two concerns remain:

- Do risks based on a subset of pathways underestimate human health risk?
- Are the PRG presented in the Process Document protective of human health?

To address these concerns a pathway assessment was performed to evaluate the impacts of considering additional exposure pathways. To accomplish this objective, human health risks are calculated using both the subset of exposure pathways and the full set of exposure pathways for each of the five exposure scenarios. The results from the pathway assessment are used to determine if the subset of exposure pathways selected to develop PRG adequately address human health risks associated with the full set of exposure pathways.

The pathway assessment is not intended to determine if final cleanup criteria should be developed from a subset of exposure pathways. However, a secondary objective of the pathway assessment identifies a minimum set of exposure pathways that should be considered in developing final site cleanup criteria. A more detailed description of the pathway assessment is provided in Attachment 1.

2.4.1 Exposure Pathway Selections

Guidance for selecting exposure pathways at the Hanford Site is found in the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995). The DOE-RL (1995) is a guidance for preparation of risk assessments consistent with current regulations and guidance, and the Tri-Party Agreement. The QRA methodology, presented in Section 5.0 of DOE-RL (1995), provides additional guidance on selection of exposure pathways for risk assessments. The QRA methodology is used to develop PRG for the 100 Area FFS documents.

For the pathway assessment, the "full set" of pathways comprises the exposure pathways described in the conceptual model for human exposure assessment in DOE-RL (1995) (Figure 3-4); the subset of pathways comprises the exposure pathways described in the QRA methodology. The following sections describe how exposure pathway selections are made in DOE-RL (1995) and in the QRA methodology.

2.4.1.1 Exposure Pathway Selections in the *Hanford Site Risk Assessment Methodology*. Exposure pathways described in DOE-RL (1995) are considered either primary or secondary pathways. Primary pathways should be evaluated quantitatively for a specific scenario (i.e., health risks should be calculated for exposures potentially occurring through primary pathways).

They are considered the risk-driving pathways at hazardous waste sites (DOE 1995) and should be evaluated for all scenarios. The primary pathways described in DOE-RL (1995) are:

- Soil ingestion
- Inhalation of fugitive dust or volatiles
- Ingestion of water (either surface water or groundwater)
- Dermal contact with soil
- External exposure from radionuclides in soil.

Several biota pathways were selected as primary exposure pathways for specific scenarios. For recreational and residential receptors, the biota pathways that are considered primary pathways are:

- Consumption of Columbia River fish
- Consumption of homegrown produce.

Secondary pathways are those that should be qualitatively evaluated, at a minimum, but may be quantitatively evaluated based on site characterization, contaminant characteristics, and contaminant migration. Secondary pathways are:

- Ingestion of sediment
- Dermal contact with sediment
- Inhalation of volatiles from water
- Dermal contact with water.

Secondary pathways are considered in DOE-RL (1995) to potentially contribute less to overall risks than primary pathways.

2.4.1.2 Exposure Pathway Selections in the Qualitative Risk Assessment Methodology. The QRA performed for each operable unit evaluates risks for high-priority waste sites using available site data to support decision-making for IRM. The QRA evaluates health risks for two exposure scenarios defined as frequent-use and occasional-use. These scenarios use exposure assumptions that are identical to those presented for the residential and recreational exposure scenarios defined in DOE-RL (1995). Within the context of the QRA, these exposure assumptions do not define a particular land-use setting but are used to represent bounding estimates of potential site risks.

The exposure pathways evaluated in the QRA are a subset of those described in DOE-RL (1995). The pathways evaluated in a QRA are:

- Soil ingestion
- Inhalation of fugitive dust or volatiles
- Ingestion of water (either surface water or groundwater)
- External exposure from radionuclides in soil.

2.4.1.3 Exposure Pathways Evaluated in the Pathway Assessment. The exposure pathways evaluated in the pathway assessment for each exposure scenario are summarized in Table 2-3.

2.4.2 Pathway Assessment Approach

As discussed previously, one objective of the pathway assessment is to evaluate whether the subset of exposure pathways used to develop PRG for the FFS are appropriate for addressing human health risks through all exposure pathways. For some contaminants (such as ^{90}Sr), human health risks may increase when additional exposure pathways are added. However, if contaminants (such as ^{90}Sr) are not significant contributors to total site risks, then the total site risk, the treatment volumes and costs, or postremediation risks would not be affected by including additional exposure pathways.

The potential effects of including the additional exposure pathways on site risks before and after remediation are addressed using the following steps:

- Develop a methodology to estimate exposures and health risks through each of the pathways presented in Table 2-3.

- Estimate total preremediation site risks for the four representative sites based on the maximum concentrations detected.

- Estimate site risks for the four representative sites based on the maximum concentrations that would remain in soil following excavation (the extent of excavation would be determined by PRG developed from the subset of pathways).

Intake factors presented in DOE-RL (1995) were used to estimate exposures and health risks through each of the pathways (Attachment 1). Exposure concentrations in soil were obtained directly from the sampling and analytical data presented for each representative site. Exposure concentrations in groundwater potentially associated with leaching of contaminants from soil were estimated using the Summers Model. Exposure concentrations in surface water were estimated assuming that both surface runoff and influx of groundwater as migration pathways. Exposure concentrations in fish and homegrown produce were estimated from concentrations in surface water and soil, respectively, using transfer factors available in the literature (see Attachment 1). Health risks were estimated as incremental cancer risks (ICR) using slope factors obtained from the EPA. A detailed description of the methodology used to calculate exposures and health risks is presented in Attachment 1 of this report.

Preremediation ICR were calculated for the maximum concentrations of contaminants reported at each depth at each representative site. The ICR for each contaminant at a specific depth were summed to estimate the total ICR for all contaminants detected at that depth. Preremediation risks were estimated for both the frequent- and occasional-use scenarios and both the subset and full set of exposure pathways.

Postremediation ICRs were calculated for the maximum concentrations of contaminants at each depth at each representative site following excavation. The depth of excavation assumed was based on a PRG developed from the subset of pathways.

2.4.3 Summary of Pathway Assessment Results

The findings of the pathway assessment indicate that there is not a significant difference between the pre or postremediation risks for the subset of pathways or full set of pathways. The contaminants providing the longest contributions to total site risks included ^{137}Cs, ^{60}Co, ^{152}Eu, ^{154}Eu, ^{226}Ra, and ^{228}Th. For ^{137}Cs, ^{60}Co, ^{152}Eu, ^{154}Eu , the external exposure pathway provide the largest contribution to total contaminant-specific risks. For ^{226}Ra and ^{228}Th, the groundwater ingestion exposure pathway provide the largest contribution to total contaminant-specific risks. The external exposure and groundwater ingestion pathways are common to both the subset and full set of exposure pathways; therefore, total site risks is not likely to differ between these two sets of pathways.

Additionally, where the full set of pathways result in slight differences in risk, the risk is mitigated by removal of the contaminated soils based on PRG derived from a subset of pathways. The findings of this report support the current approach used for the FFS documentation.

2.5 TARGET RISK SENSITIVITY EVALUATION

An integral component of the risk assessment approach is the definition of the target risk levels used to evaluate risk. Risk evaluations in the Process Document and operable unit-specific FFS were based on a 10^{-6} target risk. The EPA has identified a target risk range of 10^{-4} to 10^{-6} for CERCLA risk evaluations. One of the goals of this Sensitivity Analysis report is to assess the impacts of changing the target risk from 10^{-6} and 10^{-4}.

For the purposes of FFS evaluation, target risk level is used to establish the land surface protection PRG. As part of the evaluation process, new land surface use PRG were estimated. The 10^{-4} PRG were estimated by increasing the human health PRG established in Section 2.2 by two orders of magnitude to account for an increase in target risk level from 10^{-6} to 10^{-4}. Groundwater protection PRG are derived from the MCL, rather than from a target risk level. Modification of groundwater protection PRG to reflect a change in target risk level was not considered appropriate because MCL are not based purely on human health risk considerations.

The baseline, occasional-use, frequent-use, and modified frequent-use exposure scenarios identified in Section 2.1 were evaluated for changes in target risk levels. The complete excavation scenario was not evaluated for sensitivity to changes in target risk level because the scenario was included as a bounding condition. For baseline, occasional-use , and frequent-use scenarios, the groundwater protection PRG were found to be the limiting criteria that defined the depth of contamination removal. Depth of contamination for the modified frequent-use scenario was limited by the 4.5 m (15 ft) maximum excavation depth criteria for both target risk levels.

For the RD and RTD Alternatives, volumes and costs associated with remediation are primarily dependent on the extent of contamination. Therefore, remediation costs and volumes for the baseline, occasional-use, and frequent-use scenarios are not expected to be sensitive to a change in target risk from 10^{-6} to 10^{-4} because depth of contamination and excavation is dependent on protection of groundwater (MCL drivers) instead of target risk. Remediation costs and volumes for the modified frequent-use scenario are also not expected to be sensitive to changes to target risk level because the extent of contamination was limited to a predefined depth of excavation (4.5 m [15 ft]), rather than target risk. However, sites remediated under a modified frequent-use scenario that have a depth of contamination less than 4.5 m (15 ft), will be sensitive to a change in target risk.

In the Process Document the containment technology is applied to an area which extends 12 m (40 ft) beyond the boundaries of the site. Consequently, the Containment Alternative is dependent more on site geometry than exposure scenarios. Changes in target risk would affect the extent of application of the In Situ Treatment Alternative in a similar manner as for the RD Alternative described above.

Based on this evaluation, the remaining Sensitivity Analysis was performed assuming the 10^{-6} target risk level.

Table 2-1. Exposure Scenario Summary.

Scenario Name		Exposure Definition	
		Land Surface-Use[a]	Groundwater-Use[b]
1	Baseline	Exposure Zone: 0 to 10 feet Basis: Occasional-use human health PRG	Exposure Zone: Surface to groundwater Basis: Groundwater protection PRG developed from MCL using Summers Model
2	Occasional-Use	Exposure Zone: 0 to 10 feet Basis: Occasional-use human health PRG	Exposure Zone: Surface to groundwater Basis: Groundwater protection PRG developed for the occasional-use scenario based on MCL, Summers Model, and ratios of intake factors.
3	Frequent-Use	Exposure Zone: 0 to 15 feet Basis: Frequent-use human health PRG	Exposure Zone: surface to groundwater Basis: groundwater protection PRG developed from MCL using Summers Model
4	Modified Frequent-Use	Exposure Zone: 0 to 15 feet Basis: Frequent-use human health PRG	Exposure Zone: Not applicable Basis: Groundwater not used for human consumption. Point of compliance set at river.[c]
5	Complete Excavation	Exposure Zone: Defined by depth of contamination Basis: Frequent-use human health PRG (10^{-6} target risk)	

Note:
[a]Surface-use exposures based on soil ingestion, inhalation, and exposure to external radiation pathways in the first 0 to 3 m (0 to 10 ft) for occasional-use scenario, and 0 to 4.5 m (0 to 15 ft) for frequent-use scenario.
[b]Groundwater-use exposures based on the groundwater ingestion pathway.
[c]Scenario requires contaminant transport modeling to demonstrate that contaminants left in place would not cause the ambient water quality criteria at the river to be exceeded.

Table 2-2. PRG Summary.

SCENARIO	Baseline[a]		Occasional-Use[a]		Frequent-Use[a]		Modified Frequent-Use[a]	Complete Excavation[a]
Scenario Components	Land Surface 0-10 Ft	Groundwater 0-GW	Land Surface 0-10 Ft	Groundwater 0-GW	Land Surface 0-15 Ft	Groundwater 0-GW	Land Surface 0-15 Ft	Land Surface 0-GW
RADIONUCLIDES (pCi/g)								
Am-241	31	31	76.9	1600	1.3	31	1.3	1.3
C-14	50	50	940	940	50	50	851	851
Cs-134	517	517	3460	27000	22	517	22	22
Cs-137	5.68	775	5.68	40000	0.1	775	0.1	0.1
Co-60	17.5	1292	17.5	67000	0.11	1292	0.11	0.11
Eu-152	5.96	20667	5.96	1100000	0.1	20667	0.1	0.1
Eu-154	10.6	20667	10.6	1100000	0.1	20667	0.1	0.1
Eu-155	3080	103333	3080	5400000	20	103333	20	20
H-3	517	517	27000	27000	517	517	55900	55900
K-40	12.1	145	12.1	7500	4	145	4	4
Na-22	207	207	545	11000	4	207	4	4
Ni-63	46500	46500	184000	2400000	3530	46500	3530	3530
Pu-238	5	5	87.9	260	1.7	5	1.7	1.7
Pu-239/240	4	4	72.8	210	1.4	4	1.4	1.4
Ra-226	0.1	0.1	1.1	1.6	0.1	0.1	0.1	0.1
Sr-90	129	129	1930	6700	37	129	37	37
Tc-99	26	26	1400	1400	26	26	553	553
Th-228	1	1	5.4	5.4	1	1	47	47
Th-232	1	1	1	1	1	1	3.1	3.1
U-233/234	5	5	165	260	3.1	5	3.1	3.1
U-235	6	6	23.6	310	1	6	1	1
U-238 (e)	6	6	58.4	310	1	6	1	1
INORGANICS (mg/kg)								
Antimony	6	6	6	6	6	6	6	6
Arsenic	1	1	1	1	1	1	1	1
Barium	258	258	13000	13000	258	258	560	560
Cadmium	0.775	0.775	40	40	0.775	0.775	8	8
Chromium VI	1	1	1.4	1.4	1	1	3.9	3.9
Lead	8	8	420	420	8	8	0.3	0.3
Manganese	13	13	680	680	13	13	40	40
Mercury	0.31	0.31	16	16	0.31	0.31	2.4	2.4
Zinc	775	775	40000	40000	775	775	2400	2400
ORGANICS (mg/kg)								
Aroclor 1260 (PCB)	1.37	1.37	4.34	71	0.083	1.37	0.083	0.083
Benzo(a)pyrene	4.57	5.68	4.57	300	0.33	5.68	0.33	0.33
Chrysene	0.33	0.33	0.52	0.52	0.33	0.33	0.33	0.33
Pentachlorophenol	0.8	0.8	14	14	0.8	0.8	5.3	5.3

NOTES: Maximum depth range indicates maximum depth to which PRG would be applied. For a given site, the remediation depth may be less than maximum.
GW=Groundwater
[a] All values presented are based on a target risk of 10^{-6}. Detailed PRG tables are provided in Attachment 2.

Table 2-3. Exposure Pathways Evaluated in the Pathway Assessment.

Exposure Pathway	Scenario			
	Full Set of Pathways		Subset of Pathways	
	Frequent Use	Occasional Use	Frequent Use	Occasional Use
Soil Ingestion	✓	✓	✓	✓
Dermal Contact with Soil	✓	✓	✓	✓
External Exposure to Soil	✓	✓	✓	✓
Inhalation (Dust/Volatiles in Air)	✓	✓	✓	✓
Groundwater Ingestion	✓	✓	✓	✓
Dermal Contact with Groundwater	✓	✓		
Surface Water Ingestion	✓	✓		
Dermal Contact with Surface Water	✓	✓		
Sediment Ingestion	✓	✓		
Dermal Contact with Sediment	✓	✓		
Ingestion of Game	NE	NE		
Ingestion of Fish	✓	✓		
Ingestion of Crops	✓			

NE = Not Evaluated

3.0 METHODOLOGY AND RESULTS

Sensitivity calculations were undertaken to support the objectives of the analysis. The calculations described in this section include area, volume, and cost estimates. The areas, volumes, and costs developed for the representative sites were used to calculate summary costs in a 100 Area-wide estimates. Additionally, a section describing the general implications to the Environmental Restoration Disposal Facility (ERDF) is included.

3.1 REPRESENTATIVE WASTE SITES

This report evaluates the impacts of several exposure scenarios on waste volumes and costs. Because of the similarities between waste sites in the 100 Area, representative sites were selected from four waste site groups to streamline the evaluation. The four waste site types chosen cover a range of sizes (based on estimated site dimensions) from small to very large. The site types, designations, and relative sizes are illustrated in Table 3-1.

Table 3-1. Summary of Representative Waste Sites.

Waste Site Type	Site Designation	Relative Size
Retention Basin	116-C-5	Very Large
Process Effluent Trench	116-B-1	Large
Fuel Storage Basin Trench	116-D-1A	Medium
Pluto Crib	116-F-4	Small

The four representative waste sites were selected on the basis of size and the inventory of characterization data available. Each selected waste site has two sources of site-specific data. The 116-C-5 Retention Basin, 116-B-1 Process Effluent Trench, and the 116-D-1A Fuel Storage Basin Trench were sampled by Dorian and Richards (1978) and again during the Limited Field Investigations (DOE-RL 1993a, DOE-RL 1993b, and DOE-RL 1993c). The 116-F-4 Pluto Crib sampling results were reported in Dorian and Richards (1978) and in the Excavation Treatability Test Report (DOE-RL 1994a).

This analysis estimates the impacts of five different exposure scenarios on the excavation volumes of waste plumes associated with four representative 100 Area waste sites. Only liquid reference solid waste studies waste sites were evaluated because the sampling data for the solid waste burial grounds indicates that there are no waste plumes under or near the burial trenches. The waste volumes for the burial grounds are considered to remain constant for all scenarios. They are covered in a separate category in the 100 Area-wide estimate in Section 3.4.

3.2 DEVELOPMENT OF VOLUME ESTIMATES

The volume and area estimates in this analysis were performed in accordance with the estimating methodology used in the FFS. That methodology is summarized in Section 3.2.1.

3.2.1 Estimating Bases

Waste site contamination volume estimates in the Process Document were developed using sampling data to project waste plume dimensions (lateral and vertical extent). The lateral dimensions of the waste plumes in the Sensitivity Analysis are consistent with those used in the Process Document.

The Sensitivity Analysis excavation depths were estimated from the refined COPC tables developed for the operable unit FFS appendices. The refined COPC tables are spreadsheets that show waste concentrations in four depth zones. They are used to indicate where the waste concentrations exceed the PRG. The depth of excavation required at each waste site is the lowest elevation at which the contaminant concentration for a given waste exceeds its corresponding PRG level. Refined COPC tables are provided in Attachment 3.

After the excavation depths were determined for each waste site and exposure scenario, the volume estimates were calculated as the product of the depth and lateral dimensions. The resulting volume estimates served as input to the Micro Computer Assisted Cost Estimating System (MCACES) that was used as the basis of cost estimates in the FFS. These models are presented in detail in the *100 Area Source Operable Unit Focused Feasibility Study Cost Models* (WHC 1994a).

Table 3-2 summarizes the volume estimates for the four representative waste sites and the five scenarios considered. Both excavation volume (EV) and contaminated volume (CV) are shown in Table 3-2. The EV is the total soil volume that must be removed. It includes clean overburden and side slope material. The CV is the soil to be removed for treatment and/or disposal. Figure 3-1 is a graphic summary of Table 3-2.

The surface area for containment was estimated by taking the site dimensions of each site and extending the containment technology 12 m (40 ft) beyond the boundaries of the site on all sides. This surface area did not change under varying exposure scenarios. The surface areas for the four representative sites are 37,700 m^2 (406,000 ft^2), 5,120 m^2 (55,100 ft^2), 2,100 m^2 (22,600 ft^2), and 930 m^2 (10,000 ft^2) for the retention basin, process effluent trench, fuel storage basin, and pluto crib respectively.

3.2.2 Volume Estimate Drivers

As noted in Section 3.2.1, the variation between the Process Document and Sensitivity Analysis volume estimates (and hence costs) is because of excavation depth. The primary driver for the excavation depth in the four representative waste sites is the groundwater protection PRG because all four sites require excavation in the depth zone in which the protection of groundwater

PRG are the risk drivers (except for the modified frequent-use scenario). To demonstrate these effects, four scenario comparisons are included in the following subsections.

3.2.2.1 Comparison of Baseline and Frequent-Use Scenarios. As shown in Table 3-2, the excavation and contaminated volumes for the baseline and frequent-use scenarios are identical. This occurs despite the use of more conservative PRG in the 0 to 4.5 m (0 to 15 ft) zone for the frequent-use scenario than were used in the 0 to 3 m (0 to 10 ft) zone for the occasional-use scenario. This is because the same groundwater protection PRG are used for both scenarios. Please refer to the baseline and frequent-use scenario PRG Tables 2-1 and 2-2 in Attachment 2, and the frequent-use COPC tables (3-1 through 3-3) in Attachment 3.

3.2.2.2 Comparison of Occasional-Use and Frequent-Use Scenarios. The occasional-use and frequent-use scenarios differ in the excavation depths and volumes because of unique groundwater PRG that were developed for the occasional-use scenario. The occasional-use groundwater PRG allow higher waste concentrations below 3 m (10 ft). This yields shallower excavation depths in comparison with the frequent-use scenario for three of the waste sites. The 116-B-1 Process Effluent Trench atypically shows the same excavation depth between the two scenarios because Chromium VI was detected above the PRG at the 4.5 to 6 m (15 to 20 ft) level, and the Chromium VI PRG are nearly the same in both scenarios.

A comparison of the PRG tables in Attachment 2 for the frequent-use (Table 2-1) and occasional-use (Table 2-2) scenarios reveals that there are seven constituents (^{226}Ra, ^{228}Th, ^{232}Th, Sb, As, Cr, and chrysene) that have the same, or nearly the same PRG in the groundwater protection zone. As a result, elevated concentrations of any of these contaminants in the groundwater protection zone will drive the frequent-use and occasional-use scenarios to the same excavation depths, effectively eliminating any distinction between the two scenarios.

3.2.2.3 Comparison of Frequent-Use and Complete Excavation Scenarios. The frequent-use and complete excavation scenarios show differences in the excavation depths and volumes because of the more conservative PRG used in the complete excavation scenario. The complete excavation scenario was based on radioisotope soil concentrations that correspond to the frequent-use human health-based contaminant levels (10^{-6} target risk) applied at all depths above the groundwater table.

As Table 3-2 shows, the depth of excavation increased above the frequent-use scenario in all cases. For three of the waste sites the increased depth of excavation was only 1.5 m (5 ft). The large increase noted for the 116-D-1A waste site was influenced by the waste concentration profile that showed little change in concentration with depth, and exceeded the PRG to the bottom of the borehole (15 m [50 ft] depth). Thus, the excavation depth for that site was set at the groundwater elevation (25 m [83 ft] depth) in the complete excavation scenario.

3.2.2.4 Comparison of Modified-Frequent Use and Occasional-Use Scenarios. The modified-frequent use scenario yields total EV that are similar to those in the occasional-use scenario (135,000 m^3 vs. 128,000 m^3). However, the EV data in Table 3-2 indicates that the volume contributions from the individual waste sites vary considerably between the two scenarios. The modified frequent-use scenario shows a significant reduction in the EV at the

deep waste site (Fuel Storage Basin Trench) in comparison with the occasional-use scenario. The occasional-use scenario yields a very low EV in the retention basin waste site because of the shallow excavation depth
(3 m [10 ft]).

It is evident that the excavation depths in the modified frequent-use scenario are fixed at the -14.6 m (-15 ft) elevation regardless of waste site, or contamination levels. In comparison, excavation depth will fluctuate by waste site in the occasional-use scenario. The area of sensitivity in the occasional-use scenario is the low PRG concentrations in the groundwater protection zone. Elevated concentrations of ^{226}Ra, ^{228}Th, ^{232}Th, antimony, arsenic, chromium, or chrysene in the groundwater protection zone could drive the occasional-use scenario to greater excavation depths and volumes than the modified frequent-use scenario. This was the case for the Fuel Storage Basin Trench, which has a 14 m (45-ft) excavation depth in the occasional-use scenario due to chromium (refer to Table 3-4 of Attachment 3). If a similar condition occurs at a retention basin waste site, it could significantly impact the occasional-use scenario EV.

3.2.2.5 Summary of Volume Estimate Observations. Based on the evaluations conducted, the following observations were made:

- If excavation represents the primary remedial alternative, and the PRG applied for the protection of groundwater drive the excavation depth, the human health (land surface protection) PRG will not be a primary volume and cost driver.

- The distinction between the occasional-use and frequent-use scenarios is sensitive to elevated concentrations of seven contaminants in the groundwater protection zone. Because the PRG limits in the groundwater protection zone are the same, or nearly the same for these contaminants in the occasional-use and frequent-use scenarios, the PRG would drive excavation to the same depth for these two scenarios (refer to Section 3.2.2.2).

3.2.2.6 Uncertainties in Volume Estimates. The volume estimates developed in this analysis are useful tools for making relative comparisons between scenarios, but should not be regarded as absolute volume figures because of the uncertainties resulting from the limited analytical database. The estimated excavation depths for waste sites were at times determined by the results from a single borehole. Consequently, the database for these waste sites does not provide a statistically significant basis for accurate three dimensional waste plume estimates.

For example, analytical data shows that waste concentrations may vary by two orders of magnitude depending on the location within the waste plume at the same relative elevation (DOE-RL 1994a).

3.3 AREA ESTIMATE

Remediation areas were estimated based on the waste site dimensions. For the Containment Alternative, the remediation area was estimated by adding a 12 m (40 ft) buffer zone around the waste site. These areas are assumed to be insensitive to changes in exposure scenario.

3.4 DEVELOPMENT OF COST ESTIMATES

The area and volume estimates developed for this analysis served as input parameters for cost estimating. This section describes the cost estimating methods.

Cost estimates for the representative waste sites and remediation scenarios were generated using MCACES cost models, as in the 100 Area FFSs (WHC 1994a). Several cost models were used, according to the type of waste site and waste treatment required. The waste site dimensions and volumes for the four representative waste sites were calculated for each exposure scenario as input to the cost models.

The costs include equipment, labor, supplies, overhead, profit, and contingency. The rates for excavation, material costs, labor, and equipment depreciation and operating costs are fixed within the MCACES models. Factors for profit and overhead are adjusted for each model according to the project duration and total project cost. Table 3-3 provides a summary of the cost estimates for the four representative waste sites and five scenarios considered. Figure 3-3 is a 100 Area cost summary.

