# PRELIMINARY RISK EVALUATION OF OPTIONS FOR BURIED WASTE DISPOSITION AT THE IDAHO SITE

Revision 0

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## About CRESP

CRESP began operation in 1995 after receiving a competitive cooperative agreement from the Department of Energy.

A key purpose of CRESP is to implement the 1994 National Academy of Sciences' recommendation that the Environmental Management Office of DOE enable the establishment of an independent institutional mechanism to develop data and methodology to make risk a key part of its decision making. (See *Building Consensus through Risk Assessment and Management of the Department of Energy's Environmental Remediation Program*). Consistent with this purpose, the form of federal assistance for CRESP II is a grant and the independence of the granting agency which that form of assistance involves.

CRESP works to fulfill its mission by improving the scientific and technical basis of environmental management decisions that will

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- enhance stakeholder understanding of the conditions at the nation's nuclear weapons production facility waste sites

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2. It is independent and its beneficiaries are those who have a stake in effective cleanup of federal facilities;
3. It is organized to provide both guidance to and peer review of the evolving effort to utilize risk methods and evaluations to help guide cleanup decisions at DOE sites.

For more information, please visit http://www.cresp.org.

## Biographical Information

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# Executive Summary

**Objectives**

At the Department of Energy Idaho Site near Idaho Falls, Idaho, waste contaminated with radioactive and hazardous materials was buried in pits, trenches, and soil vaults within the Subsurface Disposal Area (SDA) between 1954 and 1970. There is a continuing low-level waste disposal program in the SDA projected to be completed by 2009. The SDA lies directly above the Snake River Plain Aquifer, which supplies drinking and irrigation water to many residents in southeast Idaho. Some contaminants from the SDA have been discovered in the underlying aquifer but have not migrated outside the Idaho Site boundary, and limited remedial measures (e.g., vacuum vapor extraction of volatile organic compounds) have been undertaken to limit migration.

The objective of this report is to develop a framework for the comparative life-cycle risk evaluation of management options for ultimate disposition of the wastes buried in the SDA. Remedial approaches may be implemented either individually or in combination to achieve the desired remedial objectives. In this context, it is essential to decide which combinations of activities (e.g., removal, treatment, in-place containment, etc.) are appropriate for the sub-sections of the SDA or contaminants present based on the characteristics of the buried wastes and other factors. Developing a risk-informed decision that considers human health and ecological risks along with other social factors should include explicit consideration of the trade-offs between reductions in human health risk achieved through each remediation option and the additional human health risks incurred as part of achieving that option. Thus, human health risk evaluation should include consideration of risks to remediation workers and other on-site and off-site populations for current and future generations. This evaluation should also consider the context of nearby waste management closure and remediation needs remaining risks and long-term stewardship needs at the SDA. Integrated evaluation of this range of human health risks often is not achieved as part of the remedial decision process. This report provides a framework and preliminary evaluation to achieve such integration.

**SDA Background**

The SDA comprises a 97-acre area (or approximately that of 88 adjoining football fields) in the Idaho Site Radioactive Waste Management Complex (RWMC). Transuranic (TRU) wastes, received from the Rocky Flats Plant near Denver, Colorado, were buried in the SDA before 1970 and stored retrievably in the RWMC after that. Other wastes (including small amounts of other TRU-contaminated wastes, fission products, and organic solvents) interred in the SDA were either received from other Department of Energy (DOE) sites or generated at the Idaho Site.

The wastes buried in the SDA are diverse in their size and forms. Wastes were buried in drums, garbage cans, and wooden and cardboard boxes; however, large pieces of contaminated equipment, loose material, and debris were also buried. Highly radioactive materials were buried in shielded casks to reduce potential radiation exposure. Low-level, but high-activity liquid wastes containing fission products were disposed of in augur holes.

The wastes buried in the SDA are unique both in their magnitude and diversity. The wastes are diverse in the variety of contaminants (i.e., radioactive and hazardous) and how contaminants are intermixed. These contaminants differ dramatically in degree of toxicity, how they are released into the subsurface environment, how they move through the environment, and how they would potentially impact both human health and the ecology. The contaminants also vary in how long they will remain toxic. The radionuclides will decay over time but at different rates, the organic constituents may be biodegraded, and the hazardous metals will retain their intrinsic toxicity; all contaminants will be subject to attenuation to varying extents by adsorption, dispersion and dilution processes.

Some examples bring the unique nature of the SDA buried wastes into sharper relief. While estimates vary, there was likely more than one metric ton (or 1000 kg) of plutonium buried throughout the SDA; this mass, if concentrated, is equivalent to that of a late-model Volkswagen Beetle. Liquid wastes containing high activity fission products (e.g., strontium and cesium) were injected into augur holes. Solvents and waste sludges were also buried in the SDA. Given the diversity of wastes, on-going and future remedial activities for SDA, performed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), will likely prove to be, if not unique, then very challenging. The current DOE baseline assumption is that volatile organic contaminants of potential concern will be removed using vapor extraction and that targeted areas containing buried TRU waste originally from the Rocky Flats Plant[4] will either be i) excavated and the retrieved TRU waste shipped to the Waste Isolation Pilot Plant (WIPP) by no later than 2018 or ii) treated to immobilize the buried TRU waste in-place. Installation of a surface barrier is envisioned for any remedial alternative involving the SDA and will include all disposal areas of the SDA, not only those currently containing TRU waste.

The wastes buried in the SDA appear somewhat well characterized as to location, type, and subsurface matrices; however, the corresponding information for the contaminants of potential concern does not seem well characterized. Previous flooding events redistributed some wastes and waste constituents. Monitoring indicates that volatile organic compounds and nitrates have migrated to the underlying aquifer from the SDA. Americium has been detected in the aquifer; however, detections have been sporadic and a plume has not been defined. Results of the on-going vapor vacuum extraction process to remove volatile organic compounds indicate that more material has been removed than was originally estimated to have been buried. These uncertainties impact the ability to assess risks for the wastes buried in the SDA. There is an on-going integrated probing project in the SDA to identify the extent of contamination and to reduce these uncertainties.

To support the Idaho Site CERCLA remedial process, site personnel have performed risk assessments for both baseline conditions as well as for the short-term risks associated with

[4] The SDA pits and trenches that TRU-contaminated wastes were buried include Pits 1-6, Pits 9-12, and Trenches 1-10. Pad A may also contain such wastes. It is known that volatile organic compounds have migrated from the original buried waste sites to the Snake River Aquifer and TRU elements may also have migrated (although the indications have been sporadic and sometimes questionable). A subsurface probing program is on-going that should reduce uncertainty in understanding the extent to which the contaminants have migrated and what must be done if the retrieve, treat, and dispose remedial alternative is selected.

four potential remedial alternatives for the wastes buried in the SDA. These assessments provide some guidance on the threats posed by the wastes in the SDA. However, these assessments have not fully considered the range of populations potentially at risk, time frames of specific risks, or land use remaining under government control in perpetuity. Explicit consideration of these issues is important to determine who is at risk, as well as when, under the range of future land use scenarios. One of the challenges for the authors of this report—and all stakeholders who might use it—is a decision concerning how complete are the extant risk characterizations and the magnitude and importance of remaining uncertainties. This report does not exist in a vacuum. It seeks to build on and help complement existing knowledge and previous and continuing remedial and information-gathering efforts at the Idaho Site and the DOE Complex.

Remedial actions to address specific areas of concern in the SDA based upon mobility and toxicity are being undertaken. Beryllium blocks, which weigh approximately 180 pounds each and became radioactive after being used as reflectors in Idaho Site test reactors, were buried in pits, trenches, and soil vault rows. These blocks are being grouted in-place to immobilize carbon-14; however, this action does not preclude future retrieval if deemed necessary. There is also an on-going removal of organic contamination in the vadose zone using vacuum vapor extraction. More than 162,000 pounds of volatile organic compounds have been successfully extracted from the SDA and destroyed using vapor vacuum extraction units.

Waste, contaminant, and subsurface characterization and proof-of-concept remedial testing have been carried out at the SDA and more is planned. Idaho Site personnel developed a new low-cost subsurface probing system for characterizing and monitoring contaminants safely from within and below hazardous waste sites including the SDA. These instruments help monitor the contaminants in the buried waste and provide valuable data from saturated or unsaturated waste zones being considered for remedial action. A series of retrieval projects has also been carried out in the SDA, the earliest beginning in 1969 and the most recent (i.e., the Pit 4 Accelerated Retrieval Project) was begun in 2005. These tests provide valuable information concerning the extent of migration of contaminants of potential concern in the subsurface, the difficulties involved with retrieval of wastes and controlling contamination spread during retrieval, and the cost of retrieval. The Accelerated Retrieval Project is using knowledge gained in past operations to retrieve approximately 20 percent (or one-half acre area) of the wastes buried in Pit 4. This pit was selected because it is considered to contain some of the highest levels of transuranic contamination in the SDA as well as volatile organic compounds, which are the most mobile contaminants in the subsurface.

**CRESP Risk Evaluation**

The Consortium for Risk Evaluation with Stakeholder Participation (CRESP) was asked by the DOE to develop a framework for the comparative life-cycle risk evaluation of management options for ultimate disposition of the wastes buried in the SDA. This document serves as technical input for further open discussion and evaluation of the management alternatives. The framework development takes as its starting point a broad series of remedial approaches that may be used in the SDA. The authors seek to understand and evaluate when, in what order, and why these remedial approaches would be appropriate for addressing the specific conditions in the SDA and sections thereof. The specific steps and rationale required for implementation of the remedial approaches are described and then the hazards and risks involved in implementation, as well as those risks anticipated to be mitigated by implementation, are explored for each remedial approach. This approach can be repeated on sub-sections of the SDA to make location or waste specific decisions. However, decisions for any specific sub-area or waste type must be made in the context of management of the entire SDA. A life-cycle risk analysis, a framework for which is provided in this report, is necessary to first assess the risks and then ultimately compare them in a consistent and transparent manner. An examination of both existing information and that additional information that is necessary but missing to assess and compare risks for the various remedial approaches is an integral part of this exploration.

The remedial alternatives evaluated in this report fall into two broad categories: 1) those approaches involving *containing the wastes where they are* to assure they do not migrate and find pathways to receptors, and 2) those involving *excavation of waste materials for treatment, packaging, and ultimate disposal* so that the contaminants will be contained. In both the supporting Idaho Site documentation and this report, *excavation* of wastes is referred to as *retrieval*, which is to be distinct from the volatile organic *extraction* (removal), which is an *in situ* process currently on-going at the SDA.

A large number of possible remedial actions and combinations of such actions were considered by Idaho Site personnel as part of the CERCLA and other compliance processes for the SDA. Combinations of actions were considered because different areas in the SDA pose different types and degrees of risk due to varying types and forms of wastes and contaminants. The remedial alternatives were screened based on CERCLA criteria, and four remedial alternatives (i.e., surface barrier, *in situ* grouting, *in situ* vitrification, and retrieve/treat/dispose) were identified for further study. Together with a "No Action" alternative necessary to assess current or baseline risks, these previously defined alternatives were investigated in this report.

The specific alternatives for disposition of the SDA buried wastes explored in this report are

1. <u>Contain in Place</u>

   The Idaho Site would contain the buried SDA wastes in-place without additional waste retrieval after completion of currently planned test retrievals and vapor extraction for removal of volatile organic contaminants. All options include long-term monitoring, maintenance, and institutional controls. Four options were examined under this remedial alternative:

   a. *"No Action"* (although long-term monitoring, maintenance, and institutional controls would be instituted);

   b. *Surface Barrier Installation* with *in situ* grouting as needed for subsurface geotechnical stabilization (to prevent future subsidence and surface barrier impact) and not for contaminant immobilization;

   c. *In Situ Grouting* for both subsurface geotechnical stabilization and contaminant of potential concern immobilization with surface barrier installation; and

d. *In Situ Vitrification* for contaminant of potential concern immobilization in concert with *in situ* grouting for subsurface geotechnical stabilization and with surface barrier installation.

2. Retrieve, Treat, and Dispose

   The Idaho Site would retrieve and treat some buried SDA wastes for both on-site (low-level and mixed low-level wastes) and off-site (TRU waste) disposal where the extent of the retrieval is based upon risks, costs, and possible future legal decisions. Two options were examined for this alternative:[5]

   a. *Targeted Rocky Flats Plant TRU Waste Retrieval* with *in situ* grouting for both subsurface geotechnical stabilization and contaminant immobilization, as well as surface barrier installation based upon a risk-informed decision incorporating risks, costs, effectiveness, etc., and

   b. *Full Rocky Flats Plant TRU Waste Retrieval* with *in situ* grouting for subsurface geotechnical stabilization and contaminant immobilization as well as surface barrier installation.

Another way to characterize these remedial alternatives is by how aggressively the wastes in the SDA must be treated. Installation of a surface barrier helps to reduce the flux of water to the buried wastes but in no way impacts either the source of contamination or the potential risks remaining if the surface barrier fails in the future. The other remedial alternatives represent a progression from less to more aggressive approaches where selected contaminants will be immobilized in-place (using grouting or vitrification) to those involving selecting the highest risk wastes that can be removed effectively for ultimate disposition in a different form and location. Thus the decision as to whether buried wastes can be effectively contained in-place or have to be retrieved must combine judgments concerning the release and mobility of the contaminants as well as the danger posed if the contaminants have pathways available to receptors when remaining in-place or during remedial operations.

Risk characterization as part of a risk-informed decision process requires consideration of different types of risk that impact different populations over different time intervals. Types of risks to be considered include traumatic injury or death (e.g., during construction, excavation, or processing activities), imminent injury or death from radiation or chemical exposure (e.g., during remedial activities), latent cancer or other disease from radiation or chemical exposure to workers or the general population. Populations and time frames to be considered include the workforce and the general population, both now and in future generations. Exposure pathways may be a consequence of workplace exposure, inappropriate land or natural resource use (i.e., contrary to established land-use restrictions as part of institutional controls), intrusion, population encroachment, or contamination of an aquifer subsequently used as a source of potable water or for agricultural purposes. Risk-informed decision making requires balancing

[5] It is possible that high-level waste (HLW), spent nuclear fuel (SNF), or wastes similar to HLW and SNF were buried in the SDA. If HLW or SNF is buried in the SDA, then according to the Nuclear Waste Policy Act of 1982 (as amended) and the 1995 Settlement Agreement this waste must be retrieved, segregated, and stored prior to disposal in a deep geologic repository; this HLW/SNF retrieval operation then would be an addition to the retrieve, treat, and dispose alternative and should be evaluated as such.

these risks based on local and state acceptability and consideration of other factors (e.g., legal, economic, etc.). Thus the decision-making process is consistent with the CERCLA approach that evaluates potential remedial alternatives against a set of nine criteria.[6] For sites like the SDA that involve complex remedial actions, it is important that all nine criteria be considered.

A remedial alternative is comprised of a series of process steps that must be completed and satisfy a number of requirements. Each process step is composed of tasks that must be executed and may represent hazards (or things that can go wrong) and thus potential human health risks.[7] Characterization of risk for a given remedial alternative requires examination of any risks posed by the tasks that must be executed. In this report, the following were identified for each task comprising a process step: the activities or events that may result in an adverse outcome (e.g., injury, fatality, etc.); what may go wrong (events); the affected population; the likelihood of the adverse event; and the severity of the adverse outcome (consequences). Herein, a template for risk characterization was developed and applied to the SDA buried wastes. This template consists of the following steps:

1. Management flow diagrams were developed outlining the generalized process (and process steps) needed to effect remediation. These diagrams (Figure 6, Figure 7, and Figure 8 in Section 6) were developed in concert with definition of the list of primary tasks for each of the process steps for each remedial option considered. The task lists are provided in Appendix B and Appendix C.
2. Risk flow diagrams were developed for the remedial alternatives. These diagrams (Figure 9, Figure 11, Figure 12, and Figure 13 in Section 0) indicate the sequences of activities that have the potential to pose significant human health risks. These risk flow diagrams incorporate conceptual site models[8] (Figure 10 and Appendix D and Appendix E) for each activity that indicate potential hazards, failure and release modes, transport pathways or media, exposure mechanisms, and impacted populations.
3. A detailed hazard analyses was performed (in Section 0) for disposition (i.e., excavation, treatment, and disposal versus containment in-place) of the wastes buried in the SDA. For each task, the following is identified: the task frequency, what can potentially go wrong, the likelihood of the adverse event, the severity of the consequences, the impacted population, the basis for characterizing the risk, and the contribution of the subtask to overall risk of the remedial alternative. This analysis resulted as a series of hazard analysis tables.

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6 The nine CERCLA evaluation criteria are: 1) Overall protection of human health and the environment, 2) Compliance with Applicable or Relevant and Appropriate Requirements (ARARs), 3) Long-term effectiveness and permanence, 4) Reduction of toxicity, mobility, or volume through treatment, 5) Short-term effectiveness, 6) Implementability, 7) Cost, 8) State acceptance, and 9) Community acceptance.

7 It is recognized that this report primarily concerns human health; however, those tasks that involve other types of risks (e.g., ecological) will be noted where deemed appropriate.

8 The conceptual site models presented in this report follow the general format provided in Appendix C of the DOE-EM memorandum entitled "Guidance to Support Implementation of DOE Policy 455.1 for a Site-Specific Risk-Based End State (RBES) Vision Document" dated September 22, 2003. Other pertinent information can be found in ASTM Standard E 1689-95, "Standard Guide for Developing Conceptual Site Models for Contaminated Sites."

4. Detailed gap analyses were performed (in Section 0) describing the key knowledge barriers, missing information, and uncertainties involved in assessing the risks for the various remedial alternatives. For each task involved in a remedial alternative, knowledge gaps were characterized by: what information is missing, how important is the missing information, and how large is the knowledge gap.
5. An integrated hazard and gap analysis was performed (in Section 0). The results are provided in the form of a summary table (Table 4) indicating the most important potential risks and information gaps for the remedial alternatives considered.

Uniform terminologies and categories for characterization of risks and information gaps were developed and used to allow for meaningful comparisons. Using these steps, the resulting analysis provides a template for risk evaluation that was applied to the specific risk-related issues associated with determining the ultimate disposition of the buried wastes in the SDA.

**CRESP Results and Recommendations**

Results of this evaluation indicate that, when relevant risk factors are taken into account, the lowest life-cycle risk option is likely to be extraction of highly mobile contaminants that may pose significant risk followed by in-place containment. The primary short- to intermediate-term risk driving contaminants are volatile organic contaminants (e.g., carbon tetrachloride, methylene chloride, and tetrachloroethylene) currently being addressed by soil vapor extraction, nitrates, and mobile fission products (e.g., Tc-99 and Sr-90) and activation products (e.g., C-14 and Cl-36). Various uranium isotopes and Np-237 buried in the SDA represent the majority of the long-term risks to human health. Currently available information indicates that nitrates and uranium isotopes are present from both Rocky Flats Plant wastes and other sources, and not all forms of the Rocky Flats Plant wastes contain significant quantities of the contaminants presenting the most unacceptable risks. Insufficient information is available to define the current spatial distribution of these key contaminants but efforts are underway to improve this understanding. Thus, greatest risk reduction appears to be achieved through removal or remedial actions targeted towards removal of significant pockets of the contaminants presenting the greatest threats to groundwater rather than through removal actions targeted based on the origin of the wastes (e.g., Rocky Flats Plant). However, the characterization of the risk associated with this option is strongly dependent on the effectiveness of the long-term stewardship following remediation. Failure of long-term stewardship may result in any of the following: site intrusion, inappropriate land or natural resource use, population encroachment, or contamination of the underlying aquifer. Each of these failure mechanisms has the potential to impact a large number of people in the (possibly) distant future. Retrieval options appear to pose the highest risks, impacting the worker population in the near term.

This report does not include quantification of risks or recommendations on the preferred waste management approach. Rather the purpose of the document is to serve as a technical input for further open discussion and evaluation of the management options. Future discussion needs to include input from the public to the decision making responsible parties and considerations of costs and public policy. The benefits of this report include (i) identification of key steps and exposure pathways that may cause significant risk, (ii) a structured approach for subsequent quantitative risk analyses, and (iii) identification of important information limitations.

For the SDA, long-term stewardship activities have three primary components: maintaining performance of the engineered containment systems (i.e., final cap); maintaining institutional controls to prevent intrusion, encroachment and inappropriate land or natural resource use; and effective monitoring strategies for both engineered containment systems and institutional controls. Each of these failure mechanisms (i.e., intrusion, encroachment and inappropriate land or natural resource use) has the potential to impact a large number of people in the (possibly) distant future. For monitoring strategies to be effective, they must provide credible warning of system degradation *before* failure occurs. With respect to engineered containment systems, this implies monitoring the integrity of caps and moisture and contaminant movement in the vadose zone. This monitoring should be construed as preemptive, rather than monitoring as the basis for the regulatory point of compliance with respect to contaminant migration. With respect to institutional controls, regular evaluation of the effectiveness of these controls is necessary. Public acceptance of these measures will depend on the credibility of DOE and the financial and legal mechanisms established for ensuring long-term stewardship.

From this work, it was apparent that some important information necessary to develop quantitative life-cycle risk assessments for the various remedial alternatives was not currently available. Thus a detailed information gap analysis was also performed. The final step in the risk characterization process was to examine the risk and gap results to determine the most important potential risks and information gaps for the remedial alternatives considered. The approach used in this report to evaluate the SDA may either be applied to the whole area or to sub-areas of a burial site to evaluate those areas (e.g., "hot-spots") that may warrant different remediation approaches from the site as a whole.

The most important information gaps identified in this report are

- estimating risk reduction and risks remaining after implementation of proposed remedial options,
- determining the geospatial distribution of wastes and waste forms,
- determining the presence and location of high-level waste, spent fuel, or similar high-activity material,
- performing additional, bounding risk calculations for the Baseline Risk Assessment ("No Action" Option), and
- evaluating the potential for facilitated plutonium transport.

In addition, there is a clear need to integrate remedial decisions for the Rock Flats waste and other historic waste disposal activities with recognition of the closure and long-term stewardship needs for the entire SDA, including the current waste disposal activities.

A recent National Research Council report highlights the importance of balancing human health risk with worker and environmental risks, costs, achievability and site-specific factors in developing a risk-informed approach that is comprehensive and transparent. In the NRC report, the observations are made in the context of exempting certain HLW and TRU wastes from disposal at a geologic repository, but have broader implications and applicability, and are consistent with the framework approach used here. In fact, this approach can be readily used by decision makers who must integrate risk considerations and the full range of regulatory requirements.

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**Appendices**

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## List of Acronyms

| | |
|---|---|
| ABRA | Ancillary Basis for Risk Analysis (of the SDA) |
| AMWTF | Advanced Mixed Waste Treatment Facility |
| ARARs | Applicable or Relevant and Appropriate Requirements |
| BRA | Baseline Risk Assessment |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CH | Contact Handled |
| COPC | Contaminant of Potential Concern |
| CRESP | Consortium for Risk Evaluation with Stakeholder Participation |
| DOE | Department of Energy |
| EPA | Environmental Protection Agency |
| ET | Evapotranspiration |
| GEM | Glovebox Excavator Method |
| HDT | Historical Data Task |
| HLW | High-level Waste |
| HQ | Hazard Quotient |
| ICDF | ICP CERCLA Disposal Facility |
| ICP | Idaho Completion Project |
| INEEL | Idaho National Engineering and Environmental Laboratory |
| INEL | Idaho National Engineering Laboratory |
| INL | Idaho National Laboratory |
| IPP | Integrated Probing Project |
| IRA | Interim Risk Assessment |
| ISG | *In Situ* Grouting |
| ISTD | *In Situ* Thermal Desorption |
| ISV | *In Situ* Vitrification |
| LLW | Low-level Waste |
| MCL | Maximum Contaminant Level |
| MLLW | Mixed Low Level Waste |
| NRC | National Research Council |
| OCVZ | Organic Contamination in the Vadose Zone |

## List of Acronyms

| | |
|---|---|
| ORNL | Oak Ridge National Laboratory |
| OU | Operable Unit |
| RCRA | Resource Conservation and Recovery Act |
| RFP | Rocky Flats Plant |
| RH | Remote Handled |
| RI/FS | Remedial Investigation/Feasibility Study |
| RTD | Retrieval/Treatment/Disposal |
| RWMC | Radioactive Waste Management Complex |
| SDA | Subsurface Disposal Area |
| SNF | Spent Nuclear Fuel |
| SRPA | Snake River Plain Aquifer |
| STRE | Short-Term Risk Evaluation |
| SVR | Soil Vault Row |
| TAN | Test Area North |
| TRU | Transuranic |
| TSA | Transuranic Storage Area |
| USGS | United States Geological Survey |
| VOC | Volatile Organic Compound |
| WAG | Waste Area Group |
| WIPP | Waste Isolation Pilot Plant |

# 1. Introduction

## 1.1. Purpose, Goals, and Objectives

A recent National Research Council report stresses the importance of balancing public health with worker and environmental risks, costs, achievability, and other site-specific factors when developing a risk-informed approach (NRC, 2005). The purpose of this report is to provide a foundation for evaluating the life-cycle risks of various remedial alternatives to obtain a sustainable end-state for buried wastes in the Subsurface Disposal Area[9] (SDA) (Schofield, 2002), Figure 1, at the Idaho Site.

In 2005 the Idaho National Engineering and Environmental Laboratory (INEEL) was renamed the Idaho National Laboratory (INL), and the cleanup operation, the Idaho Completion Project (ICP), became a separately managed effort. The SDA resides at the Idaho National Laboratory; however, cleanup of the wastes is the responsibility of the ICP. To reduce confusion, the site will be referred to as "the Idaho Site" in this report.

The specific objective of this report is to develop a framework for the comparative life-cycle risk evaluation of remedial alternatives for the wastes buried in the SDA and thus to serve as technical input for further open discussion and evaluation of the management alternatives (see Appendix A for the definition of scope). A qualitative assessment of remedial approaches including consideration of the range of life-cycle risks (e.g., near-term and long-term) and potentially impacted populations (e.g., worker and general population, on- and off-site) is also made.[10] The remedial approaches may be implemented either individually or in combination to achieve the desired remedial objectives. In this context, a critical consideration is to determine which combination of activities (e.g., removal, treatment, in-place containment) are appropriate for the sub-sections of the SDA or contaminants present based on the characteristics of the buried wastes and other factors.

The risk evaluation framework described in this report facilitates comparison of life-cycle risks for alternative disposition approaches and corresponding end-states including (i) removal and off-site disposal and (ii) in-place containment through engineered barriers and institutional controls. These primary alternatives are considered limiting cases, whereas the final approach is anticipated by Idaho Site personnel to be a combination of both, resulting in some degree of waste retrieval and in-place containment.[11] The risk evaluation framework includes:

(i) management flow diagrams (in Section 6) of the sequences of steps required to implement the alternatives,

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[9] The Subsurface Disposal Area (SDA) comprises approximately a 97-acre area in the Radioactive Waste Management Complex (RWMC) where radioactive and mixed wastes were buried in pits, trenches, and soil vaults between 1954 and 1970 (Schofield, 2002). The area of the SDA is approximately the same as that of 88 football fields (assuming that the area of a football playing field is 48,000 $ft^2$ or approximately 1.1 acre).

[10] It is recognized that this report primarily concerns human health; however, those tasks that involve other types of risks (e.g., ecological) will be noted where deemed appropriate.

[11] This information is based upon conversations held with Idaho Site personnel in August 2004.

(ii) task lists (in Appendix B and Appendix C) corresponding to the management flow diagrams,

(iii) sets of risk flow diagrams (in Section 0) for the alternatives that indicate the sequences of steps that have the potential to pose significant human health risks to workers or the public,

(iv) conceptual site models (DOE-EM, 2003)[12] (in Appendix D and Appendix E) indicating risk pathways and receptors for the steps in the risk flow diagrams,

(v) a detailed hazard analysis (in Section 0) of the most important potential upset conditions for the alternatives,

(vi) a gap analysis (in Section 0) that describes the key barriers, missing information and uncertainties to both implementing the alternatives and assessing their risks, and

(vii) an integrated hazard and gap analysis (in Section 0) and summarized (in Table 4) indicating the most important potential risks and information gaps for the remedial alternatives considered.

This report does not provide a quantitative comparison of life-cycle risks associated with various, proposed alternatives; however, it does provide a foundation for building semi-quantitative and quantitative comparisons, either deterministic or probabilistic when warranted. This approach may be used to evaluate the SDA as a whole, or, applied to sub-areas of the SDA to evaluate which areas or "hot-spots" warrant different remediation approaches from the majority of the site.

The SDA, Transuranic Storage Area (TSA), and Administrative Area comprise the Radioactive Waste Management Complex, which is also known as Waste Area Group (WAG) 7. The Radioactive Waste Management Complex is illustrated in Figure 2. Originally, this report was concerned with identifying and assessing life-cycle risks involved with achieving a protective end-state for buried *transuranic* (TRU) wastes[13] (DOE, 1999) in the Idaho Site SDA (DOE, 1997).[14] However, because non-TRU constituents dominate the short-term risks associated with the SDA, consideration of the other contaminants of potential concern in the SDA that pose significant risk must be included to form an integrated characterization of risks associated with achieving alternative end-states.