The major cost drivers for the alternatives evaluated in the Sensitivity Analysis are waste treatment processes and waste disposal; both drivers are volume dependent. Project management, overhead, and contingency are also large dollar items. These, however, are proportional costs that are factored against total project costs. A summary of the cost elements is provided in Attachment 4 to identify the cost drivers in the same manner as the *100 Area Source Operable Unit Focused Feasibility Study Report* (DOE 1994b). The Attachment 4 summary features the 116-C-5 Retention Basin for the occasional-use, frequent-use, and complete excavation scenarios. These cost element examples provide a comparison basis for the scenarios within this study only.

The MCACES cost model estimates the cost of soil washing in the RTD remediation alternative. The methodology used in this analysis was applied in DOE-RL (1994b). The soil washing process was assumed to be effective at reducing ^{137}Cs soil concentrations by 50%. Therefore, soil with initial ^{137}Cs concentrations less than or equal to two times the PRG levels was eligible for soil washing. The volume of soil eligible for treatment was divided by the estimated CV for that site. The resulting fraction was compared with default percentages of 0, 33, 67, and 100. The eligible volume fractions were rounded to the nearest default percentage. The selected default percentages were used as input to the cost estimating model.

The major cost factors for the Treatment Alternative are the soil washing process and waste disposal. Waste disposal costs are directly proportional to the disposal volume. Soil washing process costs include soil hauling, laboratory analysis, and system operation and maintenance. System operation is the most significant cost element and is driven by equipment costs, and process water.

3.5 100 AREA-WIDE ESTIMATE

The purpose of the 100 Area-wide estimate is to give decision makers a sense of how decisions on the future use of the 100 Area affect the estimated areas, volumes, and costs, and may impose logistical constraints on future remediation decisions. Many assumptions and generalizations were made for these estimates. For example, 100 Area-wide estimates are made assuming that a single alternative is implemented for all sites. In reality (and as demonstrated by the Process Document) not all alternatives are applicable for all waste sites. In addition, many assumptions were made regarding whether a given site would be remediated under one exposure scenario but not another. Consequently, the results presented here are rough estimates and should be considered only in the context of comparing the relative impact of different exposure scenarios. A summary of the approach taken and results is provided below. A more detailed description of the process assumptions is provided in Attachment 5.

3.5.1 Area, Volume, and Cost Approach

Individual representative site area, volume, and cost estimates developed in Sections 3.2, 3.3, and 3.4 were multiplied by the total number of similar size sites in the 100 Area to develop total area, volume, and cost estimates for source remediation. The initial step in the 100 Area-wide estimate was to establish the inventory of IRM and miscellaneous sites within the 100 Area Source Operable Units. The inventory effort relied on available data and estimates of the site dimensions, depth of contamination, CV, and excavation volume. Estimates for candidate IRM sites were based on available LFI data supplemented by historical information. Estimates for the miscellaneous sites were based on the *Hanford Site 100 and 300 Subproject Excavation and Waste Volume Study* (WHC 1994b).

The waste site inventory was subdivided into four categories for further assessment. (Note that these categories have been defined in this manner purely for the purpose of the 100 Area estimate.) These categories included the following:

- IRM sites. Waste sites identified in operable unit work plans and LFIs as IRM candidates.
- Contaminated miscellaneous sites. Waste sites that are not IRM sites and which are likely to contain known or suspected chemical or radionuclide contamination.
- Potential miscellaneous sites. Waste sites that are not IRM sites and which contain no known or suspected chemical or radionuclide contamination.
- Excluded sites. Waste sites that are unlikely to require cleanup under any exposure scenario. After assessment of the inventory, no sites fell within this category.

The inventory of IRM and miscellaneous sites was further screened to remove waste sites that were believed to be insensitive to exposure scenario (scenario insensitive sites). Scenario insensitive sites are characterized as sites for which the contaminated and excavated volumes would not significantly change with changing cleanup levels. For example, burial grounds that received only solids, and pipelines with little or no leakage are two types of scenario insensitive sites. The volumes and costs associated with scenario insensitive sites are constant for all scenarios. The volumes associated with scenario insensitive sites are as follows:

- Contaminated Volume 1,500,000 m^3
- Excavated Volume 3,900,000 m^3.

A cost associated with scenario insensitive sites was estimated based on burial ground cost information in the Process Document and other site-specific FFS documents (see Attachment 5 for additional detail). A cost of $600 per contaminated cubic meter was used to represent the fixed cost contributed by the scenario insensitive sites. The total remove and dispose cost for all scenario insensitive sites is estimated to be $900 million.

The remaining IRM and miscellaneous sites were assigned to groups that were analogous on the basis of size to the representative waste sites (e.g., pluto crib). Assignment to a representative size group was based on similarity of CV and depth of contamination. The size group assignment criteria included the following:

- Pluto crib. CV less than 500 m^3 with a depth of contamination less than 6 m (20 ft).

- Process effluent trench. CV less than 3,500 m^3 with a depth of contamination less than 9 m (30 ft).

- Fuel storage basin trench. CV less than 50,000 m^3.

- Retention basin. CV greater than 50,000 m^3.

Table 3-4 provides an inventory of the number of IRM and miscellaneous sites within each representative size group. The area, volume, and cost estimates were calculated by multiplying the scenario specific representative site area, volume, and cost estimates in Tables 3-2 and 3-3, by the site inventory shown in Table 3-4, then summing the results. IRM and contaminated miscellaneous sites were included in the estimates for all five scenarios. The potential miscellaneous sites (e.g., sanitary drain fields) are expected to require cleanup only under a frequent-use scenario of the near-surface soils and, therefore, were included only in the roll up for the frequent-use, modified frequent-use, and complete excavation scenarios.

3.5.2 Area, Volume, and Cost Results

The results of the 100 Area-wide contaminated and excavation volume estimates are presented in Tables 3-5 and 3-6. Subtotal volumes for each site category and overall totals are included in the estimates for each exposure scenario. Table 3-5 presents the summation of the CV estimates along with the relative percent change from the baseline scenario. Table 3-6 provides the excavation volume roll up and relative percent change from the baseline scenario. Figure 3-2 provides a graphic representation of the IRM and miscellaneous sites volume data from Tables 3-5 and 3-6.

The 100 Area-wide volume estimates for the occasional-use and modified frequent-use exposure scenarios yield lower contaminated and excavation volumes than the baseline scenario (on average 35% less). As would be expected, the complete excavation scenario leads to the greatest percentage increase in contaminated and excavation volumes, 37 and 123%, respectively. The frequent-use scenario only shows a slight increase in volume when compared to the baseline scenario. These two scenarios are relatively the same because the groundwater protection PRG, which is the same for both scenarios, is the limiting criteria for cleanup in both scenarios.

The results of the 100 Area-wide cost estimates are presented in Tables 3-7, 3-8, and 3-9. Site category subtotals and overall totals are included for each of the 5 exposure scenarios for Containment (CAP), RD, and the RTD remedial alternatives. Table 3-7 presents the summation of the RD costs along with the relative percent change from the baseline exposure scenario. Table 3-8 provides a similar cost roll up for RTD. A graphic representation of the IRM and miscellaneous sites cost data in Tables 3-7, 3-8, and 3-9 is provided in Figure 3-3.

Evaluation of the 100 Area-wide cost estimates indicates the same trends as the volume estimates. The remediation costs under occasional use and modified frequent-use scenarios are both 30 to 40% less than the baseline scenario. Cleanup actions under the complete excavation scenario are estimated to be 45 to 72% higher than the baseline scenario for the RTD and RD scenarios, respectively. The frequent-use scenario costs are within the range of the baseline scenario costs. As indicated above, groundwater protection criteria are the primary influence on costs associated with the exposure scenarios considered in this evaluation.

The surface area of the containment technology is assumed to be constant under all applicable exposure scenarios. As shown in Figure 3-3, the 100 Area cost estimates for the Containment Alternative were nearly the same as costs for the RD Alternative. The containment cost estimate for the occasional-use scenario was significantly higher than both the RD and RTD Alternatives.

3.6 ERDF CONSIDERATIONS

The objective of this section is to assess the impact of the five land-use scenarios on the ERDF project. To accomplish this, the current ERDF design is examined and the volumes from the 100 Area-wide volume roll up are compared to current ERDF assumptions.

If Containment or In Situ Treatment were selected as the preferred alternative, very little soil and other material would require disposal. Changes in exposure scenario would have little, if any effect on ERDF design parameters, and therefore, the Containment and In Situ Treatment Alternative disposal requirements are not discussed further.

3.6.1 Current ERDF Basis

The ERDF is proposed to be a single-trench landfill with expansion flexibility to handle the past practice waste generated from the 100, 200, and 300 Areas (DOE/RL 1994c).

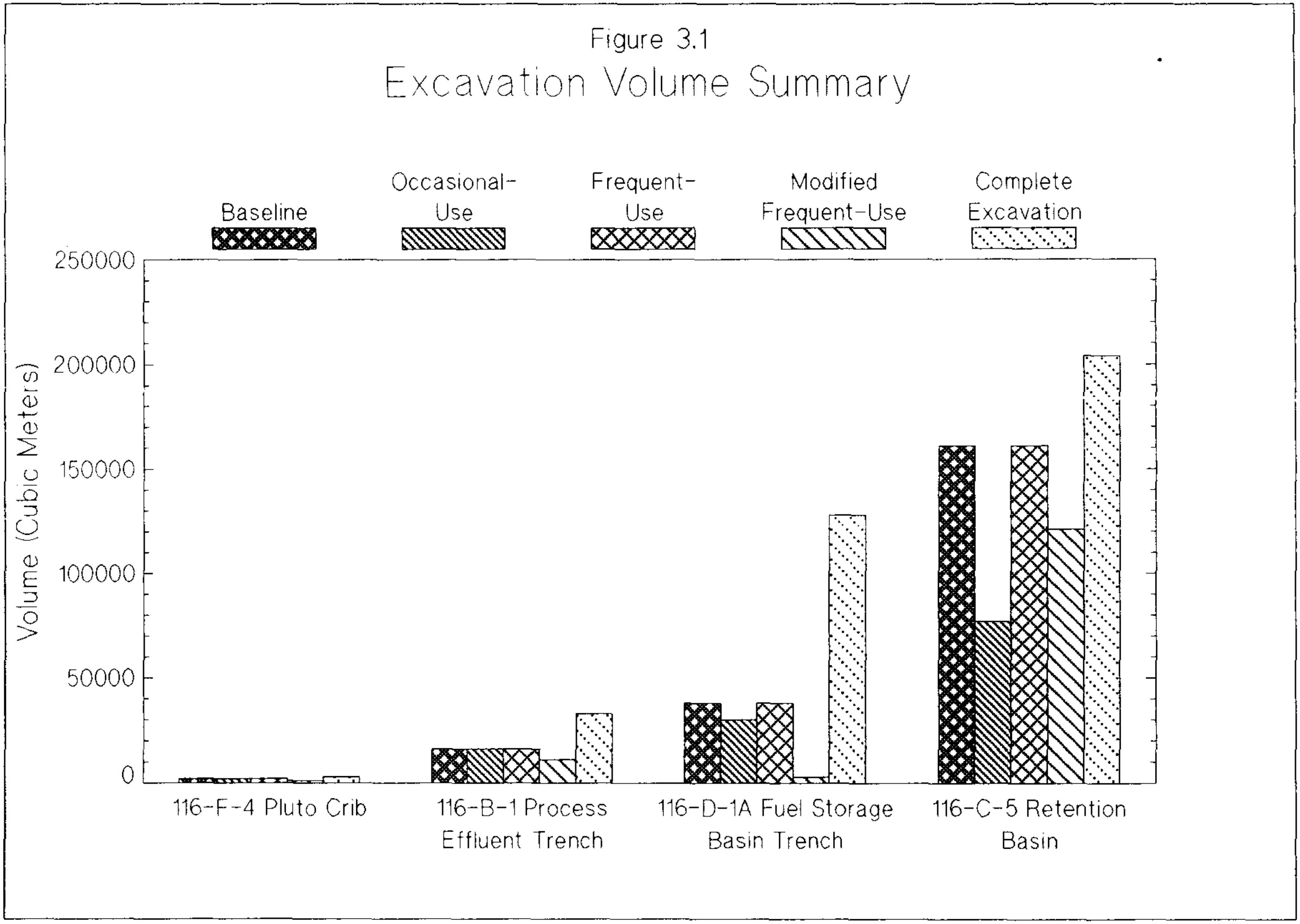
The ERDF project was originally designed as a disposal facility to accept a maximum of 21 million m^3 of waste generated during the complete remediation at the Hanford Site. The baseline (4-year) design consists of four compartment type cells in a single trench landfill design with expansion capabilities to six compartment cells. Each cell has the dimensions of approximately 150 m by 150 m by 21 m with a capacity of 500,000 m^3. Currently, the projected disposal volume for the four compartment cells in the first 4 years is under review.

The expansion capabilities still exist within the functional design of the ERDF and can be implemented by adding more cells. The design of ERDF includes a total area of 4.1 square kilometers and can be expanded to handle a projected total waste volume of 21 million m^3. The ERDF project planning is an ongoing effort and consequently these dimensions are subject to change.

3.6.2 Exposure Scenario Impacts on ERDF

As shown in Section 3.4, the contaminated soil volume is the smallest for the occasional-use scenario (1.4 million m^3) and greatest for the complete excavation scenario (3.4 million m^3). These volumes, in combination with the volume associated with scenario insensitive sites (Section 2.1, Appendix E, 1.5 million m^3), represent the 100 Area bounding conditions for this report. These volumes were based on removal and disposal of wastes without treatment to provide a worst case disposal volume. The low and high estimates are 2.9 million m^3 and 4.9 million m^3 for the occasional-use and complete excavation scenarios, respectively. These volumes fall well within the planned ERDF capacity.

Other issues, such as land disposal restrictions (LDR) and ERDF waste acceptance criteria, may have a significant impact on the land disposal alternative. Assessment of these issues is beyond the scope of this report.



Excavat.GAL

Figure 3-1. Excavation Volume Summary.

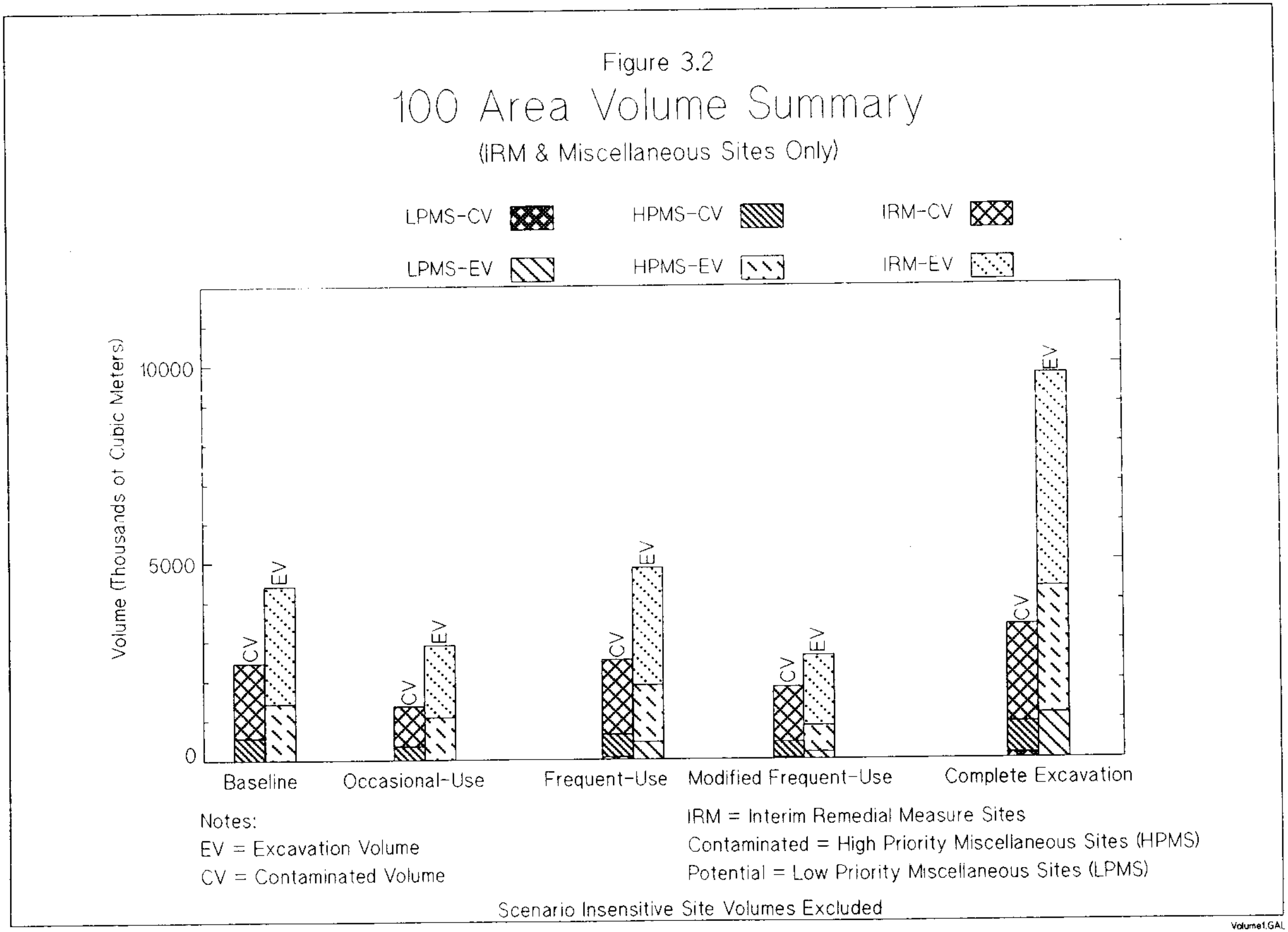
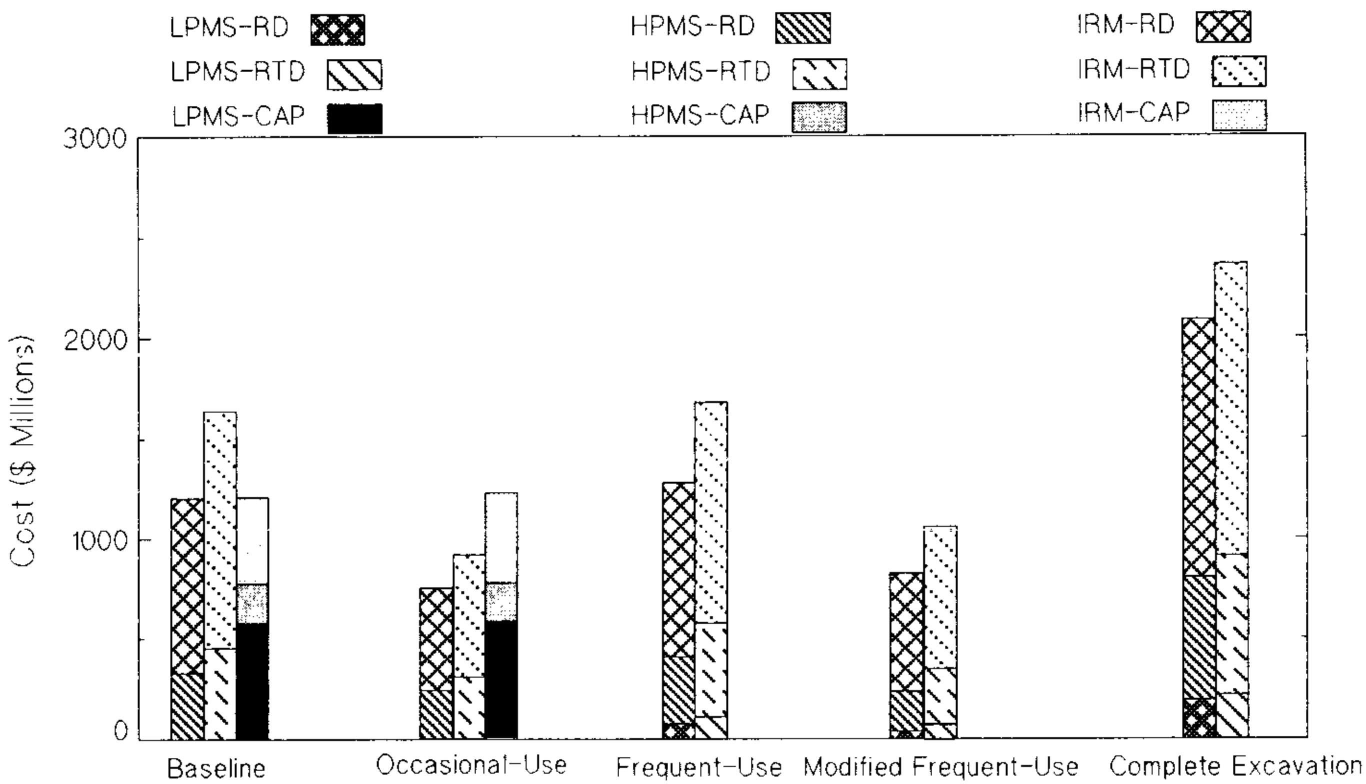


Figure 3-2. 100 Area Volume Summary.

Figure 3.3

100 Area Cost Summary

(IRM & Miscellaneous Sites Only)



Notes:

RD = Remove, Dispose

RTD = Remove, Treat, Dispose

CAP = Containment

IRM = Interim Remedial Measure Sites

Contaminated = High Priority Miscellaneous Sites (HPMS)

Potential = Low Priority Miscellaneous Sites (LPMS)

Scenario Insensitive Site Costs Excluded

Cost.GAL

Figure 3-3. 100 Area Cost Summary.

Table 3-2. Representative Site Depth and Volume Summary.

Scenario	Baseline[a]		Occasional[b] - Use (10^{-6})		Frequent[c] - Use (10^{-6})		Modified[d] Frequent - Use (10^{-6})		Complete Excavation[e]	
Representative Waste Site	Depth (ft)	Volume (m^3)	Depth (ft)	Volume/Area[f] (m^3/m^2)	Depth (ft)	Volume (m^3)	Depth (ft)	Volume (m^3)	Depth (ft)	Volume (m^3)
Retention Basin 116-C-5	20	EV=161,000 CV=145,000	10	EV=77,000 CV=73,000 Area=37,691	20	EV=161,000 CV=145,000	15	EV=121,000 CV=110,000	25	EV=204,000 CV=181,000
Process Effluent Trench 116-B-1	20	EV=16,000 CV=3,000	20	EV=16,000 CV=3,000 Area=5,119	20	EV=16,000 CV=3,000	15	EV=11,000 CV=2,000	30	EV=33,000 CV=7,000
Fuel Storage Basin Trench 116-D-1A	50	EV=38,000 CV=4,500	45	EV=30,000 CV=4,000 Area=2,104	50	EV=38,000 CV=4,500	15	EV=3,000 CV=1,000	83	EV=128,000 CV=7,000
Pluto Crib 116-F-4	20	EV=2,000 CV=200	20	EV=2,000 CV=200 Area=929	20	EV=2,000 CV=200	15	EV=1000 CV=200	25	EV=3,000 CV=300

NOTES: EV = Excavation volume
CV = Contamination volume

FOOTNOTES:
a. Baseline scenario based on occasional-use for soils and frequent-use protection of groundwater derived from the Summers Model and ARAR.
b. Soil risk and protection of groundwater based on occasional-use.
c. Soil risk and protection of groundwater based on frequent-use.
d. Soil risk is based on frequent use parameters, drinking water obtained from river, maximum excavation depth of 4.5 m (15 ft) based on MTCA.
e. Based on application of human health driven cleanup numbers to the full extent of the plume.
f. Area presented inlcudes a 12 m (40 ft) buffer zone around each site.

Table 3-3. Representative Site Remediation Cost Summary. ($ millions)

Scenario	Baseline[a]			Occasional[b] - Use (10^{-6})			Frequent[c] - Use (10^{-6})		Modified[d] Frequent-Use (10^{-6})		Complete Excavation[e]	
Representative Waste Site	RD	RTD	CAP	RD	RTD	CAP	RD	RTD	RD	RTD	RD	RTD
Retention Basin 116-C-5	59	81	23.6	29	33	23.6	59	81	43	49	70	80
Process Effluent Trench 116-B-1	3	4	5.9	3	4	5.9	3	4	2	3	8	9
Fuel Storage Basin Trench 116-D-1A	5	6	4.1	5	6	4.1	5	7	1	2	15	16
Pluto Crib 116-F-4	0.5	0.9	3.4	0.5	0.9	3.4	0.5	0.9	0.4	0.8	0.7	0.7

NOTES:
RD = Remove/Dispose of material
RTD = Remove/Treat/Dispose of material
CAP = Containment

FOOTNOTES:
a. Baseline scenario based on occasional-use for soils and frequent-use protection of groundwater derived from the Summers Model and ARAR.
b. Soil risk and protection of groundwater based on occasional-use.
c. Soil risk and protection of groundwater based on frequent-use.
d. Soil risk is based on frequent use parameters, drinking water obtained from river, maximum excavation depth of 4.5 m (15 ft) based on MTCA.
e. Based on application of human health driven cleanup numbers to the full extent of the plume.

Table 3-4. 100 Area-Wide Waste Site Inventory.

Representative Size Groups	IRM Sites		Miscellaneous Sites		TOTAL
	Process	Non-Process	Contaminated	Potential	
Pluto Crib	22	8	56	32	118
Process Effluent Trench	18	3	19	12	52
Fuel Storage Basin Trench	16	1	14	5	36
Retention Basin	11	1	3	0	15
TOTAL	67	13	92	49	221

Table 3-5. Percent Change in Total Contaminated Volume (cubic meters).