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[12] The conceptual site models presented in this report follow the general format provided in Appendix C of the DOE-EM memorandum entitled "Guidance to Support Implementation of DOE Policy 455.1 for a Site-Specific Risk-Based End State (RBES) Vision Document," dated September 22, 2003.

[13] According to DOE Manual 435.1 transuranic waste is defined as "radioactive waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for: (1) High-level radioactive waste; (2) Waste that the Secretary of Energy has determined… does not need the degree of isolation required by the 40 CFR Part 191 disposal regulations; or (3) Waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61." The transuranic elements are those having atomic number greater than 92 (i.e., that of uranium).

[14] This type of analysis is analogous to the two "No Action" alternatives analyzed for the Waste Isolation Pilot Plant or WIPP (DOE, 1997).

Remediation of buried wastes in the SDA is being managed under the Idaho Site Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. Documentation supporting the Remedial Investigation/Feasibility Study (RI/FS) phase of this process is being developed by Idaho Site personnel.

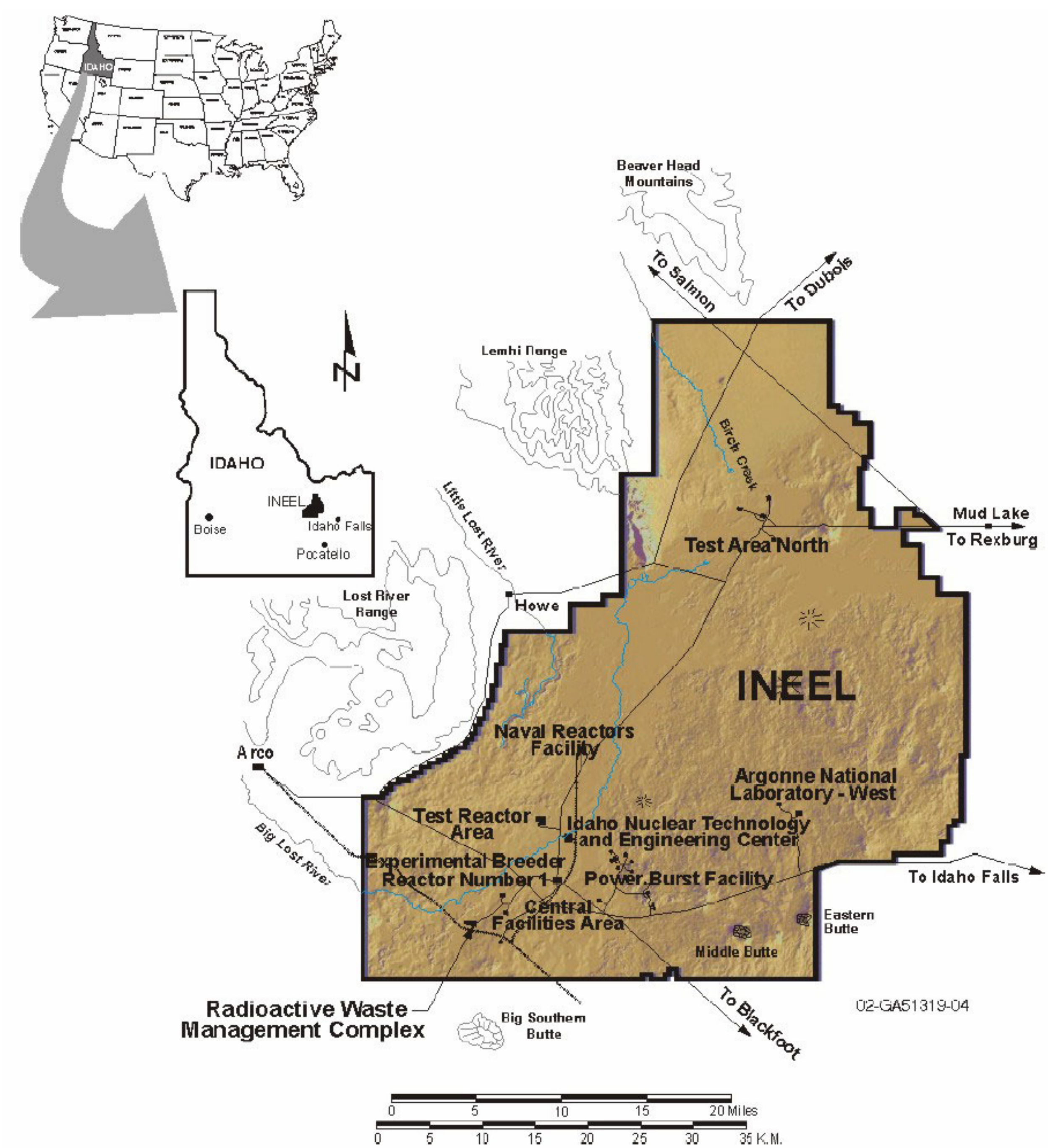


**Figure 1. Map of the Idaho National Laboratory showing locations of the Radioactive Waste Management Complex and other major facilities (Nitschke et al., 2004).**

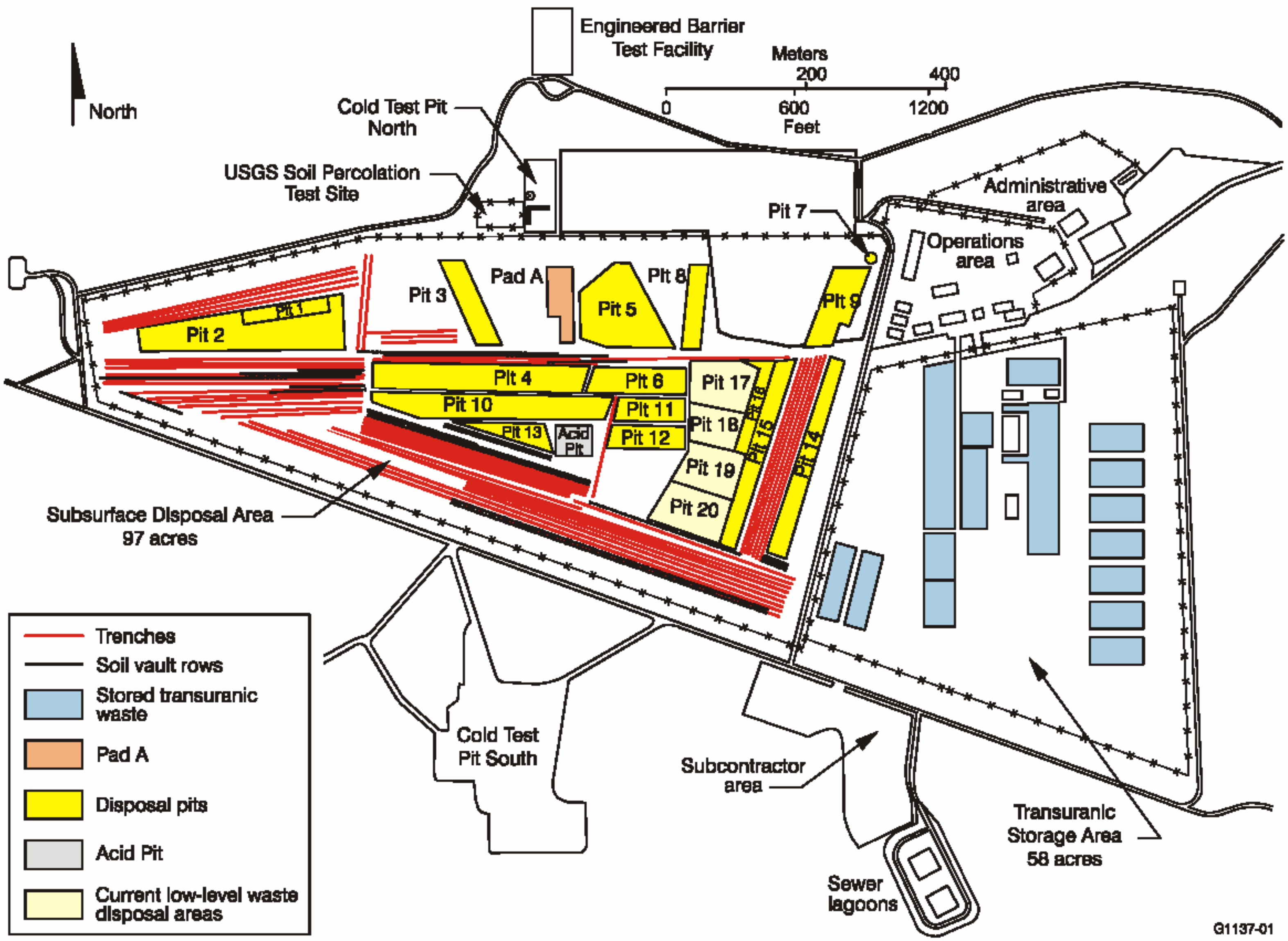


**Figure 2.** Map of the Subsurface Disposal Area (SDA) within the Radioactive Waste Management Complex (Nitschke et al., 2004).

# 2. Prior and Current Risk Assessments for the Subsurface Disposal Area

As of June 2005, four preliminary assessments were performed and documented (Schofield, 2002; Becker et al., 1998; Zitnik et al., 2002; Holdren et al., 2002) to support the CERCLA Remedial Investigation/Feasibility Study (RI/FS) process for the Idaho Site Radioactive Waste Management Complex. The first two reports that will be described, the *Interim Risk Assessment* (Becker et al., 1998) and the *Ancillary Basis for Risk Analysis* (Holdren et al., 2002), represent baseline risk assessments for conditions currently existing in the Subsurface Disposal Area (SDA). The *Preliminary Evaluation of Remedial Alternatives* (Zitnik et al., 2002) report provides a set of potential remedial alternatives that were considered by the Idaho Site to be implementable and effective in managing the SDA wastes. The *Short-Term Risk Evaluation* (Schofield, 2002) report provides risk estimates for remedial actions (i.e., short-term risks for executing selected alternatives), but does not examine the risks remaining in the SDA or for other sites that receive SDA wastes. Thus life-cycle risks are not considered in existing Idaho Site risk assessment reports.

Estimation of risks and identification of contaminants of potential concern is an iterative process for a site as complex as the SDA. The *Interim Risk Assessment* (Becker et al., 1998) was performed to assess potential risks from contaminants buried in the SDA as well as those that might have migrated into surrounding media. A total of 91 contaminants were identified in the *Interim Risk Assessment* for review,[15] of which there was sufficient information to evaluate 53 quantitatively—the other 38 were evaluated qualitatively. The quantitative analyses were performed deterministically using bounding inventory estimates for the 53 contaminants (distributed over 13 "source areas") supplemented by limited sensitivity analyses varying parameters representing contaminant release and transport. The pertinent uptake parameters used were taken from either Track 2 guidance (DOE-ID, 1994b), EPA Region 10 guidance (EPA, 1991), or Idaho Site information (LMITCO, 1996) and were not varied in the *Interim Risk Assessment* analyses. Unacceptable risks were identified in the *Interim Risk Assessment* for 25 constituents of the 53 that were examined quantitatively and nine of the 38 that were examined qualitatively. Furthermore, because this risk assessment only considered bounding inventory values (as part of the sensitivity analyses) rather than reasonable upper bounds based upon uncertainty estimates for all parameters (e.g., inventory, release, transport, etc.) important to estimating risk, additional constituents of potential concern may be identified during completion of the CERCLA RI/FS process.

The next iteration in the SDA risk assessment process was described in the *Ancillary Basis for Risk Analysis* (Holdren et al., 2002), which was developed as a "continuation and update" to the *Interim Risk Assessment*. The risk analyses in the *Ancillary Basis for Risk Analysis* were restricted to the set of contaminants of potential concern identified quantitatively in the *Interim Risk Assessment*. Because of increased confidence in inventory estimates (based upon additional research), best inventory estimates were used for all risk analyses in the *Ancillary Basis for Risk Analysis*. These estimates were again supplemented by limited sensitivity analyses to identify those parameters important to the risk calculations. The estimated human

[15] A set of more than 200 contaminants were examined prior to the *Interim Risk Assessment*.

health and ecological effects associated with the SDA wastes were estimated with the conclusion that "the Subsurface Disposal Area poses unacceptable long-term risk to human health and the environment" (Holdren et al., 2002).

However, given large uncertainties in inventory and spatial distributions of contaminants, transport parameters,[16] and uptake parameters, additional analyses have merit and should be pursued in the next phase of risks assessments for the SDA. For example, CERLCA documents (e.g., RAGS 3A (EPA, 2001)) indicate that, in addition to centroid-type estimates (even supplemented by limited sensitivity analyses), reasonable upper bound values[17] are also needed to determine necessary remedial actions. Reasonable bounding values should be obtained from simultaneous consideration of all *significant* uncertainties, which may provide different (and possibly larger) risk estimates than those currently provided in the *Ancillary Basis for Risk Analysis*.[18] It is also possible that a probabilistic risk assessment, as suggested in the *Interim Risk Assessment,* would provide important supplemental information. Both the *Interim Risk Assessment* and *Ancillary Basis for Risk Analysis* provide risk estimates associated with buried wastes in the SDA without remedial action—those risks remaining once an end-state has been achieved or associated with achieving a proposed end-state are not evaluated.

Although documents such as the *Interim Risk Assessment or the Ancillary Basis for Risk Analysis* hold no official standing in the CERCLA process (other than being referenced in the Idaho Site Administrative Record[19]) (Holdren & Broomfield, 2004), these documents are important inputs to the CERCLA process. The *Interim Risk Assessment* and *Ancillary Basis for Risk Analysis* documents present useful evaluations of the risks posed by the wastes in the Subsurface Disposal Area based upon inventory estimates supplemented by limited sensitivity analyses. However, given large uncertainties in contaminant inventories and spatial distributions as well as release and transport parameters, additional analyses better representing Reasonable Maximum Exposures have merit for inclusion in the next iteration in the baseline risk assessment process.

As of June 2005, two additional reports help to form the core of the CERCLA RI/FS process for the Radioactive Waste Management Complex.[20] The first is the *Preliminary Evaluation of Remedial Alternative* for the Subsurface Disposal Area (Zitnik et al., 2002) in which potential technologies and process options are identified and screened based upon effectiveness, implementability, and cost as prescribed by CERCLA. Five alternatives are identified for further consideration (Zitnik et al., 2002):

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[16] The large uncertainties arise from the difficulties found in linking column and field transport studies (Batcheller & Redden, 2004).

[17] A reasonable upper bound value would be the "Reasonable Maximum Exposure" which represents a conservative exposure case that is still within the range of possible exposures.

[18] It is certainly much less likely that the contaminants of potential concern identified in the Interim Risk Assessment would change dramatically. However, these contaminants of potential concern may have to be revisited based upon the results of the analyses representing Reasonable Maximum Exposures.

[19] Documents in the Idaho Site Administrative Record can be accessed via http://ar.inel.gov.

[20] The Radioactive Waste Management Complex is also known as Waste Area Group 7 or WAG 7.

1) No Action (required by EPA directive),
2) Surface Barrier,
3) *In Situ* Grouting (ISG),
4) *In Situ* Vitrification (ISV), and
5) Retrieval/Treatment/Disposal (RTD).

Four of these alternatives—excluding the "No Action" alternative—were considered feasible based on the preliminary evaluation (Zitnik et al., 2002). The *Preliminary Evaluation of Remedial Alternatives* provides an informative and extensive evaluation of potential remedial alternatives in terms of effectiveness, implementability, and cost—neither the risks associated with implementation nor remaining risks were evaluated. An additional remedial alternative (i.e., a staged cap approach allowing sufficient time for fission products to decay[21]) not presented in the *Preliminary Evaluation of Remedial Alternatives* is considered reasonable for future consideration by the Idaho Site. This alternative could prove useful depending upon what the risk drivers are for the SDA.

The final RI/FS report that will be discussed, the *Short-Term Risk Evaluation* (Schofield, 2002), evaluated the short-term risks to and effectiveness in protecting human health and the environment associated with the above alternatives during preconstruction, construction, operation, and decontamination and decommissioning activities. The inventories used in the *Short-Term Risk Evaluation* were the same best estimates that were utilized in the *Ancillary Basis for Risk Analysis*. Relative short-term radiological and mechanical risks were estimate and compared for the alternatives considered. These risk evaluations were supplemented by Maximally Exposed Individual calculations for the *in situ* vitrification and retrieval alternatives (Schofield, 2002). The evaluation of short-term risks (i.e., one of the nine CERCLA criteria) appeared comprehensive and a reasonable basis for the initial comparison of alternatives. Extension of the type of analyses performed in the *Short-Term Risk Evaluation* to the evaluation of life-cycle risks and risk reductions for the various proposed remedial alternatives would provide very useful input to the decision process. The framework developed in this report provides a basis for such life-cycle risk and risk reduction evaluations.

[21] The alternative mentioned is analogous to management of the Maxey Flats former nuclear disposal site near Hillsboro, Kentucky. This site has undergone cleanup and will be managed for the next 100 years under Superfund including monitoring and maintenance of a geomembrane barrier that has been installed over compacted clay. This primary barrier system has not been covered with a drainange system and other protective barriers. Rather, it is amenable to visual inspection and is accessible for repair as needed. After 100 years, it is anticipated that the ground surface will have fully settled and then a final cap will be installed with monitoring and maintenance continuing in perpetuity. Thus an alternative to those previously considered would be to install a temporary, low hydraulic conductivity barrier over the Subsurface Disposal Area (without in situ grouting) to allow the ground to settle. Then, after allowing time for fission product decay, a final cap could be installed and monitored.

# 3. Site Background

At the Idaho National Laboratory (Figure 1), radioactive and mixed wastes were buried in pits, trenches, and soil vaults within the Subsurface Disposal Area (SDA). There is also a continuing low-level waste (LLW) disposal program in the SDA projected to be completed by 2009 (DOE-ID, 2002; DOE-ID, 2004).[22] The SDA comprises a 97-acre area (or approximately that of 88 football fields) in the Radioactive Waste Management Complex (Figure 1) where wastes were buried in the locations illustrated in Figure 2. Most of the buried transuranic (TRU) wastes, received from the Rocky Flats Plant near Denver, Colorado, were buried in the SDA between 1954 and 1970 (Schofield, 2002). Other wastes (including small amounts of other TRU-contaminated wastes, fission products, and organic solvents) interred in the SDA were either received from other Department of Energy (DOE) sites or generated at the Idaho Site. The SDA is fairly unique in its magnitude and diversity of contaminants. For example, there is more than a metric ton (or 1000 kg) of plutonium buried in the SDA (PNNL, 2003; LMITCO, 1995a; LMITCO, 1995b).[23] Thus remediation of the SDA will likely prove to be, if not unique, then certainly challenging.

As illustrated in Figure 3, the Radioactive Waste Management Complex overlies the Snake River Plain Aquifer. This aquifer is the sole source of drinking water for many of the people in southeast Idaho and is estimated to contain approximately 1 billion acre-feet of groundwater.[24] The aquifer supplies approximately 40,000 acre-feet (or 642 billion gallons) of drinking water and nearly 2 million acre-feet of water for irrigation and industry annually.

The Radioactive Waste Management Complex is located within a natural topographic depression with no permanent surface water features; however, the local depression does tend to collect precipitation and runoff from the surrounding slopes (Holdren et al., 2002). The surface water that is collected either eventually evaporates or infiltrates to the vadose zone and the underlying aquifer.

The SDA has been flooded at least three times because of a combination of snowmelt, rain, and warm winds (Holdren et al., 2002). Dikes and drainage channels were constructed around the SDA in response to the flooding event in 1962. Following a flooding event in 1969, the height of the dike was increased and the drainage channel enlarged. However, the dike was breached by accumulated snowmelt in 1982, which resulted in a third inundation of open pits within the SDA. These inundations of open pits resulted in redistribution of wastes and contaminants and leads to additional uncertainty about the current locations and distributions of waste constituents. Significant flood-control improvements have been made including increasing the height and breadth of the dike, deepening and widening the drainage channel,

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[22] Under the Performance Management Plan (DOE-ID, 2002), the goal is to complete disposal of contact-handled low-level waste by 2008 and to completed disposal of remote-handled low-level waste by 2009.

[23] Using the best and upper bound inventories of radiological contaminants in Table S-2 of the comprehensive inventory in (LMITCO, 1995a) and appropriate specific activities (PNNL, 2003), between 1100 and 1500 kg of plutonium (over 93% Pu-239) is buried in the SDA. An estimate of 1100 kg of plutonium is given by Idaho Site personnel (LMITCO, 1995b).

[24] From "Snake River Plain Aquifer: About the Aquifer" in http://cleanup.inel.gov/aquifer/default.cfm.

and contouring to reduce formation of surface ponds and to route runoff to a drainage channel (Holdren et al., 2002).

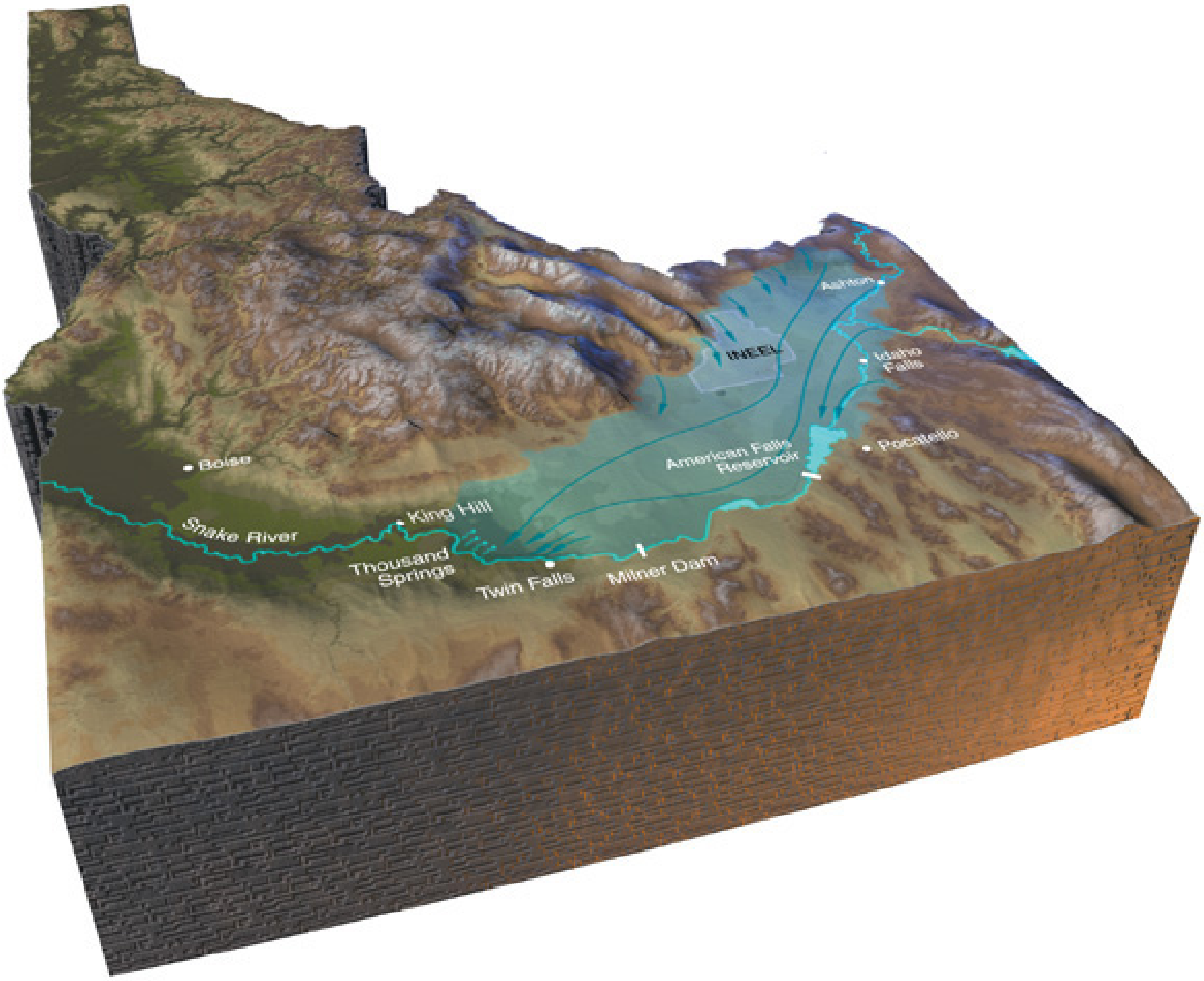


**Figure 3. The Snake River Plain Aquifer sits below a large portion of southeastern Idaho and the Idaho National Laboratory (formerly the Idaho National Engineering and Environmental Laboratory).[25]**

Transuranic and other wastes were buried in the SDA in pits, trenches, soils vaults, and stored on an above surface pad (i.e., Pad A) (Zitnik et al., 2002). Generic cross-sections of these disposal units are provided in Figure 4. Additional details for each waste unit are provided below.

[25] From "Snake River Plain Aquifer: About the Aquifer" in http://cleanup.inel.gov/aquifer/default.cfm.

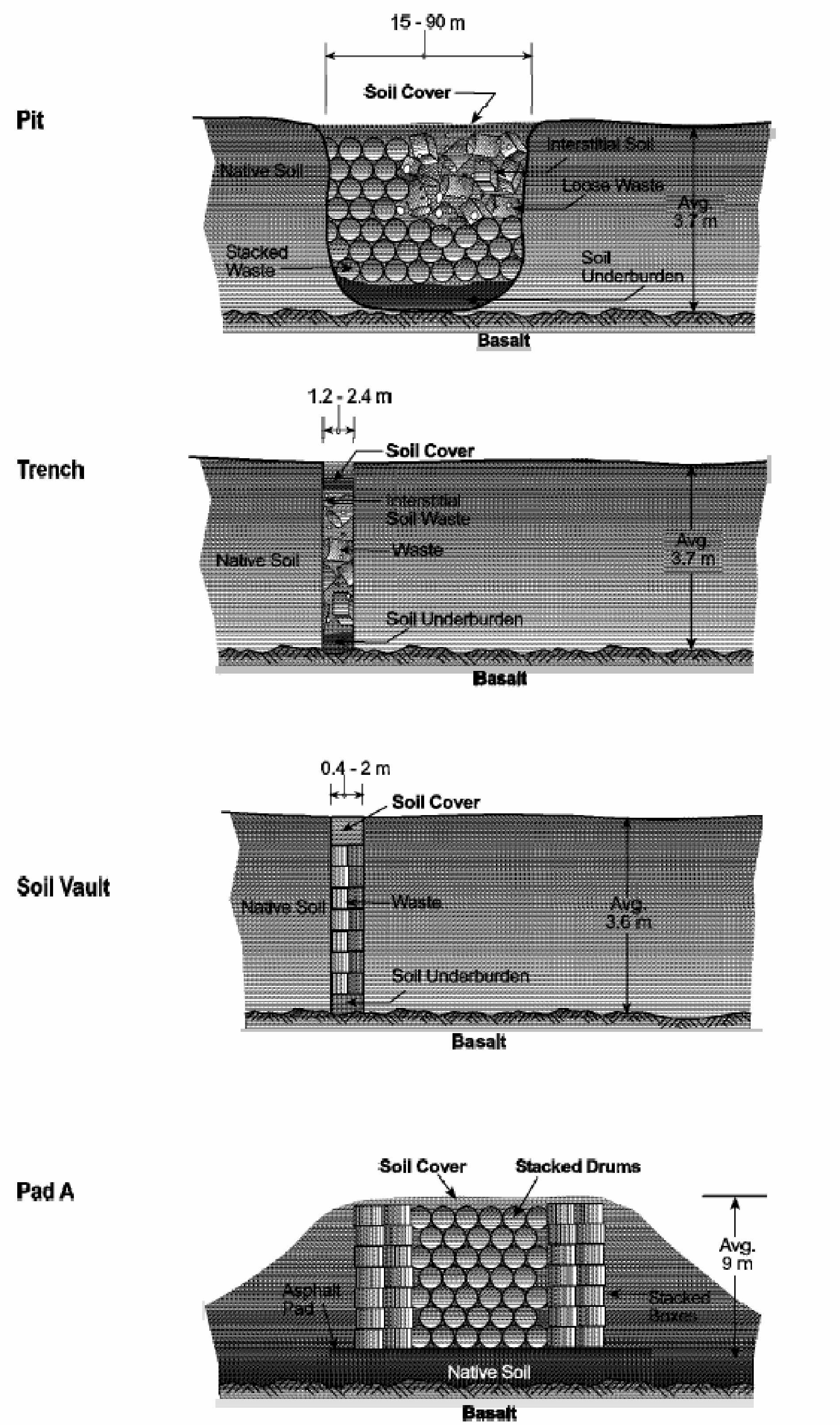


**Figure 4. Conceptual Cross-Sectional Views of the Disposal Units used at the Idaho Site Subsurface Disposal Area (Zitnik et al., 2002).**

**Pits**. A total of 16 pits (as illustrated in Figure 4) were excavated, filled with various wastes, and covered with soil between 1957 and 1984 (Zitnik et al., 2002); another 4 pits (i.e., Pits 17 through 20 in Figure 2) either have been used or will be used for active low-level waste disposal through 2009 (DOE-ID, 2002; DOE-ID, 2004a). The aforementioned 16 pits contain transuranic (TRU), mixed TRU, mixed low-level waste, and low-level waste primarily in drums, boxes, and cans; however, some wastes were not containerized including trucks, tanks, and miscellaneous debris (Zitnik et al., 2002). Originally, drums were stacked in Pits 1, 2, and 3 (from 1957 until 1963) and later randomly dumped in Pits 4 through 9 (from 1960 to 1969) to reduce worker exposure. Pits 1 through 6 and 9 through 12 received TRU waste from the Rocky Flats Plant, and the remaining pits generally received non-RFP wastes (Zitnik et al., 2002).

Pit dimensions ranged from 15 to 90 m wide, 75 to 335 m long, and averaged almost 4 m deep, and were excavated to the underlying basalt. After waste emplacement, pits were backfilled and covered with about 1 m of soil (Zitnik et al., 2002).

**Trenches.** The waste trenches in the SDA vary in length and can be up to 304 m in length (Zitnik et al., 2002). On average, the trenches are 1.2 to 2.4 m wide and 3.7 m deep. Trenches 1 through 10 received waste from 1952 until 1957, with shipments from the Rocky Flats Plant beginning in 1954. Trenches 11 through 15 received Rocky Flats Plant wastes in 1958 and 1959, and minor amounts of RFP wastes were placed in Trenches 19 and 32. These trenches received cardboard and wooden boxes as well as garbage cans containing mixed fission products and drums and wooden crates containing transuranic (TRU) waste (Zitnik et al., 2002). Trenches 11 through 58 were excavated, filled with various wastes, and covered with soil from 1958 through 1981. These trenches generally contain drums, boxes, and some loose material (Zitnik et al., 2002).

Disposal practices tended to be similar for both pits and trenches. Wastes were compacted and bailed; large, bulky items were wrapped in plastic; and smaller, non-compactable wastes were placed in wooden boxes and covered with fire-retardant paint (Becker et al., 1998). Some wastes were disposed of in shielded casks to reduce radiation exposures (Zitnik et al., 2002).

**Soil Vault Rows**. Beginning in 1977, soil vault rows were constructed to dispose of remote-handled, high-radiation low-level waste (Zitnik et al., 2002).[26] Individual soil vaults were unlined, cylindrical vertical-augured shafts with diameters of up to 2 m and depths averaging 3.6 m where each vault is separated from previously buried waste by approximately 0.6 m. Soil Vault Rows 1 through 21 have been closed and covered with soil (Zitnik et al., 2002).

**Pad A**. In 1972, an asphalt pad (i.e., 73 m by 102 m) was built on the ground in an area (as indicated in Figure 2) unsuitable for subsurface disposal because of near-surface basalt outcroppings. Pad A received low-level waste from 1972 to 1978 and primarily contains transuranic (TRU) alpha-emitting radioisotopes with concentrations less than 10 nCi/g and radiation levels less than 200 mR/hr at the container's surface (Zitnik et al., 2002; Higgins, 1995). Two shipments containing TRU wastes at concentrations greater than 100 nCi/g were

[26] Remote-handled, high-radiation low-level waste (LLW) is defined as material producing a beta-gamma exposure rate of greater than 500 mR/hr at a distance of 0.9 m.

also received and stored in Pad A. Disposal practices included stacking waste drums and plywood boxes and then covering these with soil. Waste containers occupy only the eastern half of the pad.

## 3.1. Idaho Site Waste Retrieval Activities

A series of retrieval projects has been carried out in the Idaho Site SDA, the earliest beginning in 1969 and the most recent (i.e., the Pit 4 Accelerated Retrieval Project) is currently underway. The Pit 1 project was undertaken in 1969 and was unsuccessful in locating and thus retrieving laboratory equipment inadvertently buried in Pit 1 (Holdren et al., 2002). Shortly afterwards in 1971, 16 drums were retrieved from Pits 2, 5, 10, and 11 during the Solid Radioactive Waste Retrieval Test to determine the condition of waste and containers, the extent of soil migration of plutonium contaminants, the difficulties involved with controlling contamination spread during retrieval, and the cost of retrieval (Thompson, 1972). The results indicated that the drums retrieved were in a variety of conditions from excellent to corroded through, the plutonium had migrated less than three feet, contamination spread during excavation was not a severe problem, and the direct cost (i.e., excluding capital expenditures and administrative costs) for such a large-scale excavation was approximately \$3.33 per $ft^3$ of waste (in 1972 dollars) (Thompson, 1972). No summaries were provided indicating actual worker exposure and accident rates for these past Idaho Site waste retrievals.[27]

The Initial Drum Retrieval Project at the SDA, which began in 1974 and completed in 1978, was performed to demonstrate safe retrieval of drums buried between 1968 and 1970 and provide experience in handling and packaging drums for interim storage (Zitnik et al., 2002; McKinley & McKinney, 1978). A total of 20,262 drums with a transuranic (TRU) waste volume of 4,391 $m^3$ (and 1 $m^3$ of contaminated soil) was retrieved from Pits 11 and 12 at an average cost of approximately \$80 per drum (Zitnik et al., 2002; McKinley & McKinney, 1978).

The Early Waste Retrieval Project, which began in 1976 and completed in 1978, was designed to develop methods and equipment for safely retrieving transuranic (TRU) wastes that had been buried for 22 to 24 years. During operations, 457 drums, 34.3 $m^3$ of loose waste, and 24.3 $m^3$ of contaminated soil were retrieved from Pits 1 and 2 and Trenches 5, 7, 8, 9, and 10 (Zitnik et al., 2002). Retrieved wastes were wrapped in plastic before packaging and then placed in drums and steel bins for interim storage in the Transuranic Storage Area (TSA), which is shown in Figure 2.

In 2004, the Glovebox Excavator Method Project was completed. A small portion of Pit 9, believed to contain high concentrations of volatile organic compounds and possibly a high concentration of transuranic (TRU) radionuclides (Miller, 2004), was excavated. A total of 454

[27] U.S. Department of Labor statistics (and not data from DOE operations) were used to estimate risks in the Idaho Site *Short-Term Risk Evaluation* Report (Schofield, 2002). Attempts have been previously made by the authors to estimate Complex-specific parameters, especially for the case of waste retrieval, without great success.

drums or approximately 60 $m^3$ of waste were retrieved, sorted, and packaged; this waste is currently being stored pending disposal.[28]

At the time of this report, the Accelerated Retrieval Project (DOE-ID, 2004b) is being performed to retrieve waste for treatment and disposal from a targeted area of Pit 4 that is highly contaminated with Rocky Flats Plant TRU radionuclides, volatile organic constituents, and depleted uranium.[29] A graphical indication of the waste retrievals from the Subsurface Disposal Area is provided in Figure 5.

### 3.1.1. Other Relevant DOE Complex Waste Retrievals

There are numerous other excavations and corresponding waste retrievals that are pertinent to the SDA remediation. These include (Sykes, 2002):[30]

- *Los Alamos Area P Material Disposal Area*. This disposal area was operated between 1950 and 1984 and received materials from the burning of high explosives, high explosives-contaminated equipment and material, barium nitrate, construction debris from the decontamination and decommissioning of Manhattan-era buildings, as well as trash, vehicles, empty drums, and miscellaneous containers (DOE-SNL, 2003). To mitigate hazards during excavation, all initial excavation and sorting operations were performed remotely. Over a 23-month period, over 24,000 $m^3$ of explosive-contaminated soil, including 607 tons of steel, and 500 tons of concrete were excavated. No exposure or accident information was found for this waste retrieval (Sykes, 2002; DOE-SNL, 2003).
- *Sandia Technical Area II Landfill*. In 1995 the Radioactive Waste Landfill and Chemical Disposal Pits in the Technical Area II at the Sandia National Laboratory were combined to form a single landfill site. The wastes disposed of in the Radioactive Waste Landfill include weapons components, irradiated and neutron-activated material, neutron generator parts, irradiated material from rocket tests, radium-beryllium neutron sources, thermal batteries, radioactive sources, laboratory-generated waste, and low-level waste material from nuclear reactor studies (Sykes, 2002). Chemical wastes including lead, thermal batteries, nitric acid, and tritiated waste from booster cylinders were disposed of in the Chemical Disposal Pits. A voluntary retrieval action was conducted remotely with a combination of conventional and remote equipment that removed over 7000 $m^3$ of contaminated soil. No exposure or accident information was found for this waste retrieval (Sykes, 2002; DOE-SNL, 2003).

[28] DOE News Release, March 2, 2004: "INEEL Finishes GEM Waste Retrieval Project Ahead of Schedule," available at http://newsdesk.inel.gov/press_releases/2004/03-02Pit_9.htm.

[29] INL Oversight, Updated 04/08/2005, "WAG 7: Radioactive Waste Management Complex (RWMC)," http://www.oversight.state.id.us/cleanup/7WAG_status.htm.

[30] Detailed case histories are available in (Sykes, 2002) for many of the waste retrievals listed.

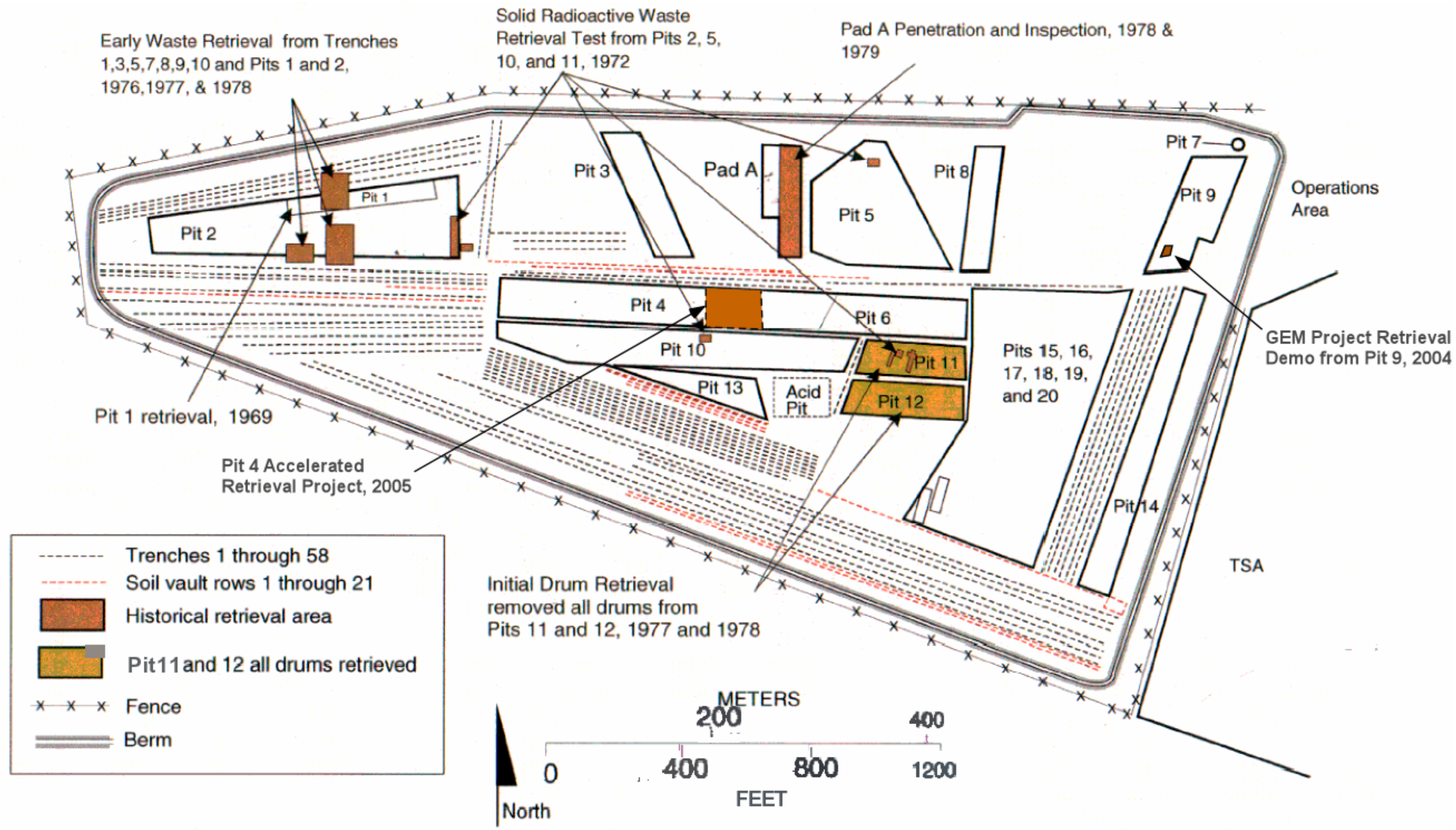


**Figure 5. Historic and Planned Waste Retrieval Activities in the Idaho Site Subsurface Disposal Area (Holdren et al., 2002). Information concerning the Pit 4 Accelerated Retrieval Project and Pit 9 GEM Project added by the authors.**

- *Rocky Flats Trench 1*. Trench 1 was used between 1954 and 1962 primarily for the disposal of depleted uranium chips generated from casting and machining operations. The retrieval and waste segregation activities were performed during the summer of 1998 using conventional equipment resulting in the removal of contaminated soil, drums (including 170 drums of pyrophoric-depleted uranium), and debris. It was reported that no OSHA-recordable injuries were experienced during either the construction or drum-handling phases of the retrieval operation.[31] No exposure information has been found for these operations.
- *Hanford 618-4 Burial Ground*: This burial ground was believed to have been used from 1955 to 1961 for low-level waste disposal although little information appears to exist concerning the inventory. Investigations indicate that buried wastes include uranium, ferrous material, volatile organics, and miscellaneous debris. Excavation was begun in 1998 but had to be halted upon the discovery of over 300 drums of depleted uranium metal shavings and uranium-oxide powder of unknown origin (Sykes, 2002; Murray et al., 2001). Ultimately 778 drums of depleted uranium were retrieved from the burial ground. No exposure or accident information was found for this waste retrieval.
- *Fernald Waste Pits.* The 37-acre waste pit area includes six waste pits ranging in size from 4000 to 20,000 $m^2$ and depths from 3 to 12 m and contains approximately 1 million tons of low-level radioactive waste (including uranium, thorium, and other contaminants) from uranium production operations (Sykes, 2002). As of December 2004, all wastes have been retrieved and dried; furthermore, 133 trains totaling 7893 railcars have been used to ship almost 850,000 tons of waste to Envirocare of Utah for disposal.[32] No exposure or accident information was found for this waste retrieval operation.
- *Maralinga Rehabilitation Project*. Maralinga is an area in Australia contaminated during British nuclear bomb development between 1955 and 1963 and is contaminated with various radioactive materials and activation products (e.g., plutonium, americium, uranium, beryllium, etc.) as well as fused sand (that contains trapped radioactivity). The remedial project was implemented from 1996 to 2000 and primarily consisted of removing the top one-foot of contaminated topsoil from an area of 2.25 $km^2$ and then burying the resulting 360,000 $m^3$ of contaminated material in trenches 10 to 15 m deep under a cap of at least five meters of clean soil.[33] Because of extreme inhalation hazards associated with the plutonium and other radioactive materials, modifications to all soil removal and monitoring equipment was required. No exposure or accident information was found for this waste retrieval operation although indications are that no plutonium migration occurred during the project (Sykes, 2002).

The information provided by both the Idaho Site and other case studies reflect limited experience with excavating buried wastes (especially those contaminated with TRU elements);

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[31] This information was indicated at http://www.stoller.com/WM_T1.htm.

[32] This information was provided on http://www.fernald.gov/Cleanup/wpits.htm.

[33] This information found at http://www.senatorchapman.com/spmini.htm.

however, the information does seem to indicate that progress is being made in retrieval technology application and that TRU-contaminated wastes can be safely retrieved with requisite planning and care (Sykes, 2002). However, a review of pertinent safety records from these excavation activities would also seem useful and prudent.

## 3.2. Nature and Extent of Buried Wastes

The nature and extent of contamination in the SDA was examined in both the Idaho Site *Interim Risk Assessment* and the *Ancillary Basis for Risk Analysis* (Becker et al., 1998; Zitnik et al., 2002; Holdren et al., 2002). The landfill was established in 1952, and the first trench was opened for disposal of solid wastes in July of that year. Between 1952 and 1957, trenches 1 through 10 were excavated down to the basalt (or bedrock); these trenches averaged 1.8 m wide, 274.3 m long, and 3.7 m deep or over 1,800 $m^3$ per trench (or approximately three-quarters of the size of an Olympic-sized swimming pool).

Before 1960 disposal practices in the SDA were based upon potential personnel exposure rates relative to daily occupational limits; waste was classified as non-routine if it could cause excessive exposure and other waste was classified as routine (Holdren et al., 2002). Routine waste often consisted of paper, glassware, filters, metal fittings, etc. contaminated by mixed fission products and was packaged in cardboard boxes that were taped shut. Non-routine waste was placed in wooden boxes or garbage cans, and special transport containers and vehicles were used to transport these wastes to the SDA. Before 1957, radiation levels for disposal were not limited, and items registering up to 12,000 rad/hour were buried (Holdren et al., 2002).[34] Non-routine wastes were covered with soil immediately, whereas, routine waste boxes may have been left exposed until the end of an operating week (Holdren et al., 2002). Early disposal records tend to be sketchy as the disposal practices were not completely standardized and documented.

From 1954 to 1957, shipments of wastes from the Rocky Flats Plant contaminated with transuranic (TRU) constituents were also received and disposed in the SDA (Holdren et al., 2002). These wastes were packaged in drums or wooden crates, which were stacked horizontally in pits and trenches along with the Idaho Site mixed fission product waste. Thus many of the trenches and Pit 1 contain Idaho Site waste interspersed with TRU-contaminated Rocky Flats Plant waste.

From 1960 to 1963, Trenches 16 through 25 and Pits 2 through 5 were excavated and more standardized waste disposal operations continued; these excavations received a mixture of Rocky Flats Plant TRU-contaminated waste, Idaho Site waste, and off-Site waste (Holdren et al., 2002). Between 1964 and the end of buried TRU waste disposal in 1970, studies were

[34] According to the “Acute Radiation Syndrome, Fact Sheet for Physicians” published in 2003 by the Centers for Disease Control and Prevention, death may occur (from the bone marrow syndrome) in some individuals with an acute, whole body exposure as little as 120 rad. Death would be expected (also from the bone marrow syndrome) in 50% of an exposed population within 60 days from an acute, whole body dose of between 250 to 500 rad. All individuals are expected to die if exposed to an acute, whole body dose of 1,000 rad.

performed to determine the risks associated with buried wastes in the SDA,[35] and disposal practices were improved. Minimum trench depths were increased, trenches were lined with soil, wastes were compacted in place, and soil overburdens were increased.

### 3.2.1. Waste Inventory and Contaminants of Potential Concern

Initially, more than 200 constituents were evaluated in the *Interim Risk Assessment* (Becker et al., 1998) to identify those having the greatest potential to impact adversely human health. Constituents were screened based upon whether the contaminant in question had

(i) been observed in media (i.e., surface soils, sedimentary interbed material, perched water, and groundwater) outside the SDA,

(ii) a predicted maximum future groundwater concentration above the pertinent maximum contaminant level (MCL)[36], or

(iii) a predicted risk greater than $10^{-7}$ or hazard quotient (HQ)[37] greater than 0.1.

The outcome was a total of 91 contaminants of potential concern that were evaluated initially in the *Interim Risk Assessment*; adequate inventory information and risk assessment parameters were available to evaluate quantitatively 53 of the 91 contaminants that might pose significant risk, and the remaining 38 were assessed qualitatively (Becker et al., 1998). Unacceptable risks were identified for 24 of the 53 contaminants that were evaluated quantitatively,[38] and nine of those evaluated qualitatively were retained for future consideration in baseline risk assessments for the Subsurface Disposal Area. The nine that would be reevaluated if further information is obtained are chloroform, dibutylethylcarbutol, nitrocellulose, organic acids, organophosphates, toluene, 1-1-1 trichloroethane, trichloroethylene, and xylene (Becker et al., 1998).

A summary of the inventory and concentration values estimated for the 24 contaminants of potential concern evaluated quantitatively in the *Interim Risk Assessment* and *Ancillary Basis*

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[35] According to (Holdren et al., 2002), these studies concluded that "previous burial of radioactive waste did not generate off-Site health or safety problems." However, improvements were recommended to monitor contaminants and mitigate potential impacts from continued waste burial (Holdren et al., 2002).

[36] According to the U.S. EPA (http://www.epa.gov/safewater/mcl.html), a maximum contaminant level (MCL) is "the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to [Maximum Contaminant Level Goals] as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards." A Maximum Contaminant Level Goal (MCLG) is the "level of a contaminant in drinking water below which there is no known or expected risk to health…."

[37] From http://web.ead.anl.gov/uranium/glossacro/, a hazard quotient (HQ) is "a comparison of an estimated chemical intake (dose) with a reference dose level below which adverse health effects are unlikely. The hazard quotient is expressed as the ratio of the estimated intake to the reference dose. The value is used to evaluate the potential for noncancer health effects, such as organ damage, from chemical exposures."

[38] An unacceptable risk in the *Interim Risk Assessment* indicates that the carcinogenic risk estimate is greater than $10^{-6}$ or a hazard index is greater than one (Becker et al., 1998). A total of 25 contaminant of potential concern including 20 radionuclides and five non-radionuclides including total uranium, were identified. However, according to the *Ancillary Basis for Risk Analysis* (Holdren et al., 2002), "[s]ubsequently, total uranium was eliminated from further analysis because the hazard index was reported erroneously in the *Interim Risk Assessment* as 1E+01 instead of 1E-01. However, five uranium isotopes were retained for analysis of carcinogenic risk."

*for Risk Analysis* is provided in Table 1. Bounding values for these contaminants are available and were used to estimate risks and identify contaminants of potential concern in the *Interim Risk Assessment.* However, best inventory estimates were exclusively used in the *Ancillary Basis for Risk Analysis* to estimate risks to human health. Because it is usual and customary in the CERCLA process to consider Reasonable Maximum Exposures, the risks may have to be estimated using bounded inventory values and concentrations in the next phase of the baseline risk assessment process (Becker et al., 1998; Holdren et al., 2002).

## 3.3. Primary Risk Drivers in the Subsurface Disposal Area

In the *Ancillary Basis for Risk Analysis*, risks from buried wastes were evaluated in a comprehensive manner by assessing cumulative risks for all pathways considered complete for the contaminants of potential concern identified in the *Interim Risk Assessment*.[39] The evaluation included exposure, dose, and toxicity assessments, risk characterizations, and limited sensitivity and uncertainty analyses (Holdren et al., 2002). Risk estimates were made for current and future occupational and residential receptors assuming a 100-year institutional control period. These risk estimates assume that no remedial actions are taken. All of the remedial options considered will reduce these risks to varying degrees. The effectiveness of each of the remedial actions to reduce risk, and risks remaining after implementation has not been quantified.

Occupational exposures were assessed for a total of 158 years to represent SDA operation beginning in 1952 and continuing until 2110—or at the end of the assumed 100-year institutional control period. Current operations preclude the drinking of contaminated groundwater as part of the occupational scenario; therefore, the pathways evaluated for the occupational scenarios include incidental soil ingestion, dermal contact with contaminated soil, particulate and vapor inhalation, and exposure to ionizing radiation (Holdren et al., 2002).

For the current resident scenario, risk from groundwater ingestion at the Idaho Site boundary under baseline conditions was assessed in the *Ancillary Basis for Risk Analysis*—surface exposure pathways were not examined because of site access restrictions (Holdren et al., 2002). Future residential exposures were assumed to begin in 2110 (to reflect remedial action in 2010 followed by a 100-year institutional control period). An engineered surface barrier and institutional controls were assumed to prevent access to the waste; however, areas immediately adjacent to the SDA were assumed to be inhabited. Risks were estimated to 1,000 years for all pathways except groundwater ingestion, which was estimated to a maximum of 10,000 years. In the *Ancillary Basis for Risk Analysis*, baseline risks for the future resident scenario, especially from groundwater ingestion, exceeded those for other scenarios including those for the occupational and current resident exposure scenarios (Holdren et al., 2002).

[39] As indicated above, total uranium was eliminated from further analysis because its hazard index was erroneously reported in the *Interim Risk Assessment* (Holdren et al., 2002).

**Table 1. Inventory Summary for 24 Contaminants of Potential Concern in the SDA**

| Contaminant | Best Estimate | | Upper Bound | |
|---|---|---|---|---|
| | Inventory [a] (Ci or g) | Concentration [b] (pCi/g or mg/kg) | Inventory [c] (Ci or g) | Concentration [b] (pCi/g or mg/kg) |
| Ac-227 | 5.12E-07 | 1.11E-06 | --- [d] | 7.62E-02 |
| Am-241 | 1.83E+05 | 3.98E+05 | 3.68E+05 | 4.35E+05 |
| C-14 | 5.00E+02 | 1.09E+03 | 8.86E+04 | 1.85E+05 |
| Cl-36 | 1.11E+00 | 2.41E+00 | 2.29E+00 | 4.79E+00 |
| Cs-137 | 6.17E+05 | 1.34E+06 | 1.67E+06 | 2.08E+06 |
| I-129 | 1.58E-01 | 3.44E-01 | 4.59E-01 | 1.08E+00 |
| Nb-94 [d] | 1.00E+03 [d] | 2.19E+03 | 9.13E+01 [d] | 1.95E+02 |
| Np-237 | 2.64E+00 | 5.75E+00 | 1.31E+01 | 2.40E+01 |
| Pa-231 | 8.64E-04 | 1.88E-03 | --- [e] | 2.18E-02 |
| Pb-210 | 5.10E-07 | 1.11E-06 | --- [e] | 1.24E-04 |
| Pu-239 | 6.49E+04 | 1.41E+05 | 1.60E+05 | 1.94E+05 |
| Pu-240 | 1.71E+04 | 3.72E+04 | 4.03E+04 | 4.79E+04 |
| Ra-226 | 6.00E+01 | 2.35E-05 | 8.86E+01 | 1.68E+02 |
| Sr-90 | 6.44E+05 | 9.84E+05 | 2.66E+06 | 2.83E+06 |
| Tc-99 | 6.05E+01 | 1.32E+02 | 1.33E+03 | 3.05E+03 |
| U-233 | 1.51E+00 | 3.28E+00 | 1.58E+00 | 3.48E+00 |
| U-234 | 6.74E+01 | 1.47E+02 | 1.62E+02 | 1.86E+02 |
| U-235 | 5.54E+00 | 1.21E+01 | 1.05E+01 | 1.34E+01 |
| U-236 | 2.86E+00 | 6.23E+00 | 6.21E+00 | 7.19E+00 |
| U-238 | 1.17E+02 | 2.55E+02 | 4.34E+02 | 3.95E+02 |
| Carbon tetrachloride | 1.2E+08 | 2.6E+02 | 1.30E+08 | 3.05E+02 |
| Methylene chloride | 1.4E+07 | 3.0E+01 | 1.50E+07 | 3.27E+01 |
| Nitrates (total) | --- | --- | 4.35E+08 | 1.35E+03 |
| Tetrachloroethylene | 2.7E+07 | 5.9E+01 | 2.90E+07 | 6.75E+01 |

a. Radionuclide inventories (in Ci) were obtained from Table 3-7 and Table 4-1 in the *Ancillary Basis for Risk Analysis* (Holdren et al., 2002). Those for the four non-radioactive contaminants (in grams) were obtained from Table 3-1b, *Historical Data Task* (LMITCO, 1995a).

b. Concentrations from are computed assuming that the inventory is uniformly distributed over a volume of soil 181 x 669 x 2.53 m with a bulk density of 1.5 kg/m$^3$ that represents the combined volumes for SDA pits, trenches, and vaults (Hampton & Becker, 2000; Holdren et al., 2002).

c. The upper bound inventory values were taken from Table 4-1 and Table 4-2 in the *Interim Risk Assessment* (Becker et al., 1998). The statistical derivation of these bounding values is described in Section 5 of the *Historical Data Task* (LMITCO, 1995a).

d. The best and upper bound estimates for Nb-94 are in conflict. These are the values provided in the *Interim Risk Assessment* and *Ancillary Basis for Risk Analysis*.

e. Although not originally buried in the SDA, the radioactive elements Ac-227, Pa-231, and Pb-210 are decay chain products (i.e., progeny of contaminants buried in the SDA) and were included in the table for completeness. Over time, these elements will contribute to the SDA inventory due to ingrowth.