		Exposure Scenario								
		Baseline (a)	**Occasional Use**		**Frequent Use**		**Mod. Freq. Use**		**Complete Excavation**	
		CV	**CV**	**%**	**CV**	**%**	**CV**	**%**	**CV**	**%**
IRM Sites	Process	1,725,400	925,400	(46.4)	1,725,400	0.0	1,266,400	(26.6)	2,235,600	29.6
	Non-Process	160,100	87,600	(45.3)	160,100	0.0	118,600	(25.9)	211,400	32.0
Miscellaneous Sites	Contaminated	566,200	343,200	(39.4)	566,200	0.0	393,200	(30.6)	790,800	39.7
	Potential	0	0	NA	64,900	NA	35,400	NA	128,600	NA
SUBTOTAL		2,451,700	1,356,200	(44.7)	2,516,600	2.6	1,813,600	(26.0)	3,366,400	37.3
Scenario Insensitive Sites		1,400,000	1,400,000	0.0	1,400,000	0.0	1,400,000	0.0	1,400,000	0.0
Total Contaminated Volume (TCV)		3,851,700	2,756,200	(28.4)	3,916,600	1.7	3,213,600	(16.6)	4,766,400	23.7

CV = Contaminated Volume. Volume in cubic meters.
TCV = Total Contaminated Volume.
(a) baseline scenario is the base case.
NA = Not applicable because base case (baseline scenario) is zero.
(#) - Parentheses around a number denotes a negative value.

Table 3-6. Percent Change in Total Excavation Volume (cubic meters).

		Exposure Scenario								
		Baseline (a)	Occasional Use		Frequent Use		Mod. Freq. Use		Complete Excavation	
		EV	EV	%	EV	%	EV	%	EV	%
IRM Sites	Process	2,711,000	1,659,000	(38.8)	2,711,000	0.0	1,599,000	(41.0)	4,952,000	82.7
	Non-Process	263,000	171,000	(35.0)	263,000	0.0	165,000	(37.3)	455,000	73.0
Miscellaneous Sites	Contaminated	1,431,000	1,067,000	(25.4)	1,431,000	0.0	670,000	(53.2)	3,199,000	123.6
	Potential	0	0	NA	446,000	NA	179,000	NA	1,132,000	NA
SUBTOTAL		4.405,000	2,897,000	(34.2)	4,851,000	10.1	2,613,000	(40.7)	9,738,000	121.1
Scenario Insensitive Sites		3,600,000	3,600,000	0.0	3,600,000	0.0	3,600,000	0.0	3,600,000	0.0
Total Excavation Volume (TEV)		8,005,000	6,497,000	(18.8)	8,451,000	5.6	6,213,000	(22.4)	13,338,000	66.6

EV = Excavation Volume. Volume in cubic meters.
TEV = Total Excavation Volume.
(a) baseline scenario is the base case.
NA = Not applicable because base case (baseline scenario) is zero.
(#) - Parentheses around a number denotes a negative value.

Table 3-7. Percent Change in Total Remove and Dispose Cost ($ in millions).

		Exposure Scenario								
		Baseline (a)	Occasional Use		Frequent Use		Modified Frequent Use		Complete Excavation	
		RD	RD	%	RD	%	RD	%	RD	%
IRM Sites	Process	794.0	464.0	(41.6)	794.0	0.0	533.8	(32.8)	1169.4	47.3
	Non-Process	77.0	47.0	(39.0)	77.0	0.0	53.2	(30.9)	114.6	48.8
Miscellaneous Sites	Contaminated	332.0	242.0	(27.1)	332.0	0.0	203.4	(38.7)	611.2	84.1
	Potential	0.0	0.0	NA	77.0	NA	41.8	NA	193.4	NA
SUBTOTAL		1203.0	753.0	(37.4)	1280.0	6.4	832.2	(30.8)	2088.6	73.6
Scenario Insensitive Sites		870.0	870.0	0.0	870.0	0.0	870.0	0.0	870.0	0.0
Total RD Cost		2073.0	1623.0	(21.7)	2150.0	3.7	1702.2	(17.9)	2958.6	42.7

RD = Remove and Dispose. Cost in millions of dollars.
(a) baseline scenario is the base case.
NA = Not applicable because base case (baseline scenario) is zero.
(#) - Parentheses around a number denotes a negative value.

Table 3-8. Percent Change in Total Remove, Treat, and Dispose Cost ($ in millions).

		Exposure Scenario								
		Baseline (a)	Occasional Use		Frequent Use		Modified Frequent Use		Complete Excavation	
		RTD	RTD	%	RTD	%	RTD	%	RTD	%
IRM Sites	Process	1078.8	550.8	(48.9)	1094.8	1.5	642.6	(40.4)	1320.0	22.4
	Non-Process	106.2	58.2	(45.2)	107.2	0.9	66.4	(37.5)	131.0	23.4
Miscellaneous Sites	Contaminated	453.4	309.4	(31.8)	467.4	3.1	276.8	(39.0)	691.0	52.4
	Potential	0.0	0.0	NA	111.8	NA	71.8	NA	220.0	NA
SUBTOTAL		1638.4	918.4	(43.9)	1781.2	8.7	1057.6	(35.4)	2362.0	44.2
Scenario Insensitive Sites		870.0	870.0	0.0	870.0	0.0	870.0	0.0	870.0	0.0
Total RTD Cost		2508.4	1788.4	(28.7)	2651.2	5.7	1927.6	(23.2)	3232.0	28.8

RTD = Remove, Treat and Dispose. Cost in millions of dollars.
(a) baseline scenario is the base case.
NA = Not applicable because base case (baseline scenario) is zero.
(#) - Parentheses around a number denotes a negative value.

Table 3-9. Area Wide Containment Cost Estimates ($ in millions).

		Occasional-Use
IRM Sites	Process	510
	Non-Process	70
Miscellaneous Sites	Contaminated	430
	Potential	200
SUBTOTAL		1200
Scenario Insensitive Sites		950
Total Containment Cost		2150

Note: The contaminated areas remain constant, therefore, the cost is the same for both scenarios.

4.0 COMPARATIVE ANALYSIS OF EXPOSURE SCENARIOS

The comparative analysis of exposure scenarios is accomplished by assessing the impacts of the additional exposure scenarios on the evaluation of seven of the standard nine CERCLA criteria relative to the baseline scenario, for the CAP, RD, and RTD Alternatives. This comparative evaluation identifies the relative impacts of changing exposure scenarios and is not intended for the purpose of comparing the CAP, RD, and RTD Alternatives. Section 6.0 of the Process Document presents a comparative analysis of all the candidate remedial alternatives with respect to the nine CERCLA evaluation criteria. The seven criteria evaluated include the following:

Threshold Criteria

- Overall protection of human health and the environment
- Compliance with ARAR

Balancing Criteria

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost.

The two remaining criteria, regulatory acceptance and community acceptance, will be considered after regulatory and public comment on the FFS documents. The nine CERCLA criteria are intended for evaluation of remedial alternatives; however, this analysis uses the criteria to evaluate alternate exposure scenarios, and therefore, should be considered with that in mind.

To effectively evaluate the criteria introduced above, the impacts of alternate exposure scenarios on specific critical parameters must be defined. Critical parameters are defined as those elements of a remedial action that are significantly impacted by a change in exposure scenario. This section first defines the critical parameters and compares exposure scenarios relative to those parameters. The evaluation against the parameters is then used in the assessment of impacts on the evaluation of the CERCLA criteria.

4.1 EVALUATION OF CRITICAL PARAMETERS

The critical parameters include EV, CV, duration of remedial action, percent of material that is treatable, and cost. The reason these parameters are significantly impacted by a change in exposure scenario is primarily because of their relationship to PRG.

The PRG are primary variables affected by changes in exposure scenarios. The PRG are used to screen site data to define the extent of contamination. The extent of contamination is used to estimate CV, which in turn defines the EV and surface area. The PRG also influence the effectiveness of treatment alternatives, such as soil washing. For example, two-stage attrition scrubbing can only effectively treat soils contaminated with ^{137}Cs when the ^{137}Cs concentrations are less than two times the PRG. Soil washing is not the only treatment alternative evaluated in the FFS; however, it is applicable at most of the waste sites and is considered most sensitive to changes in exposure scenarios. The duration of the remedial action depends on the amount of material to be remediated as well as other requirements such as treatment. The cost of remediation depends on the amount of material to be remediated, treated or disposed, as well as the duration of the remedial action. The critical parameters are defined and evaluated below based on the results presented in Table 4-1.

Table 4-1 presents a comparison of the exposure scenarios relative to the baseline scenario based on the critical parameters. This comparison consists primarily of analysis of percent changes in the critical parameters relative to the base case. Positive values represent an increase in a parameter (e.g., volume), negative values represent a decrease, and a zero represents no change from the base case. The results presented in Table 4-1 are intended to be used to evaluate impacts from changing exposure scenarios for the 100 Area waste sites as a whole. Because the critical parameters for cost do not vary significantly for the CAP Alternative, it is excluded from the table.

4.1.1 Contaminated and Excavated Volume

Contaminated volume is the material that has been identified as contaminated by comparing the site data for representative waste sites against PRG. This is the quantity of material that must be addressed by the remedial action. Excavated volume is the material (including contaminated materials) that must be excavated during remedial action. Table 4-1 presents the comparison of the 100 Area-wide estimate volumes for each size grouping. The comparison presents the percentage change in contaminated and EV for each scenario relative to the baseline scenario (base case). Because the PRG are the same for each alternative (RD and RTD) under a given exposure scenario, the percent change in volume is the same for both alternatives presented.

As shown in Table 4-1, the occasional-use scenario results in a decrease in contaminated and excavated volumes for the larger sites (i.e., fuel storage basin trench and retention basin representative size groupings). The frequent-use scenario results in an increase in volumes for all size groupings except the retention basin size group that does not change relative to the base case. The modified frequent-use scenario results in the greatest decrease in volumes and affects all size groupings. The complete excavation scenario results in the greatest volume increase for all size groupings.

4.1.2 Duration

Duration is the amount of time required to complete the remedial action. This is an important parameter when considering short-term risks to workers from industrial hazards and exposure to contaminants. The comparison presents the percentage change in duration for each scenario relative to the base case. The comparison in Table 4-1 is for an individual representative site within each size grouping.

Under the RD alternative, the occasional-use scenario results in minor changes in duration for the larger sites (a slight increase for the fuel storage basin trench size sites, and a slight decrease for the retention basin size sites). There is no change in duration realized by changing to the frequent-use scenario. The modified frequent-use scenario results in a decrease in remedial action duration for all size groupings with the largest decrease related to the fuel storage basin trench size sites. The complete excavation scenario results in an increase in duration for all size groupings with the largest increase related to the fuel storage basin trench size sites.

Under the RTD alternative, the occasional-use scenario results in an increase in duration for the fuel storage basin trench size sites only, with no change in the pluto crib and process effluent trench size groupings. The retention basin size grouping shows a decrease in duration because it is not eligible for soil washing under the occasional-use scenario. The frequent-use scenario also results in an increase in duration for the fuel storage basin trench size sites, with no change in the process effluent trench, retention basin, and pluto crib size sites. The modified frequent-use scenario results in a decrease in remedial action duration for all sites; however, the decrease in the pluto crib and retention basin size sites is due, in part, to those groups not being eligible for soil washing. The complete excavation scenario results in an increase in duration for the process effluent trench size sites, which is the only size grouping eligible for soil washing. The increase in duration for the fuel storage basin trench site and the decrease in the pluto crib and retention basin sites are due in part to their lack of eligibility for soil washing.

4.1.3 Percent Treatable

Percent treatable is the percentage of the contaminated material that can be treated by soil washing. The percentage represents the effectiveness of the treatment alternative under each exposure scenario. The comparison presents the estimated percentage of contaminated material that is subject to treatment by soil washing for each exposure scenario. The comparison in Table 4.1 can be applied to an individual site as well as the 100 Area-wide roll up because it is a percentage of contaminated material. This parameter does not apply to the RD Alternative.

The baseline scenario represents the largest percentage treatable soils because of the PRG. The occasional-use scenario results in a decrease in percent treatable for the retention basin size grouping. The retention basin size grouping becomes ineligible for soil washing under the occasional-use scenario. Under the frequent-use scenario, a decrease in percent treatable is realized for the fuel storage basin trench size sites. The modified frequent-use scenario results in only two of the four size groupings (process effluent trench and fuel storage basin trench) as eligible for soil washing, and the percentages are less than the base case. The complete excavation scenario results in three of the four size groupings as ineligible for soil washing with a decrease in the percent treatable for the process effluent trench size sites.

Under the CAP Alternative, the extent of the remedial action remains constant for all applicable scenarios; therefore, the duration of remediation remains consistent.

4.1.4 Cost

The comparison presents the percentage change in cost for each scenario relative to the base case for the 100 Area-wide estimate. Under the CAP Alternative, the cost remains constant for both applicable exposure scenarios.

For the RD Alternative, the occasional-use scenario results in a decrease in cost for the retention basin size grouping, and all other size grouping do not change relative to the base case. A cost increase for all size groupings, except the retention basin size grouping, is realized under the frequent-use scenario. The modified frequent-use scenario results in a minor increase in cost for the pluto crib size grouping. The other three size groupings decrease in cost under the modified frequent-use scenario. Costs increase for all size groupings under the complete excavation scenario, with the greatest increase realized for the process effluent trench and fuel storage basin trench size groupings.

Under the RTD Alternative, the occasional-use scenario results in a cost decrease for the retention basin size grouping with all other groups remaining the same as the base case. The frequent-use scenario results in cost increases for the pluto crib, process effluent trench, and fuel storage basin trench size groupings and no change for the retention basin size grouping. All four size groupings decrease in cost under the modified frequent-use scenario. The complete excavation scenario results in a minor increase in cost for the pluto crib size group, no change for the retention basin size group, and significant cost increases for the process effluent trench and fuel storage basin trench size groupings.

4.1.5 Natural Resources

Because of the extent of potential excavation at the 100 Area operable units, natural resources such as cultural and ecological resources are considered to be critical parameters.

4.1.5.1 Ecological Resources. The natural vegetation, sensitive habitats and wildlife species could potentially be impacted by a change in exposure scenario since these resources are directly related to the extent of excavation (footprint). Ecological resources such as animals (species known to exist at Hanford) and the habitat that supports those animals are affected by what happens to the Hanford-wide environment, as well as the waste site specific changes. The extent of impact is influenced not by just the actual excavated area but also the needed support facilities, laydown areas, and haul routes/roads required to perform the work. These staging areas can take up significant area and may or may not be located in previously undisturbed areas.

4.1.5.2 Cultural Resources. The potential impacts on cultural resources are directly related to the amount of volume excavated. A change in exposure scenario that results in a wider and deeper excavation will disturb more area at a greater depth and thus may impact cultural resources to a greater degree or increase the likelihood of encountering cultural resources. If this increased width and depth of excavation is in previously disturbed areas, then the impact of going to a larger excavation could be negligible. If the area and depth result in the excavation expanding from a previously disturbed area to an area that has not been disturbed, then impacts could be significant. Also, as discussed for ecological resources, staging areas could influence the potential for impacts to cultural resources due to grading and grubbing activities.

4.2 IMPACT ON THE EVALUATION OF THE CERCLA CRITERIA

This section identifies the impacts of changing the exposure scenario on the evaluation of the CERCLA criteria, as presented in the Process Document. The comparisons presented are not intended to recommend a preferred exposure scenario, rather they identify the relative impacts of choosing an exposure scenario that differs from the baseline scenario in the Process Document.

4.2.1 Overall Protection of Human Health and the Environment

As exposure scenarios change, so do the RAO. As long as the RAO are met, the alternative is protective of human health and the environment; therefore, there is no significant impact on the evaluation of this criterion when alternate exposure scenarios are considered.

4.2.2 Compliance with ARAR

The ARAR themselves may change as exposure scenarios change; but this criterion will be met for all scenarios either by meeting the requirement or obtaining a waiver. The remedial action will be designed and implemented in compliance with action- and location-specific ARAR, and cleanup criteria will be established in consideration of chemical-specific ARAR. The evaluation of this criterion will not likely be impacted by a change in the exposure scenario.

4.2.3 Long-Term Effectiveness and Permanence

For the RD Alternative, the evaluation of this criterion will not be impacted by changing the exposure scenario. Removal of the contamination to achieve RAO is effective and permanent. The effectiveness of the RTD Alternative, however, is impacted by changing exposure scenarios. As PRG become more stringent, the performance of treatment technologies, such as soil washing, become limited, as with the complete excavation scenario where only one of the four size groupings is eligible for soil washing. However, because removal and disposal are elements of this alternative, the action will be effective and permanent for addressing contamination. The long-term effectiveness and permanence of the CAP Alternative is not affected by changes in applicable exposure scenarios.

4.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment

For the RD and CAP Alternatives, the evaluation of this criterion will not be impacted by changing the exposure scenario. The alternatives do not involve treatment, therefore, no reductions are realized. The effectiveness of the RTD Alternative, however, is impacted by changing exposure scenarios. As PRG become more stringent, the performance of treatment technologies, such as soil washing, become limited, therefore, decreasing the amount of reduction realized. The baseline scenario allows the highest percentage of material to be treated for all size groupings. The occasional-use scenario limits the eligibility of soil washing to three size groupings. The frequent-use scenario allows soil washing for all groupings, but at a lower percentage. The modified frequent-use scenario limits soil washing to two groupings. The complete excavation scenario allow only one grouping to be eligible.

4.2.5 Short-Term Effectiveness

The evaluation of short-term effectiveness is impacted by changing exposure scenarios. As the volume of material to be addressed increases, the duration of the activity increases. This increases the risk to workers from industrial hazards as well as exposure to contaminants. As the extent of the excavation increases, there is an increased potential for disturbance of local ecological and cultural resources.

The greatest changes in EV is realized for the modified frequent-use and complete excavation scenarios. The modified frequent-use requires much less excavated material for all size groupings, which results in a decrease in remedial action durations and is therefore the most effective scenario for the short-term. The complete excavation scenario requires significant increases in excavation resulting in significant increases in duration and is therefore the least effective scenario in the short-term. The occasional-use scenario will be slightly more effective in the short-term than the base case and the frequent use scenario will be slightly less effective. The short-term effectiveness of the CAP Alternative is not affected by changes in applicable exposure scenarios.

4.2.6 Implementability

For the RD Alternative, the evaluation of implementability is not impacted by changing exposure scenarios. The technology is proven, established, and readily implementable. The RTD Alternative is impacted by the performance limitations of technologies, such as soil washing. For the alternative, as PRG become more stringent, the ability of soil washing to treat contaminants decreases, rendering RTD less implementable. The amount of soil that can be treated is the best indicator of the implementability of soil washing. The baseline scenario allows the broadest implementation, followed by frequent-use, occasional-use, modified frequent-use, and finally complete excavation, which limits the implementability of soil washing the most. The implementability of the CAP Alternative is not affected by changes in applicable exposure scenarios.

4.2.7 Cost

Because of the relationship of cost to the volume of material treated, disposed and excavated, the evaluation of cost of the remedial action is very sensitive to changes in exposure scenarios. The scenario resulting in the largest contaminated and excavated volumes will have the highest cost. This is the case for the complete excavation scenario. The costs are significantly higher than the base case (highest overall). Conversely, the modified frequent-use scenario results in less volume, which results in less cost relative to the base case (least cost overall). The frequent-use scenario has greater cost than the base case and the occasional-use scenario has less. The cost of the CAP Alternative is insensitive to changes in applicable exposure scenarios.

4.3 IMPACT ON THE EVALUATION OF NEPA ISSUES

The evaluation of potential environmental impacts is based on a discussion of where changes in exposure scenario would change the environmental impacts described in the Process Document. As discussed in Section 2.3, only cultural and ecological resources are of primary concern. Short-term issues must also be discussed but are less likely to have a potentially significant impact.

The first three resources described below address the majority of the issues in the guidance for CERCLA evaluations that include NEPA. Other NEPA related issues, such as mitigation measures, irreversible and irretrievable commitment of resources, indirect and cumulative impacts, and environmental justice are also addressed below.

4.3.1 Cultural Resources

The No Action Alternative would not be anticipated to disturb cultural resources under either a frequent-use or an occasional-use scenario. If cultural resources are present at waste sites, these resources would be left in place and not disturbed. The occasional-use alternatives of CAP and in-situ treatment would still disturb some volume of land but not the amount of volume that would be generated as part of a RD or RTD Alternative. The frequent-use RD and RTD Alternatives would result in an even greater incremental increase in the volume of soil disturbed and thus result in greater impact to cut resources than the occasional-use scenario. The greatest difference in volume is between the No Action Alternative and all other alternatives that require action. Once action is determined to be required, the incremental increase in going from one alternative to another is minimal unless there becomes a need to "chase" a waste plume, at which time excavation in previously undisturbed areas could result in a adverse impacts to cultural resources.

4.3.2 Ecological Resources

The extent of potential impact to ecological resources is related to the surface area (or footprint) that is disturbed during implementation of the alternative. The No Action Alternative would not disturb significant land area but would require current and future limitations on land surface. The waste site area would require some restrictions for an undetermined period of time. Herbicides would continue to be applied at the waste sites to prevent the uptake of contaminants by plants. The occasional-use alternatives that include CAP, RD, and RTD would all require the surface area that exists above the waste plume to be disturbed either through a removal action or excavation for the installation of a cap. The frequent-use scenarios, with a more restrictive cleanup goal, would result in a larger area of "waste" to be removed and thus a larger area of excavation. In either case, as long as the excavation is limited to previously disturbed land, then impacts to native ecological resources would be minimal. However, as in the case with cultural resources, chasing a waste plume could impact previously undisturbed land surface area. The

CAP and RTD Alternatives would also required a larger laydown area, treatment system staging areas, and other stockpiling areas to accommodate the material needed for the cap or material requiring segregation for treatment.

4.3.3 Short-Term Impacts

As the amount of material to be excavated increases, short-term impacts such as elevated noise levels, use of utilities, and aesthetics (visual impacts during remedial activities) will occur. The incremental increase of these short-term impacts need to be considered as part of the evaluation of the various exposure scenarios.

The short term impacts of No Action would be minimal. Worker safety, noise, etcetera, would not be of concern for this alternative.

> "Those alternatives that require significant excavation efforts can be expected to result in higher rates of work-related accidents. For example, the mining and heavy construction industries experience an average of 43-52 lost workdays per 100 full time employees, per year, respectively. Although DOE safety procedures provide an extra margin of protection, it can be expected that large excavation efforts will result in impacts to worker health and safety." (National Safety Council, 1992)

The RTD and RD Alternatives for the occasional-use or frequent-use scenarios would involve the performance of excavation related. The treatment associated with the RTD Alternative would add another step to this alternative than the RD Alternative and thus would involve an incremental increase in noise, worker safety, etc. The CAP Alternative associated with the occasional-use scenario involves a different construction technique. Although there would be some requirement for excavation, the CAP Alternative would primarily involve the handling and staging of cap material such as rock, clay, and other barrier material.

4.3.4 Mitigation Measures

The mitigation measures described in the Process Document are general mitigation measures that may be utilized when avoidance is not possible. These general mitigation measures are still applicable to all the alternatives discussed in this Sensitivity Analysis. Alternatives that require more extensive activity have a greater potential to require some mitigation measures to be implemented. However, as described earlier, innovative remedial action planning should minimize adverse impacts to the extent practicable.

4.3.5 Irreversible and Irretrievable Commitment of Resources

The irreversible and irretrievable commitment of resources discussion contained in the Process Document also applies to the alternatives discussed in this Sensitivity Analysis. The CAP Alternative for the Occasional-use exposure scenario should be considered a commitment of land-to-waste management at the waste site. The disposal of contaminated soil in the RD and RTD Alternatives (either the occasional-use or frequent-use scenario) would be a commitment of land-to-waste management at the disposal site (e.g., ERDF). Any of the alternatives that include a surface barrier or extensive requirements for clean fill material would be a commitment to obtain offsite material, with the potential for impacts to cultural and ecological resources. A commitment of funds and potentially sensitive habitats or cultural resources destruction must be considered as a possibility for any remedial action to take place at the Hanford Site.

4.3.6 Indirect and Cumulative Impacts

As discussed in the Process Document, the net cumulative impact to the overall protection of human health and the environment is expected to be positive. Negative impacts are expected to be minor and short term. Remedial action planning will include the impacts of remediating multiple waste sites within a local area and thus properly address cumulative and indirect impacts.

4.3.7 Socioeconomic Impacts

Resources such as socioeconomic, transportation, health care and human services, and police and fire protection relate to the number of workers present and not to the extent of contamination remediated or the footprint of the remedial action. Even though there would be an incremental change in the amount of work to be performed, the impacts on health care, etcetera, evaluated in the Process Document are all relatively constant (i.e., the number of workers and the duration of work) will not significantly change, causing an impact to these factors. Issues such as recreational use and aesthetics, noise, and utilities are affected by the extent of contamination and the footprint of the remedial action, but are considered secondary impacts that only occur during the time remedial action is taking place and do not significantly affect cost or long term environmental considerations.

4.3.8 Environmental Justice

The assessment on environmental justice contained in the Process Document directly applies to all the alternatives and exposure scenarios utilized in the Sensitivity Analysis. Environmental justice issues, as discussed in the Process Document, do not identify any adverse impacts to a specific group. The Native American group was specifically reviewed for disproportionate impacts and the remediation alternatives comply with the objectives of the environmental justice executive order.

Table 4-1. 100 Area Wide Comparative Evaluation of Exposure Scenarios.

EVALUATION CRITERIA	ALTERNATIVE / EXPOSURE SCENARIO	REMOVE AND DISPOSE					REMOVE, TREAT AND DISPOSE				
		BASE-LINE	OCCA-SIONAL	FREQUENT	MODIFIED FREQUENT	COMPLETE EXCAVATION	BASE-LINE	OCCA-SIONAL	FREQUENT	MODIFIED FREQUENT	COMPLETE EXCAVATION
EXCAVATED VOLUME (% change)											
• Retention Basin		BC	(52)	0	(25)	27	BC	(52)	0	(25)	27
• Process Effluent Trench		BC	0	30	(11)	169	BC	0	30	(11)	169
• Fuel Storage Basin Trench		BC	(21)	16	(91)	291	BC	(21)	16	(91)	291
• Pluto Crib		BC	0	37	(31)	106	BC	0	37	(31)	106
CONTAMINATED VOLUME (% change)											
• Retention Basin		BC	(50)	0	(24)	25	BC	(50)	0	(24)	25
• Process Effluent Trench		BC	0	30	(13)	203	BC	0	30	(13)	203
• Fuel Storage Basin Trench		BC	(11)	16	(74)	81	BC	(11)	16	(74)	81
• Pluto Crib		BC	0	37	37	106	BC	0	37	37	106
DURATION (% change)											
• Pluto Crib		BC	0	0	(21)	32	BC	0	0	(62)	(36)
• Process Effluent Trench		BC	0	0	(23)	76	BC	0	0	(20)	81
• Fuel Storage Basin Trench		BC	5	0	(75)	298	BC	5	24	(65)	244
• Retention Basin		BC	(45)	0	(22)	21	BC	(75)	0	(65)	(46)
PERCENT TREATABLE (%)											
• Retention Basin		NA	NA	NA	NA	NA	33	0	33	0	0
• Process Effluent Trench		NA	NA	NA	NA	NA	100	100	100	67	33
• Fuel Storage Basin Trench		NA	NA	NA	NA	NA	100	100	67	33	0
• Pluto Crib		NA	NA	NA	NA	NA	33	33	33	0	0
COST (% change)											
• Retention Basin		BC	(51)	0	(27)	19	BC	(59)	0	(40)	(1)
• Process Effluent Trench		BC	0	30	(13)	247	BC	0	30	(3)	193
• Fuel Storage Basin Trench		BC	0	16	(77)	248	BC	0	36	(61)	210
• Pluto Crib		BC	0	37	10	92	BC	0	37	22	53

Notes:
NA = not applicable
BC = base case
all values are presented as percentages
(#)=denotes a negative value

5.0 CONCLUSIONS

This section summarizes the conclusions of this report. As a reminder, the primary analysis objective of the Sensitivity Analysis was to assess the effects of additional exposure scenarios on the baseline volumes and costs of remediation. Related secondary objectives were to identify the impacts of changing the target risk basis, and to evaluate the impact of considering additional exposure pathways. The conclusions discussed in this section are presented in the context of these objectives.

5.1 SENSITIVITY TO CHANGES IN TARGET RISK

The baseline, occasional-use, frequent-use, and modified frequent-use exposure scenarios were evaluated for changes in target risk levels (i.e., 10^{-4} versus 10^{-6}). The complete excavation scenario was not evaluated for sensitivity to changes in target risk because this scenario was developed and analyzed as a bounding condition based on a target risk of 10^{-6}. For the baseline, occasional-use, and frequent-use scenarios, the protection of groundwater PRG were the limiting criteria that defines the extent of remediation, even under scenarios assuming only occasional use of the groundwater. Because of this, these scenarios are unaffected by changes in target risk. Likewise, the 4.5 m (15 ft) maximum excavation for the modified frequent-use scenario minimizes the effect of changing target risk. The remediation costs and volumes for the four representative sites were not sensitive to changes in target risk.

5.2 PATHWAY ASSESSMENT

The Process Document, 100 Area operable unit-specific FFS, and related QRA rely on a subset of exposure pathways to assess risk and develop PRG. This subset includes soil ingestion, dermal contact with soil, inhalation of fugitive dust or volatiles, ingestion of groundwater, and external exposure from radionuclides in soil. A full baseline risk assessment usually considers additional exposure pathways, such as consumption of homegrown produce, ingestion of sediments, and dermal contact with water. This report includes an assessment of whether risk levels vary significantly when a full set of exposure pathways are considered in lieu of a pathway subset.

The findings of the pathway assessment indicated that risk and human health PRG are not sensitive to the differences between a subset and a full set of exposure pathways. There is not significant difference between the pre or postremediation risks for the subset of pathways or full set of pathways. In those few cases where the full set of pathways indicate potential increases in preremediation risk, the risk is mitigated by remediation to the human health PRG derived from the subset of exposure pathways. Based on the findings of the pathway assessment, no change is recommended for the current exposure pathway approach used in the Process Document and the 100 Area operable unit-specific FFS documents.

5.3 FOCUSED FEASIBILITY STUDY SENSITIVITY TO EXPOSURE SCENARIOS

Based on the analysis of the four representative sites and the Area-wide estimate, exposure scenarios are not sensitive to changes in target risk levels, nor are they sensitive to expanded exposure pathways. Therefore, the remaining evaluations in this report were performed using a 10^{-6} target risk level and the subset of exposure pathways. Furthermore, the exposure scenario comparisons were performed on the basis of current PRG. These PRG are appropriate for purposes of the FFS documentation and this appendix; however, as available site-specific information is refined and decisions about acceptable cleanup objectives are made, the PRG will change. Thus, the current PRG are not appropriate as the bases for final cleanup criteria.

The points of compliance for IRM and final remediation have not yet been established; therefore, assumptions were made in the Sensitivity Analysis for each exposure scenario. For example, all scenarios assume that ambient water quality criteria in the river (the assumed point of compliance) would not be exceeded. Another assumption for some scenarios is that groundwater is currently suitable for drinking water; therefore, remediation of the soils should be based on protection of that pristine resource. In reality, the groundwater has already been impacted beneath most of the waste sites.

Various models were used for PRG development and cost estimating. These models employed assumptions that could require further refinement before actual cleanup criteria can be determined. However, because the assumptions and models were applied consistently for all exposure scenarios, the analyses presented in this report are valid as a basis for a relative comparison of scenarios.

5.3.1 Key Results

Specific findings relating to the sensitivity of volume and cost to different exposure scenarios is discussed in Section 5.3.1.1. Section 5.3.1.2 discusses the relative sites of the CERCLA criteria to differing exposure scenarios.

5.3.1.1 Volume and Costs. The Sensitivity Analysis found that the selection of exposure scenario can have a considerable impact on total remediation volumes and costs. For summary purposes, the 100 Area-wide roll up of volumes and costs have been used in the discussion below.

The Sensitivity Analysis indicates that the occasional-use scenario results in the lowest CV, approximately 2,900,000 m^3 (102,410,000 ft^3). This CV is over 1,000,000 m^3 (35,314,000 ft^3) less (27%) than the base case (FFS) scenario, which had a CV of nearly 4,000,000 m^3 (141,256,000 ft^3). The exposure scenario with the second lowest CV is the modified frequent-use scenario, which results in over 600,000 m^3 (21,188,000 ft^3) less CV than the baseline scenario. The frequent-use scenario had only a slightly larger CV than the baseline scenario. The complete excavation scenario had the largest CV, nearly 4,900,000 m^3 (173,039,000 ft^3).

Excavation volume is dependent on CV and, therefore exhibits similar sensitivities to changes in the exposure scenario; however, the scenarios with the greatest extent of excavation (e.g., complete excavation) result in a disproportionate increase in excavation volume over contaminated soil volume. That is, the ratio of EV over contaminated soil volume becomes increasingly larger as lower PRG are considered. The cost analysis indicates that waste disposal is the primary component of both the RD and RTD costs. Because disposal cost is proportional to volume, the cost sensitivity was found to be similar to the volume sensitivity. In addition, the RTD cost varied in a similar manner as the RD costs; therefore, the following comparisons were made using only the RD costs.

For the RD Alternative, the exposure scenario resulting in the least cost was the occasional-use scenario, with an estimated total cost of nearly $1.7 billion. Although this cost was only 22% less than the baseline scenario, the cost difference amounts to nearly $500 million. The modified frequent-use scenario had a cost slightly larger than the occasional-use scenario. The third ranked exposure scenario was the baseline scenario with an estimated cost of over $2.1 billion. The frequent-use scenario was slightly larger than the baseline scenario (approximately $70 million more). Similar to the volume comparison, the complete excavation scenario results in the highest remediation cost of over $3 billion. This cost is $900 million more than the cost of the baseline scenario and $1.4 billion more than the cost of the occasional-use scenario.

Under the baseline scenario, the CAP Alternative cost nearly the same as the RD Alternative ($2.2 billion). Under the occasional-use scenario, the CAP Alternative is 23% more expensive than the RD Alternative.

5.3.1.2 CERCLA Criteria Comparison. A comparative analysis of the exposure scenarios was performed based on the standard CERCLA criteria to assess the occasional-use, frequent-use, modified frequent-use, and complete excavation scenarios relative to the baseline scenario. The three remediation methods included in the analysis were CAP, RD, and RTD. In general, the comparative analysis indicates the following:

- Overall protection of human health and the environment and compliance with ARAR are not sensitive to changing exposure scenarios.

- Short-term effectiveness and cost criteria are sensitive to changing exposure scenarios for both RD and RTD. The key factor responsible for this sensitivity is changes in volume across scenarios, which can significantly influence near term worker risk, project duration, local ecological and cultural resource impacts, and overall project costs. The short-term effectiveness of the CAP Alternative is not significantly influenced by changes in exposure scenarios.

- Long-term effectiveness and permanence; reduction of toxicity, mobility and volume through treatment; and implementability are sensitive only to changing exposure scenarios for RTD; they are not sensitive to scenario changes for RD. The key factor responsible for this sensitivity is the PRG differences across scenarios, which significantly influence the appropriateness and effectiveness of soil washing treatment.

The long-term effectiveness and permanence of the CAP Alternative is not significantly influenced by changes in exposure scenarios.

The CERCLA criteria evaluations affected by PRG are also highly dependent on exposure scenarios because exposure pathways, remediation durations, depths, and risk are the primary factors affecting the PRG. The application of demonstrated and easy-to-conduct treatment technologies could help mitigate this sensitivity, particularly in the area of implementability, and thereby reduce the influence of changing exposure scenarios. However, PRG decisions, which will rely heavily on exposure scenarios, have the most effect on the performance and effectiveness of RTD remedial options.

5.3.2 General Trends

The primary trend observed in the Sensitivity Analysis is that remediation of soils to levels protective of groundwater is the primary factor influencing the remediation volumes and costs; this trend is discussed in more detail in Section 5.3.2.1. Section 5.3.2.2 addresses other significant trends and conclusions relevant to exposure scenario sensitivities.

5.3.2.1 Influences of Groundwater Use. Exposure scenarios, which include protection of groundwater use, result in greater volumes of contaminated soil than scenarios designed primarily to protect against exposure to contaminated surface and near-surface soil. For example, there is a significant difference between the contaminated soil volumes for the frequent-use and modified frequent-use scenarios; both scenarios are based on the assumption of frequent land surface use, but the modified frequent-use scenario assumes drinking water could be obtained from the Columbia River, resulting in a significantly lower contaminated soil volume and cost. The reduction in contaminated soil volume between the baseline scenario and the occasional-use scenario is also substantial (more than a 40% reduction in contaminated soil volume).

For scenarios where groundwater is assumed as the drinking water source, the land surface use plays a much smaller role in determining contaminated soil volumes. This is demonstrated by comparing the baseline scenario to the frequent-use scenario (the increase in CV is less than 5% when land surface use changed from occasional- to frequent-use.)

For scenarios where use of groundwater as a drinking water source is prohibited, the specified land surface use is the key factor influencing the volume of contaminated soils requiring remediation. For example, between the occasional-use and modified frequent-use scenarios, the modified frequent-use scenario (where groundwater use is restricted) has a larger CV, even though groundwater is used under the occasional-use scenario. As another example, although the baseline scenario includes only occasional use of the land surface, the associated CV is significantly higher than for the modified frequent-use scenario; this appears to be almost entirely attributable to the inclusion of groundwater use in the baseline scenario.

The sensitivity of remediation costs to changing exposure scenarios follows the same trends described above for the sensitivity of volumes. Any minor differences are primarily attributable to variabilities in excavation volumes, which depend on the predicted depth of contamination and geometry of the waste management sites being considered.

Given the sensitivity of remediation costs to groundwater use assumptions, a careful evaluation of future groundwater use options must be an essential component of developing long-term remediation strategy for the 100 Area.

5.3.2.2 Other Significant Trends. Several other significant trends are listed below:

- The majority of the volumes and costs are associated with waste management sites in the Retention Basin Representative Size Group (i.e., very large). This is significant, because although only 15 Retention Basin-size waste sites are identified out of the total inventory of 236 sites (approximately 6% of the total number of sites), these sites account for about 50% or more of the total volumes and costs, regardless of the exposure scenario. Based on this finding, a proportionately higher level of attention should be paid to the remediation strategy for larger waste management sites.

- The 70 waste management sites currently identified as candidates for IRM (30% of the total inventory of 236 sites) account for a majority of the volumes and costs, typically in the range of about 60% to 75%. This finding indicates that attention has been appropriately focused on the candidate IRM sites.

- Although volumes and costs for scenario insensitive sites are not affected by changes in exposure scenarios, these sites represent a significant contribution (on the order of 30% to 50%) to the total volumes and costs. Based on this finding, other factors influencing the volume and cost associated with cleanup of scenario insensitive sites (e.g., cleanup goals, remediation alternatives) should be a primary focus of attention for future investigation and cleanup decisions at scenario insensitive sites (e.g., burial grounds, landfills).

- Cost differentials between RD and RTD are only slightly sensitive to exposure scenarios; typically the difference is in the range of 10% to 20%.

- The CAP Alternative is more cost effective than RD and RTD when the depth of remediation is controlled by protection of groundwater. When the protection on human health controls the remediation depth, the CAP Alternative has the potential to be more expensive.

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ATTACHMENT 1

PATHWAY ASSESSMENT

ATTACHMENT 1
PATHWAY ASSESSMENT FOR THE 100 AREA FOCUSED FEASIBILITY STUDY - SENSITIVITY ANALYSIS

1.0 INTRODUCTION

The pathway assessment addresses the risk assessment methodology used to develop PRG for protection of human health. The PRG were used to estimate the volumes of soil at sites to be addressed by the remedial alternatives in the FFS. PRGs developed for the 100 Area FFS are intended to achieve RAO for protection of human health and the environment.

1.1 PURPOSE

The purpose of the pathway assessment is to verify that the risk assessment methodology used in developing PRG result in PRG that achieve the RAO. The pathway assessment evaluates the range of possible exposure pathways to identify those pathways providing the largest contributions to total site risks. The PRG achieve the RAO to the extent that they are based on the exposure pathways providing the largest contributions to site risks.

1.2 BACKGROUND

PRG are numeric expressions of the RAO and establish initial concentrations that are protective of human health and the environment for the defined exposure scenario (DOE-RL 1994a). These initial concentrations are used to evaluate the extent of contamination at a site and define the volume of waste or contaminated soil to be addressed by remedial alternatives.

Calculation of the PRG associated with a particular exposure scenario involves identifying the potential receptors (i.e. recreational or residential) and the exposure pathways associated with the scenario. The PRG developed in the 100 Area Process Document (DOE-RL 1994b) for estimation of remediation volumes and costs were based on a specific subset of the total number of exposure pathways that could be considered in a risk assessment. Exposure pathways used in the development of the PRG are consistent with those used in the QRAs performed for the 100 Area operable units. However, this approach raises the concern that a subset of exposure pathways may underestimate human health risks and that the PRG used in the Process Document may not be protective of human health.

1.3 PATHWAY ASSESSMENT APPROACH

The pathway assessment compares human health risks calculated using the subset of exposure pathways and the full set of exposure pathways. These comparisons were made for the four representative sites addressed in the sensitivity analysis report. The results from the pathway assessment are used to determine if the subset of exposure pathways selected to develop PRG in the Process Document adequately address human health risks associated with the full set of exposure pathways. The pathway assessment involves the following steps:

- Develop a methodology to estimate exposures and health risks through each of the pathways described below.

- Estimate total site risks (i.e. health risks associated with all contaminants detected at a site) for the four representative sites based on the maximum concentrations detected. Health risks are were estimated assuming potential exposure either through the subset of pathways or the full set of pathways.

- Estimate site risks for the four representative sites based on the maximum concentrations remaining in soil following excavation where the extent of excavation assumed is predicted on the basis of PRG developed from the subset of pathways.

Human health risks are calculated in the pathway assessment using the risk assessment methodology presented in the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995). The risk assessment methodology is based on a series of conservative assumptions, simplified models, and interpretations of site data that tend to overstate the magnitude of health risks associated with contaminants detected at the site. Numerical risk estimates developed in this report are not predictions of actual health outcomes. These risk estimates are calculated in a manner that overestimates risk, and thus any actual risks are likely to be lower than these estimates and may even be zero. This risk assessment methodology (DOE-RL 1995) consisted of the following elements:

- Describe the exposure scenarios used to estimate health risks associated with contaminants at the representative site.

- Describe the exposure pathways associated with each exposure scenario

- Estimate the exposure concentrations of contaminants in different media (soil, air, surface water, groundwater and biota) through which potential receptors could become exposed via the pathways for each exposure

- Estimate the contaminant intake rates through the exposure pathways

- Characterize potential human health risks associated with estimated contaminant intake rates, using toxicity factors described in DOE-RL (1995).

The results obtained from this methodology are used to identify the contribution of different pathways to total risk in each exposure scenario, identify the contaminants providing the largest contributions to total site risks at the four representative sites, and make a comparison between the risks calculated with the full set of exposure pathways and risks calculated with the subset of exposure pathways.

The pathway assessment is not intended to determine if final cleanup criteria should be developed from a subset of exposure pathways. However, a secondary objective of the pathway assessment is to identify those exposure pathways that should be considered in developing final site cleanup criteria.

1.4 DOCUMENT OVERVIEW

The pathway assessment is presented in the following sections. The contents of each section are described below.

- Section 2.0, Evaluation of Exposure Pathway Selections. This section describes the different exposure scenarios considered in the pathway assessment and describes the rationale for how exposure pathways are selected for each scenario.

- Section 3.0, Exposure/Risk Calculation Methodology. This section presents the methodology used to estimate exposures and health risks for each exposure pathway.

- Section 4.0, Exposure Pathway Contribution to Contaminant-Specific Risks. This section presents the contribution of each exposure pathway to total risk associated with each contaminant and identifies those pathways providing the largest contributions to risks for each contaminant

- Section 5.0, Evaluation of Pre-remediation and Post-remediation Risks. This section calculates health risks associated with contaminants detected at the four representative sites. This section compares the calculated health risks with the health risks associated with concentrations remaining in soil following excavation where the extent of excavation assumed is predicted on the basis of PRGs developed from the subset of pathways.

2.0 EVALUATION OF EXPOSURE PATHWAY SELECTIONS

Guidance for selecting exposure pathways to be evaluated in risk assessments performed at the Hanford Site is found in DOE-RL (1995). DOE-RL (1995) prepares risk assessments consistent with current regulations and guidance pursuant to the Tri-Party Agreement. The QRA methodology, presented in Section 5.0 of DOE-RL (1995), provides additional guidance on selection of exposure pathways for risk assessments. The QRA methodology provides the approach for performing risk assessments in support of an IRM path. The QRA methodology was used to develop PRG for the 100 Area Process Document consistent with those used in performance of QRAs for the 100 Area operable units on the IRM path.

For purposes of the pathway assessment, the exposure pathways described in the conceptual model for human exposure assessment in DOE-RL (1995) (Figure 3-4) are considered the full set of pathways; the exposure pathways described in the QRA methodology are considered the subset of pathways. The following sections describe how exposure pathway selections are made in DOE-RL (1995) and the QRA methodology.

2.1 EXPOSURE PATHWAY SELECTIONS IN THE *HANFORD SITE RISK ASSESSMENT METHODOLOGY*

Exposure pathways described in DOE-RL (1995) are considered either primary or secondary pathways for Hanford Site risk assessments. Primary pathways should be evaluated quantitatively for a specific scenario (i.e. health risks should be calculated for exposures potentially occurring through primary pathways). The following are considered the risk-driving pathways at hazardous waste sites (DOE 1995) and should be evaluated for all scenarios:

- Soil ingestion
- Inhalation of fugitive dust or volatiles
- Ingestion of water (either surface water or groundwater)
- Dermal contact with soil
- External exposure from radionuclides in soil.

Several biota pathways have also been selected as primary exposure pathways for specific scenarios. For recreational and residential receptors, the biota pathways that are considered primary pathways are:

- Consumption of Columbia River fish
- Consumption of homegrown produce.

Secondary pathways are those that should be qualitatively evaluated, at a minimum, but may be quantitatively evaluated based on site characterization, contaminant characteristics and contaminant migration. Secondary pathways are:

- Ingestion of sediment
- Dermal contact with sediment
- Inhalation of volatiles from water
- Dermal contact with water.

Secondary pathways are considered in DOE-RL (1995) to potentially contribute less to overall risks than primary pathways.

2.2 EXPOSURE PATHWAY SELECTIONS IN THE QUALITATIVE RISK ASSESSMENT METHODOLOGY

The QRA evaluates risks for high-priority waste sites at an operable unit using available site data to support decision-making for IRM. The QRA evaluates health risks for two exposure scenarios defined as frequent-use and occasional-use. These scenarios use exposure assumptions that are identical to those presented for the residential and recreational exposure scenarios defined in DOE-RL (1995). Within the context of the QRA, these exposure assumptions are not intended to define a particular land use setting but instead are used to represent bounding estimates of potential site risks.

The exposure pathways that are evaluated in the QRA are a subset of those described in DOE-RL (1995). These are considered to be the exposure pathways providing the largest contributions to total site risks. The pathways evaluated in a QRA are:

- Soil ingestion
- Inhalation of fugitive dust or volatiles
- Ingestion of water (either surface water or groundwater)
- External exposure from radionuclides in soil.

2.3 EXPOSURE PATHWAYS EVALUATED IN THE PATHWAY ASSESSMENT

The exposure pathways evaluated in the pathway assessment for each exposure scenario are summarized in Table 1-1. Pre-remediation risks for zone 4 soils were not calculated because zone 4 PRG were based on MCLs, which are an ARAR and are accepted as being protective of human health.

3.0 EXPOSURE/RISK CALCULATION METHODOLOGY

The elements of the exposure/risk calculation methodology are as follows:

- Exposure assessment
- Toxicity assessment
- Risk characterization.

The exposure assessment in the pathway assessment is conducted in a manner similar to that described in Section 3.2 of DOE-RL (1995). Procedures for toxicity assessment consist of identification and selection of contaminant-specific toxicity factors as described in Section 3.3 of DOE-RL (1995). Characterization of health risks associated with contaminants detected at a site involves combining the results of the toxicity and exposure assessments to provide numerical estimates of potential health risks, as described in Section 3.4 of DOE-RL (1995). For purposes of the pathway assessment (i.e., comparing risks associated with the subset and the full set of exposure pathways), health risks are characterized as incremental cancer risks (ICR) associated with carcinogenic or radioactive contaminants at the four representative sites. Noncancer hazard quotients are not calculated for the pathway assessment. Calculation of ICR is considered adequate for the purpose of comparing risks across different sets of exposure pathways.

3.1 EXPOSURE ASSESSMENT

The exposure assessment provides an estimation of contaminant intake for the pathways associated with the different exposure scenarios. Contaminant intakes are estimated by combining exposure concentrations of contaminants in different media (soil, air, surface water, groundwater and biota) with intake factors presented in Appendix A of DOE-RL (1995). These intake factors are presented in Table 1-2. Exposure concentrations in soil are obtained directly from the sampling and analytical data from the four representative sites. Exposure concentrations in the other media are estimated from the concentrations in soil at the four representative sites using modeling. The level of sophistication in the modeling effort is consistent with the objectives of the pathway assessment, the available data, and the required accuracy of the results. To the largest extent possible, simplified modeling approaches were used in the pathway assessment. The exposure assessment methodology used for the exposure pathways presented in Table 1-1 is described in the following sections.

3.1.1 Soil Ingestion

Soil ingestion exposure to either chemical contaminants or radionuclides is estimated as follows:

$$I = C_s \times SI$$

where

I	=	Intake (mg/kg-day or pCi)
C_s	=	Concentration in soil (mg/kg or pCi/g)
SI	=	Soil ingestion intake factor from Table 1-2

3.1.2 Dermal Contact with Soil

DOE-RL (1995) provides no guidance on estimating the dermal absorption factors from soil (ABS) for use with the dermal contact with soil exposure factor in Table 1-2. In most cases there are scientific limitations in evaluating quantitatively the exposure from dermal contact with soil. EPA recommends using ABS values for quantitatively evaluating exposure from dermal contact with soil only for dioxins, PCBs, and cadmium (EPA 1992a). In the absence of appropriate ABS values, the following procedure was used for estimating exposure from dermal contact with soil:

- For volatiles and inorganics, dermal absorption is considered negligible relative to ingestion and/or inhalation exposures.

- For semivolatiles, a default of 10% dermal absorption is assumed. At this % absorption, the intake from dermal contact with soil is estimated to equal the intake from soil ingestion using the best estimate default exposure assumptions presented in EPA (1992a). This approach is consistent with the approach used by various EPA regional areas for developing PRG (EPA 1994).

3.1.3 Inhalation

Exposure concentrations in air are estimated using assumptions presented in Appendix A of the Process Document (DOE-RL 1994b). Exposure concentrations in air from contaminant concentrations in soil are estimated assuming an average dust particle concentration of 50 ug/m^3 in air at a site, and that all of the dust in the air originates from contaminated soil (DOE-RL 1994a). With these assumptions, concentrations of radionuclides in air are estimated as follows:

$$C_a = C_s \times 50\,ug/m^3 \times 10^{-6}\,g/ug$$

where

C_a	=	Contaminant concentration in air (pCi/m^3)
C_s	=	Contaminant concentration in soil (pCi/g)

Concentrations of chemical contaminants in air were estimated as follows:

$$C_a = C_s \times 50\,ug/m^3 \times 10^{-9}\,kg/ug$$

where

C_a = Contaminant concentration in air (mg/m^3)
C_s = Contaminant concentration in soil (mg/kg)

Intake from inhalation exposure was estimated as follows:

$$I = C_a \times INH$$

where

I = Intake (mg/kg-day or pCi)
C_a = Contaminant concentration in air (mg/m^3 or pCi/m^3)
INH = Inhalation intake factor from Table 1-2.

3.1.4 Groundwater Ingestion

Exposure concentrations in groundwater potentially resulting from the migration of contaminants in soil are estimated using the Summers model and the accompanying assumptions are presented in Appendix A of the Process Document (DOE-RL 1994b). Contaminant intake from groundwater was estimated as follows:

$$I = C_{gw} \times GWI$$

where

I = Intake (mg/kg-day or pCi)
C_{gw} = Contaminant concentration in groundwater (mg/L or pCi/L)
GWI = Groundwater ingestion intake factor from Table 1-2

3.1.5 Groundwater Dermal Contact

Intake from dermal contact with groundwater is calculated only for nonradioactive chemical contaminants DOE-RL (1995) does not include an intake factor for dermal contact with radionuclides. The dermal permeability coefficients (K_p) values were obtained from EPA (1992a), and are presented in Table 1-3.