Peak risks or hazard indices estimated for contaminants of potential concern in the SDA for the aforementioned future residential exposure scenario are provided in Table 2 under the baseline or "no action" assumption. Similar risk estimates were made for current residential as well as current and future occupational exposure scenarios, but are found to be less than those in Table 2. When risk-based criteria of $10^{-5}$ risk and a cumulative hazard quotient of 2 were applied,[40] 16 contaminants of potential concern (including 12 radionuclides and the four non-radioactive constituents) were identified as illustrated in Table 2. Three plutonium isotopes (i.e., Pu-238, Pu-239, and Pu-240) were also included for further consideration because of uncertainty in plutonium mobility (Holdren et al., 2002).

The volatile organic compounds (i.e., carbon tetrachloride, methylene chloride, and tetrachloroethylene) and total nitrates, most of which originated at the Rocky Flats Plant, present the most *imminent* risk to human health under the baseline conditions. Carbon tetrachloride has been detected in the Snake River Plain Aquifer (that underlies the SDA) and is being extracted from the vadose zone to reduce or remove the contamination source and thus reduce risks further. Vapor vacuum extraction will continue in the future, and if risks are not sufficiently mitigated, they will continue to pose the most imminent risk to human health. Vapor vacuum extraction does not address the risks associated with nitrates, which are thought to have migrated to the aquifer from the SDA.[41]

Mobile, long-lived fission and activation products pose the next most immediate concern to human health under baseline conditions. Most of the mobile fission and activation products were generated by Idaho Site reactor operations (Holdren et al., 2002). For example, those contaminants that have peak risks greater than $1x10^{-6}$ in the 100-year period following institutional control (i.e., ending in 2110) include (where the peak risk is provided in the parentheses):[42]

$$\text{Tc-99 } (4x10^{-4}) > \text{Sr-90 } (1x10^{-4}) > \text{I-129 } (6x10^{-5}) > \text{Cl-36 } (6x10^{-6}) > \text{Cs-137 } (5x10^{-6})$$

Large uncertainties have been noted for the model parameters used to estimate risks for C-14, I-129, and Tc-99 (Holdren et al., 2002). These contaminants have been detected sporadically in the subsurface and additional work is necessary to model their transport through the Idaho Site environment.

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40 In the *Interim Risk Assessment* (Becker et al., 1998), an unacceptable risk meant that the carcinogenic risk estimate was greater than $10^{-6}$ or a hazard index was greater than one. No reason is provided for the change in screening criteria for contaminants of potential concern.

41 The high background levels of nitrates in the aquifer make these determinations difficult; however, there appears to be an increasing trend in nitrate in monitoring wells in the vicinity of the SDA that is most likely attributable to the SDA.

42 The peak risk presented in Table 2 for C-14 is $6x10^{-4}$ in 2278. However, the risk is greater than $1x10^{-6}$ before the year 2110 (from Figure 6-3 in the *Ancillary Basis for Risk Analysis* (Holdren et al., 2002)) and thus the on-going effort to immobilize the C-14 by grouting the areas around the beryllium block appears warranted from a risk reduction perspective. Although the peak hazard index for methylene chloride is less than unity, the peak carcinogenic risk is $2x10^{-5}$ just 80 years after the end of institutional control (in 2110). Although no figure describing the methylene chloride carcinogenic risk as a function of time is provided in the *Ancillary Basis for Risk Analysis* (Holdren et al., 2002), it appears likely that this contaminant is a likely short-term risk driver.

**Table 2. Baseline Risks Estimated for Human Health Contaminants of Potential Concern (Table E-1 from *Ancillary Basis for Risk Analysis* (Holdren et al., 2002))**

| Contaminant | Note | Peak Risk | Year | Peak Hazard Index | Year | Primary 1,000-Year Exposure Pathway |
|---|---|---|---|---|---|---|
| Ac-227 | 1,3 | 3E-06 | 3010[a] | NA[b] | NA | Groundwater ingestion |
| **Am-241** | | **3E-05** | 2953 | NA | NA | Soil ingestion, inhalation, external exposure, and crop ingestion |
| Am-243 | | 4E-08 | 3010[a] | NA | NA | External exposure |
| **C-14** | 1,4 | **6E-04** | 2278 | NA | NA | Groundwater ingestion |
| Cl-36 | | 6E-06 | 2110 | NA | NA | Groundwater ingestion |
| Cs-137 | | 5E-06 | 2110 | NA | NA | External exposure |
| **I-129** | 1,3 | **6E-05** | 2110 | NA | NA | Groundwater ingestion |
| **Nb-94** | 1,3 | **8E-05** | 3010[a] | NA | NA | External exposure (groundwater ingestion) |
| **Np-237** | 1,4 | **4E-04** | 3010[a] | NA | NA | Groundwater ingestion |
| Pa-231 | | 3E-06 | 3010[a] | NA | NA | Groundwater ingestion |
| Pb-210 | | 5E-07 | 3010[a] | NA | NA | Soil and crop ingestion |
| **Pu-238** | 2 | **1E-09** | 2286 | NA | NA | Soil and crop ingestion |
| **Pu-239** | 2 | **2E-06** | 3010[a] | NA | NA | Soil and crop ingestion |
| **Pu-240** | 2 | **2E-06** | 3010[a] | NA | NA | Soil and crop ingestion |
| Ra-226 | | 3E-06 | 3010[a] | NA | NA | Soil and crop ingestion |
| **Sr-90** | 1,4 | **1E-04** | 2110 | NA | NA | Crop ingestion |
| **Tc-99** | 1,4 | **4E-04** | 2110 | NA | NA | Groundwater ingestion and crop ingestion |
| Th-229 | | 4E-07 | 3010[a] | NA | NA | Groundwater ingestion |
| Th-230 | | 7E-07 | 3010[a] | NA | NA | Groundwater ingestion |
| Th-232 | | 1E-09 | 3010[a] | NA | NA | Groundwater ingestion |
| **U-233** | 1,3 | **3E-05** | 3010[a] | NA | NA | Groundwater ingestion |
| **U-234** | 1,4 | **2E-03** | 3010[a] | NA | NA | Groundwater ingestion |
| **U-235** | 1,4 | **1E-04** | 2662 | NA | NA | Groundwater ingestion |
| **U-236** | 1,4 | **1E-04** | 3010[a] | NA | NA | Groundwater ingestion |
| **U-238** | 1,4 | **3E-03** | 3010[a] | NA | NA | Groundwater ingestion |
| **Carbon tetrachloride** | 1,5 | **2E-03**[c] | 2105 | **5E+01**[c] | 2105 | Inhalation and groundwater ingestion |
| **Methylene chloride** | 1,3 | **2E-05**[c] | 2185 | 1E-01[c] | 2185 | Groundwater ingestion |
| **Nitrates** | 1,6 | NA | NA | **1E+00** | 2120 | Groundwater ingestion |
| **Tetrachloroethylene** | 1,6 | NA | NA | **1E+00**[c] | 2137 | Groundwater ingestion and dermal exposure to contaminated water |

Notes: For toxicological risk, the peak hazard index is given, and for carcinogenic probability, the peak risk is given.
1. Green = the contaminant is identified as a human health contaminant of concern based on carcinogenic risk greater than 1E-05 or a hazard index greater than or equal to 1 contributing to a cumulative hazard index greater than 2.
2. Brown = plutonium isotopes are classified as special case contaminants of concern to acknowledge uncertainties about plutonium mobility in the environment and to reassure stakeholders that risk management decisions for the SDA will be fully protective.
3. Blue = carcinogenic risk between 1E-05 and 1E-04.
4. Red = carcinogenic risk greater than 1E-04.
5. Pink = toxicological (noncarcinogenic) hazard index greater than or equal to 1.

a. The peak groundwater concentration does not occur before the end of the 1,000-year simulation period. Groundwater ingestion risks and hazard indices were simulated for the peak concentration occurring within 10,000 years and are not presented in this table.
b. NA = not applicable.
c. The risk estimates were produced by scaling the results from the *Interim Risk Assessment* (Becker et al., 1998) based on inventory updates.

Various uranium isotopes and Np-237 buried in the SDA represent the majority of the long-term risks to human health. For example, based upon the peak risk estimates in Table 2, those contaminants that have a peak risk greater than or equal to $1x10^{-4}$ after the end of the institutional control period in 2110 include (where the peak risk and year are provided in the parentheses):[43]

U-238 ($3x10^{-3}$ after 3010) > U-234 ($2x10^{-3}$ after 3010) > C-14 ($6x10^{-4}$ in 2278)
> Np-237 ($4x10^{-4}$ after 3010) > U-235 ($1x10^{-4}$ in 2662) and U-236 ($1x10^{-4}$ after 3010)

Uranium, approximately one-half of which came from the Rocky Flats Plant, has been detected in the vadose zone, indicating potential migration. Most of the disposals of Np-237 originated at the Idaho Site; however, nearly all the Am-241 (the parent of Np-237) was generated at Rocky Flats Plant (Holdren et al., 2002). Although Am-241 has been detected sporadically in the vadose zone in the vicinity of the SDA, Np-237 has not been detected to date. Apart from Am-241 and Np-237, four additional transuranic contaminants (i.e., Am-243 and the three plutonium isotopes) were identified; however, only the Np-237 and Am-241 transuranic contaminants were identified quantitatively as being contaminants of potential concern as illustrated in Table 2.[44]

The majority of the inventories of those contaminants (i.e., carbon tetrachloride, methylene chloride, tetrachloroethylene, and nitrates) that pose the most *imminent* threat to human health originated at the Rocky Flats Plant. The volatile organic components currently are being treated using vacuum vapor extraction and the further benefit of excavation with respect to these contaminants is unclear. Soil vapor extraction will not reduce either the source or extent of nitrate contamination. Nitrates are highly water soluble and mobile in the vadose zone and groundwater, with water migration the rate limiting process. It is highly uncertain whether the majority of the nitrates disposed in the SDA still remain in or near the original disposal locations. Verification of significant pockets of nitrates that represent a large fraction of the total nitrate inventory would be necessary for excavation to have a significant impact on reduction of risks from nitrate contamination. The next most immediate concern is posed by the mobile, long-lived fission and activation products that were primarily generated during Idaho Site reactor operations. The on-going beryllium block grouting project will help to reduce the release of C-14 from these blocks; however, this project and other project involving only the areas containing Rocky Flats Plant wastes will not effectively limit the release or transport of the other mobile, long-lived fission and activation products because these contaminants have other sources. The long-term risks to human health result primarily from uranium (of which approximately one-half originated at the Rocky Flats Plant) and other long-lived actinides (some of which are activation products generated at the Idaho Site and others originating at the Rocky Flats Plant). Thus the immediacy, magnitude, and source of the risks

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43 The contaminants that have a peak risk greater than or equal to $1x10^{-6}$ and less than $1x10^{-4}$ after the end of the institutional control period in 2110 include (where the peak risk and year are provided in the parentheses):

Nb-94 ($8x10^{-5}$ after 3010) > Am-241 ($3x10^{-5}$ in 2953) and U-233 ($3x10^{-5}$ after 3010)
> Ac-227, Pa-231, & Ra-226 ($3x10^{-6}$ after 3010) > Pu-239 & Pu-240 ($2x10^{-6}$ after 3010)

44 The three plutonium isotopes (i.e., Pu-238, Pu-239, and Pu-240) were selected as special cases for continued study to assure that uncertainties in plutonium mobility do not unnecessarily exclude these important constituents.

must be taken into account to determine the best path forward for remedial action. Tables analogous to Table 2 should be developed for each remedial alternative that present the estimated residual risk after each remedial option is implemented and allow understanding and comparisons of the magnitude of human health risk reductions achieved through each management option.

# 4. Primary Sources of Information

Remediation of buried wastes in the Subsurface Disposal Area (SDA) is being managed under the Idaho Site CERCLA process and currently is in the Remedial Investigation/Feasibility Study (RI/FS) phase. Documentation supporting the Idaho Site CERCLA process is available in the Idaho Site Administrative Record[45] and has been relied upon extensively in developing this report.

The primary sources of information publicly available and used to develop this report are summarized as follows:

1. Work Plans (and Addenda) for the CERCLA Remedial Investigation/Feasibility Study (RI/FS) Process for the SDA:
    a. CERCLA Waste Area Group 7 Work Plan, Rev. 0 (Becker et al., 1996)
    b. First Addendum to CERCLA WAG 7 Work Plan (DOE-ID, 1998)
    c. Second Addendum to CERCLA WAG 7 Work Plan (Holdren & Broomfield, 2004)

2. Operable Unit 7-13/14 Treatability Study Work Plans:
    a. *In Situ* Thermal Desorption (ISTD) Treatability Study Work Plan (DOE-ID, 1999a)
    b. *In Situ* Grouting (ISG) Treatability Study Work Plan (DOE-ID, 1999b)
    c. *In Situ* Vitrification (ISV) Treatability Study Work Plan (Farnsworth et al., 1999)
    d. *Ex Situ* Treatability Study Work Plan (DOE-ID, 1999b)

3. Preliminary Baseline Risk Assessments (i.e., part of the CERCLA Remedial Investigation process):
    a. *Interim Risk Assessment* for Waste Area Group 7 (which includes the SDA) (Becker et al., 1998)
    b. *Ancillary Basis for Risk Analysis* of the SDA (Holdren et al., 2002)

4. Preliminary Remedial Action Alternatives (i.e., part of the CERCLA Feasibility Study process):
    a. *Short-Term Risk Evaluation* (Schofield, 2002)
    b. *Preliminary Evaluation of Remedial Alternatives* (Zitnik et al., 2002)

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[45] Documents in the Idaho Site Administrative Record can be accessed via http://ar.inel.gov.

5. Specialized Risk Assessments External to the Idaho Site:
    a. Waste Isolation Pilot Plant (WIPP) No Action Alternative 2 Analysis (Buck et al., 1997)[46]

6. Health and Safety Plans:
    a. *Health and Safety Plan* for Pad A Maintenance (Higgins, 1995)
    b. *Health and Safety Plan* for the Pit 4 Accelerated Retrieval Project (Wooley, 2004a)
    c. *Health and Safety Plan* for the Early Actions Beryllium Block Encapsulation Project (using *in situ* grouting) (ICP, 2004a)
    d. *Health and Safety Plan* for Radioactive Waste Management Complex (RWMC) Routine Monitoring (Wooley, 2004b)
    e. *Health and Safety Plan* for Long-term Groundwater Monitoring (ICP, 2004b)
    f. *Health and Safety Plan* for Pit 9 Glovebox Excavator Method (GEM) Project (Miller, 2004)
    g. *Health and Safety Plan* for Vacuum Vapor Extraction for Organic Contamination in the Vadose Zone (Miller & Wooley, 2004)
    h. *Health and Safety Plan* for the *In Situ* Grouting Treatability Study (Miller, 2001)
    i. *Health and Safety Plan* for Operable Unit 7-13 and 7-14 Integrated Probing Project (Miller, 2003)

7. Feasibility Study Preliminary Documented Safety Analyses:
    a. *Preliminary Documented Safety Analysis* for *In Situ* Thermal Desorption (Abbott, 2003)
    b. *Preliminary Documented Safety Analysis* for *In Situ* Grouting (Abbott & Santee, 2004)
    c. *Preliminary Documented Safety Analysis* for *In Situ* Vitrification (Santee, 2003)

8. Engineered Barrier Design for the SDA:
    a. Preliminary Design for the SDA Engineered Surface Barrier (Mattson et al., 2004)

9. Inventory Summaries (which also include the *Interim Risk Assessment* (Becker et al., 1998) and *Ancillary Basis for Risk Analysis* (Holdren et al., 2002)):
    a. SDA Comprehensive Inventory for Years 1952-1983 or *Historical Data Task* (LMITCO, 1995a)
    b. SDA Comprehensive Inventory for Years 1984-2003 (LMITCO, 1995b)
    c. Inventory Sent from Test Area North to the SDA 1960-1993 (INEEL, 2003a)

[46] There was also an initial WIPP No Action alternative; however, this analysis focused primarily on short-term (i.e., not life-cycle) risks from leaving the buried TRU wastes in place (Buck et al., 1997). Thus it is the No Action Alternative 2 that is of most interest here.

d. Inventory Sent from the Idaho Nuclear Technology and Engineering Center to the SDA 1952-1993 (Vail et al., 2004)
e. Inventory Sent from the Argonne National Laboratory-West to the SDA 1952-1993 (Carboneau & Vail, 2004)
f. Inventory Sent from the Naval Reactors Facility to the SDA 1952-1999 (Giles et al., 2005)

It is anticipated that future documents supporting the CERCLA Feasibility Study will consider the potential use of an evapotranspiration (ET) cap, currently the desired cap design for the SDA (Holdren & Broomfield, 2004), in place of the modified RCRA Subtitle "C" type cap considered in the *Preliminary Evaluation of Remedial Alternatives* and *Short-Term Risk Evaluation*.

# 5. Alternatives Considered

The Consortium for Risk Evaluation with Stakeholder Participation (CRESP) was asked by DOE to develop a framework for the comparative life-cycle risk evaluation of management options for ultimate disposition of the wastes buried in the Subsurface Disposal Area (SDA). A broad series of remedial approaches that may be used in the SDA is taken as its starting point for evaluation. The evaluation focuses on understanding when, in what order, and why these remedial approaches would be appropriate for addressing the specific conditions in the SDA and sections thereof. The specific steps required for implementation of the remedial approaches are described and then the hazards and risks involved in implementation, as well as those future risks anticipated to be mitigated by implementation, are explored for each remedial approach. This evaluation can be repeated on sub-sections of the SDA to make location or waste specific decisions. However, decisions for any specific sub-area or waste type must be made in the context of the management of the entire SDA. A life-cycle analysis is necessary to first assess the risks and then ultimately compare them in a consistent and transparent manner. An examination of existing information as well as additional information needed to assess and compare risks for the various remedial approaches is an integral part of this exploration.

## *5.1. Alternatives Considered in Prior Evaluations*

There is no "preferred remedial alternative" for the buried wastes currently stored in the Subsurface Disposal Area (SDA) landfill because the Idaho Site is currently in the Remedial Investigation/Feasibility Study (RI/FS) stage of the CERCLA process.[47] Waste inventory information will be refined and alternatives necessary to reduce risks from both hazardous and radioactive contaminants in the SDA to acceptable levels will be compared as part of the RI/FS process. Wastes contaminated with large quantities of fissions products (i.e., gamma and beta emitters) were buried in some areas; whereas, wastes contaminated with large quantities of transuranic elements and hazardous organics were buried in other areas. Thus risks vary significantly from one area of the SDA to the next. The following alternatives were considered in the *Preliminary Evaluation of Remedial Alternatives* (Zitnik et al., 2002):

- A No Action Alternative (relying upon monitoring; this alternative is required by EPA as a basis for comparison of remedial alternatives),
- A Limited Action Alternative (including access controls, a surface barrier, and land use restrictions),
- Two Containment Alternatives (relying upon either surface or subsurface barriers to prevent access to waste and to control future contaminant migration),
- Two *In Situ* Treatment Alternatives (using either *in situ* grouting or *in situ* vitrification to treat and stabilize wastes and contaminated soil in place), and

47 The draft remedial investigation and baseline risk assessment report must be submitted to the Idaho Department of Environmental Quality and the U.S. Environmental Protection Agency by August 2006. The draft feasibility study report is due December 2006 (Holdren & Broomfield, 2004).

- A Retrieval, Treatment, and Disposal Alternative (retrieving and treating the waste and contaminated soil with off-site disposal of the TRU material and on-site disposal of low-level waste and treated mixed low-level waste material).

Based upon EPA guidance (EPA, 1988), the potentially applicable remedial technologies and process options were identified and screened based on three of the nine CERCLA criteria: effectiveness, implementability, and cost (Zitnik et al., 2002). The alternatives found to satisfy the screening criteria for the SDA were

- **Surface Barrier**. This alternative includes *in situ* grouting and *in situ* thermal desorption pretreatment at selected sites, Pad A reconfiguration,[48] installation of a long-term multi-layer cover, land-use restrictions, and long-term monitoring and maintenance.
- ***In Situ* Grouting**. This alternative employs *in situ* grouting to treat and stabilize waste and contaminated soil in place, Pad A retrieval and *ex situ* treatment/disposal, *in situ* thermal desorption pretreatment[49] (Abbott, 2003) in areas with high organic concentrations, a long-term multi-layer cover installation, land-use restrictions, and long-term monitoring and maintenance.
- ***In Situ* Vitrification**. This alternative uses *in situ* vitrification to treat and stabilize waste and contaminated soil in place, Pad A reconfiguration, *in situ* grouting and *in situ* thermal desorption pretreatment of selected areas, installation of a long-term multi-layer cover, land-use restrictions, and long-term monitoring and maintenance.
- **Retrieval, Treatment, and Disposal**. This alternative employs retrieval and *ex situ* treatment of the waste,[50] disposal of TRU material at the Waste Isolation Pilot Plant, on-site disposal of low-level waste and treated mixed low-level waste material in a new Idaho Site disposal cell, *in situ* grouting and *in situ* thermal desorption pretreatment of selected areas, a long-term multi-layer cover installation, land-use restrictions, and long-term monitoring and maintenance.

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48 Pad A was constructed in 1972 and received wastes in drums and boxes until 1978 (Zitnik et al., 2002). It consists of an asphalt pad (i.e., 73 m x 102 m) built in an area unsuitable for subsurface disposal because of near-surface outcroppings of basalt. Wastes in Pad A primarily contain transuranic (TRU) radioisotopes with concentrations less than 10 nCi/g and radiation levels less than 200 mR/hr at the surface (Zitnik et al., 2002). Any remedial alternative considered for the SDA includes emplacement of a surface barrier; therefore, Pad A must be reconfigured before any surface barrier can be constructed.

49 *In situ* thermal desorption (ISTD) is a remedial process where heat and vacuum are applied to contaminated soil (Abbott, 2003). In the SDA, those pits considered for *in situ* thermal desorption pretreatment contain organic and nitrate sludges, combustible solids, and graphite wastes, all of which are contaminated with plutonium. ISTD may be employed in areas with high organic concentrations to remove nonradioactive contaminants. Two major processes comprise ISTD: (1) underground thermal desorption and (2) subsequent off-gas treatment (Abbott, 2003).

50 Five types of technological options were originally considered for *ex situ* treatment of wastes retrieved from the SDA: 1) physical, 2) chemical, 3) thermal, 4) electrokinetic, and 5) biological. Of these, three (i.e., physical, chemical, and thermal treatment) options were retained for further consideration (Zitnik et al., 2002). The final decision on the specific treatment technology will be made in conjunction with DOE Idaho, EPA, Idaho Department of Environmental Quality, and other stakeholders. Because of experience with the Advanced Mixed Waste Treatment Facility (AMWTF), it is assumed here that *ex situ* treatment will consist primarily of compaction (Zitnik et al., 2002).

The short-term risks associated with these remedial alternatives were evaluated in the *Short-Term Risk Evaluation* (Schofield, 2002).

From both the *Preliminary Evaluation of Remedial Alternatives* (Zitnik et al., 2002) and *Short-Term Risk Evaluation* (Schofield, 2002), all of the alternatives examined and selected by Idaho Site personnel for final consideration would appear to provide adequate stabilization and containment of the wastes buried in the Subsurface Disposal Area (SDA). These alternatives appear reasonable from what is known of the SDA, the wastes buried there, and available remedial technologies. Furthermore, it does not appear from the information available that application of the remaining six CERCLA evaluation criteria would dramatically change the alternatives that should be considered.

## 5.2. Alternatives Included in the CRESP Review

The remedial alternatives evaluated in this report fall into two broad categories: 1) those approaches involving *containing the wastes where they are* to assure they do not migrate and find pathways to receptors, and 2) those involving *excavation of waste materials for treatment, packaging, and ultimate disposal* so that the contaminants will be contained. In both the supporting Idaho Site documentation and this report, *excavation* of wastes is referred to as *retrieval*, which is to be distinct from the volatile organic *extraction* (removal) currently on-going at the SDA. Options such as the specific type of engineered surface barrier to be used and whether *in situ* thermal desorption (ISTD) pretreatment will be necessary appear to be less important in terms of life-cycle risks (and costs) than whether or not wastes will have to be retrieved and the TRU waste packaged and sent off-site to the Waste Isolation Pilot Plant (WIPP) for long-term disposal. Table 3 summarizes the set of alternatives considered during the CERCLA process and examined in this report. No additional alternatives are evaluated in this report. [51]

[51] For example, it was decided that a complete excavation of the 97-acre SDA requiring removal of all material down to the basalt would not be evaluated because the retrieval options considered in this report were considered to be protective and more manageable. One additional alternative that should be considered is a staged cap approach such as used in management of the Maxey Flats former nuclear disposal site near Hillsboro, Kentucky. This site has undergone cleanup and will be managed for the next 100 years under Superfund including monitoring and maintenance of a low hydraulic conductivity cap. After 100 years, it is anticipated that the ground surface will have fully settled and then a final cap will be installed; monitoring and maintenance will continue in perpetuity. Thus an alternative to those in Table 3 would be to install a temporary, low-permeability barrier over the SDA (without *in situ* grouting) allowing the ground to settle. Then a final cap could be installed after allowing time for fission product decay and monitoring.

**Table 3. Possible Idaho Site Buried Waste Disposition Alternatives**

| | Stabilization | Barrier | *In Situ* Treatment | *Ex Situ* Treatment | On-Site Disposal | Off-Site Disposal |
|---|---|---|---|---|---|---|
| 1. Contain-in-Place Alternative (4 options) | | | | | | |
| 1A. No Action option[a] | | | | | | |
| 1B. Surface barrier with selected *in situ* grouting | | X | | | X | |
| 1C. *In Situ* Grouting with surface barrier | X | X | X | | X | |
| 1D. *In Situ* Vitrification with surface barrier[b] | X | X | X | | X | |
| 2. Retrieve/Treat/Dispose Alternative (2 options) | | | | | | |
| 2A. Targeted RFP TRU waste retrieval with surface barrier[c] | | X | X | X | X | X |
| 2B. Full RFP TRU waste retrieval with surface barrier[c] | | X | X | X | X | X |

a. This option represents baseline conditions and is required under CERCLA for comparison purposes. Although no further actions would be taken to reduce contaminant mobility, toxicity, or volume, long-term monitoring, maintenance, and institutional controls would be instituted.

b. Although identified as a potential option (Schofield, 2002; Zitnik et al., 2002), *in situ* vitrification has since been removed from consideration for the SDA (Holdren & Broomfield, 2004). Although no formal reasons are provided in (Holdren & Broomfield, 2004) for exclusion, this omission is likely due to safety considerations based upon testing at PNNL, Oak Ridge, and other sites. This option has been retained in this report for comparison purposes.

c. The retrieval alternatives may hinge on future legal decisions concerning to what extent the TRU wastes originating from the Rocky Flats Plant (RFP) must be removed from the SDA. The options presented here concern targeted or "hot-spot" retrieval of RFP TRU wastes versus full retrieval of all buried RFP TRU wastes (however, not including contaminated soil) down to the basalt. The TRU waste retrieved would be treated, and transferred to the Waste Isolation Pilot Plant for ultimate disposal. The non-TRU wastes retrieved would be disposed of on-site at the Idaho Site. It is also possible that high-level waste (HLW), spent nuclear fuel (SNF), or wastes similar to HLW and SNF were buried. If HLW or SNF is buried in the SDA, then additional retrieval, segregation, and storage prior to disposal in a deep geologic repository should be evaluated as part of this alternative.

The specific alternatives for disposition of the SDA buried wastes explored in this report are:

1. <u>Contain in Place</u>

   The Idaho Site would contain the buried SDA wastes in-place without additional waste retrieval after completion of currently planned test retrievals and vapor extraction for removal of volatile organic contaminants. All options include long-term monitoring, maintenance, and institutional controls. Four options were examined under this remedial alternative:

   a. *"No Action"* (although long-term monitoring, maintenance, and institutional controls would be instituted);

   b. *Surface Barrier Installation* with *in situ* grouting as needed for subsurface geotechnical stabilization (i.e., to prevent future subsidence and surface barrier impact);

   c. *In Situ Grouting* for both subsurface geotechnical stabilization and contaminant of potential concern immobilization with surface barrier installation; and

d. *In Situ Vitrification* for contaminant of potential concern immobilization in concert with *in situ* grouting for subsurface geotechnical stabilization and surface barrier installation.

2. Retrieve, Treat, and Dispose

   The Idaho Site would retrieve and treat some buried SDA wastes for both on-site (low-level and mixed low-level wastes) and off-site (TRU waste) disposal where the extent of the retrieval is based upon risks, costs, and possible future legal decisions. Two options were examined for this alternative:

   a. *Targeted Rocky Flats Plant TRU Waste Retrieval* with *in situ* grouting for both subsurface geotechnical stabilization and contaminant immobilization, as well as surface barrier installation based upon a risk-informed decision incorporating risks, costs, effectiveness, etc., and

   b. *Full Rocky Flats Plant TRU Waste Retrieval* with *in situ* grouting for subsurface geotechnical stabilization and contaminant immobilization as well as surface barrier installation.

Another way to characterize these remedial alternatives is by how aggressively the wastes in the SDA must be treated. Installation of a surface barrier helps to reduce the flux of water to the buried wastes, but does not impact the source of contamination or the potential risks remaining if the surface barrier fails in the future. The other remedial alternatives represent a progression from less to more aggressive approaches where selected contaminants will be immobilized in-place (using grouting or vitrification) to those involving selecting the highest risk wastes that can be removed effectively for ultimate disposition in a different form and location. For example, it appears as though the nitrates, Tc-99, and Sr-90 may present the greatest short-term risks after the volatile organic compounds that are currently being extracted. Thus the decision as to whether buried wastes can be effectively contained in-place or have to be retrieved should be based on the current form, geospatial distribution, and retrievability of the risk-driving contaminants, as well as the risk reduction achieved through the proposed retrieval actions.

The different areas where wastes have been buried within the SDA present very different hazards and risks;[52] therefore, both the remedial approach and approach to risk evaluation must be able to consider these different risks. The approach used in this report may be used to evaluate the SDA as a whole, or applied to sub-areas of the SDA to evaluate which areas or "hot-spots" warrant different remediation approaches from the remainder of the site. From evaluating the available information, it appears that the best risk-informed decisions concerning remedial actions in the SDA will likely not include a single remedial action for the entire site. Instead a graded approach appears warranted that addresses each sub-area in the SDA, the risks posed by the waste buried there, and the remedial actions that must be taken to place the wastes in a safe state as well as the risks involved to achieve the remedial actions. Thus the retrievability of the contaminants of potential concern that drive the risks must be

[52] For example, the pits and trenches where Rocky Flats Plant wastes containing volatile organic compounds and TRU-contaminated wastes and sludges pose decidedly different risks than those areas where liquid wastes containing fission products were disposed of in augur holes.

more clearly defined before determining the risk reduction that may be achieved through waste excavation. In addition, area-specific considerations should be made in the context of closure, remedial actions, long-term stewardship needs, and remaining risks posed by the entire SDA.

## 5.3. Additional Information for Alternative 1 (Contain in Place)

Alternative 1 involves containing the SDA wastes in-place; the final step for any of the contain-in-place options (excluding the No Action option) requires installation of a long-term, multilayer, low-permeability cap over the SDA without retrieval of any of the hazardous or radioactive contaminants—after completion of the test waste retrievals in Pits 9 and 4 and vapor extraction to remove volatile organic contaminants. A number of possible cap designs (e.g., modified RCRA Subtitle "C" Type, evapotranspiration, etc.) are available that would likely provide sufficient hydrologic isolation of the landfill contaminants. One design that has been considered for the SDA (Schofield, 2002; Zitnik et al., 2002) is the same as that selected for the Idaho Site CERCLA Disposal Facility (ICDF) landfill. This cap is a modified RCRA Subtitle "C" type cap (Zitnik et al., 2002), which includes a low-permeability layer to limit surface water infiltration as well as a biotic barrier to deter intrusion into the burial site from burrowing animals and deep-rooted plants. The cap would also include a gas collection layer to control future volatile organic compound emissions from the buried waste. However, an evapotranspiration cap may be a simpler, more viable approach currently under consideration for the SDA (Holdren & Broomfield, 2004). Furthermore, because there is an active low-level waste disposal program in the SDA, cap installation may have to be completed using a phased approach.

The primary option being considered for immobilizing contaminants in place before a cap is installed is *in situ* grouting. Pretreatment using *in situ* thermal desorption would be performed, if found necessary, on selected pits and trenches with high volatile organic concentrations prior to *in situ* grouting operations. Therefore, evaluation of this alternative requires:

1. defining the waste inventory in the SDA and determining the geographical distribution of contaminants of potential concern,
2. determining what, if any, pretreatment and stabilization measures are necessary prior to cap installation, and
3. determining the type of surface barrier or cap (e.g., modified RCRA Type "C" or evapotranspiration) to be placed over the SDA.

## 5.4. Additional Information for Alternative 2 (Retrieve/Treat/Dispose)

Alternative 2 requires retrieving and treating wastes for both on-site (in the cases of low-level and mixed low-level wastes) and off-site (for TRU waste) disposal. During retrieval activities high-level waste, spent nuclear fuel, or wastes similar to high-level waste and spent nuclear fuel may be encountered (Schofield, 2002; Zitnik, 2002; Holdren & Broomfield, 2004). The *Short-Term Risk Evaluation* (Schofield, 2002) suggests that, if such material is encountered, it would be removed to a separate cell, grouted, and contained in place in either a cell or trench.

However, if this material is either high-level waste or has properties similar to spent nuclear fuel, it may be required to be disposed of as such and the operations necessary for its retrieval need to be included in this alternative and its evaluation. For example, the Nuclear Waste Policy Act of 1982 (as amended) specifies that high-level radioactive waste will be disposed of underground, in a deep geologic repository (currently proposed off-site at Yucca Mountain, Nevada) and not grouted in-place. Furthermore, the 1995 Settlement Agreement[53] between the Governor of Idaho, DOE, and the Department of the Navy states that "DOE shall treat all high-level waste currently at [the Idaho Site] so that it is ready to be moved out of Idaho for disposal by a target date of 2035."

This alternative also includes placement of a protective barrier over the entire SDA after retrieval activities have been concluded. For Alternative 2, retrieved waste will be treated and managed on-site (i.e., returned to the SDA or stored at some other on-site location) if classified non-TRU waste. If the retrieved waste is classified as TRU waste, it will be packaged for shipment to WIPP for disposal. Truck and rail are possible transportation alternatives to WIPP. To evaluate this alternative, the following decisions must be made:

1) the extent to which contaminated material must be retrieved,
2) the extent to which the retrieved non-TRU material must be treated (to remove organics, fixate regulated metals and radionuclides, etc.) before on-site disposal (Zitnik et al., 2002),
3) the non-TRU material packaging requirements (for on-site disposal),
4) the extent to which retrieved TRU material must be treated (to solidify liquids, remove prohibited items, and eliminate ignitability, corrosivity, or reactivity) before packaging for shipment to the Waste Isolation Pilot Plant (WIPP) (Zitnik et al., 2002),
5) the TRU material packaging requirements (for WIPP disposal), and
6) the method (e.g., truck or rail) and route(s) by which the packaged TRU waste will be transported to WIPP.

As indicated in Table 3, the primary difference between the two options for Alternative 2 is the extent to which the Rocky Flats Plant buried wastes must be retrieved from the SDA.[54] Once removed, the wastes will be segregated (i.e., into TRU, low-level, mixed low-level, and special handling fractions), treated, and packaged for either disposal on-site (for the low-level and mixed low-level fractions) or transportation to WIPP (for the TRU fraction). For example, the Transuranic Package Transporter Model 2 (TRUPACT-II) and RH-72B could be used to transport contact-handled (CH) and remote-handled (RH) TRU wastes, respectively, to WIPP (Schofield, 2002).

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[53] The 1995 Settlement Agreement was found at www.id.doe.gov/doeid/RFP-NE&NSD/SEC%20J%20Attachments/J-M%201995%20SA.pdf.

[54] There has been litigation concerning the extent to which the buried transuranic wastes must be retrieved from the Subsurface Disposal Area (NRC, 2005), and there may be additional legal action taken in the future. Therefore, there is likely to be a great deal of programmatic uncertainty associated with Alternative 2.

# 6. Risk Evaluation Framework

In this section, a framework for evaluating the risks associated with the remedial alternatives considered is presented. This information provides a structure for risk evaluation and insights to those areas where further detailed analysis is warranted.

Characterization of risk for a remedial alternative requires the identification of what may go wrong (i.e., those activities or events that may result in an adverse outcome, e.g., injury, fatality, etc.); the likelihood of an adverse event; the severity of the adverse outcome (i.e., consequences); and the affected population. A preliminary risk characterization was achieved through the following steps:

1. Task lists were developed in conjunction with the management flow diagrams described in Section 5, which include the primary subtasks required to implement the alternatives. The task lists for Alternative 1 and Alternative 2 are provided in Appendix B and Appendix C, respectively.
2. Risk flow diagrams were developed (as shown in Section 0) for the alternatives that indicate the sequences of activities that have the potential to pose significant health risks to workers or the general public. These risk flow diagrams incorporate conceptual site models (in Appendix D and Appendix E) for each activity that indicate potential hazards, failure and release modes, transport pathways or media, exposure mechanisms, and impacted populations.
3. Uniform terminologies and categories are necessary to characterize both the knowledge gaps and risks in a meaningful fashion. The applicable terminology is provided in Appendix F.
4. Detailed hazard analyses are provided for Alternative 1 and Alternative 2 in Appendix G and Appendix H, respectively. For each primary subtask, the following is determined: the task frequency, what can potentially go wrong, how likely is the adverse event to occur, the severity of the consequences, the impacted population, the basis for characterizing the risk, and the contribution of the subtask to overall risk of the remedial alternative.
5. Detailed gap analyses describing the key knowledge barriers, missing information, and uncertainties involved in implementing Alternative 1 and Alternative 2 are provided in Appendix I and Appendix J, respectively, and summarized in Section 8. For each primary subtask, knowledge gaps were identified and then characterized by: what information is missing, how important the missing information is, and how large the knowledge gap is according to the terminology provided in Appendix F.
6. An integrated hazard and gap analysis was performed and is provided in the form of a summary table (Table 4 in Section 0) of the most important potential risks and information gaps for the remedial alternatives considered.

A recent National Research Council report stresses the importance of balancing public health with worker and environmental risks, costs, achievability, and other site-specific factors when developing a risk-based approach (NRC, 2005). The aforementioned observations were made in the context of possible exemption of certain high-level and transuranic wastes from disposal in a geologic repository; however, the observations have broader implications and applicability. Furthermore, they are consistent with the framework approach employed herein.

A preliminary risk characterization and identification of the most important information gaps were developed based primarily upon review of the extensive document database provided in the Idaho Site Administrative Record concerning details of the Idaho Site CERCLA process.[55] Related materials pertaining to other sites (e.g., Oak Ridge National Laboratory, Waste Isolation Pilot Plant, etc.) within the DOE Complex were also utilized. Idaho Site personnel provided additional insights and answered extensive questions. The results of the review expressed in this report reflect the judgment and opinions of the authors, who collectively have extensive relevant experience. However, further detailed analysis and evolving information may identify additional considerations that impact risk characterization for the remedial alternatives considered in this report. The risk characterization process itself should be viewed as a vehicle for gathering and organizing additional information as well as assessing the new information to inform the overall management and decision process.

This report was developed to promote a more broad discussion amongst DOE, regulators, public representatives, and the general public on the most appropriate path forward for remediation of the wastes buried in the SDA. Risk is but one of several important aspects that must be considered in decisions impacting public welfare. Imperfect and/or incomplete information, inherent variability and uncertainty, and differences in individual values and perspectives will undoubtedly lead to differing views on the appropriate path forward. These differences highlight the necessity for a clearly defined and engaged stakeholder participation process as an integral part of the on-going decision and management process for wastes buried in the SDA.

## 6.1. Major Process Components for the Alternatives Considered

As indicated in Table 3, the primary alternatives considered in this report are

1. Contain the wastes buried in the SDA in-place
2. Retrieve buried wastes and treat the wastes for both on-site (in the cases of low-level and mixed low-level wastes) and off-site (for TRU waste) disposal

These alternatives can be broken down into the major process steps required to achieve successful completion of the remedial action. Commonality amongst individual process steps within the alternatives (and remedial options) allowed identification of the primary risk drivers within each process step and highlighting how the risk drivers changed from one alternative to the other as well as one remedial option to another. There are 14 basic process steps that were identified for the alternatives for dispositioning wastes currently buried in the SDA. These process steps are

[55] The Idaho Site Administrative Record can be accessed via http://ar.inel.gov.

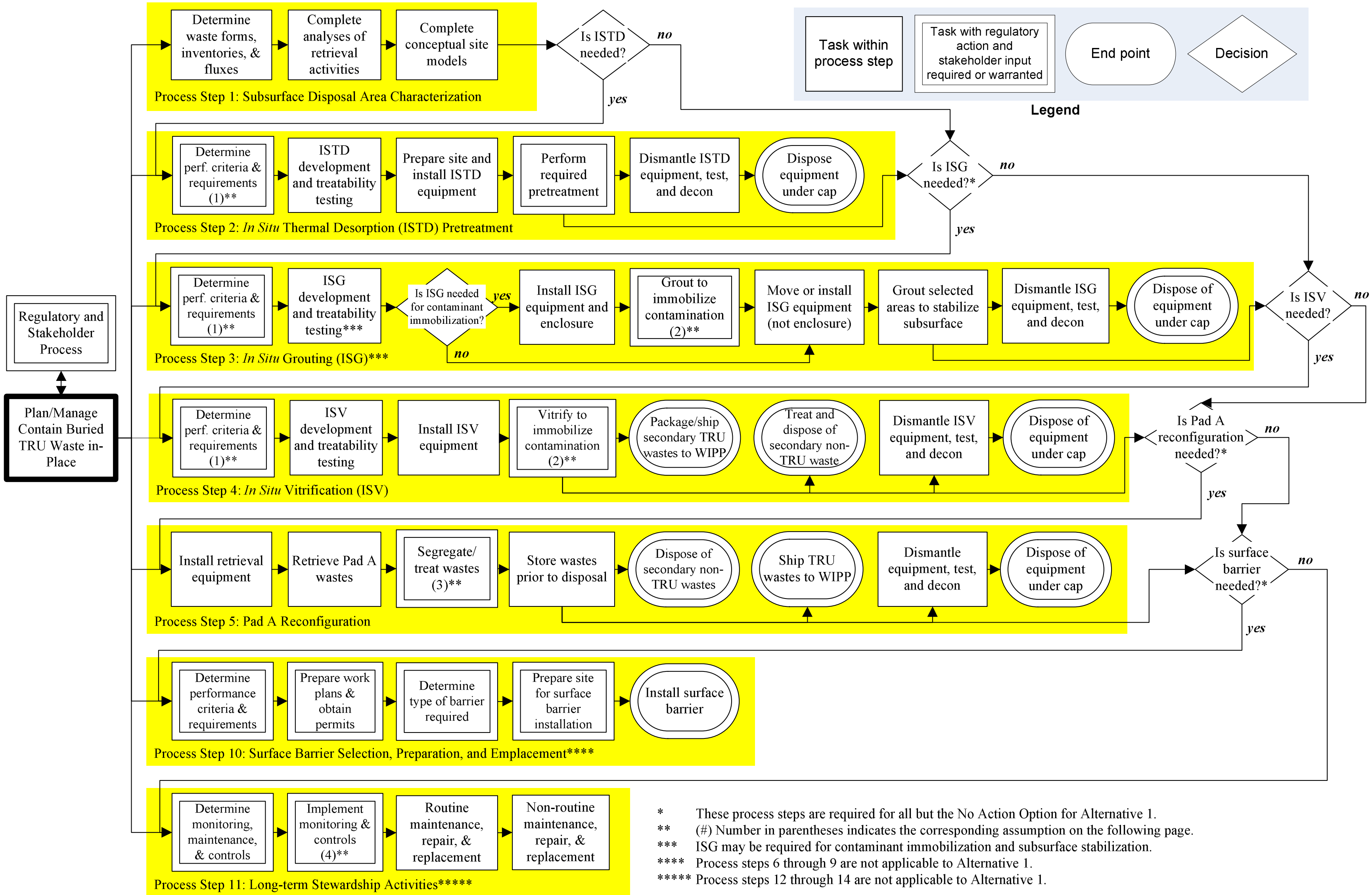
1. Subsurface Disposal Area (SDA) Characterization
2. *In Situ* Thermal Desorption Pretreatment
3. *In Situ* Grouting
4. *In Situ* Vitrification
5. Pad A Reconfiguration
6. Locate, Retrieve, and Segregate Buried Waste
7. *Ex Situ* Treatment (e.g., Compaction)
8. Package Retrieved Wastes
9. Intermediate Storage of Retrieved and Packaged Wastes
10. Surface Barrier Selection, Preparation, and Emplacement
11. Long-term Stewardship Activities for the SDA
12. Construct New SDA Disposal Cell
13. Long-term Stewardship Activities for New SDA Disposal Cell
14. Off-site Shipment and Disposal at WIPP

As indicated in Table 3, all process steps are not required for each alternative. The characteristics of the buried waste site and the extent to which remediation must be exercised impact the decision logic and risks associated with the remedial actions. To evaluate these considerations, management flow diagrams were developed for each alternative.

Two sets of diagrams are provided for each alternative in this report: the aforementioned management flow diagram and a risk evaluation framework or risk flow diagram. The management flow diagram for an alternative consists of the general steps that must be completed—and the order in which they should be taken—to provide a protective end-state for the wastes buried in the SDA. The companion risk flow diagram, which will be discussed in Section 0, provides a detailed delineation of the major sources of risk both to workers and the general public.

### 6.1.1. Management Flow Diagram for Alternative 1

The management flow diagram for Alternative 1 (i.e., contain in-place) is provided in Figure 6. This may be used to evaluate the SDA as a whole, or, applied to sub-areas of the SDA to evaluate which areas or "hot-spots" warrant different remedial actions from the majority of the site. This alternative is based upon the assumption that no wastes will be retrieved (other than those already retrieved or will be retrieved during the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b)). Note that the four options, with the exception of the No Action option, are reasonably similar in terms of the actions that will be executed; therefore, only a single management flow diagram (i.e., Figure 6) has been constructed for the options under the contain-in-place alternative.

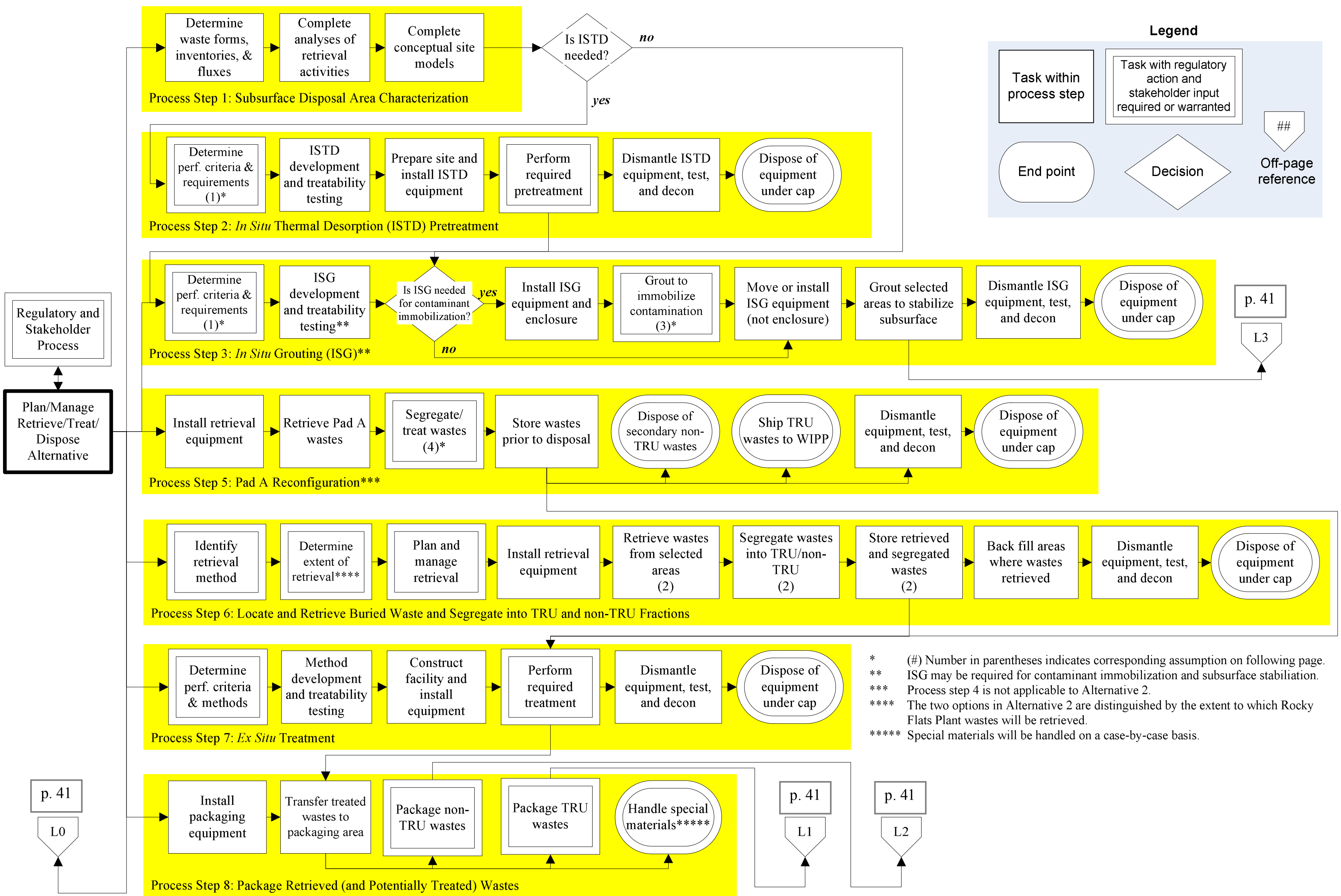



* These process steps are required for all but the No Action Option for Alternative 1.
** (#) Number in parentheses indicates the corresponding assumption on the following page.
*** ISG may be required for contaminant immobilization and subsurface stabilization.
**** Process steps 6 through 9 are not applicable to Alternative 1.
***** Process steps 12 through 14 are not applicable to Alternative 1.

**Figure 6. Management flow diagram for Idaho Site Buried Waste Disposition Alternative 1: Contain in Place. The No Action Option includes only Long-term Stewardship and Institutional Controls.**

**Assumptions for Figure 6 Alternative 1: Contain in Place (with or without *In Situ* Treatment and Stabilization)**

1. The impact of the organic contamination in the vadose zone (OCVZ) treatment system is not considered in this analysis of Alternative 1. Continued use of the OCVZ treatment system could reduce groundwater risks associated with VOCs significantly (Zitnik et al., 2002; DOE-ID, 1994a), and thus the analysis should be conservative. Areas may be discovered prior to capping with high VOC concentrations that must be treated with *in situ* thermal desorption.
2. Alternative 1 assumes either that (i) the subsurface contamination will not need to be stabilized for a protective condition to result (for the No Action option) or (ii) either *in situ* grouting or *in situ* vitrification will be adequate to immobilize the contaminants of potential concern to permit installation of the final surface barrier.
3. Alternative 1 assumes that the Pad A wastes will be retrieved and processed through an external sorting/packaging facility (that must be constructed in the RWMC). Then the packaged Pad A wastes will be placed under the surface barrier near the center of the SDA. Also this alternative assumes that there will be temporary storage available for the Pad A wastes prior to both processing and disposal in the SDA.
4. Alternative 1 assumes that there are both the regulatory and funding mechanisms in place to support the appropriate long-term stewardship of the SDA site after capping.




* (#) Number in parentheses indicates corresponding assumption on following page.
** ISG may be required for contaminant immobilization and subsurface stabilization.
*** Process step 4 is not applicable to Alternative 2.
**** The two options in Alternative 2 are distinguished by the extent to which Rocky Flats Plant wastes will be retrieved.
***** Special materials will be handled on a case-by-case basis.

**Figure 7. Management flow diagram (1 of 2) for Idaho Site Buried Waste Disposition Alternative 2: Retrieve/Treat/Dispose**

**Assumptions for Figure 7 Alternative 2: Retrieve/Treat/Dispose**

1. The impact of the organic contamination in the vadose zone (OCVZ) treatment system on the waste inventory is not considered in this analysis for Alternative 2. Continued use of this treatment system could reduce groundwater risks associated with volatile organic contaminants significantly (Zitnik et al., 2002; DOE-ID, 1994a), and thus the analysis should be conservative. Areas may be discovered in the Subsurface Disposal Area (SDA) with high volatile organic contaminant concentrations that will be treated with *in situ* thermal desorption (ISTD).
2. Alternative 2 assumes that facilities will be in place to both retrieve and segregate any wastes retrieved from the SDA. For example, during retrieval activities high-level waste (HLW) or spent nuclear fuel (SNF) may be encountered as well as TRU, low-level, and mixed low-level wastes (Schofield, 2002). If HLW or SNF material is encountered, Idaho Site personnel have proposed that it will be removed to a separate cell, grouted, and contained in-place in either a cell or trench (Schofield, 2002). However, if this material is high-level waste, it may be required to be disposed of as such, that is, underground, in a deep geologic repository.
3. Alternative 2 assumes that *in situ* grouting will be adequate to immobilize the contaminants of potential concern in selected areas prior to installation of the selected engineered surface barrier. *In situ* grouting will be required for geotechnical stabilization even though buried wastes will be retrieved (Zitnik et al., 2002).
4. Alternative 2 assumes that the Pad A wastes will be retrieved and processed through an external sorting/packaging facility (that must be constructed in the RWMC). Then the packaged Pad A wastes will then be emplaced under the surface barrier near the center of the SDA. Also this alternative assumes that there will be temporary storage available for the Pad A wastes prior to both processing and emplacement.

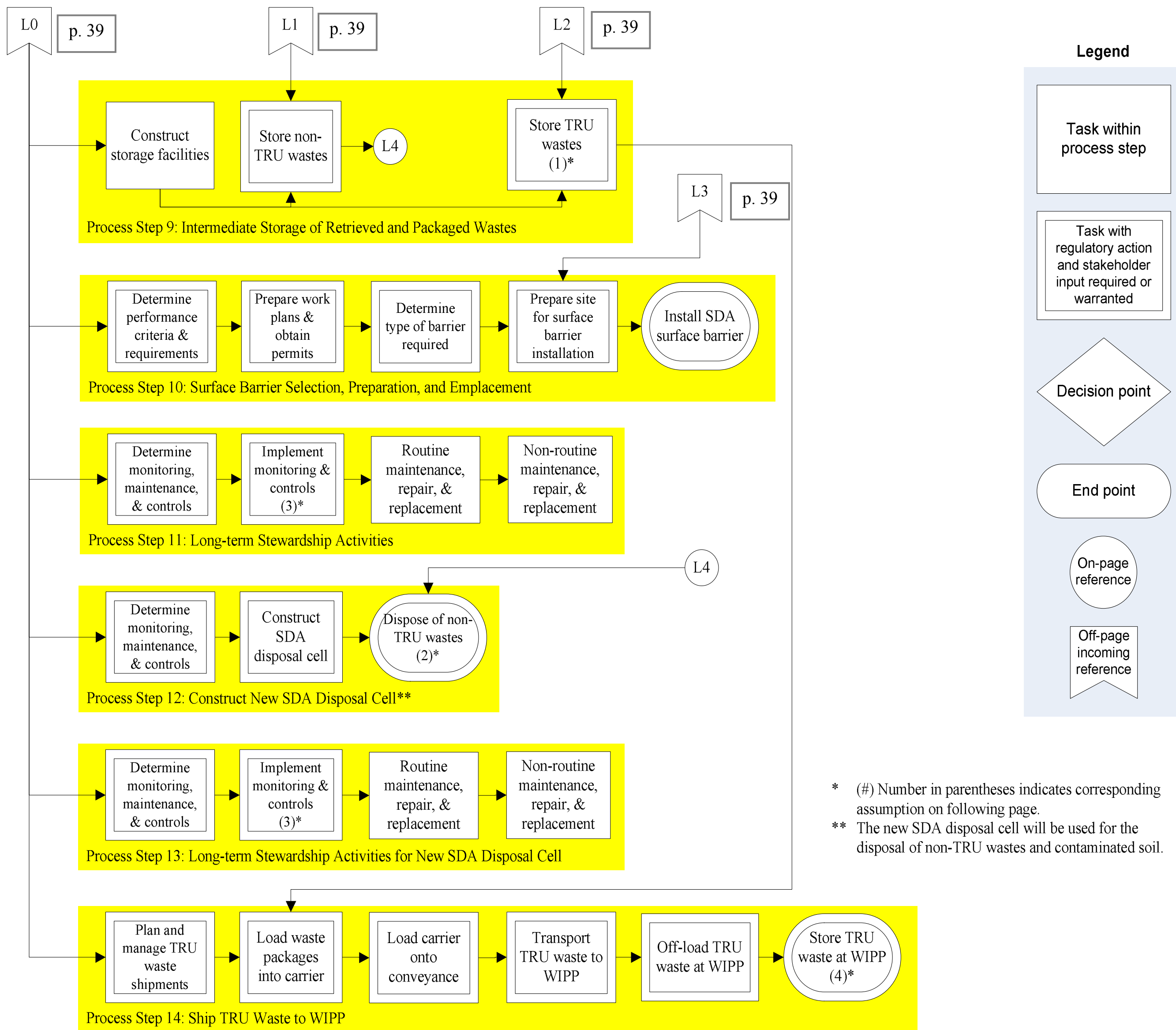



**Figure 8. Management flow diagram (2 of 2) for Idaho Site Buried Waste Disposition Alternative 2: Retrieve/Treat/Dispose**

**Assumptions for Figure 8 Alternative 2: Retrieve/Treat/Dispose**

1. Alternative 2 assumes that there will be a facility that can store the packaged TRU containers until they can be shipped to WIPP.
2. Alternative 2 assumes that the appropriate regulatory and physical mechanisms are in place to manage and store low-level waste on the Idaho Site. For example, the low-level and mixed low-level wastes may be emplaced near the center of the SDA prior to capping (Zitnik et al., 2002).
3. Alternative 2 assumes that there are both the regulatory and funding mechanisms in place to support the appropriate long-term stewardship of the SDA site after capping.
4. Alternative 2 assumes that there will be sufficient capacity at WIPP to store the TRU waste retrieved from the SDA (and then treated and packaged).