Intake from dermal contact with groundwater was estimated as follows:

$$I = C_{gw} \times GWDC \times K_p$$

where

I = Intake (mg/kg-day)
C_{gw} = Concentration in groundwater, estimated with the Summers model (mg/L)
GWDC= Intake factor for groundwater dermal contact from Table 1-2.

3.1.6 Surface Water-Related Pathways

Surface water-related pathways are surface water ingestion, dermal contact with surface water, and ingestion of fish. Estimation of intake through each of these exposure pathways requires an exposure concentration in surface water.

3.1.6.1 Estimation of Exposure Concentrations in Surface Water. Contaminant concentrations in surface water could arise from runoff of soil from sites and from influx of groundwater to surface water.

The movement of contaminated soil to surface water is described using the Universal Soil Loss Equation (USLE). The USLE is an empirically derived formula based on erosion field research data that considers 1) the erosive force of precipitation on soil particulates; 2) the tendency for soil particulates to be transported by precipitation; 3) the combined effects of slope length and gradient on soil particulate transport; and 4) soil loss under different vegetative conditions. The USLE provides annual-average estimates of soil loss from a site. The USLE is expressed in the following form:

$$A = R \times K \times LS \times C \times P$$

where:

A	=	average-annual soil loss (tons/hectare-year)
R	=	Rainfall erodibility factor (J/ha)
K	=	Soil erodibility factor (ton/J)
LS	=	Slope length and steepness factor (dimensionless)
C	=	vegetative cover factor (dimensionless)
P	=	Erosion control practices factor (dimensionless).

The parameters for the USLE were developed from data presented in the *Remedial Action Priority System (RAPS): Mathematical Formulations* (Whelan et al. 1987). These parameters are described in Table 1-4.

Assumptions used to calculate contaminant runoff to surface water are summarized in Table 1-5.

The annual average sediment runoff to the river is calculated with the USLE to be 1.92 tons/ha-yr. This sediment runoff is assumed to occur from an area 800 ft x 800 ft, the surface area of the Site 116-C-5 retention basins; this assumption was used in the Process Document (DOE 1994b). Contaminant loading to surface water from surface runoff was calculated as follows:

$$M_{sw} = C_s \times 0.001\, g/mg \times A \times SA$$

where

M_{sw} = Contaminant mass entering surface water (g/yr or pCi/yr)
C_s = Concentration in surface soil (mg/kg or pCi/g)
A = Sediment runoff from USLE (kg/ha-yr)
SA = Surface area from which sediment runoff occurs (ha).

Influx of groundwater contaminants to surface water is estimated by combining groundwater contaminant concentrations with estimated groundwater influx rates. Groundwater contaminant concentrations originating from contaminant concentrations in soil are estimated using the Summers model. An estimate of the groundwater influx to surface water of 0.08 m^3/s was obtained from the 100-BC FFS work plan (DOE-RL 1993). Influx of radionuclide contaminants to surface water is estimated as follows:

$$M_{sw} = \frac{C_{gw} \times 0.001\,L/m^3 \times 0.08\,m^3/s}{3.17E\text{-}08\,s/yr}$$

At the U.S. Department of Energy, Richland, Washington, the concentration in groundwater is in units of pCi/L. Influx of chemical contaminants to surface water was estimated as follows:

$$M_{sw} = \frac{C_{gw} \times 0.001\,L/m^3 \times 0.001\,g/mg \times 0.08\,m^3/s}{3.17E\text{-}08\,s/yr}$$

where the concentration in groundwater is in units of mg/L.

Concentrations in surface water are estimated using a low-stage flow rate for the Columbia River of 1,020 m^3/s (DOE-RL 1995). Contaminant concentrations in surface water are estimated as follows (EPA 1988):

$$C_{sw} = \left(\frac{M_{sw}}{Q}\right) \times 1{,}000\,mg/g \times 3.17E\text{-}08\,s/yr$$

where Q is the flow rate of the river.

Concentrations of chemical contaminants in fish are estimated from concentrations in water using a contaminant-specific bioconcentration factor (BCF). BCF values for selected contaminants were obtained from EPA (1979). Radionuclides without readily available BCF are assumed to have a BCF of 1,000. BCF values are presented in Table 1-6.

Concentrations of chemical contaminants in fish were estimated as follows:

$$C_f = C_{sw} \times BCF$$

where

C_f = Concentration in fish (mg/kg)

C_{sw} = Concentration in surface water (mg/L)
BCF = Bioconcentration factor (L/kg)

Concentrations of radionuclide contaminants in fish are estimated as follows:

$$C_f = Csw \times BCF \times 0.001\,kg/g$$

3.1.6.2 Contaminant Intake from Surface Water-Related Pathways. Contaminant intake from surface water ingestion and dermal contact with surface water is calculated in a manner similar to intake from groundwater ingestion and dermal contact with surface water, except that the surface water intake factors are used in the intake equations. Contaminant intake from fish ingestion is calculated as follows:

$$I = C_f \times FI$$

where

I = Intake (mg/kg-day or pCi)
C_f = Concentration in fish (mg/kg or pCi/g)
FI = Fish ingestion intake factor.

3.1.7 Sediment-Related Pathways

Sediment-related pathways are sediment ingestion and dermal contact with sediment. Contaminant intake through these pathways is calculated in a manner similar to soil ingestion and dermal contact with soil, except that different intake factors are used in the intake equations. Simplified models are not available for estimating contaminant concentrations in sediments associated with runoff from soil. Therefore, the exposure concentration in sediment is assumed to be the same as the concentration in soil at the site.

3.1.8 Crop Ingestion

Estimation of contaminant intake through ingestion of fruits and vegetables from a backyard garden requires estimates of concentrations in vegetation resulting from uptake from soil. The methodology for estimating concentrations of elements and radionuclides in vegetation was derived from Baes et al. (1984). Baes et al. (1984) is recommended for this purpose by EPA (EPA 1989).

Quantification of radionuclide and element transport involves parameters describing soil-to-plant uptake for vegetative growth (leaves and stems), B_v; and nonvegetative growth (fruits, seeds and tubers), B_r. Root uptake of elements or nuclides incorporated into the surface horizon of soil is parameterized as follows:

$$B_V = \frac{C_v}{C_s}$$

and

$$B_r = \frac{C_r}{C_s}$$

where

B_v	=	Soil to plant transfer coefficient for vegetative portions of food crops
B_r	=	Soil to plant transfer coefficient for nonvegetative (reproductive) portions of food crops
C_v	=	Concentration in vegetative portions of food crops (dry weight basis) at edible maturity
C_r	=	Concentration in nonvegetative portions of food crops (dry weight basis) at edible maturity
C_s	=	Concentration in soil in root zone.

Leafy vegetables are the only food group for which B_v is the appropriate transfer parameter. Nationally, leafy vegetables comprise a relatively small portion of food crop production and are assumed to be insignificant compared with other fruits and vegetables. Therefore, assessment of exposures and health risks through this pathway is based solely on B_r.

These transfer parameters are estimated on a dry crop weight basis. However, contaminant intake is estimated on a fresh weight basis. Therefore, B_r values tabulated in Baes et al. (1984) were adjusted by a dry-to-wet weight conversion factor for use in estimating contaminant intake from crop ingestion. Baes et al. (1984) recommends a value of 0.428 g dry/g wet for this conversion. These transfer parameters are summarized in Table 1-7.

Uptake of organic compounds from soil to plants is dependent upon the solubility of the contaminant in water, which is inversely proportional to the octanol-water partition coefficient (K_{ow}) (Travis and Arms 1988). The uptake factor for an organic compounds (B) can then be calculated from the following regression equation:

$$B = 1.588 - 0.578 \log K_{ow}$$

This equation is based on the uptake factors estimated for 29 chemicals (Travis and Arms 1988). K_{ow} values for the four organic contaminants were obtained from EPA (1979). The K_{ow} and B values are summarized in Table 1-8.

Intake factors in DOE-RL (1995) are estimated separately for "fruits" and "vegetables." These values are summed in developing the intake factors used in the pathway assessment because the transfer parameters do not recognize this distinction between "fruits" and "vegetables." All nonvegetative portions of food crops are considered in developing the intake factor. Contaminant intake through crop ingestion is then estimated as:

$$I = C_r \times CI$$

where

I	=	Intake (mg/kg-day or pCi)
C_r	=	Concentration in fruits and vegetables (mg/kg or pCi/g)
CI	=	Crop ingestion factor presented in Table 1-1.

3.1.9 Exposure Assessment Summary

The exposure concentrations in different media are calculated on a "unit concentration" basis (i.e. concentration in groundwater, air, surface water, or biota per mg/kg or pCi/g in soil). These exposure concentrations are summarized in Exhibit 1.

3.2 TOXICITY ASSESSMENT

Toxicity factors used to characterize health risks associated with estimated contaminant intakes are obtained either from the EPAs Integrated Risk Information System (IRIS) database, or from the health effects assessment summary tables (EPA 1992b). As discussed previously, health risks were characterized as increased cancer risks (ICR). The estimated ICR from potential exposure to a carcinogenic contaminant or radionuclide through each exposure pathway is calculated as follows:

$$ICR = Intake \times SF$$

where SF is the slope factor in units of $(mg/kg\text{-}day)^{-1}$ or pCi^{-1}. Estimated ICR for all pathways are then summed to obtain the contaminant-specific ICR. Contaminant-specific ICR are then summed to obtain the total site risk associated with contaminants in soil at a specific site.

The factors used in the pathway assessment are summarized in Exhibit 2.

4.0 EXPOSURE PATHWAY CONTRIBUTION TO CONTAMINANT-SPECIFIC RISK

ICR for each carcinogenic contaminant or radionuclide, summed across all exposure pathways, were calculated for a concentration in soil of either 1 pCi/g or 1 mg/kg. For each exposure scenario (frequent-use or occasional-use), contaminant-specific risks were summed across the full set of exposure pathways and the subset of exposure pathways. The results from this evaluation are summarized in Exhibit 3.

Contaminant-specific risks do not differ between the full set and the subset of exposure pathways except for those contaminants described below. Under the frequent-use scenario, contaminant-specific risks calculated with the full set of exposure pathways are 3-fold greater for ^{90}Sr and Aroclor 1260, 7-fold greater for benzo(a)pyrene, and 4-fold greater for chrysene and pentachlorophenol, compared with the corresponding contaminant-specific risks calculated with the subset of exposure pathways. Under the occasional-use scenario, contaminant-specific risks calculated with the full set of exposure pathways are less than 3-fold greater than risks calculated with the subset of exposure pathways. The risks associated with ^{90}Sr are greater because the crop ingestion pathway represent a large percentage of total risk for that contaminant. The risks associated with the organic contaminants are greater because the crop ingestion and dermal contact with groundwater exposure pathways represent large percentages of total risks for those contaminants. However, these differences in risks between the two sets of exposure pathways would become discernable only for sites where these contaminants were predominant in soil. For most of the remaining contaminants, the external exposure or the groundwater ingestion exposure pathways represent a large percentage of the total contaminant-specific risk. These two exposure pathways are common to both the subset and the full set of pathways.

5.0 EVALUATION OF PRE-REMEDIATION AND POST-REMEDIATION RISKS

5.1 PRE-REMEDIATION RISKS

Pre-remediation ICR for the four representative sites are summarized in Exhibit 4. The ICR presented in these tables represent risks summed across the maximum concentration of each contaminant detected at a particular depth.

The results presented in Exhibit 4 indicate that there are relatively few differences in ICR estimated using either the subset or the full set of exposure pathways for the four representative sites.

Exhibit 4 summarizes the percent contribution to total ICR from different contaminants detected at the representative sites. The contaminant providing the largest contribution to total site risk at Site 116-B-1 is ^{152}Eu, with lesser contributions from ^{60}Co and ^{137}Cs. The contaminants providing the largest contributions to total site risk at Site 116-C-5 are ^{152}Eu, ^{154}Eu, ^{60}Co and ^{137}Cs. The contaminants providing the largest contributions to total site risk at Site 116-D-1A are ^{152}Eu, ^{154}Eu, ^{137}Cs, ^{226}Ra, and ^{228}Th. The contaminants providing the largest contributions to total site risk at Site 116-F-4 are ^{137}Cs, ^{90}Sr and arsenic.

As shown in Exhibit 3, contaminant-specific risks for contaminants driving risks at the four representative sites are driven mostly by the external exposure (i.e. from ^{152}Eu, ^{154}Eu, ^{137}Cs, and ^{60}Co) and groundwater ingestion exposure pathways (i.e., from ^{228}Ra and arsenic). These two pathways are included in the subset of pathways; therefore, increased cancer risks associated with contaminants in soil are unlikely to be sensitive to the additional pathways considered in the full set of pathways.

Evaluation of the pre-remediation risks at the representative sites suggests that a limited number of contaminants and pathways drive estimates of total site risk. In the case of ^{90}Sr, the pathway contributing greatest to estimated increased cancer risk is the crop ingestion pathway. However, risks from ^{90}Sr that occurs in soil along with ^{137}Cs are masked by the risks associated with ^{137}Cs, unless ^{90}Sr was present at far higher concentrations than ^{137}Cs; at equivalent concentrations, ^{137}Cs is associated with a higher ICR than ^{90}Sr, as shown in Table 1-8.

5.2 POST-REMEDIATION RISKS

Site risks were estimated for the four representative sites, based on the maximum concentrations remaining in soil following excavation. The extent of excavation assumed is predicted on the basis of PRG developed from the subset of pathways. The purpose of this evaluation is to determine if a PRG developed from the subset of pathways provided the same magnitude of risk reduction for risks estimated from either the subset or full set of exposure pathways. The risks presented in this section do not reflect the risk levels that could be achieved following remedial action. The risk levels that could be achieved following remedial action depend upon future use of the site. In many cases, remedial exposure to human receptors and post-remediation risks could be zero.

Risks associated with excavated soils are assumed to be reduced to zero (the excavations are assumed to be backfilled with clean soil); risks associated with contaminants below the maximum depth of excavation are unchanged. In the case of the four representative sites, the PRG resulted in an excavation depth of at least 3 m (10 ft); therefore, contaminants in zones 1 through 3 would be removed. Note that post-remediation risks for zone 4 soils, because zone 4 PRG were based on MCLs, which are an ARAR and are accepted as being protective of human health.

Since PRG result in excavation to at least a depth of 3 m (10 ft) for the four representative sites, post-remediation risks do not differ substantially between the scenarios based on the subset of pathways and the full set of pathways for all of the representative sites.

6.0 REFERENCES

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Table 1-1. Exposure Pathways Evaluated in the Pathway Assessment.

Exposure Pathway	Scenario			
	Full Set of Pathways		Subset of Pathways	
	Frequent Use	Occasional Use	Frequent Use	Occasional Use
Soil Ingestion	✓	✓	✓	✓
Dermal Contact with Soil	✓	✓	✓	✓
External Exposure to Soil	✓	✓	✓	✓
Inhalation (Dust/Volatiles in Air)	✓	✓	✓	✓
Groundwater Ingestion	✓	✓	✓	✓
Dermal Contact with Groundwater	✓	✓		
Surface Water Ingestion	✓	✓		
Dermal Contact with Surface Water	✓	✓		
Sediment Ingestion	✓	✓		
Dermal Contact with Sediment	✓	✓		
Ingestion of Game	NE	NE		
Ingestion of Fish	✓	✓		
Ingestion of Crops	✓			

NE= Not Evaluated

Table 1-2. HSRAM Intake Factors[a].

	Occasional-Use Scenario			Frequent-Use Scenario		
Exposure Pathway	Non-carcinogens	Carcinogens	Radio-nuclides	Non-carcinogens	Carcinogens	Radio-nuclides
Soil Ingestion	2.40E-07	3.00E-08	2.50E+01	1.30E-05	1.60E-06	1.30E+03
Dermal Contact with Soil[b]	3.4E-07 x ABS[c]	1.5E-07 x ABS		8.7E-06 x ABS	3.7E-06 x ABS	
Inhalation	1.20E-02	2.30E-03	4.20E+03	6.30E-01	1.20E-01	2.20E+05
Groundwater Ingestion	1.20E-03	2.30E-04	4.20E+02	6.30E-02	1.20E-02	2.20E+04
Groundwater Dermal Contact	9.3E-04 x K_p[d]	4E-04 x K_p		4.9E-02 x K_p	2.1E-02 x K_p	
Surface Water Ingestion	1.20E-03	2.30E-04	4.20E+02	6.30E-02	1.20E-02	2.20E+04
Surface Water Dermal Contact	6.1E-03 x K_p	6.1E-03 x K_p		4.9E-02 x K_p	2.1E-02 x K_p	
Sediment Ingestion	2.40E-07	3.00E-08	2.50E+01	2.40E-07	3.00E-08	2.50E+01
Sediment Dermal Contact[e]	3.4E-07 x ABS	1.5E-07 x ABS		3.4E-07 x ABS	1.5E-07 x ABS	
External Exposure			1.50E-01			2.40E+01
Biota (fish)	3.90E-04	1.70E-04	3.00E+05	3.90E-04	1.70E-04	3.00E+05
Biota (crops)				1.70E-03	7.50E-04	1.34E+06

[a]Source: DOE-RL 1995
[b]Risks associated with this pathway are assumed to be equivalent to the risks associated with soil ingestion; see Section 3.1.2
[c]ABS - dermal absorption factor from soil.
[d]K_p - Dermal permeability coefficient (contaminant-specific); see Section 3.1.5
[e]Risks associated with this pathway are assumed to be equivalent to the risks associated with sediment ingestion; see Section 3.1.7

Table 1-3. Dermal Permeability Coefficients.

Contaminant	Permeability Coefficient (cm/hr)
Inorganics	0.001
Aroclor 1260	0.7
Benzo(a)pyrene	1.2
Chrysene	0.81
Pentachlorophenol	0.65

Source: EPA 1992a

Table 1-4. USLE Parameter Descriptions.

Parameter	Value	Source/Assumptions
R	20	Wischmeier and Smith, 1978 R-factor map on page 4.32 of RAPS manual (Whelan et al. 1987)
K	0.30	Value for fine sandy loam with 2 percent organic matter (page 4.40 of RAPS)
LS	0.40	Based on 3% slope and 100 m (300 ft) slope length (i.e. the site is located 300 feet from the river) (page 4.42 of RAPS)
C	1.00	Assumed no vegetative cover
P	0.80	Condition of surface material is loose with a rough surface to a depth of >0.3 m (page 4.44 of RAPS)

Table 1-5. Parameters Used to Estimate Contaminant Loading to Surface Water from Surface Runoff.

Parameter	Value	Units
Sediment Yield from USLE:	1.92	tons/ha-yr
	1,7436	kg/ha-yr
Site Surface Area:	640,000	ft^2
	5.94	ha

Table 1-6. Bioconcentration Factors in Fish.

Contaminant	BCF (L/kg)
Antimony	40
Arsenic	333
Barium	1,000
Cadmium	3,000
Chromium VI	200
Lead	60
Manganese	1,000
Mercury	1,000
Zinc	1,000
Aroclor 1260	87,000
Benzo(a)pyrene	30
Chrysene	30
Pentachlorophenol	11,500
Other Contaminants	1,000

Source: EPA 1979

Table 1-7. Soil to Plant Transfer Parameters.

Contaminant	B_r Values[a]	Wet-weight B_r values[b]
Am-241	0.00025	0.000107
C-14	5.5	2.354
Cs-134	0.03	0.01284
Cs-137	0.03	0.01284
Co-60	0.007	0.002996
Eu-152	0.004	0.001712
Eu-154	0.004	0.001712
Eu-155	0.004	0.001712
H-3	4.8	2.0544
K-40	0.55	0.2354
Na-22	0.055	0.02354
Ni-63	0.06	0.02568
Pu-238	0.0045	0.001926
Pu-239	0.0045	0.001926
Pu-240	0.0045	0.001926
Ra-226	0.0015	0.000642
Sr-90	0.25	0.107
Tc-99	1.5	0.642
Th-228	0.000085	0.0000364
Th-232	0.000085	0.0000364
U-233	0.004	0.001712
U-234	0.004	0.001712
U-235	0.004	0.001712
U-238	0.004	0.001712
Antimony	0.03	0.01284
Arsenic	0.006	0.002568

Contaminant	B_r Values[a]	Wet-weight B_r values[b]
Barium	0.015	0.00642
Cadmium	0.15	0.0642
Chromium VI	0.0045	0.001926
Lead	0.0045	0.001926
Manganese	0.05	0.0214
Mercury	0.2	0.0856
Zinc	0.9	0.3852
Contaminant	Kow	B
Aroclor 1260	6.8	0.0045457
Benzo(a)pyrene	6.06	0.0121708
Chrysene	5.61	0.0221524
Pentachlorophenol	5.05	0.0466767

[a]Tabulated in Baes et al. 1984.

[b]Corrected to wet-weight basis using conversion factor of 0.428 g dry/g wet weight.

Table 1-8. Comparison of Increased Cancer Risks for Cs-137 and Sr-90 per Unit Concentration in Soil (1 pCi/g).

Contaminant	Concentration in Soil (pCi/g)	Soil Ingestion	Inhalation	Ground-water Ingestion	Surface Water Ingestion	Sediment Ingestion	External Exposure	Fish Ingestion	Crop Ingestion	Total Risk
Cs-137	1	3.64E-08	2.09E-10	9.12E-07	2.86E-16	7.00E-10	4.80E-05	3.90E-15	4.82E-07	4.94E-05
Sr-90	1	4.68E-08	6.82E-10	2.34E-06	7.36E-16	9.00E-10	0.00	1.00E-14	5.16E-06	7.55E-06

Exhibit 1

Summary of Exposure Concentrations

Exhibit 1

Summary of Exposure Concentrations per Unit Concentration in Soil (mg/kg or pCi/g)

Contaminant	Concentration in Soil		Concentration in Air		Concentration in Groundwater		Concentration in Surface Water		Concentration in Sediment		Concentration in Fish		Concentration in Crops	
	Conc.	Units	Conc.	Units	Conc.	Units	Conc.	Units	Conc.	Units	Conc.	Units	Conc.	Units
Am-241	1	pCi/g	0.00005	pCi/m^3	3.70E-01	pCi/L	2.93E-11	pCi/L	1	pCi/g	2.93E-11	pCi/g	0.000107	pCi/g
C-14	1	pCi/g	0.00005	pCi/m^3	1.48E+02	pCi/L	1.16E-08	pCi/L	1	pCi/g	1.16E-08	pCi/g	2.354	pCi/g
Cs-134	1	pCi/g	0.00005	pCi/m^3	1.48E+00	pCi/L	1.16E-10	pCi/L	1	pCi/g	1.16E-10	pCi/g	0.01284	pCi/g
Cs-137	1	pCi/g	0.00005	pCi/m^3	1.48E+00	pCi/L	1.16E-10	pCi/L	1	pCi/g	1.16E-10	pCi/g	0.01284	pCi/g
Co-60	1	pCi/g	0.00005	pCi/m^3	1.48E+00	pCi/L	1.16E-10	pCi/L	1	pCi/g	1.16E-10	pCi/g	0.002996	pCi/g
Eu-152	1	pCi/g	0.00005	pCi/m^3	3.70E-01	pCi/L	2.93E-11	pCi/L	1	pCi/g	2.93E-11	pCi/g	0.001712	pCi/g
Eu-154	1	pCi/g	0.00005	pCi/m^3	3.70E-01	pCi/L	2.93E-11	pCi/L	1	pCi/g	2.93E-11	pCi/g	0.001712	pCi/g
Eu-155	1	pCi/g	0.00005	pCi/m^3	3.70E-01	pCi/L	2.93E-11	pCi/L	1	pCi/g	2.93E-11	pCi/g	0.001712	pCi/g
H-3	1	pCi/g	0.00005	pCi/m^3	1.48E+03	pCi/L	1.16E-07	pCi/L	1	pCi/g	1.16E-07	pCi/g	2.0544	pCi/g
K-40	1	pCi/g	0.00005	pCi/m^3	1.85E+01	pCi/L	1.45E-09	pCi/L	1	pCi/g	1.45E-09	pCi/g	0.2354	pCi/g
Na-22	1	pCi/g	0.00005	pCi/m^3	1.85E+01	pCi/L	1.45E-09	pCi/L	1	pCi/g	1.45E-09	pCi/g	0.02354	pCi/g
Ni-63	1	pCi/g	0.00005	pCi/m^3	2.47E+00	pCi/L	1.94E-10	pCi/L	1	pCi/g	1.94E-10	pCi/g	0.02568	pCi/g
Pu-238	1	pCi/g	0.00005	pCi/m^3	2.96E+00	pCi/L	2.32E-10	pCi/L	1	pCi/g	2.32E-10	pCi/g	0.001926	pCi/g
Pu-239	1	pCi/g	0.00005	pCi/m^3	2.96E+00	pCi/L	2.32E-10	pCi/L	1	pCi/g	2.32E-10	pCi/g	0.001926	pCi/g
Pu-240	1	pCi/g	0.00005	pCi/m^3	2.96E+00	pCi/L	2.32E-10	pCi/L	1	pCi/g	2.32E-10	pCi/g	0.001926	pCi/g
Ra-226	1	pCi/g	0.00005	pCi/m^3	1.48E+03	pCi/L	1.16E-07	pCi/L	1	pCi/g	1.16E-07	pCi/g	0.000642	pCi/g
Sr-90	1	pCi/g	0.00005	pCi/m^3	2.96E+00	pCi/L	2.32E-10	pCi/L	1	pCi/g	2.32E-10	pCi/g	0.107	pCi/g
Tc-99	1	pCi/g	0.00005	pCi/m^3	1.48E+03	pCi/L	1.16E-07	pCi/L	1	pCi/g	1.16E-07	pCi/g	0.642	pCi/g
Th-228	1	pCi/g	0.00005	pCi/m^3	1.48E+03	pCi/L	1.16E-07	pCi/L	1	pCi/g	1.16E-07	pCi/g	3.638E-05	pCi/g
Th-232	1	pCi/g	0.00005	pCi/m^3	1.48E+03	pCi/L	1.16E-07	pCi/L	1	pCi/g	1.16E-07	pCi/g	3.638E-05	pCi/g
U-233	1	pCi/g	0.00005	pCi/m^3	3.70E+01	pCi/L	2.90E-09	pCi/L	1	pCi/g	2.90E-09	pCi/g	0.001712	pCi/g
U-234	1	pCi/g	0.00005	pCi/m^3	3.70E+01	pCi/L	2.90E-09	pCi/L	1	pCi/g	2.90E-09	pCi/g	0.001712	pCi/g
U-235	1	pCi/g	0.00005	pCi/m^3	3.70E+01	pCi/L	2.90E-09	pCi/L	1	pCi/g	2.90E-09	pCi/g	0.001712	pCi/g
U-238	1	pCi/g	0.00005	pCi/m^3	3.70E+01	pCi/L	2.90E-09	pCi/L	1	pCi/g	2.90E-09	pCi/g	0.001712	pCi/g
Antimony	1	mg/kg	5E-08	mg/m^3	1.48E+00	mg/L	4.38E-10	mg/L	1	mg/kg	1.75E-08	mg/kg	0.01284	mg/kg
Arsenic	1	mg/kg	5E-08	mg/m^3	1.48E+00	mg/L	4.38E-10	mg/L	1	mg/kg	1.46E-07	mg/kg	0.002568	mg/kg
Barium	1	mg/kg	5E-08	mg/m^3	2.96E-03	mg/L	3.22E-10	mg/L	1	mg/kg	3.22E-07	mg/kg	0.00642	mg/kg
Cadmium	1	mg/kg	5E-08	mg/m^3	2.47E-03	mg/L	3.22E-10	mg/L	1	mg/kg	9.67E-07	mg/kg	0.0642	mg/kg
Chromium VI	1	mg/kg	5E-08	mg/m^3	1.48E+00	mg/L	4.38E-10	mg/L	1	mg/kg	8.76E-08	mg/kg	0.001926	mg/kg
Lead	1	mg/kg	5E-08	mg/m^3	2.47E-03	mg/L	3.22E-10	mg/L	1	mg/kg	1.93E-08	mg/kg	0.001926	mg/kg
Manganese	1	mg/kg	5E-08	mg/m^3	1.48E-03	mg/L	3.22E-10	mg/L	1	mg/kg	3.22E-07	mg/kg	0.0214	mg/kg
Mercury	1	mg/kg	5E-08	mg/m^3	2.47E-03	mg/L	3.22E-10	mg/L	1	mg/kg	3.22E-07	mg/kg	0.0856	mg/kg
Zinc	1	mg/kg	5E-08	mg/m^3	2.47E-03	mg/L	3.22E-10	mg/L	1	mg/kg	3.22E-07	mg/kg	0.3852	mg/kg
Aroclor 1260	1	mg/kg	5E-08	mg/m^3	1.40E-04	mg/L	3.22E-10	mg/L	1	mg/kg	2.80E-05	mg/kg	0.0045457	mg/kg
Benzo(a)pyrene	1	mg/kg	5E-08	mg/m^3	1.35E-05	mg/L	3.22E-10	mg/L	1	mg/kg	9.66E-09	mg/kg	0.0121708	mg/kg
Chrysene	1	mg/kg	5E-08	mg/m^3	3.70E-04	mg/L	3.22E-10	mg/L	1	mg/kg	9.67E-09	mg/kg	0.0221524	mg/kg
Pentachlorophenol	1	mg/kg	5E-08	mg/m^3	1.40E-03	mg/L	3.22E-10	mg/L	1	mg/kg	3.71E-06	mg/kg	0.0466767	mg/kg