The major process-related decision points for Alternative 1 within the management diagram (Figure 6) are

- Whether or not pretreatment using *in situ* thermal desorption (ISTD) will be needed for those areas with high residual organic contaminant concentrations.
- Whether or not *in situ* stabilization (e.g., grouting or vitrification) will be necessary.
- The type of surface barrier (e.g., modified RCRA Type "C" or evapotranspiration) will be used.

### 6.1.2. Management Flow Diagram for Alternative 2

The management flow diagram for Alternative 2, retrieve, treat, and dispose (RTD) with subsequent capping, is provided in Figure 7 and Figure 8. The two options for this alternative are similar in terms of the actions that must be executed (i.e., they differ in the extent of buried material that will be retrieved); therefore, only one management flow diagram (i.e., that in Figure 7 and Figure 8) is provided for the two options under consideration. The major process-related decision points within the management flow diagram include:

- Definition of the locations for waste retrieval that would result in significant risk reduction.
- The type of enclosure and retrieval process necessary to ensure worker protection.
- The types of *ex situ* treatment (e.g., physical, chemical, or thermal) and packaging necessary for both non-TRU and TRU wastes.
- Whether or not pretreatment using *in situ* thermal desorption (ISTD) will be needed for areas with high residual organic contaminant concentrations. There is an on-going treatment operation to remove organic contamination in the vadose zone (Housley & Sondrup, 2004).
- Whether or not *in situ* stabilization (e.g., grouting or vitrification) will be needed for contaminant immobilization.
- The type of surface barrier (e.g., modified RCRA Type "C" or evapotranspiration) that will be used.

The two alternatives presented (i.e., contain the wastes in-place and retrieve, treat, and dispose) bracket the management pathways because they involve either minimal action (contain the waste in-place with continued monitoring) or full Rocky Flats Plant TRU waste retrieval and shipment to WIPP. Remedial actions may need to include the entire SDA or specific, high-risk sub-areas of concern (i.e., "hot-spots")—the proposed framework can address these issues of scale. Institutional controls will be added to either alternative to restrict access and enforce future land use decisions. It is assumed that environmental monitoring, cap integrity monitoring, and maintenance would be conducted on an annual basis to prevent significant cap degradation. Provisions would also be established for access restrictions and necessary maintenance.

# 7. Preliminary Conceptual-level Hazard and Risk Analysis

Risk flow diagrams help form the foundation for life-cycle risk assessment and comparison. These diagrams indicate the sequence of steps that have the potential to pose significant human health risks to workers or the public. The top-level, life-cycle risk flow diagram for the Idaho Site buried waste is presented in Figure 9. Note that one of the steps taken prior to evaluating the various alternatives is to examine and evaluate the current, baseline, or "No Action" (in CERCLA terms) situation. This can be done by examining the risks associated with the relevant conceptual site model provided in Figure 10.

## *7.1. Alternative 1 – Elements of Risk*

The first alternative for the disposition of buried wastes at the Idaho Site considered in this report is containing the waste in place using a surface barrier without first excavating (and retrieving) any of the wastes (other than the volatile organic constituents via vapor extraction). As illustrated in Table 3, there are three potential options: 1) no stabilization, 2) stabilization using *in situ* grouting, and 3) stabilization using *in situ* vitrification. All three options involve placement of a surface barrier with various degrees of *in situ* waste treatment. The major steps involved that present significant potential risk elements are indicated in Figure 11 and Figure 12.

### 7.1.1. Conceptual Site Models for Alternative 1

The conceptual site model for the current state of the Idaho Site buried waste sites in the SDA was depicted in Figure 10. Note that this conceptual model is independent of the disposition option and thus can be examined prior to analyzing the risks associated with any alternative.

The first step in this alternative (as illustrated in Figure 11) is to determine whether or not areas there are areas in the SDA with excessively high concentrations of volatile organic constituents that must be treated. The prescribed treatment is *in situ* thermal desorption (Zitnik et al., 2002; Holdren & Broomfield, 2004). It has been suggested that *in situ* thermal desorption may not be necessary (Holdren & Broomfield, 2004); hence the pertinent decision point in Figure 11.[56]

[56] The pertinent conceptual site model for the *in situ* thermal desorption process is provided in Figure D-1.

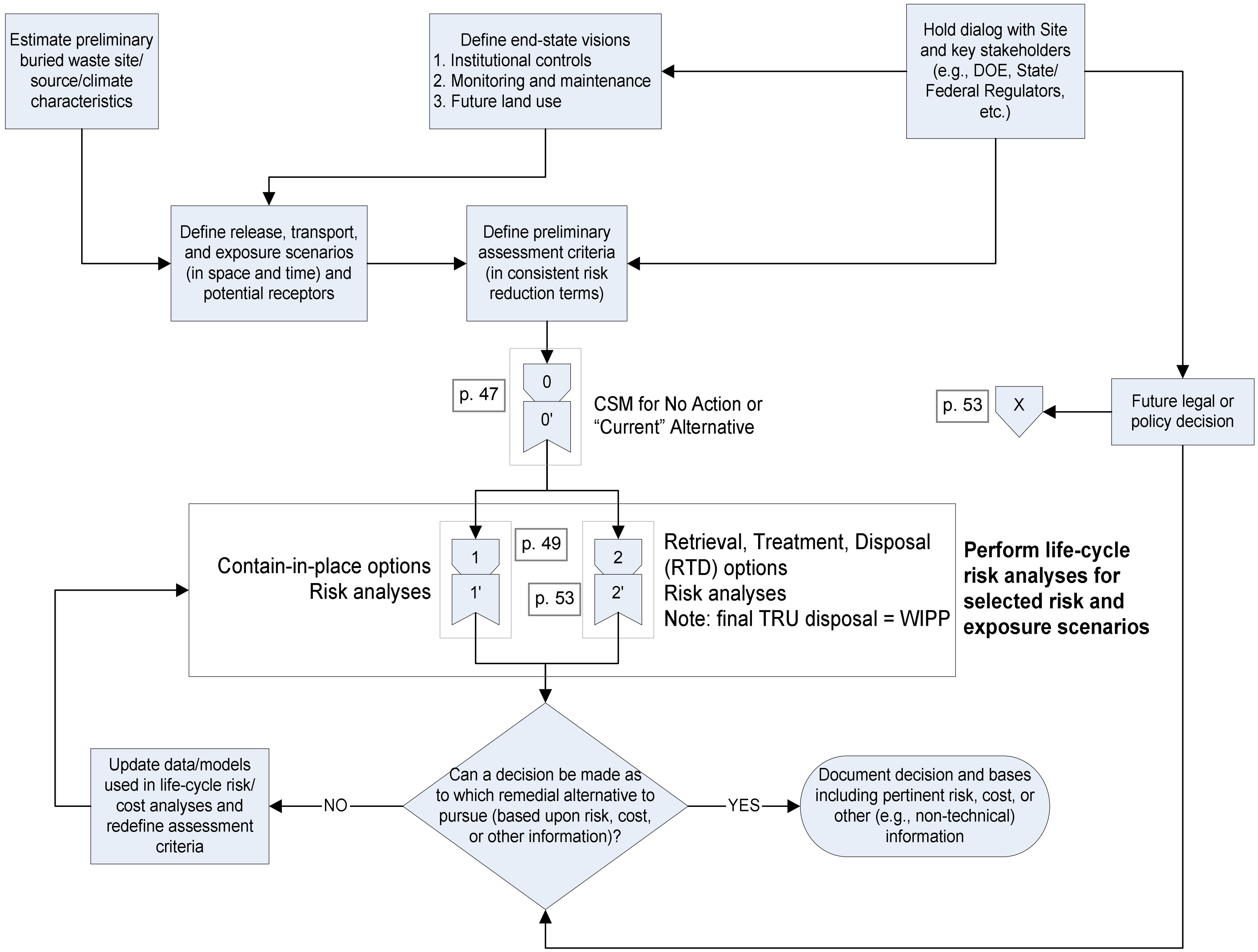



**Figure 9. Idaho Site Risk Flow Diagram for Buried Wastes**

The next step in the process (illustrated in Figure 11) is to disposition (or reconfigure) the waste and other material in Pad A. This is an above grade disposal Pad A that cannot be buried under the surface barrier (as it will cause instability). Thus the material will be retrieved and the waste will be sent to an *ex situ* treatment facility (i.e., which is also called for in the RTD alternative). In this paper, the primary *ex situ* treatment technology for the wastes retrieved from the SDA is assumed to be compaction.[57]

Once Pad A has been reconfigured, the next issue that must be considered in this alternative is the extent of *in situ* grouting that will be necessary. It is assumed that some degree of *in situ* grouting will be necessary for geotechnical stabilization against subsidence prior to surface barrier emplacement (or capping) (Zitnik et al., 2002; Holdren & Broomfield, 2004).[58] The decision to be made is whether there will be areas of high contaminant concentrations that must be immobilized using *in situ* grouting prior to capping. This decision should be made after the relevant risks are quantified and compared.[59]

As indicated above, a decision must be made as to what kind of *in situ* treatment would be needed if none of the Rocky Flats Plant wastes are removed. It appears that the decision has been made by Idaho Site personnel that *in situ* vitrification would be unnecessary or inappropriate under any circumstances (Holdren & Broomfield, 2004). However, *in situ* vitrification has been included in this alternative for comparison purposes and completeness especially because the life-cycle risks have not been quantified to this point.[60] There again is a decision point as to whether or not *in situ* vitrification would be necessary to provide sufficient protection against contaminant migration.

Once the volatile organic constituents have been treated (if necessary), Pad A has been reconfigured, the subsurface has been stabilized using *in situ* grouting, and Rocky Flats Plant wastes immobilized using *in situ* grouting or *in situ* vitrification (if necessary), then the final step will be to emplace a surface barrier to limit infiltration into the buried waste site (and possibly prevent biotic intrusion). The capping process may have to be executed in stages because there is still an active low-level waste disposal program in the SDA.[61]

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57 The conceptual site model for the Pad A reconfiguration is illustrated in Figure D-2.

58 Other methods (e.g., preloading or dynamic compaction) for subsidence control may be considered for the SDA (Zitnik et al., 2002; Holdren & Broomfield, 2004); however, it is assumed in this report that *in situ* grouting will be used prior to surface barrier installation.

59 The pertinent conceptual site model for the *in situ* grouting process is provided in Figure D-3.

60 The conceptual site model for *in situ* vitrification is provided in Figure D-4.

61 A conceptual site model representing the capping process (as shown in Figure 12) for the buried waste site is depicted in Figure D-5. A conceptual site model representing a possible protective end state for the buried wastes in the SDA after surface barrier installation is depicted in Figure D-6.

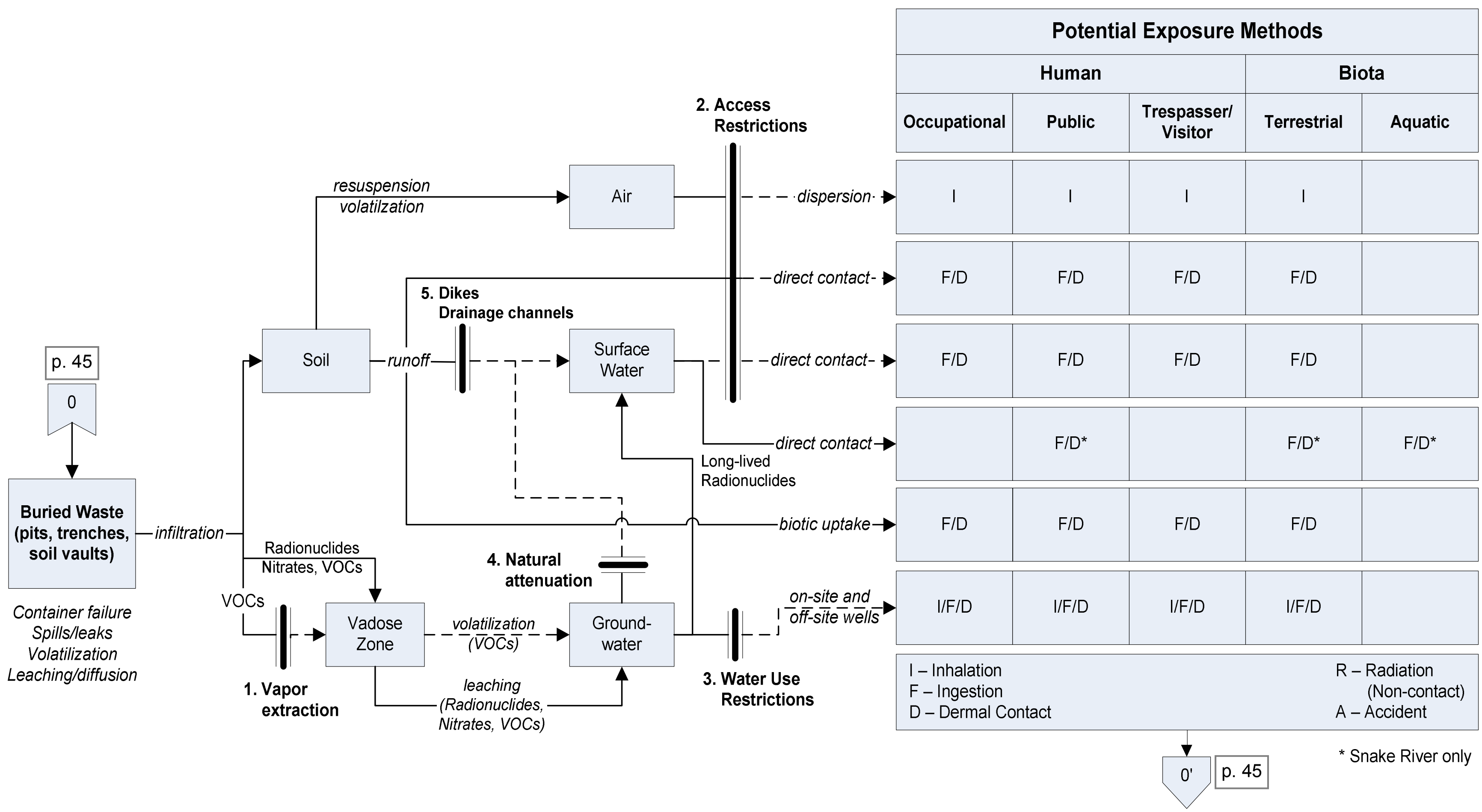


**Figure 10. Conceptual Site Model (CSM) Representation for the Idaho Site Buried Waste Area – Current or "No Action" State**[62]

[62] Vapor extraction is included in the "No Action" conceptual site model because this is an on-going process.

**Narrative for Figure 10 Conceptual Site Model (CSM) Representation for the Idaho Site Buried Waste Area – Current or "No Action" State**

Volatile organic compounds (i.e., carbon tetrachloride and tetrachloroethylene) and nitrates pose the most imminent risk to human health (Becker et al., 1998; DOE-ID, 2004a). Carbon tetrachloride has been detected in the Snake River Plain Aquifer (SRPA) above the maximum contaminant level (MCL) and is being extracted from the vadose zone to reduce said risk. Mobile long-lived fission and activation products are the next most immediate concern (Becker et al., 1998; DOE-ID, 2004a).

The following barriers (or steps taken to mitigate impacts) are shown in Figure 10:

1. A vapor extraction system extending into the vadose zone is being used to mitigate VOC migration to the aquifer (DOE-ID, 2004a). Multiple vapor vacuum extraction with treatment units were installed within the SDA and brought into operation in 1996. Data from monitoring well vapor samples are being used to assess the effectiveness of the remedy and to optimize VOC removal.
2. The Idaho Site has restricted access to prevent intrusion by the public, and the SDA is surrounded by a security fence (DOE-ID, 2004a).
3. An extensive groundwater-monitoring program is in place at RWMC. Drinking water wells used to supply potable water to the work force are located outside of the SDA and are routinely monitored for water quality (DOE-ID, 2004a).
4. Natural attenuation of volatile organic compounds, nitrates, short-lived radionuclides (e.g., Cs-137, Sr-90, etc.), and some (e.g., immobile) long-lived radionuclides will prevent them from reaching the Snake River via the Snake River plain Aquifer.
5. An extensive surface water management system, including dikes and drainage channels, has been implemented at the SDA to minimize the potential for flooding and releases by way of surface water (DOE-ID, 2004a).

For very long-lived and reasonably mobile radionuclides (as well as mobile nitrates and heavy metals) that are already in the vadose zone, a pathway exists from the SDA to the Snake River via the vadose zone and groundwater. The only potential "barriers" that exist are decay, dispersion, and dilution for the radionuclides and dispersion and dilution for the nitrates and heavy metals.

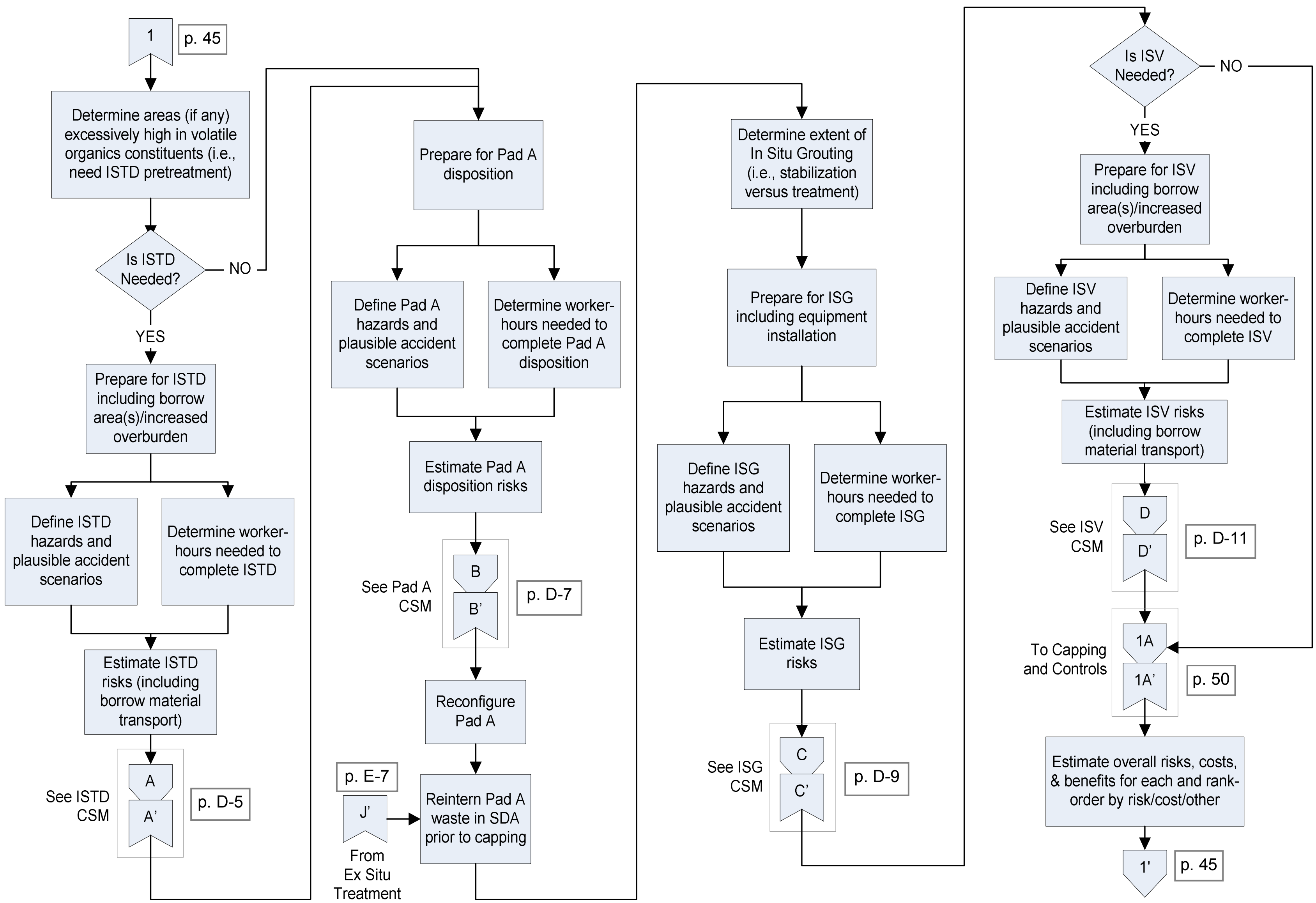


**Figure 11. Idaho Site Alternative 1: Contain in Place (1 of 2)**

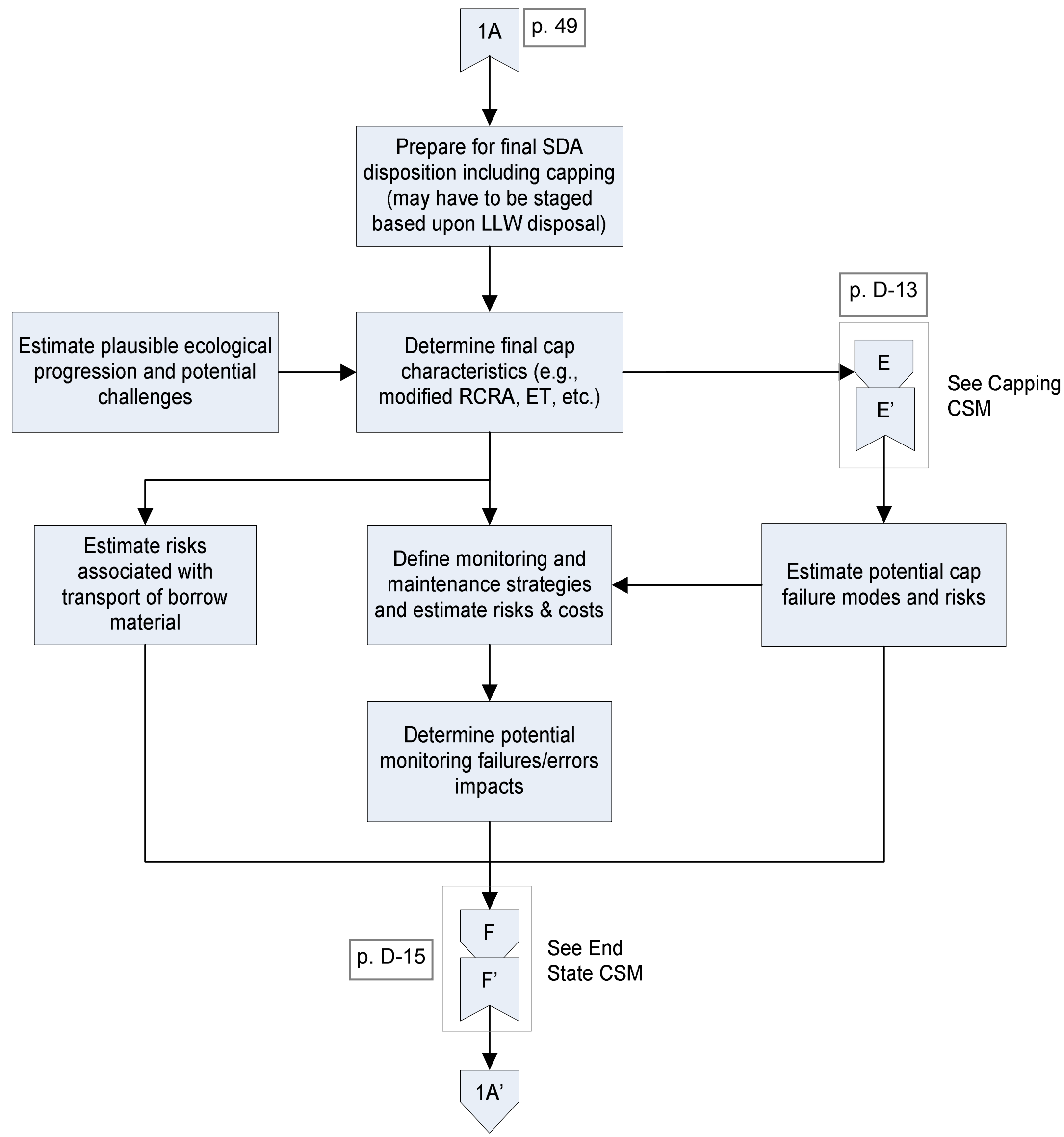


**Figure 12. Idaho Site Alternative 1: Contain in Place (2 of 2)**

## 7.2. *Alternative 2 – Elements of Risk*

The second alternative for the disposition of buried waste at the Idaho Site considered in this report is to retrieve, treat ex situ (e.g., using compaction), package, transport TRU to WIPP, and dispose TRU waste at WIPP and low-level wastes at the Idaho Site (likely in the SDA under the cap). The major steps involved that have significant, potential risk elements are illustrated in Figure 13. There are many similarities between the flowcharts for the two alternatives.

### 7.2.1. Conceptual Site Models for Alternative 2

The conceptual site model for the current or No Action state of the Idaho Site buried waste site in the SDA is depicted in Figure 10. This conceptual site model is irrespective of the final disposition alternative and can be evaluated prior to examining alternatives. The first step in this alternative is to determine the extent to which Rocky Flats Plant TRU wastes must be retrieved from the SDA to provide a protective end state. (This step is illustrated in Figure 13 and may be influenced by future litigation.) Once the extent to which Rocky Flats Plant TRU wastes must be retrieved is determined, then the material will be retrieved based upon experience gained in the Pit 9 and Pit 4 test retrievals.[63]

After the Rocky Flats Plant wastes have been retrieved for subsequent *ex situ* treatment (e.g., using compaction as discussed below), the disposition of the SDA is very similar to that for the contain-in-place alternative outlined in Figure 11 and Figure 12.[64] However, because of the nature of the remaining wastes, very different risks may exist and very different decisions may be made in the modified version of the contain-in-place portion of the retrieve, transport, and dispose alternative. For example, *in situ* thermal desorption, *in situ* grouting, or *in situ* vitrification may not be required for this alternative (i.e., Figure 11); thus worker risks would be significantly different.[65]

Material from Pad A (in this alternative) and Rocky Flats Plant wastes must be treated ex situ in a facility yet to be designed and constructed. Here the primary *ex situ* treatment technology for the wastes retrieved from the SDA is assumed to be compaction (although treatment of volatile organic constituents in retrieved wastes is also likely) (Zitnik et al., 2002).[66]

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63 The conceptual site model for the retrieval (or excavation) process from the SDA is depicted in Figure E-1.

64 This is indicated by the conceptual site model for the “Modified Contain-in-Place” alternative as indicated in Figure E-1.

65 A conceptual site model representing a possible protective end state for wastes remaining in the SDA after retrieval would be very similar to that depicted in Figure D-6 where additional source material would be removed.

66 According to the *Preliminary Evaluation of Remedial Alternatives* (Zitnik et al., 2002), *ex situ* treatment entails treating retrieved soil and waste via chemical, physical, thermal, electrokinetic, or biological technologies. These technologies focus on physical and radiological segregation as well as processing to reduce toxicity, mobility, and waste volume. The necessary processing depends on pertinent requirements for specific waste, but could include sizing, treatment to destroy organics or stabilize heavy metals, absorption of liquids, and repackaging. *Ex situ* treatment for TRU waste and soil will be focused primarily on segregation and sizing technologies to provide for off-site disposal at WIPP.

Temporary storage will likely be necessary prior to treating all wastes.[67] The treated material must also be packaged for either shipping to WIPP (for ultimate disposal of TRU wastes) or for disposal on-site at the Idaho Site (e.g., under the SDA cap).

Transport of the packaged wastes must now be considered. In this alternative, only those risks associated with transportation of TRU wastes to WIPP are considered; the travel distances for low-level wastes that will be disposed of on-site (e.g., under the SDA cap) are relatively insignificant.[68]

The final step in this alternative is to manage the disposal of the wastes retrieved from the SDA; these wastes will include TRU, low-level, and mixed low-level wastes. The TRU wastes will be transported to WIPP for ultimate disposal and the non-TRU wastes will be assumed disposed of at the Idaho Site (e.g., under the SDA surface barrier).[69] The end state is based on the assumption that any contaminated equipment is disposed of by burial in the SDA under the cap without prior decontamination.[70]

## 7.3. Preliminary Hazard Analysis

The intent of this report is to provide a *framework* for assessing and comparing risks associated with the various remedial alternatives investigated and a preliminary qualitative evaluation of those risks. Detailed hazard analysis tables were developed and are provided for Alternative 1 and Alternative 2 in Appendix G and Appendix H, respectively. For each primary subtask, the following is determined:

- the task frequency,
- what can potentially go wrong,
- how likely is the adverse event to occur,
- the severity of the consequences,
- the impacted population,
- the basis for characterizing the risk, and
- the contribution of the subtask to overall risk of the remedial alternative.

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67 The conceptual site models for the *ex situ* treatment process (i.e., assuming compaction is used) and end state are provided in Figure E-2 and Figure E-3, respectively.

68 The conceptual site models for the transportation process and corresponding end state are provided in Figure E-6 and Figure E-7, respectively.

69 The relevant process and end state conceptual site models for these disposal options are provided in Figure E-8 and Figure E-9, respectively. Note that all pathways are blocked in Figure E-9 indicating that the end state would be protective.

70 The conceptual site models for the packaging process and end state are provided in Figure E-4 and Figure E-5, respectively.

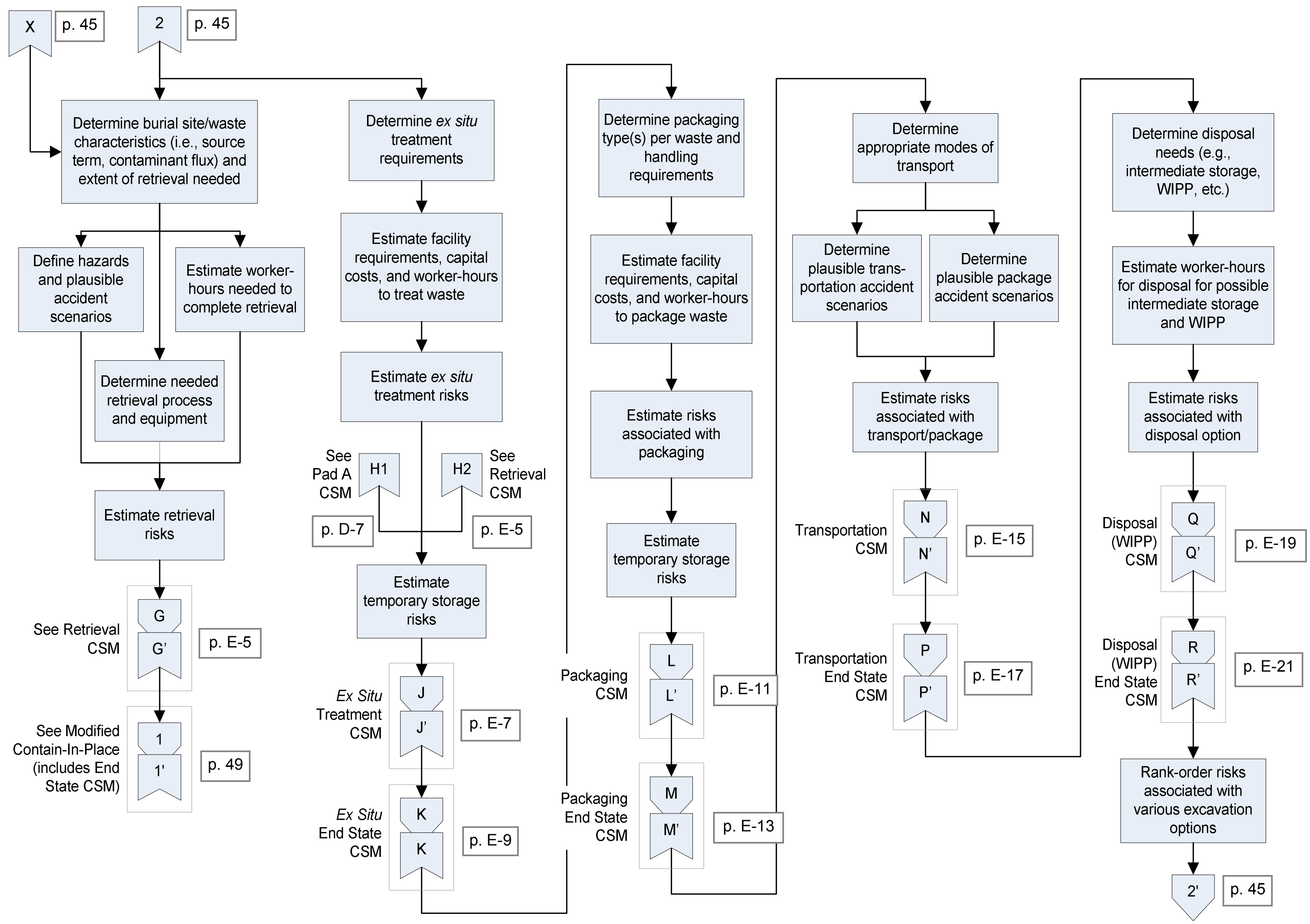


**Figure 13. Idaho Site Alternative 2: Retrieve, Transport, Dispose (RTD)**

The detailed hazard analyses presented in Appendix G and Appendix H for the SDA remedial alternatives are summarized in Table 4. It is impossible for the authors to identify properly every conceivable process hazard at this stage of evaluation. Furthermore, Idaho Site personnel have published two baseline risk assessments (Becker et al., 1998; Holdren et al., 2002) for the SDA as well as one that focuses on the short-term impacts associated with the various remedial alternatives (Schofield, 2002). This examination allows known process risks that are significant in terms of both likelihood and consequence to be identified. Specifically, those events that were deemed (using the definitions in Appendix F) as 1) *probable* and either *critical* or *severe* and 2) *possible* and *severe* were classified as *high-risk* hazards. The focus of the following discussion is on said *high-risk* hazards, which are examined in Table 4. The full preliminary hazard analysis can be found in Appendix G and Appendix H.

The intent of this report is not to rehash existing risk assessment information, but instead to examine the existing risk information from an independent, qualitative perspective and to note when needed risk information is lacking. The risk assessments provided in the *Interim Risk Assessment* and the *Ancillary Basis for Risk Analysis* only provide risk estimates for the baseline or "no action" conditions. The evaluations of risk impacts presented in the Short-term Risk Evaluation do not consider the full life-cycle risks involved in the remedial alternatives considered. Thus potential life-cycle risk reductions that may be achieved through the remedial alternatives considered have not been addressed by the Idaho Site to date.

### 7.3.1. Risk Categories

For the purposes of this evaluation, a *probable* event is defined as something very likely to occur during task execution and a *possible* event is defined as something with a reasonable expectation of occurring. A *severe* consequence is defined as the loss of the ability to satisfy applicable and relevant design and performance criteria and protect human health (both worker and general public) and the environment (both on- and off-site) and a *critical* consequence is defined as significantly degraded performance versus applicable and relevant design and performance criteria and the ability to protect human health and the environment. These terms are further defined in terms of injuries, illnesses, fatalities, environmental damage and equipment or property damage in Appendix F. In this report, permutations of *probable*/*critical*, *possible*/*severe* and *probable*/*severe* combine sufficient likelihood of occurrence with significant human health and environmental impact to deem the corresponding hazards *high-risk*.

The determinations made in this report are based upon the hazard and risk categories defined in Appendix F. Although it is understood that there is not likely to be unanimous agreement on any set of definitions, a common basis must be used for assessing the tasks in question. These definitions allow reviewers to "mean the same thing" when generic terms such as "*low*" or "*high*" are used. Because some assessment of the risks must be made (and precise values cannot be placed on the risks or gaps), the authors have agreed on the descriptions provided. These categories are subject to change as further knowledge is obtained; however, any such set of categories must be both defined and consistent to be of use.

## 7.4. Major Hazards

Based upon the preliminary hazard analysis presented in Appendix G and Appendix H, the most significant hazards are from the *in situ* grouting and *in situ* vitrification process steps. Each of these steps has a subtask that appears to be both *probable* and *severe* (in terms of consequences). For example, *in situ* vitrification has been removed by the Idaho Site from consideration for remediation of the SDA buried wastes (by immobilizing contaminants of potential concern) due to both its inherent hazards as well as costs (Holdren & Broomfield, 2004); this decision would seem warranted based upon the preliminary hazard analysis performed in this report. *In situ* grouting is an alternative for immobilizing subsurface contaminants of potential concern; however, as illustrated in Table 4, this process step also presents significant hazards.

It is the intent of process design and implementation to mitigate hazards and minimize unacceptable risks to the greatest extent practical. However, all hazards and risks cannot be completely mitigated, and as a result, adverse outcomes do occur. Therefore, identification of risks is important not only for process selection, but also to carry out the intended management option as safely as possible.

### 7.4.1. Failure of High-Pressure Grout System Resulting in Projectiles or Grout Release and Injuries (*In Situ* Grouting)

According to the *Preliminary Documented Safety Analysis* for *in situ* grouting in the SDA (Abbott & Santee, 2004), a failure of the high-pressure (6,000 psi) grout system resulting in projectiles or grout release as well as subsequent worker injury or even fatality is *anticipated* during grouting operations.[71] A system similar to that planned for *in situ* grouting use failed during a test program at the Idaho Site and generated a projectile that injured a worker (Abbott & Santee, 2004). No radioactive or hazardous material is used in the grouting system, so none would be released during system failure; however, a "failure could generate a projectile or release high-pressure grout with sufficient energy to cause a fatality" (Abbott & Santee, 2004). Therefore, it appears more than reasonable to classify this failure event as both *probable* and *severe*. The impacts would be restricted to the site. The hazards associated with the grouting would be compounded if it would be used for both contaminant immobilization as well as subsurface stabilization.

[71] According to Table 3-9 in the preliminary safety analysis (Abbott & Santee, 2004) for *in situ* grouting in the SDA, the likelihood category is *anticipated* and the consequence category is *moderate*. *Anticipated* means that the event is expected to occur during the lifetime of the facility (frequency between once in 10 and once in 100 years) and is the most probable likelihood category in the safety analysis. *Moderate* means that there is likelihood of on-site contamination and worker exposures of up to 100 rem (TEDE) and is the second highest of four such categories.

## Table 4. Summary of Most Important Human Health Risks and Knowledge Gaps for the SDA Remedial Alternatives[a]

| Process Step | 1A. No Action | 1B. Surface Barrier | 1C. *In Situ* Grouting | 1D. *In Situ* Vitrification | 2A. Selective Retrieval | 2B. Full Retrieval | What can go wrong?[b] | How likely is it? | What are the consequences? | Who is impacted? | Highest Priority Information Gap(s)[c] | Overall Contribution to Risk[d] (H,S,L,N/C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SDA Characterization | √ | √ | √ | √ | √ | √ | • No *high-risk* hazards | • N/A | • N/A | • N/A | • Potential for facilitated plutonium transport<br>• Possible presence and location of spent fuel or similar material<br>• Geospatial distribution of wastes and waste forms | Significant (0,3,2,2) |
| *In Situ* Thermal Desorption Pretreatment | | √ | √ | √ | √ | √ | • No *high-risk* hazards | • N/A | • N/A | • N/A | • Geospatial distribution of volatile organics | Significant (0,6,14,1) |
| *In Situ* Grouting[e] | | √ | √√ | √√ | √√ | √√ | • Failure of high-pressure grout system resulting in projectiles or grout release and injuries | • Probable | • Severe | • Worker | • Geospatial distribution of wastes and waste forms | High (1-2,4,13-22,1) |
| *In Situ* Vitrification | | | | √ | | | • Injuries and exposure to radiological/toxic chemicals from fire, deflagration, detonation, or melt expulsion | • Probable | • Severe | • Worker Public | • Amounts/distributions of water, volatiles, vapor pockets, and drums<br>• Geospatial distribution of wastes and waste forms | High (1,5,20,2) |
| Pad A Reconfiguration | | √ | √ | √ | √ | √ | • No *high-risk* hazards | • N/A | • N/A | • N/A | • No *high-priority* gaps | Significant (0,6,14,1) |
| Locate, Retrieve, & Segregate Buried Waste | | | | | √ | √ | • Contaminated soil removal resulting in radiological/toxic chemical exposure<br>• Loaded tote-bin dropped outside confinement area releasing radioactive material<br>• Traumatic injury (e.g., cave-in occurs during excavation operation and buries a worker) | • Probable<br>• Probable<br>• Possible | • Critical<br>• Critical<br>• Severe | • Worker<br>• Worker<br>• Worker | • Future legal decisions and resulting actions<br>• Geospatial distribution of wastes and waste forms | Significant-High[f] (0,8,31,3) |

| Process Step | 1A. No Action | 1B. Surface Barrier | 1C. *In Situ* Grouting | 1D. *In Situ* Vitrification | 2A. Selective Retrieval | 2B. Full Retrieval | What can go wrong?[b] | How likely is it? | What are the consequences? | Who is impacted? | Highest Priority Information Gap(s)[c] | Overall Contribution to Risk[d] (H,S,L,N/C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ex Situ* Treatment | | | | | √ | √ | • No *high-risk* hazards | • N/A | • N/A | • N/A | • No *high-priority* gaps | Significant (0,5,13,1) |
| Package Retrieved Wastes | | | | | √ | √ | • Containment/ventilation system failure and resulting exposure to radiological and toxic substances | • Possible | • Severe | • Worker | • No *high-priority* gaps | Significant (0,2,17,0) |
| Intermediate Storage | | | | | √ | √ | • No *high-risk* hazards | • N/A | • N/A | • N/A | • No *high-priority* gaps | Low (0,0,5,0) |
| Surface Barrier Installation | | √ | √ | √ | √ | √ | • No *high-risk* hazards | • N/A | • N/A | • N/A | • No *high-priority* gaps | Low (0,0,8,3) |
| LTS Activities for the SDA | √ | √ | √ | √ | √ | √ | • Failure of LTS (Alternative 1)<br>• Failure of LTS (Alternative 2) | • Probable<br>• Probable | • Severe<br>• Critical | • Public<br>• Public | • Geospatial and temporal distribution of wastes and waste forms | High (1,7,8,1) |
| Construct New Disposal Cell | | | | | √ | √ | • Cave-in during excavation operation and buries a worker | • Possible | • Severe | • Worker | • No *high-priority* gaps | Significant (0,2,12,1) |
| LTS Activities for New SDA Disposal Cell | | | | | √ | √ | • Failure of LTS (Alternative 1)<br>• Failure of LTS (Alternative 2) | • Probable<br>• Probable | • Severe<br>• Critical | • Public<br>• Public | • Geospatial and temporal distribution of wastes and waste forms | High (1,7,8,1) |
| Off-site Shipment and Disposal | | | | | √ | √ | • Injuries from heavy equipment operation | • Probable | • Critical | • Worker | • No *high-priority* gaps | Significant (0,3,11,1) |

*a)* A check (√) indicates that the process step is used in the option. Shading indicates that the process step is not used in the remedial option. "N/A" means "not applicable."

b) *High-risk* hazards are those that are considered by the authors to be 1) *probable* with either *critical* or *severe* consequences or 2) *possible* with *severe* consequences based upon the definitions in Appendix F.

c) *High-priority* gaps are those considered by the authors to be *critical* (in terms of safety) and *large* (meaning little or no information is available) as indicated in Appendix F.

d) The overall contribution to risk for a given process step is based upon the hazard information provided in Appendix G for Alternative 1 or Appendix H for Alternative 2 assessed using the methodology provided in Appendix F for rolling up hazard contributions to a single risk metric. The numbers in parentheses indicate number of failure mode events in a process step that are (*High*, *Significant*, *Low*, *Not Considered*). The subtasks and corresponding failure events change significantly for only the *In Situ* Grouting process step because it may be used for subsurface stabilization as well as subsurface stabilization and contaminant immobilization.

e) Two check marks (√) in this column indicate that in situ grouting will potentially be used for both subsurface stabilization and contaminant immobilization.

f) The fact that there are three *high-risk* hazards associated with this process step makes it highly significant from a risk perspective so much so that is may need to be considered a *high-risk* step even though there are no events that would be considered both *probable* and *severe* (in terms of consequences).

### 7.4.2. Injuries and Exposure to Radiological/Toxic Chemicals from Fire, Deflagration, Detonation, or Melt Expulsion (*In Situ* Vitrification)

According to the *Preliminary Documented Safety Analysis* for *in situ* vitrification in the SDA (Santee, 2003), a melt expulsion is considered “unlikely” to occur during operations; however, if it did occur, the consequences would be considered “high” based upon the definitions in the *Safety Analysis*.[72] Melt expulsions are initiated by conditions below the surface of the melt and could be caused by (Santee, 2003):

(1) Rapid depressurization of a pressurized container (e.g., sealed drums, gas cylinders, etc.),

(2) Steam pressurization resulting from the presence of significant quantities of moisture or volatiles beneath the melt, and

(3) Deflagration from the mixing of nitrate salts and either pyrolyzed combustibles or finely divided graphite.

Of the 300 test, demonstration, or commercial melts using this technique, there have been at least five melt expulsions (Santee, 2003), one of which at the Oak Ridge National Laboratory involved the expulsion of approximately 20 tons of contaminated molten material (DOE, 1996). Fortunately, the radioactive contamination was fixed in the vitrified material in this case. The authors agree with the Idaho Site assessment that the consequences of a failure of this type during SDA processing would be *severe* (as defined in Appendix F) and restricted primarily to on-site impacts. Because the likelihood of such an accident is tied to the presence of sealed drums and volatiles (both of which are present in the SDA in large numbers) and no amount of site conditioning would totally disrupt the integrity of the drums or remove the water or volatiles that this type of failure is deemed *probable* for processing in the SDA. Therefore, the reason to remove *in situ* vitrification as a potential remedial action for immobilizing contaminants of potential concern in the SDA appears reasonable.

### 7.4.3. Injuries and Exposure due to Excavation and Related Material-Handling Activities (Locate, Retrieve, & Segregate Buried Waste)

Other than the *in situ* grouting and *in situ* vitrification process steps, four of the other 12 steps had at least one hazard that was considered to be *high-risk*[73]. These hazards tend to be either traumatic injuries from excavation-related or tote-bin handling activities or exposure due to failure of a containment system. The process step that will be highlighted here is one that presents three *high-risk* hazards (where the others have one each).

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[72] According to Table 3-9 in the preliminary safety analysis (Santee, 2003) for *in situ* vitrification in the SDA, the likelihood category is “unlikely” and the consequence category is “high.” The term “unlikely” indicates that the event may occur but is not anticipated during the lifetime of the facility (frequency between once in 100 and once in 10,000 years) and is the second most probable of four likelihood categories. A “high” consequence event is one where there is likelihood of on- and off-site contamination as well as worker exposures of more than 100 rem (TEDE) and is the highest of four such categories.

[73] High-risk failures are those events that were deemed (using the definitions in Appendix F) as 1) *probable* and either *critical* or *severe* and 2) *possible* and *severe* were classified as *high-risk* hazards. These are highlighted in Table 4.

The Locate, Retrieve, and Segregate Buried Waste (for Alternative 2) process step presents the following three *high-risk* hazards:

- Contaminated soil removal resulting in radiological/toxic chemical exposure
- Loaded tote-bin is dropped outside confinement area releasing radioactive material
- Cave-in occurs during excavation operation and buries a worker or worker is otherwise injured during excavation operations.

Although none of these hazards are deemed both *probable* and have *severe* consequences (which would translate into an overall *high* contribution to alternative risk), the fact that there are three *high-risk* hazards highlights the potential difficulties in retrieving and handling buried wastes from the SDA.

### 7.4.4. Failure of Long-Term Stewardship (Alternative 1)

The risks to the general population associated with Alternative 1 (contain the wastes in-place) depend largely on the effectiveness of the long-term stewardship associated with the SDA. Failure of the long-term stewardship may result in any of the following: site intrusion, inappropriate land or natural resource use, population encroachment, or contamination of the underlying aquifer. Each of these failure mechanisms has the potential to impact a large number of people.

The necessary long-term stewardship will have three primary components: maintaining performance of the engineered containment systems (i.e., final cap); maintaining institutional controls to prevent intrusion, encroachment, and inappropriate land or natural resource use; and effective monitoring strategies for both engineered containment systems and institutional controls. For monitoring strategies to be effective, they must credibly provide warning of system degradation before failure occurs. With respect to engineered containment systems, this implies monitoring the integrity of caps, and moisture and contaminant movement in the vadose zone. This monitoring should be construed as preemptive, rather than monitoring as the basis for the regulatory point of compliance. With respect to institutional controls, regular evaluation of the effectiveness of these controls is necessary. Public acceptance of these measures will depend on the credibility of DOE and the financial and legal mechanisms established for insuring long-term stewardship.

# 8. Gap Analysis

The nature of the risk assessments in the *Ancillary Basis for Risk Analysis* (Holdren et al., 2002) and the *Short-Term Risk Evaluation* (Schofield, 2002) indicate that there are uncertainties and gaps in knowledge that must be addressed prior to completing a comprehensive analysis of the risks posed by placing the wastes buried in the SDA into a more secure state. A detailed analysis of gaps in knowledge is provided in Appendix I and Appendix J for Alternative 1 and 2, respectively. The key knowledge gaps[74] or missing pieces of information that are considered to be of highest priority for resolution are provided in this section on an overall, as well as a process-specific, basis. The relationship among these information gaps and the highest risk hazards is provided in Table 4.

## *8.1. Gaps in Knowledge Relevant to All Remedial Alternatives*

### 8.1.1. Risk Reduction and Risks Remaining after Implementation of Remedial Options

The extent of risk reduction that would be achieved and remaining risks as a consequence of each of the potential SDA remedial options has not been quantified. Furthermore, the impact of proposed future land use (i.e., perpetual government control) on risk estimates has not been evaluated. These risk reductions and residual risks for specific areas of the SDA should be evaluated in the context of remaining risks, closure and stewardship requirements for the entire SDA, including areas currently receiving additional wastes for disposal.

### 8.1.2. Geospatial Distribution of Wastes and Waste Forms

The inventories and geospatial distributions of the radioactive, organic, and inorganic contaminants of potential concern are highly uncertain; however, they drive both the evaluation of risk and the necessary remedial alternatives. Knowledge of the specific location of the risk driving contaminants is required to estimate the effectiveness of excavation or retrieval options and identify locations for targeted retrieval actions. For example, if nitrates originally present in waste packages are now widely dispersed in the disposal area and vadose zone, waste retrieval actions will be ineffective in reducing the risk associated with nitrate contamination. Similar concerns exist with respect to the fission products contaminants of potential concern. In addition, knowledge of the geospatial distribution of both risk-driving contaminants and wastes that potentially can lead to high radiation doses to workers is needed to achieve protection of remediation workers.

### 8.1.3. Presence and Location of High-Level Waste, Spent Fuel, or Similar High-Activity Material

The *Short-Term Risk Evaluation* (Schofield, 2002) stated that "[d]uring retrieval activities, high-level waste and possibly spent nuclear fuel may be encountered [in the SDA]." The *Preliminary Evaluation of Remedial Alternatives* (Zitnik et al., 2002) further states that

[74] Key information gaps are those that are both *critical* (from a safety standpoint) and *large* (indicating little or no information is available) based upon the definitions provided in Appendix F.

"[w]aste buried in the SDA before 1970 contains small quantities of irradiated fuel material…." Finally, in the *Second Addendum to the Work Plan for the WAG 7 RI/FS* (Holdren & Broomfield, 2004), the following statement appears:

> "Some shipments to the SDA contained waste that is similar to spent nuclear fuel or high-level waste and may exhibit some characteristics of these waste forms."

where

> "The [above] assumption reflects information developed since the First Addendum *[DOE-ID, 1998]* through review of waste shipment and inventory records. Waste similar to spent nuclear fuel or high-level waste may require specific attention in modeling (e.g., contaminant inventories and release and transport mechanisms) and in analyzing alternatives (e.g., safety issues related to exposure rates, potential security concerns, and interference with remedial technologies such as retrieval and ISG)."

Therefore, there is some uncertainty concerning the presence, type, and amount of high-level waste and spent nuclear fuel (or similar material) in the SDA. Special requirements are necessary when handling this type of material due to its high activity.

If it is discovered that high-level waste was buried in the SDA, then this waste may be required to be disposed of as such and the operations necessary for its retrieval added to the Retrieve, Treat, and Dispose alternative (i.e., Alternative 2) and its evaluation. For example, the Nuclear Waste Policy Act of 1982 (as amended) specifies that high-level radioactive waste must be disposed of in a deep geologic repository (currently proposed off-site at Yucca Mountain, Nevada). Furthermore, the 1995 Settlement Agreement[75] between the Governor of Idaho, DOE, and the Department of the Navy states that "DOE shall treat all high-level waste currently at [the Idaho Site] so that it is ready to be moved out of Idaho for disposal by a target date of 2035."

### 8.1.4. Baseline Risk Assessment ("No Action" Option)

A first step in assessing the information needed to assess risks for any given alternative is to evaluate the information available before any remedial actions are undertaken so there is a basis for comparison—this can be done by examining the information gaps for the No Action option. In this option, no *additional* actions[76] are assumed to be taken to treat or immobilize

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[75] The 1995 Settlement Agreement was found at www.id.doe.gov/doeid/RFP-NE&NSD/SEC%20J%20Attachments/J-M%201995%20SA.pdf.

[76] For example, some waste will be retrieved during the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b). Beryllium blocks, which weigh approximately 180 pounds each and became radioactive after being used as reflectors in Idaho Site test reactors, were buried in pits, trenches and soil vault rows. These blocks are being grouted in-place to immobilize C-14; however, this does not preclude future retrieval is found necessary (Lopez & Schultz, 2004; Lopez, 2004). There is also an on-going removal of organic contamination in the vadose zone using vacuum vapor extraction. More than 162,000 pounds of volatile organic compounds have been successfully extracted from the SDA and destroyed using vapor vacuum extraction units.

the wastes buried in the SDA to reduce risks further (DOE-ID, 2004b; Lopez & Schultz, 2004; Lopez, 2004). However, in any event, environmental monitoring, maintenance, and institutional controls would be implemented.

Semi-quantitative and qualitative baseline risk analyses were previously performed in the *Interim Risk Assessment* (Becker et al., 1998) and *Ancillary Basis for Risk Analysis* (Holdren et al., 2002) for the wastes buried in the Subsurface Disposal Area (SDA). The conclusions for both reports were that the wastes buried in the SDA pose "unacceptable long-term risk to human health and the environment" (Becker et al., 1998; Holdren et al., 2002). Sufficient information existed for many contaminants of potential concern to estimate respective risks to receptors quantitatively; the risks from other contaminants that might be of potential concern (however without sufficient inventory and/or toxicological information) had to be addressed qualitatively. However, in the most recent and comprehensive baseline risk assessment (Holdren et al., 2002), the risks for those that were assessed quantitatively were based solely upon best inventory estimates instead of also examining reasonable bounding quantities; this information was supplemented by limited sensitivity and uncertainty analyses.

Because a modeling effort is required to assess the risks posed in any proposed scenario, a significant part of the gap analysis can be conceptualized in terms of the modeling effort required. Generally, there are key methodological, release, transport, and fate aspects of modeling that must be adequately addressed before the model (or suite of models) can be useful for assessing risks. In general, these key aspects for a given contaminant of potential concern are

a) ability of the model used to adequately describe the true situation,
b) contaminant release and source term (including contaminant flux to the surface or subsurface media),
c) surface transport of contaminant through both air and water,
d) subsurface transport of contaminant including both vadose and groundwater zones,
e) exposure mechanisms, and
f) receptors and effects.

Many of these key aspects are described by the conceptual site model (ASTM, 1995; DOE, 2003) of the waste burial site.

Some of the above aspects are likely to be unknown (i.e., gaps). Table I-1 in Appendix I provides a detailed analysis of the known gaps in knowledge for the No Action option including not only the modeling tasks but also the long-term stewardship and institutional control activities. From the definitions provided in Appendix F, those gaps in information concerning the No Action option (for Alternative 1) that are both *critical* (from a safety standpoint) and *large* (i.e., little if anything is known) are

- Potential for facilitated plutonium transport

- Presence and location of spent fuel[77] or similar high-activity material

These knowledge gaps are also relevant to all remedial alternatives considered.

### 8.1.5. Potential for Facilitated Plutonium Transport

The wastes buried in the Subsurface Disposal Area (SDA) appear to be unique both in their magnitude and diversity. Plutonium is one of the radioactive elements found buried in the SDA. Estimates indicate that between 1 and 1½ metric tons of plutonium may have been buried in the SDA (INEEL, 2004a; Sentieri, 2003a; Neeley, 2003; Sentieri, 2003b; Sentieri, 2003c; Sentieri & Taylor, 2003).[78] Under oxidizing and consolidated conditions, plutonium has been found to be generally fairly immobile in the environment. However, plutonium can move significant distances when present as fine particulates, chelated, or under reducing conditions in the subsurface or if it is present as, transformed into, or attached to a colloid (Flury & Harsh, 2003). For example, if plutonium is of small particle size (i.e., less than 1 μm), it can be transported as a colloid (Batcheller & Redden, 2004) or it can form an intrinsic colloid by polymerization (Flury & Harsh, 2003). Also it can form aqueous complexes with organic materials, such as EDTA, which is present in the SDA. Finally, when reduced to a soluble species, plutonium can sorb or bind to other, natural "colloidal" material such as zeolites or clays, which are ubiquitous in the subsurface and can be transported (Flury & Harsh, 2003).