Exhibit 2

Toxicity Factors

Exhibit 2
Toxicity Assessment Used in the Pathway Assessment

Contaminant	Chemical Carcinogen Slope Factors		Radionuclide Slope Factors		
	Ingestion	Inhalation	Ingestion	Inhalation	External Exposure
Am-241			2.40E-10	3.20E-08	4.90E-09
C-14			9.00E-13	6.40E-15	0
Cs-134			4.10E-11	2.80E-11	5.20E-06
Cs-137			2.80E-11	1.90E-11	2.00E-06
Co-60			1.50E-11	1.50E-10	8.60E-06
Eu-152			2.10E-12	1.10E-10	3.60E-06
Eu-154			3.00E-12	1.40E-10	4.10E-06
Eu-155			4.50E-13	1.80E-11	5.90E-08
H-3			5.40E-14	7.80E-14	0
K-40			1.10E-11	7.60E-12	5.40E-07
Na-22			6.80E-12	4.80E-12	7.20E-06
Ni-63			2.40E-13	1.80E-12	0
Pu-238			2.20E-10	3.80E-08	2.80E-11
Pu-239			2.30E-10	3.80E-08	1.70E-11
Pu-240			2.30E-10	3.80E-08	2.70E-11
Ra-226			1.20E-10	3.00E-09	6.00E-06
Sr-90			3.60E-11	6.20E-11	0
Tc-99			1.30E-12	8.30E-12	6.00E-13
Th-228			5.50E-11	7.80E-08	5.60E-06
Th-232			1.20E-11	2.80E-08	2.60E-11
U-233			1.60E-11	2.70E-08	4.20E-11
U-234			1.60E-11	2.60E-08	3.00E-11
U-235			1.60E-11	2.50E-08	2.40E-07
U-238			2.80E-11	5.20E-08	3.60E-08
Antimony					
Arsenic	1.8	15			
Barium					
Cadmium		6.3			
Chromium VI		42			
Lead					
Manganese					
Mercury					
Zinc					
Aroclor 1260	7.7	7.7			
Benzo(a)pyrene	7.3	7.3			
Chrysene	0.0073	0.0073			
Pentachlorophenol	0.12	0.12			

Exhibit 3

Pathway Contribution to Contaminant-Specific Risk

Exhibit 3

Table 1. Increased Cancer Risks per Unit Concentration (1 mg/kg or 1 pCi/g) - Frequent Use Scenario

Contaminant	Exposure Pathway												Total Risk - Full Pathways	Total Risk - Subset of Pathways
	Soil Ingestion	Dermal Contact with Soil	Inhalation	Groundwater Ingestion	Groundwater Dermal Contact	Surface Water Ingestion	Surface Water Dermal Exposure	Sediment Ingestion	Sediment Dermal Contact	External Exposure	Fish Ingestion	Crop Ingestion		
Am-241	3.12E-07		3.52E-07	1.95E-06		1.55E-16		6.00E-09		1.18E-07	2.11E-15	3.44E-08	2.78E-06	2.74E-06
C-14	1.17E-09		7.04E-14	2.93E-06		2.30E-16		2.25E-11		0.00E+00	3.13E-15	2.84E-06	5.77E-06	2.93E-06
Cs-134	5.33E-08		3.08E-10	1.33E-06		1.05E-16		1.03E-09		1.25E-04	1.43E-15	7.05E-07	1.27E-04	1.26E-04
Cs-137	3.64E-08		2.09E-10	9.12E-07		7.17E-17		7.00E-10		4.80E-05	9.78E-16	4.82E-07	4.94E-05	4.89E-05
Co-60	1.95E-08		1.65E-09	4.88E-07		3.84E-17		3.75E-10		2.06E-04	5.24E-16	6.02E-08	2.07E-04	2.07E-04
Eu-152	2.73E-09		1.21E-09	1.71E-08		1.36E-18		5.25E-11		8.64E-05	1.85E-17	4.82E-09	8.64E-05	8.64E-05
Eu-154	3.90E-09		1.54E-09	2.44E-08		1.94E-18		7.50E-11		9.84E-05	2.64E-17	6.88E-09	9.84E-05	9.84E-05
Eu-155	5.85E-10		1.98E-10	3.66E-09		2.90E-19		1.13E-11		1.42E-06	3.96E-18	1.03E-09	1.42E-06	1.42E-06
H-3	7.02E-11		8.58E-13	1.76E-06		1.38E-16		1.35E-12		0.00E+00	1.88E-15	1.49E-07	1.91E-06	1.76E-06
K-40	1.43E-08		8.36E-11	4.48E-06		3.51E-16		2.75E-10		1.30E-05	4.79E-15	3.47E-06	2.09E-05	1.75E-05
Na-22	8.84E-09		5.28E-11	2.77E-06		2.17E-16		1.70E-10		1.73E-04	2.96E-15	2.14E-07	1.76E-04	1.76E-04
Ni-63	3.12E-10		1.98E-11	1.30E-08		1.02E-18		6.00E-12		0.00E+00	1.40E-17	8.26E-09	2.16E-08	1.34E-08
Pu-238	2.86E-07		4.18E-07	1.43E-05		1.13E-15		5.50E-09		6.72E-10	1.53E-14	5.68E-07	1.56E-05	1.50E-05
Pu-239	2.99E-07		4.18E-07	1.50E-05		1.18E-15		5.75E-09		4.08E-10	1.60E-14	5.94E-07	1.63E-05	1.57E-05
Pu-240	2.99E-07		4.18E-07	1.50E-05		1.18E-15		5.75E-09		6.48E-10	1.60E-14	5.94E-07	1.63E-05	1.57E-05
Ra-226	1.56E-07		3.30E-08	3.91E-03		3.06E-13		3.00E-09		1.44E-04	4.18E-12	1.03E-07	4.05E-03	4.05E-03
Sr-90	4.68E-08		6.82E-10	2.34E-06		1.84E-16		9.00E-10		0.00E+00	2.51E-15	5.16E-06	7.55E-06	2.39E-06
Tc-99	1.69E-09		9.13E-11	4.23E-05		3.32E-15		3.25E-11		1.44E-11	4.53E-14	1.12E-06	4.34E-05	4.23E-05
Th-228	7.15E-08		8.58E-07	1.79E-03		1.40E-13		1.38E-09		1.34E-04	1.92E-12	2.68E-09	1.93E-03	1.93E-03
Th-232	1.56E-08		3.08E-07	3.91E-04		3.06E-14		3.00E-10		6.24E-10	4.18E-13	5.85E-10	3.91E-04	3.91E-04
U-233	2.08E-08		2.97E-07	1.30E-05		1.02E-15		4.00E-10		1.01E-09	1.39E-14	3.67E-08	1.34E-05	1.33E-05
U-234	2.08E-08		2.86E-07	1.30E-05		1.02E-15		4.00E-10		7.20E-10	1.39E-14	3.67E-08	1.34E-05	1.33E-05
U-235	2.08E-08		2.75E-07	1.30E-05		1.02E-15		4.00E-10		5.76E-06	1.39E-14	3.67E-08	1.91E-05	1.91E-05
U-238	3.64E-08		5.72E-07	2.28E-05		1.79E-15		7.00E-10		8.64E-07	2.44E-14	6.42E-08	2.43E-05	2.43E-05
Antimony	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Arsenic	2.88E-06		9.00E-08	3.20E-02	5.59E-05	9.47E-12	1.66E-14	5.40E-08			4.47E-11	3.47E-06	3.20E-02	3.20E-02
Barium	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cadmium	0.00E+00		3.78E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00	0.00E+00	3.78E-08	3.78E-08
Chromium VI	0.00E+00		2.52E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00	0.00E+00	2.52E-07	2.52E-07
Lead	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Manganese	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mercury	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Zinc	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00	0.00E+00	0.00E+00	0.00E+00
Aroclor 1260	1.23E-05	1.23E-05	4.62E-08	1.29E-05	1.58E-05	2.98E-11	3.65E-11	2.31E-07			3.67E-08	2.63E-05	7.99E-05	2.53E-05
Benzo(a)pyrene	1.17E-05	1.17E-05	4.38E-08	1.18E-06	2.48E-06	2.82E-11	5.93E-11	2.19E-07			1.20E-11	6.66E-05	9.39E-05	1.29E-05
Chrysene	1.17E-08	1.17E-08	4.38E-11	3.24E-08	4.59E-08	2.82E-14	4.00E-14	2.19E-10			1.20E-14	1.21E-07	2.23E-07	4.41E-08
Pentachlorophenol	1.92E-07	1.92E-07	7.20E-10	2.01E-06	2.29E-06	4.64E-13	5.28E-13	3.60E-09			7.56E-11	4.20E-06	8.89E-06	2.20E-06

Exhibit 3

Table 2. Percent Contribution of Exposure Pathways to Contaminant-Specific ICR - Frequent Use Scenario

	Exposure Pathway											
Contaminant	Soil Ingestion	Dermal Contact with Soil	Inhalation	Groundwater Ingestion	Groundwater Dermal Contact	Surface Water Ingestion	Surface Water Dermal Exposure	Sediment Ingestion	Sediment Dermal Contact	External Exposure	Fish Ingestion	Crop Ingestion
Am-241	11.24%		12.68%	70.38%		<0.01%		0.22%		4.24%	<0.01%	1.24%
C-14	0.02%		<0.01%	50.78%		<0.01%		<0.01%		<0.01%	<0.01%	49.20%
Cs-134	0.04%		<0.01%	1.05%		<0.01%		<0.01%		98.35%	<0.01%	0.56%
Cs-137	0.07%		<0.01%	1.84%		<0.01%		<0.01%		97.11%	<0.01%	0.97%
Co-60	<0.01%		<0.01%	0.24%		<0.01%		<0.01%		99.72%	<0.01%	0.03%
Eu-152	<0.01%		<0.01%	0.02%		<0.01%		<0.01%		99.97%	<0.01%	<0.01%
Eu-154	<0.01%		<0.01%	0.02%		<0.01%		<0.01%		99.96%	<0.01%	<0.01%
Eu-155	0.04%		0.01%	0.26%		<0.01%		<0.01%		99.61%	<0.01%	0.07%
H-3	<0.01%		<0.01%	92.20%		<0.01%		<0.01%		<0.01%	<0.01%	7.80%
K-40	0.07%		<0.01%	21.40%		<0.01%		<0.01%		61.95%	<0.01%	16.58%
Na-22	<0.01%		<0.01%	1.57%		<0.01%		<0.01%		98.30%	<0.01%	0.12%
Ni-63	1.44%		0.09%	60.24%		<0.01%		0.03%		<0.01%	<0.01%	38.20%
Pu-238	1.83%		2.68%	91.81%		<0.01%		0.04%		<0.01%	<0.01%	3.64%
Pu-239	1.83%		2.57%	91.92%		<0.01%		0.04%		<0.01%	<0.01%	3.64%
Pu-240	1.83%		2.57%	91.92%		<0.01%		0.04%		<0.01%	<0.01%	3.64%
Ra-226	<0.01%		<0.01%	96.44%		<0.01%		<0.01%		3.55%	<0.01%	<0.01%
Sr-90	0.62%		<0.01%	31.03%		<0.01%		0.01%		<0.01%	<0.01%	68.33%
Tc-99	<0.01%		<0.01%	97.42%		<0.01%		<0.01%		<0.01%	<0.01%	2.57%
Th-228	<0.01%		0.04%	92.97%		<0.01%		<0.01%		6.98%	<0.01%	<0.01%
Th-232	<0.01%		0.08%	99.92%		<0.01%		<0.01%		<0.01%	<0.01%	<0.01%
U-233	0.16%		2.22%	97.34%		<0.01%		<0.01%		<0.01%	<0.01%	0.27%
U-234	0.16%		2.14%	97.42%		<0.01%		<0.01%		<0.01%	<0.01%	0.27%
U-235	0.11%		1.44%	68.13%		<0.01%		<0.01%		30.13%	<0.01%	0.19%
U-238	0.15%		2.35%	93.68%		<0.01%		<0.01%		3.55%	<0.01%	0.26%
Antimony												
Arsenic	<0.01%		<0.01%	99.81%	0.17%	<0.01%	<0.01%	<0.01%			<0.01%	0.01%
Barium												
Cadmium	<0.01%		100.00%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%			<0.01%	<0.01%
Chromium VI	<0.01%		100.00%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%			<0.01%	<0.01%
Lead												
Manganese												
Mercury												
Zinc												
Aroclor 1260	15.42%	15.42%	0.06%	16.14%	19.78%	<0.01%	<0.01%	0.29%			0.05%	32.85%
Benzo(a)pyrene	12.44%	12.44%	0.05%	1.26%	2.64%	<0.01%	<0.01%	0.23%			<0.01%	70.96%
Chrysene	5.23%	5.23%	0.02%	14.52%	20.58%	<0.01%	<0.01%	0.10%			<0.01%	54.32%
Pentachlorophenol	2.16%	2.16%	<0.01%	22.62%	25.73%	<0.01%	<0.01%	0.04%			<0.01%	47.27%

Exhibit 3

Table 3. Increased Cancer Risks per Unit Concentration (1 mg/kg or 1 pCi/g) - Occasional Use Scenario

	Exposure Pathway													
Contaminant	Soil Ingestion	Dermal Contact with Soil	Inhalation	Groundwater Ingestion	Groundwater Dermal Contact	Surface Water Ingestion	Surface Water Dermal Exposure	Sediment Ingestion	Sediment Dermal Contact	External Exposure	Fish Ingestion	Crop Ingestion	Total Risk - Full Pathways	Total Risk - Subset of Pathways
Am-241	6.00E-09		6.72E-09	3.73E-08		2.96E-18		6.00E-09		7.35E-10	2.11E-15		5.68E-08	5.08E-08
C-14	2.25E-11		1.34E-15	5.59E-08		4.39E-18		2.25E-11		0.00E+00	3.13E-15		5.60E-08	5.60E-08
Cs-134	1.03E-09		5.88E-12	2.55E-08		2.00E-18		1.03E-09		7.80E-07	1.43E-15		8.08E-07	8.07E-07
Cs-137	7.00E-10		3.99E-12	1.74E-08		1.37E-18		7.00E-10		3.00E-07	9.78E-16		3.19E-07	3.18E-07
Co-60	3.75E-10		3.15E-11	9.32E-09		7.33E-19		3.75E-10		1.29E-06	5.24E-16		1.30E-06	1.30E-06
Eu-152	5.25E-11		2.31E-11	3.26E-10		2.59E-20		5.25E-11		5.40E-07	1.85E-17		5.40E-07	5.40E-07
Eu-154	7.50E-11		2.94E-11	4.66E-10		3.70E-20		7.50E-11		6.15E-07	2.64E-17		6.16E-07	6.16E-07
Eu-155	1.13E-11		3.78E-12	6.99E-11		5.55E-21		1.13E-11		8.85E-09	3.96E-18		8.95E-09	8.93E-09
H-3	1.35E-12		1.64E-14	3.36E-08		2.63E-18		1.35E-12		0.00E+00	1.88E-15		3.36E-08	3.36E-08
K-40	2.75E-10		1.60E-12	8.55E-08		6.71E-18		2.75E-10		8.10E-08	4.79E-15		1.67E-07	1.67E-07
Na-22	1.70E-10		1.01E-12	5.28E-08		4.14E-18		1.70E-10		1.08E-06	2.96E-15		1.13E-06	1.13E-06
Ni-63	6.00E-12		3.78E-13	2.49E-10		1.95E-20		6.00E-12		0.00E+00	1.40E-17		2.61E-10	2.55E-10
Pu-238	5.50E-09		7.98E-09	2.74E-07		2.15E-17		5.50E-09		4.20E-12	1.53E-14		2.92E-07	2.87E-07
Pu-239	5.75E-09		7.98E-09	2.86E-07		2.25E-17		5.75E-09		2.55E-12	1.60E-14		3.05E-07	3.00E-07
Pu-240	5.75E-09		7.98E-09	2.86E-07		2.25E-17		5.75E-09		4.05E-12	1.60E-14		3.05E-07	3.00E-07
Ra-226	3.00E-09		6.30E-10	7.46E-05		5.85E-15		3.00E-09		9.00E-07	4.18E-12		7.55E-05	7.55E-05
Sr-90	9.00E-10		1.30E-11	4.48E-08		3.52E-18		9.00E-10		0.00E+00	2.51E-15		4.66E-08	4.57E-08
Tc-99	3.25E-11		1.74E-12	8.08E-07		6.34E-17		3.25E-11		9.00E-14	4.53E-14		8.08E-07	8.08E-07
Th-228	1.38E-09		1.64E-08	3.42E-05		2.68E-15		1.38E-09		8.40E-07	1.92E-12		3.50E-05	3.50E-05
Th-232	3.00E-10		5.88E-09	7.46E-06		5.85E-16		3.00E-10		3.90E-12	4.18E-13		7.47E-06	7.47E-06
U-233	4.00E-10		5.67E-09	2.49E-07		1.95E-17		4.00E-10		6.30E-12	1.39E-14		2.55E-07	2.55E-07
U-234	4.00E-10		5.46E-09	2.49E-07		1.95E-17		4.00E-10		4.50E-12	1.39E-14		2.55E-07	2.55E-07
U-235	4.00E-10		5.25E-09	2.49E-07		1.95E-17		4.00E-10		3.60E-08	1.39E-14		2.91E-07	2.90E-07
U-238	7.00E-10		1.09E-08	4.35E-07		3.41E-17		7.00E-10		5.40E-09	2.44E-14		4.53E-07	4.52E-07
Antimony	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		0.00E+00	0.00E+00
Arsenic	5.40E-08		1.73E-09	6.13E-04	1.07E-06	1.81E-13	4.81E-15	5.40E-08			4.47E-11		6.14E-04	6.13E-04
Barium	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		0.00E+00	0.00E+00
Cadmium	0.00E+00		7.25E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		7.25E-10	7.25E-10
Chromium VI	0.00E+00		4.83E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		4.83E-09	4.83E-09
Lead	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		0.00E+00	0.00E+00
Manganese	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		0.00E+00	0.00E+00
Mercury	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		0.00E+00	0.00E+00
Zinc	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		0.00E+00	0.00E+00
Aroclor 1260	2.31E-07	2.31E-07	8.86E-10	2.47E-07	3.01E-07	5.71E-13	1.06E-11	2.31E-07			3.67E-08		1.28E-06	4.79E-07
Benzo(a)pyrene	2.19E-07	2.19E-07	8.40E-10	2.26E-08	4.71E-08	5.41E-13	1.72E-11	2.19E-07			1.20E-11		7.28E-07	2.42E-07
Chrysene	2.19E-10	2.19E-10	8.40E-13	6.21E-10	8.75E-10	5.41E-16	1.16E-14	2.19E-10			1.20E-14		2.15E-09	8.41E-10
Pentachlorophenol	3.60E-09	3.60E-09	1.38E-11	3.85E-08	4.36E-08	8.89E-15	1.53E-13	3.60E-09			7.56E-11		9.30E-08	4.21E-08

Exhibit 3

Table 3. Increased Cancer Risks per Unit Concentration (1 mg/kg or 1 pCi/g) - Occasional Use Scenario

	Exposure Pathway													
Contaminant	Soil Ingestion	Dermal Contact with Soil	Inhalation	Groundwater Ingestion	Groundwater Dermal Contact	Surface Water Ingestion	Surface Water Dermal Exposure	Sediment Ingestion	Sediment Dermal Contact	External Exposure	Fish Ingestion	Crop Ingestion	Total Risk - Full Pathways	Total Risk - Subset of Pathways
Am-241	6.00E-09		6.72E-09	3.73E-08		2.96E-18		6.00E-09		7.35E-10	2.11E-15		5.68E-08	5.08E-08
C-14	2.25E-11		1.34E-15	5.59E-08		4.39E-18		2.25E-11		0.00E+00	3.13E-15		5.60E-08	5.60E-08
Cs-134	1.03E-09		5.88E-12	2.55E-08		2.00E-18		1.03E-09		7.80E-07	1.43E-15		8.08E-07	8.07E-07
Cs-137	7.00E-10		3.99E-12	1.74E-08		1.37E-18		7.00E-10		3.00E-07	9.78E-16		3.19E-07	3.18E-07
Co-60	3.75E-10		3.15E-11	9.32E-09		7.33E-19		3.75E-10		1.29E-06	5.24E-16		1.30E-06	1.30E-06
Eu-152	5.25E-11		2.31E-11	3.26E-10		2.59E-20		5.25E-11		5.40E-07	1.85E-17		5.40E-07	5.40E-07
Eu-154	7.50E-11		2.94E-11	4.66E-10		3.70E-20		7.50E-11		6.15E-07	2.64E-17		6.16E-07	6.16E-07
Eu-155	1.13E-11		3.78E-12	6.99E-11		5.55E-21		1.13E-11		8.85E-09	3.96E-18		8.95E-09	8.93E-09
H-3	1.35E-12		1.64E-14	3.36E-08		2.63E-18		1.35E-12		0.00E+00	1.88E-15		3.36E-08	3.36E-08
K-40	2.75E-10		1.60E-12	8.55E-08		6.71E-18		2.75E-10		8.10E-08	4.79E-15		1.67E-07	1.67E-07
Na-22	1.70E-10		1.01E-12	5.28E-08		4.14E-18		1.70E-10		1.08E-06	2.96E-15		1.13E-06	1.13E-06
Ni-63	6.00E-12		3.78E-13	2.49E-10		1.95E-20		6.00E-12		0.00E+00	1.40E-17		2.61E-10	2.55E-10
Pu-238	5.50E-09		7.98E-09	2.74E-07		2.15E-17		5.50E-09		4.20E-12	1.53E-14		2.92E-07	2.87E-07
Pu-239	5.75E-09		7.98E-09	2.86E-07		2.25E-17		5.75E-09		2.55E-12	1.60E-14		3.05E-07	3.00E-07
Pu-240	5.75E-09		7.98E-09	2.86E-07		2.25E-17		5.75E-09		4.05E-12	1.60E-14		3.05E-07	3.00E-07
Ra-226	3.00E-09		6.30E-10	7.46E-05		5.85E-15		3.00E-09		9.00E-07	4.18E-12		7.55E-05	7.55E-05
Sr-90	9.00E-10		1.30E-11	4.48E-08		3.52E-18		9.00E-10		0.00E+00	2.51E-15		4.66E-08	4.57E-08
Tc-99	3.25E-11		1.74E-12	8.08E-07		6.34E-17		3.25E-11		9.00E-14	4.53E-14		8.08E-07	8.08E-07
Th-228	1.38E-09		1.64E-08	3.42E-05		2.68E-15		1.38E-09		8.40E-07	1.92E-12		3.50E-05	3.50E-05
Th-232	3.00E-10		5.88E-09	7.46E-06		5.85E-16		3.00E-10		3.90E-12	4.18E-13		7.47E-06	7.47E-06
U-233	4.00E-10		5.67E-09	2.49E-07		1.95E-17		4.00E-10		6.30E-12	1.39E-14		2.55E-07	2.55E-07
U-234	4.00E-10		5.46E-09	2.49E-07		1.95E-17		4.00E-10		4.50E-12	1.39E-14		2.55E-07	2.55E-07
U-235	4.00E-10		5.25E-09	2.49E-07		1.95E-17		4.00E-10		3.60E-08	1.39E-14		2.91E-07	2.90E-07
U-238	7.00E-10		1.09E-08	4.35E-07		3.41E-17		7.00E-10		5.40E-09	2.44E-14		4.53E-07	4.52E-07
Antimony	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		0.00E+00	0.00E+00
Arsenic	5.40E-08		1.73E-09	6.13E-04	1.07E-06	1.81E-13	4.81E-15	5.40E-08			4.47E-11		6.14E-04	6.13E-04
Barium	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		0.00E+00	0.00E+00
Cadmium	0.00E+00		7.25E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		7.25E-10	7.25E-10
Chromium VI	0.00E+00		4.83E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		4.83E-09	4.83E-09
Lead	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		0.00E+00	0.00E+00
Manganese	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		0.00E+00	0.00E+00
Mercury	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		0.00E+00	0.00E+00
Zinc	0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00		0.00E+00	0.00E+00
Aroclor 1260	2.31E-07	2.31E-07	8.86E-10	2.47E-07	3.01E-07	5.71E-13	1.06E-11	2.31E-07			3.67E-08		1.28E-06	4.79E-07
Benzo(a)pyrene	2.19E-07	2.19E-07	8.40E-10	2.26E-08	4.71E-08	5.41E-13	1.72E-11	2.19E-07			1.20E-11		7.28E-07	2.42E-07
Chrysene	2.19E-10	2.19E-10	8.40E-13	6.21E-10	8.75E-10	5.41E-16	1.16E-14	2.19E-10			1.20E-14		2.15E-09	8.41E-10
Pentachlorophenol	3.60E-09	3.60E-09	1.38E-11	3.85E-08	4.36E-08	8.89E-15	1.53E-13	3.60E-09			7.56E-11		9.30E-08	4.21E-08

Exhibit 3

Table 4. Percent Contribution of Exposure Pathways to Contaminant-Specific ICR - Occasional Use Scenario

	Exposure Pathway											
Contaminant	Soil Ingestion	Dermal Contact with Soil	Inhalation	Groundwater Ingestion	Groundwater Dermal Contact	Surface Water Ingestion	Surface Water Dermal Exposure	Sediment Ingestion	Sediment Dermal Contact	External Exposure	Fish Ingestion	Crop Ingestion
Am-241	10.57%		11.84%	65.72%		<0.01%		10.57%		1.30%	<0.01%	
C-14	0.04%		<0.01%	99.92%		<0.01%		0.04%		<0.01%	<0.01%	
Cs-134	0.13%		<0.01%	3.16%		<0.01%		0.13%		96.59%	<0.01%	
Cs-137	0.22%		<0.01%	5.46%		<0.01%		0.22%		94.10%	<0.01%	
Co-60	0.03%		<0.01%	0.72%		<0.01%		0.03%		99.22%	<0.01%	
Eu-152	<0.01%		<0.01%	0.06%		<0.01%		<0.01%		99.92%	<0.01%	
Eu-154	0.01%		<0.01%	0.08%		<0.01%		0.01%		99.90%	<0.01%	
Eu-155	0.13%		0.04%	0.78%		<0.01%		0.13%		98.92%	<0.01%	
H-3	<0.01%		<0.01%	99.99%		<0.01%		<0.01%		<0.01%	<0.01%	
K-40	0.16%		<0.01%	51.17%		<0.01%		0.16%		48.50%	<0.01%	
Na-22	0.02%		<0.01%	4.66%		<0.01%		0.02%		95.31%	<0.01%	
Ni-63	2.30%		0.14%	95.26%		<0.01%		2.30%		<0.01%	<0.01%	
Pu-238	1.88%		2.73%	93.51%		<0.01%		1.88%		<0.01%	<0.01%	
Pu-239	1.88%		2.61%	93.62%		<0.01%		1.88%		<0.01%	<0.01%	
Pu-240	1.88%		2.61%	93.62%		<0.01%		1.88%		<0.01%	<0.01%	
Ra-226	<0.01%		<0.01%	98.80%		<0.01%		<0.01%		1.19%	<0.01%	
Sr-90	1.93%		0.03%	96.11%		<0.01%		1.93%		<0.01%	<0.01%	
Tc-99	<0.01%		<0.01%	99.99%		<0.01%		<0.01%		<0.01%	<0.01%	
Th-228	<0.01%		0.05%	97.55%		<0.01%		<0.01%		2.40%	<0.01%	
Th-232	<0.01%		0.08%	99.91%		<0.01%		<0.01%		<0.01%	<0.01%	
U-233	0.16%		2.22%	97.46%		<0.01%		0.16%		<0.01%	<0.01%	
U-234	0.16%		2.14%	97.54%		<0.01%		0.16%		<0.01%	<0.01%	
U-235	0.14%		1.81%	85.53%		<0.01%		0.14%		12.38%	<0.01%	
U-238	0.15%		2.41%	96.09%		<0.01%		0.15%		1.19%	<0.01%	
Antimony												
Arsenic	<0.01%		<0.01%	99.81%	0.17%	<0.01%	<0.01%	<0.01%			<0.01%	
Barium												
Cadmium	<0.01%		100.00%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%			<0.01%	
Chromium VI	<0.01%		100.00%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%			<0.01%	
Lead												
Manganese												
Mercury												
Zinc												
Aroclor 1260	18.06%	18.06%	0.07%	19.33%	23.54%	<0.01%	<0.01%	18.06%			2.87%	
Benzo(a)pyrene	30.10%	30.10%	0.12%	3.10%	6.48%	<0.01%	<0.01%	30.10%			<0.01%	
Chrysene	10.17%	10.17%	0.04%	28.84%	40.62%	<0.01%	<0.01%	10.17%			<0.01%	
Pentachlorophenol	3.87%	3.87%	0.01%	41.44%	46.85%	<0.01%	<0.01%	3.87%			0.08%	

Exhibit 4

Pre-Remediation Risks

Exhibit 4

Summary of Pre-Remediation ICRs - Site 116-B-1

Scenario	Zone in Soil		
	Zone 1	Zone 2	Zone 3
Occasional Use Scenario - Full Set of Pathways	0.00E+00	3.01E-07	2.06E-07
Occasional Use Scenario - Subset of Pathways	0.00E+00	3.01E-07	2.06E-07
Frequent Use Scenario - Full Set of Pathways	0.00E+00	4.80E-05	3.30E-05
Frequent Use Scenario - Subset of Pathways	0.00E+00	4.79E-05	3.27E-05

Summary of Pre-Remediation ICRs - Site 116-C-5

Scenario	Zone in Soil		
	Zone 1	Zone 2	Zone 3
Occasional Use Scenario - Full Set of Pathways	1.07E-02	2.77E-03	2.10E-05
Occasional Use Scenario - Subset of Pathways	1.06E-02	2.77E-03	2.09E-05
Frequent Use Scenario - Full Set of Pathways	1.68E+00	4.33E-01	3.29E-03
Frequent Use Scenario - Subset of Pathways	1.67E+00	4.30E-01	3.26E-03

Summary of Pre-Remediation ICRs - Site 116-D-1A

Scenario	Zone in Soil		
	Zone 1	Zone 2	Zone 3
Occasional Use Scenario - Full Set of Pathways	3.60E-05	6.28E-05	8.52E-05
Occasional Use Scenario - Subset of Pathways	3.60E-05	6.28E-05	8.52E-05
Frequent Use Scenario - Full Set of Pathways	3.70E-03	1.00E-02	4.76E-03
Frequent Use Scenario - Subset of Pathways	3.63E-03	9.98E-03	4.70E-03

Summary of Pre-Remediation ICRs - Site 116-F-4

Scenario	Zone in Soil		
	Zone 1	Zone 2	Zone 3
Occasional Use Scenario - Full Set of Pathways	5.64E-04	5.44E-05	3.97E-03
Occasional Use Scenario - Subset of Pathways	5.62E-04	5.39E-05	3.95E-03
Frequent Use Scenario - Full Set of Pathways	7.42E-02	7.63E-03	5.39E-01
Frequent Use Scenario - Subset of Pathways	7.01E-02	4.64E-03	5.00E-01

Exhibit 4

Percent Contribution to Total Increased Cancer Risk - Site 116-B-1

Contaminant	Zone 1	Zone 2	Zone 3
Cs-134		0.08%	
Cs-137		8.55%	
Co-60		11.58%	8.43%
Eu-152		79.60%	90.43%
Eu-155		0.05%	0.06%
Sr-90		0.14%	1.09%

Percent Contribution to Total Increased Cancer Risk - Site 116-C-5

Contaminant	Zone 1	Zone 2	Zone 3
Am-241	<0.01%	<0.01%	
C-14	0.09%		
Cs-134	0.06%	16.18%	<0.01%
Cs-137	6.32%	24.50%	41.52%
Co-60	24.08%	14.59%	39.08%
Eu-152	29.60%	27.36%	15.07%
Eu-154	38.32%	16.15%	3.48%
Eu-155	0.05%	0.02%	<0.01%
H-3	0.20%	<0.01%	
Ni-63	<0.01%		
Pu-238	<0.01%		
Pu-239	0.22%	0.03%	0.12%
Ra-226	0.20%	0.64%	
Sr-90	0.35%	0.52%	0.72%
U-238	<0.01%	<0.01%	
Chromium VI	<0.01%		
Pentachlorophenol	0.49%		

ATTACHMENT 2

PRG TABLES

Table 2-1. Potential Preliminary Remediation Goals, Baseline Scenario.

	HUMAN HEALTH		Protection of GW	CRQL/ CRDL	ZONE SPECIFIC PRG			
	TR = 1E-06(a)	HQ = 0.1	(b)	(c)	1 0-3 ft	2 3-6 ft	3 6-10 ft	4 >10 ft
RADIONUCLIDES (pCi/g)								
Am-241	76.9	N/A	31	1	31	31	31	31
C-14	44200	N/A	18	50	50	50	50	50
Cs-134	3460	N/A	517	0.1 (d)	517	517	517	517
Cs-137	5.68	N/A	775	0.1	5.68	5.68	5.68	775
Co-60	17.5	N/A	1292	0.05	17.5	17.5	17.5	1292
Eu-152	5.96	N/A	20667	0.1	5.96	5.96	5.96	20667
Eu-154	10.6	N/A	20667	0.1	10.6	10.6	10.6	20667
Eu-155	3080	N/A	103333	0.1	3080	3080	3080	103333
H-3	2900000	N/A	517	400	517	517	517	517
K-40	12.1	N/A	145	4 (e)	12.1	12.1	12.1	145
Na-22	545	N/A	207	4 (e)	207	207	207	207
Ni-63	184000	N/A	46500	30	46500	46500	46500	46500
Pu-238	87.9	N/A	5	1	5	5	5	5
Pu-239/240	72.8	N/A	4	1	4	4	4	4
Ra-226	1.1	N/A	0.03	0.1	0.1	0.1	0.1	0.1
Sr-90	1930	N/A	129	1	129	129	129	129
Tc-99	28900	N/A	26	15	26	26	26	26
Th-228	7260	N/A	0.103	1 (f)	1	1	1	1
Th-232	162	N/A	0.013	1	1	1	1	1
U-233/234	165	N/A	5	1	5	5	5	5
U-235	23.6	N/A	6	1	6	6	6	6
U-238 (g)	58.4	N/A	6	1	6	6	6	6
INORGANICS (mg/kg)								
Antimony	N/A	1669	0.002	6	6	6	6	6
Arsenic	16.2	1251	0.013	1	1	1	1	1
Barium	N/A	1000000 (h)	258	20	258	258	258	258
Cadmium	1360	4171	0.775	0.5	0.775	0.775	0.775	0.775
Chromium VI	204	20857	0.026	1	1	1	1	1
Lead	N/A	N/A	8	0.3	8	8	8	8
Manganese	N/A	20857	13	1.5	13	13	13	13
Mercury	N/A	1251	0.31	0.02	0.31	0.31	0.31	0.31
Zinc	N/A	100000 (h)	775	2	775	775	775	775
ORGANICS (mg/kg)								
Aroclor 1260 (PCB)	4.34	N/A	1.37	0.033	1.37	1.37	1.37	1.37
Benzo(a)pyrene	4.57	N/A	5.68	0.33	4.57	4.57	4.57	5.68
Chrysene	N/A	N/A	0.01	0.33	0.33	0.33	0.33	0.33
Pentachlorophenol	279	N/A	0.27	0.8	0.8	0.8	0.8	0.8

CRQL=contract required quantitation limit
CRDL=contract required detection limit
N/A= NOT APPLICABLE
NC=NOT CALCULATED. Appropriate calculation not established at this time
TR=Target Risk
HQ=Hazard Quotient
(a)=Recreational exposure scenario accounting for decay to 2018
(b)=Based on Summer's Model (EPA 1989b)
(c)=Based on 100-BC-5 OU Work Plan QAPjP (DOE-RL 1992)
(d)=Detection limit assumed to be same as Cs-137
(e)=Based on gross beta analysis
(f)=Detection limit assumed to be same as Th-232
(g)=Includes total U if no other data exist
(h)=Value calculated exceeds 1,000,000 ppm therefore use 100,000 ppm as default

Table 2-2. Potential Preliminary Remediation Goals, Occasional-Use Scenario.

	HUMAN HEALTH		Protection of GW	CRQL/ CRDL	ZONE SPECIFIC PRG			
	TR = 1E-06(a)	HQ = 0.1	(b)	(c)	1 0-3 ft	2 3-6 ft	3 6-10 ft	4 >10 ft
RADIONUCLIDES (pCi/g)								
Am-241	76.9	N/A	1600	1	76.9	76.9	76.9	1600
C-14	44200	N/A	940	50	940	940	940	940
Cs-134	3460	N/A	27000	0.1 (d)	3460	3460	3460	27000
Cs-137	5.68	N/A	40000	0.1	5.68	5.68	5.68	40000
Co-60	17.5	N/A	67000	0.05	17.5	17.5	17.5	67000
Eu-152	5.96	N/A	1100000	0.1	5.96	5.96	5.96	1100000
Eu-154	10.6	N/A	1100000	0.1	10.6	10.6	10.6	1100000
Eu-155	3080	N/A	5400000	0.1	3080	3080	3080	5400000
H-3	2900000	N/A	27000	400	27000	27000	27000	27000
K-40	12.1	N/A	7500	4 (e)	12.1	12.1	12.1	7500
Na-22	545	N/A	11000	4 (e)	545	545	545	11000
Ni-63	184000	N/A	2400000	30	184000	184000	184000	2400000
Pu-238	87.9	N/A	260	1	87.9	87.9	87.9	260
Pu-239/240	72.8	N/A	210	1	72.8	72.8	72.8	210
Ra-226	1.1	N/A	1.6	0.1	1.1	1.1	1.1	1.6
Sr-90	1930	N/A	6700	1	1930	1930	1930	6700
Tc-99	28900	N/A	1400	15	1400	1400	1400	1400
Th-228	7260	N/A	5.4	1 (f)	5.4	5.4	5.4	5.4
Th-232	162	N/A	0.68	1	1	1	1	1
U-233/234	165	N/A	260	1	165	165	165	260
U-235	23.6	N/A	310	1	23.6	23.6	23.6	310
U-238 (g)	58.4	N/A	310	1	58.4	58.4	58.4	310
INORGANICS (mg/kg)								
Antimony	N/A	1669	0.1	6	6	6	6	6
Arsenic	16.2	1251	0.68	1	1	1	1	1
Barium	N/A	100000 (h)	13000	20	13000	13000	13000	13000
Cadmium	1360	4171	40	0.5	40	40	40	40
Chromium VI	204	20857	1.4	1	1.4	1.4	1.4	1.4
Lead	N/A	N/A	420	0.3	420	420	420	420
Manganese	N/A	20857	680	1.5	680	680	680	680
Mercury	N/A	1251	16	0.02	16	16	16	16
Zinc	N/A	100000 (h)	40000	2	40000	40000	40000	40000
ORGANICS (mg/kg)								
Aroclor 1260 (PCB)	4.34	N/A	71	0.033	4.34	4.34	4.34	71
Benzo(a)pyrene	4.57	N/A	300	0.33	4.57	4.57	4.57	300
Chrysene	N/A	N/A	0.52	0.33	0.52	0.25	0.52	0.52
Pentachlorophenol	279	N/A	14	0.8	14	14	14	14

CRQL=contract required quantitation limit
CRDL=contract required detection limit
N/A= NOT APPLICABLE
NC=NOT CALCULATED. Appropriate calculation not established at this time
TR=Target Risk
HQ=Hazard Quotient
(a)=Recreational exposure scenario accounting for decay to 2018
(b)=Based on Summer's Model (EPA 1989b), using a "recreational" GW limit
(c)=Based on 100-BC-5 OU Work Plan QAPjP (DOE-RL 1992)
(d)=Detection limit assumed to be same as Cs-137
(e)=Based on gross beta analysis
(f)=Detection limit assumed to be same as Th-232
(g)=Includes total U if no other data exist
(h)=Value calculated exceeds 1,000,000 ppm therefore use 100,000 ppm as default

Table 2-3. Potential Preliminary Remediation Goals, Frequent-Use Scenario.

	HUMAN HEALTH		Protection of GW	CRQL/ CRDL	ZONE SPECIFIC PRG	
	TR = 1E-06(a)	HQ = 0.1	(b)	(c)	1 0-15 ft	2 >15 ft
RADIONUCLIDES (pCi/g)						
Am-241	1.3	N/A	31	1	1.3	31
C-14	851	N/A	18	50	50	50
Cs-134	22	N/A	517	0.1 (d)	22	517
Cs-137	0.036	N/A	775	0.1	0.1	775
Co-60	0.11	N/A	1292	0.05	0.11	1292
Eu-152	0.038	N/A	20667	0.1	0.1	20667
Eu-154	0.067	N/A	20667	0.1	0.1	20667
Eu-155	20	N/A	103333	0.1	20	103333
H-3	55900	N/A	517	400	517	517
K-40	0.077	N/A	145	4 (e)	4	145
Na-22	3.5	N/A	207	4 (e)	4	207
Ni-63	3530	N/A	46500	30	3530	46500
Pu-238	1.7	N/A	5	1	1.7	5
Pu-239/240	1.4	N/A	4	1	1.4	4
Ra-226	0.007	N/A	0.03	0.1	0.1	0.1
Sr-90	37	N/A	129	1	37	129
Tc-99	553	N/A	26	15	26	26
Th-228	47	N/A	0.103	1 (f)	1	1
Th-232	3.1	N/A	0.013	1	1	1
U-233/234	3.1	N/A	5	1	3.1	5
U-235	0.17	N/A	6	1	1	6
U-238 (g)	0.68	N/A	6	1	1	6
INORGANICS (mg/kg)						
Antimony	N/A	3.2	0.002	6	6	6
Arsenic	0.31	2.4	0.013	1	1	1
Barium	N/A	560	258	20	258	258
Cadmium	26	8	0.775	0.5	0.775	0.775
Chromium VI	3.9	40	0.026	1	1	1
Lead	N/A	N/A	8	0.3	8	8
Manganese	N/A	40	13	1.5	13	13
Mercury	N/A	2.4	0.31	0.02	0.31	0.31
Zinc	N/A	2400 (h)	775	2	775	775
ORGANICS (mg/kg)						
Aroclor 1260 (PCB)	0.083	N/A	1.37	0.033	0.083	1.37
Benzo(a)pyrene	0.088	N/A	5.68	0.33	0.33	5.68
Chrysene	N/A	N/A	0.01	0.33	0.33	0.33
Pentachlorophenol	5.3	N/A	0.27	0.8	0.8	0.8

CRQL=contract required quantitation limit
CRDL=contract required detection limit
N/A= NOT APPLICABLE
NC=NOT CALCULATED. Appropriate calculation not established at this time
TR=Target Risk
HQ=Hazard Quotient
(a)=Residential exposure scenario accounting for decay to 2018
(b)=Based on Summer's Model (EPA 1989b)
(c)=Based on 100-BC-5 OU Work Plan QAPjP (DOE-RL 1992)
(d)=Detection limit assumed to be same as Cs-137
(e)=Based on gross beta analysis
(f)=Detection limit assumed to be same as Th-232
(g)=Includes total U if no other data exist
(h)=Value calculated exceeds 1,000,000 ppm therefore use 100,000 ppm as default

Table 2-4. Potential Preliminary Remediation Goals Modified Frequent-Use Scenario.

	HUMAN HEALTH		CRQL/ CRDL	ZONE SPECIFIC PRG
	TR = 1E-06(g)	HQ = 0.1	(c)	1 0-15 ft
RADIONUCLIDES (pCi/g)				
Am-241	1.3	N/A	1	1.3
C-14	851	N/A	50	851
Cs-134	22	N/A	0.1 (h)	22
Cs-137	0.036	N/A	0.1	0.1
Co-60	0.11	N/A	0.05	0.11
Eu-152	0.038	N/A	0.1	0.1
Eu-154	0.067	N/A	0.1	0.1
Eu-155	20	N/A	0.1	20
H-3	55900	N/A	400	55900
K-40	0.077	N/A	4 (i)	4
Na-22	3.5	N/A	4 (i)	4
Ni-63	3530	N/A	30	3530
Pu-238	1.7	N/A	1	1.7
Pu-239/240	1.4	N/A	1	1.4
Ra-226	0.007	N/A	0.1	0.1
Sr-90	37	N/A	1	37
Tc-99	553	N/A	15	553
Th-228	47	N/A	1 (d)	47
Th-232	3.1	N/A	1	3.1
U-233/234	3.1	N/A	1	3.1
U-235	0.17	N/A	1	1
U-238 (e)	0.68	N/A	1	1
INORGANICS (mg/kg)				
Antimony	N/A	3.2	6	6
Arsenic	0.31	2.4	1	1
Barium	N/A	560	20	560
Cadmium	26	8	0.5	8
Chromium VI	3.9	40	1	3.9
Lead	N/A	N/A	0.3	0.3
Manganese	N/A	40	1.5	40
Mercury	N/A	2.4	0.02	2.4
Zinc	N/A	2400 (f)	2	2400
ORGANICS (mg/kg)				
Aroclor 1260 (PCB)	0.083	N/A	0.033	0.083
Benzo(a)pyrene	0.088	N/A	0.33	0.33
Chrysene	N/A	N/A	0.33	0.33
Pentachlorophenol	5.3	N/A	0.8	5.3

CRQL=contract required quantitation limit
CRDL=contract required detection limit
N/A= NOT APPLICABLE
NC=NOT CALCULATED. Appropriate calculation not established at this time
TR=Target Risk
HQ=Hazard Quotient

(a)=Recreational exposure scenario accounting for decay to 2018
(b)=Based on 100-BC-5 OU Work Plan QAPjP (DOE-RL 1992)
(c)=Detection limit assumed to be same as Cs-137
(d)=Based on gross beta analysis
(e)=Detection limit assumed to be same as Th-232
(f)=Includes total U if no other data exist
(g)=Value calculated exceeds 1,000,000 ppm therefore use 100,000 ppm as default

Table 2-5. Potential Preliminary Remediation Goals Complete Excavation Scenario.

	HUMAN HEALTH		CRQL/ CRDL		ZONE SPECIFIC PRG
	TR = 1E-06(g)	HQ = 0.1	(c)		1 0-GW
RADIONUCLIDES (pCi/g)					
Am-241	1.3	N/A	1		1.3
C-14	851	N/A	50		851
Cs-134	22	N/A	0.1	(h)	22
Cs-137	0.036	N/A	0.1		0.1
Co-60	0.11	N/A	0.05		0.11
Eu-152	0.038	N/A	0.1		0.1
Eu-154	0.067	N/A	0.1		0.1
Eu-155	20	N/A	0.1		20
H-3	55900	N/A	400		55900
K-40	0.077	N/A	4	(i)	4
Na-22	3.5	N/A	4	(i)	4
Ni-63	3530	N/A	30		3530
Pu-238	1.7	N/A	1		1.7
Pu-239/240	1.4	N/A	1		1.4
Ra-226	0.007	N/A	0.1		0.1
Sr-90	37	N/A	1		37
Tc-99	553	N/A	15		553
Th-228	47	N/A	1	(d)	47
Th-232	3.1	N/A	1		3.1
U-233/234	3.1	N/A	1		3.1
U-235	0.17	N/A	1		1
U-238 (e)	0.68	N/A	1		1
INORGANICS (mg/kg)					
Antimony	N/A	3.2	6		6
Arsenic	0.31	2.4	1		1
Barium	N/A	560	20		560
Cadmium	26	8	0.5		8
Chromium VI	3.9	40	1		3.9
Lead	N/A	N/A	0.3		0.3
Manganese	N/A	40	1.5		40
Mercury	N/A	2.4	0.02		2.4
Zinc	N/A	2400 (f)	2		2400
ORGANICS (mg/kg)					
Aroclor 1260 (PCB)	0.083	N/A	0.033		0.083
Benzo(a)pyrene	0.088	N/A	0.33		0.33
Chrysene	N/A	N/A	0.33		0.33
Pentachlorophenol	5.3	N/A	0.8		5.3

CRQL=contract required quantitation limit
CRDL=contract required detection limit
N/A= NOT APPLICABLE
NC=NOT CALCULATED. Appropriate calculation not established at this time
TR=Target Risk
HQ=Hazard Quotient
(a)=Recreational exposure scenario accounting for decay to 2018
(b)=Based on 100-BC-5 OU Work Plan QAPjP (DOE-RL 1992)
(c)=Detection limit assumed to be same as Cs-137
(d)=Based on gross beta analysis
(e)=Detection limit assumed to be same as Th-232
(f)=Includes total U if no other data exist
(g)=Value calculated exceeds 1,000,000 ppm therefore use 100,000 ppm as default

ATTACHMENT 3

VOLUME DOCUMENTATION

9513387.0928

Figure 3-1. 116-C-5 Occasional-Use Scenario.

116-C-5	Zone 1		Zone 2		Zone 3		Zone 4										Refined COPC Summary
	0 - 3 ft		3 - 6 ft		6 - 10 ft		10 - 15 ft		15 - 20 ft		20 - 25 ft		25 - 30 ft		30 - 35 ft		
	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	
RADIONUCLIDES (pCi/g)																	
Am-241	3.40E+01	NO a b c	1.30E-01	NO b c d e		NO c d e		NO d e	4.00E-03	NO d e		NO d e		NO d e		NO d e	
C-14	2.59E+02	NO a b c		NO b c d e		NO c d e		NO d e	4.10E-01	NO d e		NO d e		NO d e		NO d e	
Cs-134	7.82E+00	NO a b c d	5.52E-01	NO b c d	1.15E-03	NO c d e	7.82E-04	NO d e	6.90E-04	NO d e	3.91E-03	NO d e		NO d e		NO d e	
Cs-137	1.73E+03	YES	2.15E+03	YES	2.77E+01	YES d	1.04E+02	NO d	8.30E+01	NO d	2.21E+01	NO d		NO d e		NO d e	YES
Co-60	1.95E+03	YES	3.05E+02	YES d	6.22E+00	NO c d	3.17E+01	NO d	5.00E+01	NO d	5.85E+00	NO d		NO d e		NO d e	YES
Eu-152	5.75E+03	YES d	1.37E+03	YES d	5.75E+00	NO c d	1.64E+02	NO d	1.72E+02	NO d	2.61E+01	NO d		NO d e		NO d e	YES
Eu-154	6.53E+03	YES d	7.10E+02	YES d	1.16E+00	NO c d	4.54E-01	NO d	4.83E+01	NO d	8.24E+00	NO d		NO d e		NO d e	YES
Eu-155	5.35E+02	NO a b c d	7.38E+01	NO b c d	1.07E-01	NO c d	1.71E+00	NO d	3.32E+00	NO d	9.20E-01	NO d		NO d e		NO d e	
H-3	2.47E+01	NO a b c d e	1.78E+03	NO b c		NO c d e	2.07E-01	NO d e		NO d e		NO d e		NO d e		NO d e	
K-40		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Na-22		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Ni-63	4.56E+03	NO a b c d		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Pu-238	9.40E+00	NO a b c		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Pu-239/240	2.30E+02	YES	7.90E+00	NO b c	2.40E-01	NO c d e	1.80E+00	NO d	1.90E+00	NO d	2.90E-01	NO d e		NO d e		NO d e	YES
Ra-226	8.40E-01	NO a b c	6.80E-01	NO b c		NO c d e		NO d e	1.02E+00	NO		NO d e		NO d e		NO d e	f
Sr-90	7.70E+02	NO a b c	2.99E+02	NO b c	3.12E+00	NO c d	6.79E+00	NO d	5.43E+00	NO d	4.21E+00	NO d		NO d e		NO d e	
Tc-99		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Th-228		NO a b c d e		NO b c d e		NO c d e		NO d e	4.40E+00	NO		NO d e		NO d e		NO d e	
Th-232		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
U-233/234	1.40E+00	NO a b c d		NO b c d e		NO c d e	7.80E-01	NO d e	8.40E-01	NO d e		NO d e		NO d e		NO d e	
U-235	8.00E-02	NO a b c d e		NO b c d e		NO c d e		NO d e	9.00E-03	NO d e		NO d e		NO d e		NO d e	
U-238	3.00E+00	NO a b c d	9.90E-01	NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
INORGANICS (mg/kg)																	
Antimony		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Arsenic		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Barium		NO a b c d e	2.60E+02	NO b c		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Cadmium		NO a b c d e		NO b c d e		NO c d e		NO d e	8.40E-01	NO		NO d e		NO d e		NO d e	
Chromium VI	6.09E+02	YES a b c		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	YES
Lead	5.64E+02	YES		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	YES
Manganese		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Mercury	4.30E+00	NO a b c		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Zinc	3.09E+02	NO a b c d		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
ORGANICS (mg/kg)																	
Aroclor 1260 (PCB)		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Benzo(a)pyrene		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Chrysene	1.00E-01	NO e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Pentachlorophenol	9.20E-01	NO		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	

* Maximum concentrations are screened against the PRG.
The COPC are refined based on the soil concentration and the PRG.
The elimination of a COPC is described by the letters which follow (i.e., a, b, c, d, e, f).
a) Soil concentration < or = human health concentration
b) Soil concentration < or = animal concentration
c) Soil concentration < or = plant concentration
d) Soil concentration < or = protectiveness of ground water concentration
e) Soil concentration < or = CRQL/CRDL
f) Ra-226 is eliminated as a COPC because non-waste site samples presented in Table 3-1 of the 100-BC-2 Operable Unit LFI Report (DOE-RL 1994d) show Radium-226 at a concentration of approximately 1 pCi/g (i.e., average + 2 standard deviations).

PRG = Preliminary Remediation Goals
COPC = contaminants of potential concern
PCB = polychlorinated biphenyls
CRQL = contract required quantitation limit
CRDL = contract required detection limit
LFI = limited field investigation
Max = Blank: No information is available, or not detected
Screening = YES: Exceeds PRG
Screening = NO: Eliminated as COPC

Sources:

Dorian, J.J., and V.R. Richards, 1978, Tables 2.7-4, 5, 8, 13

DOE-RL, 1993b, Tables 3-31, 32, 33, 36

This COPC table shows that excavation is required to the 10' depth

[box] = INDICATES CONTAMINANT CONCENTRATIONS ABOVE PRG LEVELS FOR THIS SCENARIO

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Figure 3-2. 116-C-5 Frequent-Use Scenario.

116-C-5	Zone 1 0-3 ft Max	Zone 1 0-3 ft Screening*	Zone 2 3-6 ft Max	Zone 2 3-6 ft Screening*	Zone 3 6-10 ft Max	Zone 3 6-10 ft Screening*	Zone 4 10-15 ft Max	Zone 4 10-15 ft Screening*	Zone 4 15-20 ft Max	Zone 4 15-20 ft Screening*	Zone 4 20-25 ft Max	Zone 4 20-25 ft Screening*	Zone 4 25-30 ft Max	Zone 4 25-30 ft Screening*	Zone 4 30-35 ft Max	Zone 4 30-35 ft Screening*	Refined COPC Summary
RADIONUCLIDES (pCi/g)																	
Am-241	3.40E+01	YES a b c	1.30E-01	NO b c d e		NO c d e		NO d e	4.00E-03	NO d e		NO d e		NO d e		NO d e	YES
C-14	2.59E+02	YES a b c		NO b c d e		NO c d e		NO d e	4.10E-01	NO d e		NO d e		NO d e		NO d e	YES
Cs-134	7.82E+00	NO a b c d	5.52E-01	NO b c d	1.15E-03	NO c d e	7.82E-04	NO d e	6.90E-04	NO d e	3.91E-03	NO d e		NO d e		NO d e	
Cs-137	1.73E+03	YES	2.15E+03	YES	2.77E+01	YES d	1.04E+02	YES d	8.30E+01	NO d	2.21E+01	NO d		NO d e		NO d e	YES
Co-60	1.95E+03	YES	3.05E+02	YES d	6.22E+00	YES c d	3.17E+01	YES d	5.00E+01	NO d	5.86E+00	NO d		NO d e		NO d e	YES
Eu-152	5.75E+03	YES d	1.37E+03	YES d	5.75E+00	YES c d	1.64E+02	YES d	1.72E+02	NO d	2.61E+01	NO d		NO d e		NO d e	YES
Eu-154	6.53E+03	YES d	7.10E+02	YES d	1.16E+00	YES c d	4.54E+01	YES d	4.83E+01	NO d	8.24E+00	NO d		NO d e		NO d e	YES
Eu-155	5.35E+02	YES a b c d	7.38E+01	YES b c d	1.07E-01	YES c d	1.71E+00	YES d	3.32E+00	NO d	9.20E-01	NO d		NO d e		NO d e	YES
H-3	2.47E+01	NO a b c d e	1.78E+03	YES b c		NO c d e	2.07E-01	YES d e		NO d e		NO d e		NO d e		NO d e	YES
K-40		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Na-22		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Ni-63	4.56E-03	YES a b c d		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	YES
Pu-238	9.40E+[illegible]	YES a b c		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	YES
Pu-239/240	2.30E+02	YES	7.90E+00	YES b c	2.40E-01	NO c d e	1.80E+00	YES d	1.90E+00	NO d	2.90E-01	NO d e		NO d e		NO d e	YES
Ra-226	8.40E-01	YES a b c	6.60E-01	YES b c		NO c d e		NO d e	1.02E+00	YES		NO d e		NO d e		NO d e	YES f
Sr-90	7.70E+02	YES a b c	2.99E+02	YES b c	3.12E+00	NO c d	6.79E+00	NO d	5.43E+00	NO d	4.21E+00	NO d		NO d e		NO d e	YES
Tc-99		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Th-228		NO a b c d e		NO b c d e		NO c d e		NO d e	4.40E+00	YES		NO d e		NO d e		NO d e	YES
Th-232		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
U-233/234	1.40E+00	NO a b c d		NO b c d e		NO c d e	7.80E-01	NO d e	8.40E-01	NO d e		NO d e		NO d e		NO d e	
U-235	8.00E-02	NO a b c d e		NO b c d e		NO c d e		NO d e	9.00E-03	NO d e		NO d e		NO d e		NO d e	
U-238	3.00E+00	YES a b c d	9.90E-01	NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	YES
INORGANICS (mg/kg)																	
Antimony		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Arsenic		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Barium		NO a b c d e	2.60E+02	YES b c		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	YES
Cadmium		NO a b c d e		NO b c d e		NO c d e		NO d e	8.40E-01	YES		NO d e		NO d e		NO d e	YES
Chromium VI	6.09E+02	YES a b c		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	YES
Lead	5.64E+02	YES		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	YES
Manganese		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Mercury	4.30E+00	YES a b c		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	YES
Zinc	3.09E+02	NO a b c d		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
ORGANICS (mg/kg)																	
Aroclor 1260 (PCB)		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Benzo(a)pyrene		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Chrysene	1.00E-01	NO e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Pentachlorophenol	9.20E-01	YES		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	YES

* Maximum concentrations are screened against the PRG.
The COPC are refined based on the soil concentration and the PRG.
The elimination of a COPC is described by the letters which follow (i.e., a, b, c, d, e, f).
a) Soil concentration < or = human health concentration
b) Soil concentration < or = animal concentration
c) Soil concentration < or = plant concentration
d) Soil concentration < or = protectiveness of ground water concentration
e) Soil concentration < or = CRQL/CRDL
f) Ra-226 is eliminated as a COPC because non-waste site samples presented in Table 3-1 of the 100-BC-2 Operable Unit LFI Report (DOE-RL 1994d) show Radium-226 at a concentration of approximately 1 pCi/g (i.e., average + 2 standard deviations).

PRG = Preliminary Remediation Goals
COPC = contaminants of potential concern
PCB = polychlorinated biphenyls
CRQL = contract required quantitation limit
CRDL = contract required detection limit
LFI = limited field investigation
Max = Blank: No information is available, or not detected
Screening = YES: Exceeds PRG
Screening = NO: Eliminated as COPC

Sources:

Dorian, J.J., and V.R. Richards, 1978, Tables 2.7-4, 5, 8, 13

DOE-RL, 1993b, Tables 3-31, 32, 33, 36

This COPC table shows that excavation is required to the 20' depth

[box] = INDICATES CONTAMINANT CONCENTRATIONS ABOVE PRG LEVELS FOR THIS SCENARIO

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Figure 3-3. 116-C-5 Complete Excavation Scenario.

116-C-5	Zone 1		Zone 2		Zone 3		Zone 4										Refined COPC Summary
	0 - 3 ft		3 - 6 ft		6 - 10 ft		10 - 15 ft		15 - 20 ft		20 - 25 ft		25 - 30 ft		30 - 35 ft		
	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	Max	Screening*	
RADIONUCLIDES (pCi/g)																	
Am-241	3.40E-01	YES a b c	1.30E-01	NO b c d e		NO c d e		NO d e	4.00E-03	NO d e		NO d e		NO d e		NO d e	YES
C-14	2.59E+02	YES a b c		NO b c d e		NO c d e		NO d e	4.10E-01	NO d e		NO d e		NO d e		NO d e	YES
Cs-134	7.82E+00	YES a b c d	5.52E-01	NO b c d	1.15E-03	NO c d e	7.82E-04	NO d e	6.90E-04	NO d e	3.91E-03	NO d e		NO d e		NO d e	YES
Cs-137	1.73E+03	YES	2.15E+03	YES	2.77E+01	YES d	1.04E+02	YES d	8.30E+01	YES d	2.21E+01	YES d		NO d e		NO d e	YES
Co-60	1.95E+03	YES	3.05E+02	YES d	6.22E+00	YES c d	3.17E+01	YES d	5.00E+01	YES d	5.86E+00	YES d		NO d e		NO d e	YES
Eu-152	5.75E+03	YES d	1.37E+03	YES d	5.75E+00	YES c d	1.64E+02	YES d	1.72E+02	YES d	2.61E+01	YES d		NO d e		NO d e	YES
Eu-154	6.53E+03	YES d	7.10E+02	YES d	1.16E+00	NO c d	4.54E+01	YES d	4.83E+01	YES d	8.24E+00	YES d		NO d e		NO d e	YES
Eu-155	5.35E+02	YES a b c d	7.38E+01	NO b c d	1.07E-01	NO c d	1.71E+00	NO d	3.32E+00	NO d	9.20E-01	NO d		NO d e		NO d e	YES
H-3	2.47E+01	NO a b c d e	1.78E+03	YES b c		NO c d e	2.07E-01	NO d e		NO d e		NO d e		NO d e		NO d e	YES
K-40		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Na-22		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Ni-63	4.56E+03	YES a b c d		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	YES
Pu-238	9.40E+00	NO a b c		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Pu-239/240	2.30E+02	YES	7.90E+00	NO b c	2.40E-01	NO c d e	1.80E+00	NO d	1.90E+00	NO d	2.90E-01	NO d e		NO d e		NO d e	YES
Ra-226	8.40E-01	NO a b c	6.80E-01	NO b c		NO c d e		NO d e	1.02E+00	YES		NO d e		NO d e		NO d e	YES f
Sr-90	7.70E+02	YES a b c	2.99E+02	YES b c	3.12E+00	YES c d	6.79E+00	YES d	5.43E+00	YES d	4.21E+00	YES d		NO d e		NO d e	YES
Tc-99		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Th-228		NO a b c d e		NO b c d e		NO c d e		NO d e	4.40E+00	YES		NO d e		NO d e		NO d e	YES
Th-232		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
U-233/234	1.40E+00	NO a b c d		NO b c d e		NO c d e	7.80E-01	NO d e	8.40E-01	NO d e		NO d e		NO d e		NO d e	
U-235	8.00E-02	NO a b c d e		NO b c d e		NO c d e		NO d e	9.00E-03	NO d e		NO d e		NO d e		NO d e	
U-238	3.00E+00	NO a b c d	9.90E-01	NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
INORGANICS (mg/kg)																	
Antimony		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Arsenic		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Barium		NO a b c d e	2.60E+02	NO b c		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Cadmium		NO a b c d e		NO b c d e		NO c d e		NO d e	8.40E-01	NO		NO d e		NO d e		NO d e	
Chromium VI	6.09E+02	YES a b c		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	YES
Lead	5.64E+02	YES		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	YES
Manganese		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Mercury	4.30E+00	NO a b c		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Zinc	3.09E+02	NO a b c d		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
ORGANICS (mg/kg)																	
Aroclor 1260 (PCB)		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Benzo(a)pyrene		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Chrysene	1.00E-01	NO e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Pentachlorophenol	9.20E-01	NO		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e	

* Maximum concentrations are screened against the PRG.
The COPC are refined based on the soil concentration and the PRG.
The elimination of a COPC is described by the letters which follow (i.e., a, b, c, d, e, f).

a) Soil concentration < or = human health concentration
b) Soil concentration < or = animal concentration
c) Soil concentration < or = plant concentration
d) Soil concentration < or = protectiveness of ground water concentration
e) Soil concentration < or = CRQL/CRDL
f) Ra-226 is eliminated as a COPC because non-waste site samples presented in Table 3-1 of the 100-BC-2 Operable Unit LFI Report (DOE-RL 1994d) show Radium-226 at a concentration of approximately 1 pCi/g (i.e., average + 2 standard deviations).

PRG = Preliminary Remediation Goals
COPC = contaminants of potential concern
PCB = polychlorinated biphenyls
CRQL = contract required quantitation limit
CRDL = contract required detection limit
LFI = limited field investigation
Max = Blank: No information is available, or not detected
Screening = YES: Exceeds PRG
Screening = NO: Eliminated as COPC

Sources:

Dorian, J.J., and V.R. Richards, 1978, Tables 2.7-4, 5, 8, 13

DOE-RL, 1993b, Tables 3-31, 32, 33, 36

This COPC table shows that excavation is required to the 25' depth

[box] = INDICATES CONTAMINANT CONCENTRATIONS ABOVE PRG LEVELS FOR THIS SCENARIO

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Figure 3-4. 116-D-1A Waste Site Occasional-Use Scenari

116-C-5	Zone 1 0 - 3 ft Max	Zone 1 0 - 3 ft Screening*	Zone 2 3 - 6 ft Max	Zone 2 3 - 6 ft Screening*	Zone 3 6 - 10 ft Max	Zone 3 6 - 10 ft Screening*	Zone 4 10 - 15 ft Max	Zone 4 10 - 15 ft Screening*	Zone 4 15 - 20 ft Max	Zone 4 15 - 20 ft Screening*	Zone 4 20 - 25 ft Max	Zone 4 20 - 25 ft Screening*	Zone 4 25 - 30 ft Max	Zone 4 25 - 30 ft Screening*	Zone 4 30 - 35 ft Max	Zone 4 30 - 35 ft Screening*	Zone 4 35-40 ft Max	Zone 4 35-40 ft Screening	Zone 4 40-45 ft Max	Zone 4 40-45 ft Screening	Zone 4 45-50 ft Max	Zone 4 45-50 ft Screening	Refined COPC Summary
RADIONUCLIDES (pCi/g)																							
Am-241	1.70E-01	NO a b c d e		NO b c d e	1.20E-01	NO c d e	1.50E-02	NO d e	1.06E+00	NO d e	1.10E+00	NO d	1.10E+00	NO d	1.40E+00	NO d		NO d e	1.30E+00	NO d	1.30E+00	NO d	
C-14	4.00E-01	NO a b c d e		NO b c d e	4.00E-01	NO c d e		NO d e	4.50E-01	NO d e		NO d e	4.80E-01	NO d e	1.50E-01	NO d e		NO d e	3.60E-01	NO d e	2.90E-02	NO d e	
Cs-134	2.25E-04	NO a b c d e		NO b c d e		NO c d e	7.00E-02	NO d e		NO d e	1.79E-02	NO d e	6.40E-03	NO d e		NO d e		NO d e		NO d e		NO d e	
Cs-137	2.57E+01	YES d	2.28E+01	YES d	7.85E-02	NO c d e	4.57E+01	NO	1.48E+02	NO	3.74E+02	NO d	3.05E+02	NO d	1.90E+02	NO d		NO d e	9.46E-01	NO d	9.46E-01	NO d	YES
Co-60	1.03E+00	NO a b c d	7.93E-01	NO b c d		NO c d e	1.15E+01	NO	1.09E+01	NO	8.91E+00	NO d	5.25E+00	NO d	1.54E+00	NO d		NO d e	5.57E+00	NO d	5.57E+00	NO d	
Eu-152	9.17E+00	YES d	6.63E+00	YES d		NO c d e	1.24E+02	NO	1.12E+02	NO	5.75E+01	NO d	7.07E+01	NO d	3.81E+01	NO d		NO d e	5.90E+01	NO d	5.90E+01	NO d	YES
Eu-154	8.69E-01	NO a b c d	8.24E-01	NO b c d		NO c d e	1.79E+01	NO	1.00E+01	NO	5.97E+00	NO d	6.25E+01	NO d	6.17E+00	NO d		NO d e	7.25E+00	NO d	7.25E+00	NO d	
Eu-155	8.24E-02	NO a b c d e	2.03E-02	NO b c d e		NO c d e	2.00E-01	NO		NO d e	3.32E+00	NO d	2.35E+00	NO d		NO d e		NO d e		NO d e		NO d e	
H-3		NO a b c d e		NO b c d e		NO c d e	3.40E+01	NO d e		NO d e	4.46E+01	NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	
K-40	1.04E+01	NO a b c d		NO b c d e	1.11E+01	NO c d	1.34E+01	NO	6.40E+00	NO	7.73E+00	NO d	8.79E+00	NO d	8.27E+00	NO d		NO d e	1.20E+01	NO d	1.20E+01	NO d	
Na-22	3.38E-01	NO a b c d e		NO b c d e		NO c d e		NO d e	4.72E+00	NO	2.39E+00	NO d e	2.39E+00	NO d e	1.84E+00	NO d e		NO d e	2.60E+00	NO d e	2.60E+00	NO d e	
Ni-63		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Pu-238		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Pu-239/240	4.60E-01	NO a b c d e	2.70E-01	NO b c d e	4.70E-01	NO c d e	4.50E+00	NO	6.80E+00	NO	7.10E+00	NO	7.10E+00	NO	8.30E+00	NO		NO d e	5.70E+00	NO	5.70E+00	NO	
Ra-226		NO a b c d e		NO b c d e	8.03E-01	NO c	1.00E+00	YES		NO d e	4.28E+01	YES	4.28E-01	YES		NO d e		NO d e		NO d e		NO d e	YES
Sr-90	5.00E+00	NO a b c d	2.99E+00	NO b c d	4.20E+00	NO c d	3.67E+01	NO	1.10E-01	NO d e	3.94E+00	NO d	6.65E+00	NO d	1.20E+00	NO d		NO d e	2.20E+00	NO d	1.80E+00	NO d	
Tc-99		NO a b c d e		NO b c d e		NO c d e	8.00E-02	NO d e	9.90E-02	NO d e		NO d e	2.70E-01	NO d e	5.10E-01	NO d e		NO d e		NO d e		NO d e	
Th-228	5.62E-01	NO a b c e		NO b c d e	6.36E-01	NO c e	6.30E-01	NO		NO d e		NO d e	5.00E-01	NO e		NO d e		NO d e		NO d e		NO d e	
Th-232		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	
U-233/234		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	
U-235	7.10E-03	NO a b c d e		NO b c d e	4.40E-03	NO c d e	5.40E-03	NO d e	6.70E-03	NO d e	1.20E-02	NO d e	1.20E-02	NO d e	7.30E-03	NO d e		NO d e	9.10E-03	NO d e	8.60E-03	NO d e	
U-238	1.10E-01	NO a b c d e		NO b c d e	1.30E-01	NO c d e	1.80E-01	NO d e	2.80E-01	NO d e	2.70E-01	NO d e	4.00E-02	NO d e	1.10E-01	NO d e		NO d e	1.20E-01	NO d e	1.20E-01	NO d e	
INORGANICS (mg/kg)																							
Antimony		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Arsenic		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Barium		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Cadmium		NO a b c d e		NO b c d e		NO c d e		NO d e	1.00E+00	NO		NO d e		NO d e		NO		NO d e	1.00E+00	NO		NO d e	
Chromium VI		NO a b c d e		NO b c d e		NO c d e	4.16E+01	YES	8.71E+01	YES		NO d e		NO d e	9.50E-01	NO		NO d e	4.21E+01	YES		NO d e	YES
Lead		NO a b c d e		NO b c d e		NO c d e		NO d e	3.86E-01	NO	1.94E+01	NO	2.76E+01	NO	1.08E+02	YES		NO d e	3.60E-01	NO	3.60E+01	NO	YES
Manganese		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e	5.19E+01	NO d e		NO d e		NO d e		NO d e	
Mercury		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Zinc		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	
ORGANICS (mg/kg)																							
Aroclor 1260 (PCB)		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Benzo(a)pyrene		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Chrysene		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	
Pentachlorophenol		NO a b c d e		NO b c d e		NO c d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e		NO d e	

* Maximum concentrations are screened against the PRG.
The COPC are refined based on the soil concentration and the PRG.
The elimination of a COPC is described by the letters which follow (i.e., a, b, c, d, e, f).
a) Soil concentration < or = human health concentration
b) Soil concentration < or = animal concentration
c) Soil concentration < or = plant concentration
d) Soil concentration < or = protectiveness of ground water concentration
e) Soil concentration < or = CRQL/CRDL
f) Ra-226 is eliminated as a COPC because non-waste site samples presented in Table 3-1 of the 100-BC-2 Operable Unit LFI Report (DOE-RL 1994d) show Radium-226 at a concentration of approximately 1 pCi/g (i.e., average + 2 standard deviations).

PRG = Preliminary Remediation Goals
COPC = contaminants of potential concern
PCB = polychlorinated biphenyls
CRQL = contract required quantitation limit
CRDL = contract required detection limit
LFI = limited field investigation
Max = Blank: No information is available, or not detected
Screening = YES: Exceeds PRG
Screening = NO: Eliminated as COPC

Sources:

Dorian, J.J., and V.R. Richards, 1978, Tables 2.7- 4, 5, 8, 13

DOE-RL, 1993b, Tables 3-31, 32, 33, 36

This COPC table shows that excavation is required to the 45' depth

[box] = INDICATES CONTAMINANT CONCENTRATIONS ABOVE PRG LEVELS FOR THIS SCENARIO

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