In fact, because of their low solubility in water and strong sorption potential, actinides such as plutonium are ideal candidates for colloid-facilitated transport (Flury & Harsh, 2003; Honeyman, 1999). When in colloidal form or attached to colloidal particles, plutonium can move through the subsurface at velocities equal to the average velocity of water—that is, unretarded (Flury & Harsh, 2003). Colloid concentrations in natural subsurface systems tend to be low resulting in limited facilitated colloidal transport of plutonium and resulting colloids may not stable over the long distances necessary to reach the aquifer. It has been estimated that as much as 5% (or 75 kg) of the plutonium[79] buried in the SDA may be of the size that could form colloids. There is also information that suggests that complexing agents such as EDTA may have been buried in the SDA.[80] The stability of the colloids and the distances over which

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[77] According to the Nuclear Regulatory Commission (www.nrc.gov/reading-rm/basic-ref/glossary/spent-nuclear-fuel.html), spent fuel is defined as "[f]uel that has been removed from a nuclear reactor because it can no longer sustain power production for economic or other reasons."

[78] As indicated in footnote 23 on page 8 of this report, there is a large quantity of fissionable material buried in the SDA. Thus one might consider the potential for a criticality accident to be both *high-risk* and/or a critical information gap. However, the preliminary safety analyses (Abbott, 2003; Abbott & Santee, 2004; Santee, 2003) for the proposed remedial actions indicate that any conceivable criticality accident would have a frequency less than once in 10,000 years. The conclusion from these safety analyses are supported by criticality analyses for the SDA (INEEL, 2004a; Sentieri, 2003a; Neeley, 2003; Sentieri, 2003b; Sentieri, 2003c; Sentieri & Taylor, 2003), which indicated that criticality accidents were either extremely unlikely or not credible.

[79] The 95% upper confidence limit on the colloid-sized plutonium in the SDA is 4.9% of the 1100 kg (best estimate) to 1500 kg (upper bound) (Batcheller & Redden, 2004). These values translate into 55 kg and 75 kg of plutonium, respectively.

[80] According to the *Interim Risk Assessment* (Becker et al., 1998), up to 71,000 kg of versenes (assumed to be EDTA) could have been disposed of in the SDA. Versenes are organic chelating agents.

this facilitated transport can occur is strongly a function of specific field conditions. There is insufficient field data that can be used to test or calibrate possible colloid transport models [81] Therefore, some facilitated transport of plutonium cannot be ruled out and presents potentially a significant gap in information that must be addressed to assess the risks posed by the wastes buried in the SDA.

### 8.1.6. Other Important Knowledge Gaps

There are a number of knowledge gaps that, even though they were not classified as *critical* and *large* in Appendix I and Appendix J, are still important enough to emphasize. These include:

- Carcinogenic and non-carcinogenic risks were estimated using standard exposure parameters at the downgradient Idaho Site boundary for a hypothetical 100-year institutional control period (Holdren & Broomfield, 2004). In the Remedial Investigation/Feasibility Study (RI/FS) for the SDA (Holdren & Broomfield, 2004), only a single acute well-drilling, intruder scenario will be evaluated. A residential groundwater ingestion scenario was evaluated to 10,000 years at the SDA boundary after completion of the 100-year institutional control period (Holdren & Broomfield, 2004). Additional exposure scenarios and pathways need to be evaluated that are more relevant to projected, future land use and local values.
- There are on-going low-level waste disposal operations being carried out in the SDA. Wastes were also removed during the Pit 9 test retrieval and additional wastes are being removed during the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b). The SDA inventory should be updated to account for these events if the change in inventory would result in doses beyond that represented by the uncertainty present in the current dose assessments.[82]
- It is uncertain whether *in situ* grouting will have to be used to immobilize contaminants of potential concern in selected areas of the SDA. However, the *in situ* vitrification option has been removed from consideration for the SDA due to inherent safety considerations (Holdren & Broomfield, 2004).[83] There is also uncertainty as to the extent of *in situ* grouting needed for both contaminant immobilization, if necessary, and subsurface (geotechnical) stabilization.

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81 The limitations on the plutonium transport information include: few appropriate laboratory (or column) studies, insufficient field data that can be used to test or calibrate possible colloid transport models, and no link made between the laboratory and field characteristics (Batcheller & Redden, 2004). Often the column studies used to estimate the transport parameters do not consider preferential flow pathways.

82 The SDA inventory will be updated as part of the Idaho Site CERCLA Remedial Investigation/Feasibility Study process (Holdren & Broomfield, 2004).

83 Of the 300 test, demonstration, or commercial melts using *in situ* vitrification, there have been at least five melt expulsions (Santee, 2003), one of which at the Oak Ridge National Laboratory involving the expulsion of approximately 20 tons of contaminated molten material (DOE, 1996). Because the likelihood of such accidents is tied to the presence of sealed drums and volatiles (both of which are present in the SDA in large numbers) and no amount of site conditioning would totally disrupt the integrity of the drums or remove the water or volatiles that this type of failure is deemed probable for processing in the SDA. Therefore, the reason to remove in situ vitrification as a potential remedial action for immobilizing contaminants of potential concern in the SDA appears reasonable.

- Because the final applicable or relevant and appropriate requirements (ARARs) for the SDA will not be defined until the Record of Decision is finalized, the regulatory requirements for SDA remedial actions may change from those assumed in this report.
- A significant amount of fill, or "borrow," material will be required to backfill areas in the SDA, prevent subsidence, and complete the surface barrier.[84] Under the most favorable circumstances, this material can be taken from the spreading areas less than one mile from the SDA. However, this material may have to be moved (by truck) from a location more than 40 miles from the SDA (Schofield, 2002). This activity would substantially increase both the risks and costs associated with this alternative because as many as 159,000 truck loads (at 22 $yd^3$ per load) of material may be required if a RCRA type "C" cap is employed.

## 8.2. *Process-Specific Knowledge Gaps*

The key gaps in knowledge[85] covered in this section are specific to various alternatives or process steps. The detailed gap analysis for Alternative 1 (Contain in Place) is provided in Appendix I and that for Alternative (Retrieve/Treat/Dispose) is provided in Appendix J.

### 8.2.1. Amounts and Distributions of Water, Volatiles, Vapor Pockets, and Drums (Alternative 1: Contain in Place; Option D: *In Situ* Vitrification)

Alternative 1 involves containing the buried wastes in place—that is, no additional waste will be retrieved. As illustrated in Table 3, there are four options associated with this alterative whose gaps were examined in detail in Appendix I. Option D for Alternative 1[86] included employing *in situ* vitrification to immobilize subsurface contamination that would otherwise be retrieved (i.e., Alternative 2). A single data gap (i.e., "Amounts and Distributions of Water and Volatiles in the SDA") is identified as both *critical* (in terms of safety) and *large* (indicating little or no is known about it) as defined in Appendix F.

When *in situ* vitrification is applied to areas with large amounts of volatile compounds or vapor pockets (e.g., in drummed waste), there is a high probability that the gases released will result in bubbling and the splattering of molten material and a very real safety concern. For

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[84] From (Zitnik et al., 2002): "Preliminary assessments indicate that suitable materials are available from borrow areas on and off the INEEL. However, this project would require extensive excavation within the designated areas. For example, approximately 3.5 million $yd^3$ [or over 159,000 truck-loads] of silt loam materials would be required to complete construction of the [RCRA-type] cover. Assuming this was retrieved from a single pit with an average extraction depth of 20 ft, it is projected that the pit surface would cover approximately 100 acres [or approximately the size of the SDA]." This may need to be revisited because there are obvious problems associated with leaving an open pit of this size including risks, pooling of water and snow, etc. Also, less borrow material would be necessary if an evapotranspiration-type cover is ultimately selected for the SDA.

[85] Please refer to footnote 74 on page 60.

[86] Table I-4 in Appendix I provides the detailed gap analysis for Option 1D (i.e., contain the wastes in-place using in situ vitrification).

example, a melt expulsion[87] involving approximately 20 tons of contaminated molten material occurred during *in situ* vitrification of 216 tons of contaminated soil at the Oak Ridge National Laboratory (DOE, 1996; INEEL, 2004b). Volatile gas collection hoods have even ignited. Events such as the ORNL melt expulsion and other safety concerns have prompted the Idaho Site to remove *in situ* vitrification from the list of remedial actions considered for the SDA. It was retained here for comparison purposes.

### 8.2.2. Possible Future Legal Decisions and Resulting Actions (Alternative 2: Retrieve/Treat/Dispose; Options A and B)

Alternative 2 involves retrieving buried wastes from the Subsurface Disposal Area (SDA), segregating and treating the retrieved wastes, and disposing the non-TRU wastes at the Idaho Site and the TRU wastes at WIPP. As illustrated in Table 3, there are two options associated with this alterative whose gaps were examined in detail in Appendix J. These options differ in the extent to which buried wastes must be retrieved.

The extent to which buried waste must be retrieved from the SDA is controversial and may ultimately be the result of legal decisions concerning the ultimate disposition of Rocky Flats Plant waste buried in the SDA prior to 1970. The 1995 Settlement Agreement between the Governor of Idaho, DOE, and the Department of the Navy states that[88]

> "DOE shall ship all transuranic waste now located at INEL, currently estimated at 65,000 cubic meters in volume, to the Waste Isolation Pilot Plant (WIPP) or other such facility designated by DOE, by a target date of December 31, 2015, and in no event later than December 31, 2018."

The Idaho Site and DOE indicated that the approximately 65,000 $m^3$ of transuranic waste referred to in the Settlement Agreement is that currently stored in the Transuranic Storage Area and does not include that buried in the SDA. However, in *United States of America v. Dirk Kempthorne* (USA v. Kempthorne, Civil Case No. 91-0054-S-EJL), a judge ruled that:[89]

> "The intent and spirit of the 1995 Settlement Agreement was to establish a binding process and timeline for the removal of all INEEL high-level and transuranic waste, both stored and buried, out of the State of Idaho and to statutorily compliant permanent geologic repositories."

In the judge's opinion, "all" meant *both stored and buried* transuranic and *all* high-level wastes. DOE appealed this ruling to the U.S. Court of Appeals for the Ninth Circuit (NRC, 2005). In December 2004, the decision was reversed and the case remanded to district court indicating that all evidence (including the source of the 65,000 $m^3$ estimate) must be

87 A melt expulsion is the violent upsurge of gas through the melt that has the potential to elevate the hood and release both gaseous and entrained melt contaminants. This was observed during testing of ISV at the Oak Ridge National Laboratory (DOE, 1996).

88 The 1995 Settlement Agreement was found at www.id.doe.gov/doeid/RFP-NE&NSD/SEC%20J%20Attachments/J-M%201995%20SA.pdf.

89 The text of the court ruling was found at personalpages.tds.net/~edinst/publications/EDI.amicus.Buried.final.htm.

considered.[90] The outcome of such legal actions in the future may dictate the extent to which wastes buried in the SDA will have to be retrieved and/or immobilized and the concomitant risks involved in the selected remedial action. The Idaho Site has little control over such legal matters; however, because such actions may dictate the remedial actions that must be taken, these actions also directly influence the risks associated with the SDA remediation.

## 8.3. Suggestions for Gap Resolution

The path forward for resolving the knowledge gaps identified in this report can be considered as part of the on-going CERCLA Remedial Investigation/Feasibility Study process, and it is hoped that this report could be useful as input to that process. For example, an assessment of the size and impact of each knowledge gap indicated in this report could be used as a way of determining the order in which gaps should be resolved. Information concerning risk reduction achievable through each remedial alternative, remaining risks after remediation, inventory, geospatial distribution, waste form, release, fate, and transport of contaminants of potential concern in the SDA should be collected. This data collection effort should be focused on the risk-driving contaminants of potential concern that have been previously identified. An assessment of the potential to uncover high-radiation material (especially spent nuclear fuel or similar material) should be performed early in this process. Contingencies should be developed to prepare for the possibility that a future court decision mandates the extent to which buried transuranic wastes from the Rocky Flats Plant must be retrieved for shipment to WIPP.

[90] The reversal can be found at: http://www.ca9.uscourts.gov/coa/memdispo.nsf/pdfview/120304/$File/03-35470.PDF.

# 9. Preliminary Comparison of Alternatives

Coupling the hazard and gap analyses allows for a qualitative ranking of the various remedial alternatives in terms of risk, human health, environmental, and programmatic factors. When assessed for these various factors, the remedial alternatives for the SDA buried wastes can be qualitatively ranked.

For Alternative 1, there are no options that would be considered *low-risk*. For example, the No Action option (1A) is considered *high-risk* because nothing would be done to isolate the subsurface contamination from percolating water. Therefore, even though long-term monitoring, maintenance, and institutional controls would be instituted, this option would still have to be considered *high-risk*. The high-risk hazard for this option is associated with failure of long-term stewardship actions. Such activities are required for any of the proposed remedial options; however, a surface barrier will be emplaced for all but the No Action option and thus the risks would be lower.

Therefore, all remedial options (including No Action) for Alternative 1 and Alternative 2 would be classified as *high-risk* primarily because they employ one or more of the *high-risk* process steps (i.e., *in situ* grouting, *in situ* vitrification, and long-term stewardship). However, this is not to say that there is not a rank-ordering possible amongst the various options.

For example, significant programmatic risk is associated with the waste retrieval options represented by Alternative 2. Another factor that impacts the overall risk would be how extensively a *high-risk* process step may be employed. A number of the remedial options employ *in situ* grouting for both subsurface stabilization and contaminant immobilization. On the other hand, the *in situ* vitrification option (1D) for Alternative 1, employs both *in situ* grouting (for subsurface stabilization and contaminant immobilization) and *in situ* vitrification, which are both classified as *high-risk* process steps. However, for the *in situ* vitrification option (1D), *in situ* grouting may be employed over a smaller area of the SDA.

Significant risks are also associated with the retrieval process employed in Alternative 2. Assuming that risk increases with increasing waste retrieval, one might assume that the full Rocky Flats Plant TRU waste retrieval option (2B) would present more risk than the targeted or "hot-spot" Rocky Flats Plant TRU waste retrieval option (2A). Furthermore, because all options employ at least one *high-risk* process step, a *possible* rank-ordering of the remedial options in terms of risk might produce the following:[91]

(1A) >> (1D) > (2B) > (2A) > (1C) > (1B)

or

[91] This rank-ordering is based upon the following assumptions: 1) risk increases with increased waste retrieval, 2) employing both *in situ* grouting and *in situ* vitrification is much higher in risk than employing just *in situ* grouting even for both subsurface stabilization and contaminant immobilization, 3) employing *in situ* grouting for both subsurface stabilization and contaminant immobilization is higher risk than when *in situ* grouting is used for only subsurface stabilization, and 4) not containing the wastes using a surface barrier would have the potential to impact by far the greatest number the public, which would overwhelm any reduced worker risks.

No Action >> In Situ Vitrification > Full Retrieval > Targeted Retrieval
> In Situ Grouting > Surface Barrier

However, the above rank-ordering is subjective and based upon a number of assumptions concerning comparison of the *qualitative* risk classifications made in this report. Furthermore, not all of the above options (e.g., No Action) would be considered satisfactory from a remedial standpoint. A quantitative assessment of risks or examination of remedial requirements (e.g., retrieval of buried Rocky Flats Plant TRU wastes) might produce a different rank-ordering or set of remedial options than that provided.

## 9.1. Interpretation of the Overall Risk Classification

The results of the hazard analysis identify no clear, ideal choice for dispositioning the wastes buried in the SDA from the alternatives considered. One could qualitatively rank-order the various remedial options based upon assumptions concerning the relative risks and remedial requirements; however, additional programmatic and regulatory information will be required to identify an acceptable choice.

For example, the 1995 Settlement Agreement calls for removing at least the 65,000 $m^3$ of retrievably stored TRU waste in the Transuranic Storage Facility that borders the SDA. However, past legal action has been undertaken by various stakeholders resulting in court decisions that *all* buried TRU wastes from the Rocky Flats Plant must also be retrieved and sent to WIPP for disposal (NRC, 2005).[92] If such a decision would be binding in the future, then only the full retrieval option (2B) would satisfy the regulatory requirement for remediation of the SDA. If, on the other hand, the buried TRU waste retrieval requirement is based upon risk information, then all options (except for No Action) might be acceptable. Numerous factors including risk, cost, regulatory requirement, etc. should factor into the decision process for the best remedial alternative.

Because of the experience both at the Idaho Site and other DOE complex sites in employing the various remedial actions reviewed in this report, there is a great deal of information available to assess and compare quantitatively such factors as overall risk and cost for the proposed remedial actions. Many of these factors are being assessed as part of the Idaho Site CERCLA process for remediation of the SDA. For example, the most recent baseline risk assessment was developed in the Idaho Site *Ancillary Basis for Risk Analysis* (Holdren et al., 2002) report. Risks for various remedial options were also examined in the Idaho Site *Short-Term Risk Evaluation* report (Schofield, 2002); however, life-cycle risks were not evaluated.

The development of analogous risk assessments (to those in the baseline risk assessment documents) that define risk reduction and remaining risks (in the context of the entire SDA) for proposed remedial actions would provide very informative inputs to the decision-making process. It is necessary to characterize the contaminants of potential concern based on their geospatial distributions and forms in the context of the overall SDA closure and stewardship,

92 The Department of Energy appealed this ruling to the U.S. Court of Appeals for the Ninth Circuit (NRC, 2005), and the decision was reversed.

which will allow the risk drivers and their potential impacts over time to be identified and managed appropriately. An example should make this clear. If the buried TRU wastes from the Rocky Flats Plant were retrieved (which would remove TRU contaminants, perhaps one-half of the nitrate source, and much of the volatile organic material that had not already migrated from the SDA), this would have little impact on many of the contaminants of potential concern (e.g., Tc-99, Sr-90, etc.) and thus limited reduction to the overall risk presented by the SDA.

Results of the evaluation in this report indicate that the lowest risk option is likely to be removal of the highly mobile contaminants (i.e., volatile organics and nitrates) that pose significant short-term risks followed by in-place containment. The containment will isolate the remaining contaminants in-place and reduce their ability to migrate to the environment. However, the characterization of the risk associated with this option is strongly dependent on the effectiveness of the long-term stewardship following remediation. Failure of the long-term stewardship may result in any of the following: site intrusion, inappropriate land or natural resource use, population encroachment, or contamination of the underlying aquifer. Each of these failure mechanisms has the potential to impact a large number of people in the (possibly distant) future. Retrieval options appear to pose the highest risks to the worker population in the near term.

# 10. Conclusions and Recommendations

The information provided in this report provides a foundation for improved risk characterization and assessment of remedial alternatives and identifies the most important gaps in information that must be resolved to provide improved risk assessment and enable risk-informed decision making. The most important information gaps concern i) risk reductions potentially achieved through implementation of each remedial option and remaining risks after remediation in the context of the overall SDA closure, ii) current geospatial distribution of the risk-driving contaminants of concern, and iii) future court decisions that may mandate the extent to which buried transuranic waste from the Rocky Flats Plant must be retrieved for shipment to WIPP. These findings appear to be consistent with recent National Academy findings and recommendations that suggest that the effort, exposure, and costs associated with retrieval, immobilization, and disposition of transuranic wastes buried without intent for retrieval may not warrant the corresponding risk reduction that would be achieved (NRC, 2005). The risk assessment framework presented here provides a foundation for answering these types of questions concerning remedial alternatives.

The primary recommendations resulting from this report are to

i) explore new techniques or technologies to either mitigate or circumvent (using new and safer techniques) the hazards identified in this report for the remedial actions that will be undertaken in the SDA, concentrating initially on those that are deemed *probable* and would result in *severe* consequences,
ii) gather additional inventory (focusing on geospatial distributions and forms), release, fate, and transport information for the contaminants of potential concern in the SDA,
iii) resolve knowledge gaps as information becomes available, concentrating on those highlighted in this report as both *large* and *critical*,
iv) use the new information obtained to generate improved risk assessments for both baseline conditions and proposed remedial actions as input to improved decision-making in the Idaho Site CERCLA process for the SDA, and
v) continue to communicate to resolve their differences concerning the relative risks concerned with either retrieving or leaving the buried TRU waste in place.

Results of this evaluation indicate that, when relevant risk factors are taken into account, the lowest life-cycle risk option is likely to be extraction of highly mobile contaminants that may pose significant risk followed by in-place containment. The primary short- to intermediate-term risk driving contaminants are volatile organic contaminants (e.g., carbon tetrachloride, methylene chloride, and tetrachloroethylene) currently being addressed by soil vapor extraction, nitrates, and mobile fission products (e.g., Tc-99 and Sr-90) and activation products (e.g., C-14 and Cl-36). Various uranium isotopes and Np-237 buried in the SDA represent the majority of the long-term risks to human health. Currently available information indicates that nitrates and uranium isotopes are present from both Rocky Flats Plant wastes and other sources, and not all forms of the Rocky Flats Plant wastes contain significant quantities of the contaminants presenting the most unacceptable risks. Insufficient information is available to define the current spatial distribution of these key contaminants but efforts are underway to improve this understanding.  Thus greatest risk reduction is achieved through removal or remedial actions targeted towards removal of significant pockets of these contaminants presenting the greatest threats to groundwater rather than through removal actions targeted based on the origin of the wastes (e.g., Rocky Flats Plant).  However, the characterization of the risk associated with this option is strongly dependent on the effectiveness of the long-term stewardship following remediation. Failure of the long-term stewardship may result in any of the following: site intrusion, inappropriate land or natural resource use, population encroachment, or contamination of the underlying aquifer. Each of these failure mechanisms has the potential to impact a large number of people in the (possibly) distant future. Retrieval options pose the highest risks, impacting the worker population in the near term.

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# A. CRESP Evaluation of Management Alternatives for Buried Wastes in the Subsurface Disposal Area (SDA) at the Idaho Site (DRAFT)

**CRESP Evaluation of Management Alternatives for Buried Wastes in the Subsurface Disposal Area (SDA) at INEEL**

Objectives:

1. Develop a framework for comparative life-cycle risk evaluation of management options for ultimate disposition of the wastes buried in the Subsurface Disposal Area at INEEL with emphasis on buried transuranic (TRU) waste.

2. Describe the primary activities, processes, and their relationships that are necessary to carry out each of the proposed management alternatives.

3. Identify the major sources of risks, data gaps, and uncertainties for each of the primary processes or activities necessary to carry out each of the proposed management alternatives.

4. Identify prior risk assessments at INEEL and/or other sites or analogues that serve as bases for evaluation of hazards or risks and provide a qualitative or semi-quantitative characterization of such hazards or risks. Characterization of risks will include consideration of expert opinion, where necessary, based on team and other experience, and relative ranking of risks.

This evaluation will not include quantification of risks or recommendations on the preferred waste management approach. The purpose of the document is to serve as technical input for further open discussion and evaluation of the management alternatives. Future discussion should include public input as well as consideration of costs and public policy.

The management alternatives for INEEL buried waste disposition can be divided into two broad categories: 1) contain the wastes in place without retrieval, and 2) appropriately retrieve, treat, package, store, ship, and dispose the wastes. Inherent to these alternatives there are a number of options:

1. Contain the SDA Buried Wastes in Place
    A. Surface barrier emplacement with selected *in situ* grouting for subsurface geotechnical stabilization.
    B. *In situ* grouting for both contaminant immobilization and subsurface geotechnical stabilization with surface barrier emplacement.
    C. *In situ* vitrification for contaminant immobilization, *in situ* grouting for subsurface geotechnical stabilization, and surface barrier emplacement.

2. Retrieve/Treat/Dispose Wastes
    A. Selective retrieval of buried wastes with treatment, packaging, interim storage, and either on-site or off-site shipping and final disposal.

B. Full retrieval of buried wastes (i.e., from the Rocky Flats Plant) with segregation, treatment, packaging, interim storage, and either on-site or off-site shipping and final disposal. Off-site disposal of TRU-contaminated wastes is assumed to be at the Waste Isolation Pilot Plant (WIPP) in New Mexico.

With both management alternatives above, the following is to be considered:

A. Disposition of the SDA buried wastes is being performed as a CERCLA non-time critical removal action. INEEL assumes that remedial activities will likely commence around 2010.

B. There currently is an on-going soil vapor extraction (SVE) of organic contamination in the vadose zone (OCVZ) around the SDA that may impact the waste inventory and associated risks to workers and the general public during future operations.

C. There currently is an on-going program to grout the areas around the beryllium reflector blocks (to prevent $^{14}C$ release) that will impact the associated risks to workers and the general public. This work does not preclude future retrieval, if found necessary.

D. There may be need to perform *in situ* thermal desorption pretreatment if areas are found to have too high concentrations of organic contamination following soil vapor extraction operations.

E. Buried wastes will be retrieved during the planned Pit 4 Accelerated Retrieval Project; this will marginally reduce the waste inventory and associated risks.

F. There are current and planned low-level and mixed low-level waste disposal activities in the SDA that impact both the inventory and associated risks.

G. Both management alternatives involve emplacement of a surface barrier to limit surface water infiltration and to deter intrusion into the burial site from burrowing animals and deep-rooted plants. The emplacement is likely to be carried out in stages based upon the closure of the active low-level and mixed low-level waste disposal operations in the SDA.

H. Final closure of the SDA will require long-term stewardship activities (e.g., environmental monitoring, repair and maintenance, institutional controls, etc.) independent of the management alternative selected.

For the Retrieve/Treat/Dispose alternative, there is an added consideration that interim storage facilities and capacity will be necessary for retrieved, segregated, and packaged wastes, including low-level, mixed low-level, TRU, etc.

For each management alternative identified above, the report will contain:

1. A management flow diagram of major activities, decisions, and processes necessary to achieve each alternative. (example included below, Figure 6)

2. A risk flow diagram that identifies the major processes that incur risk to human health or the environment. Associated conceptual site models for each process step will be included in appendices, but will not include detailed evaluation of ecological impact. (example included below, Figures 8 and 10)
3. A summary table listing the primary failure modes and hazards or sources of risk associated with each major process step. This will also identify the populations at risk (e.g., workers, local public, off-site public) for each of the associated hazards or risks. *Table format is under development.*
4. A table listing the primary data gaps associated with the evaluation of risk for each major process step, based on current information.
5. The available basis and approach for estimating risks associated with each major process step.
6. In appendices, (a) task list for each major process step, (b) conceptual site models for each major process step associated with the material flow diagrams (item 2 above), (c) gap analysis for each major process step (example below, Table 6), (d) hazard analysis for each major process step (examples below, Tables 7 and 8).
7. Document will be less than 30 pages of text (in addition to the tables and figures identified above, appendices identified above, and two page executive summary).

# B. Tasks for Alternative 1: Contain in Place (4 Options)

# Table of Contents



# List of Figures



# List of Tables

There are 14 basic process steps that have been identified for the alternatives for dispositioning wastes currently buried in the Subsurface Disposal Area (SDA) at the Idaho Site. These are enumerated in Table B-1. The task lists that are composed of the various process steps in Table B-1 are provided in Appendices B and C. The format of the lists is illustrated in Figure B-1.

**Table B-1. Process Steps Available for Dispositioning SDA Buried Wastes***

| | **Alt. 1** | | | | **Alt. 2** | |
|---|---|---|---|---|---|---|
| **Process Step** | **1A. No Action** | **1B. Surface Barrier** | **1C. *In Situ* Grouting** | **1D. *In Situ* Vitrification** | **2A. Targeted RFP TRU Waste RTD**** | **2B. Full RFPTRU Waste RTD**** |
| 1. Subsurface Disposal Area (SDA) Characterization | √ | √ | √ | √ | √ | √ |
| 2. *In Situ* Thermal Desorption Pretreatment | | √ | √ | √ | √ | √ |
| 3. *In Situ* Grouting*** | | √ | √√ | √√ | √√ | √√ |
| 4. *In Situ* Vitrification | | | | √ | | |
| 5. Pad A Reconfiguration | | √ | √ | √ | √ | √ |
| 6. Locate, Retrieve, and Segregate Buried Waste | | | | | √ | √ |
| 7. *Ex Situ* Treatment (e.g., Compaction) | | | | | √ | √ |
| 8. Package Retrieved Wastes | | | | | √ | √ |
| 9. Intermediate Storage of Retrieved and Packaged Wastes | | | | | √ | √ |
| 10. Surface Barrier Selection, Preparation, and Emplacement | | √ | √ | √ | √ | √ |
| 11. Long-term Stewardship Activities for the SDA | √ | √ | √ | √ | √ | √ |
| 12. Construct New SDA Disposal Cell | | | | | √ | √ |
| 13. Long-term Stewardship Activities for New SDA Disposal Cell | | | | | √ | √ |
| 14. Off-site Shipment and Disposal at WIPP | | | | | √ | √ |

* Two basic alternatives have been identified for dispositioning the SDA buried wastes: 1) contain the wastes in place or 2) retrieve, treat, and dispose (RTD) the wastes.

** The two options associated with the retrieve, treat, and dispose (RTD) alternative include A) targeted retrieval of Rocky Flats Plant (RFP) TRU wastes or B) full retrieval of Rocky Flats Plant TRU wastes.

*** Two check marks (√) in this column indicate that in situ grouting will potentially be used for both subsurface stabilization and contaminant immobilization.

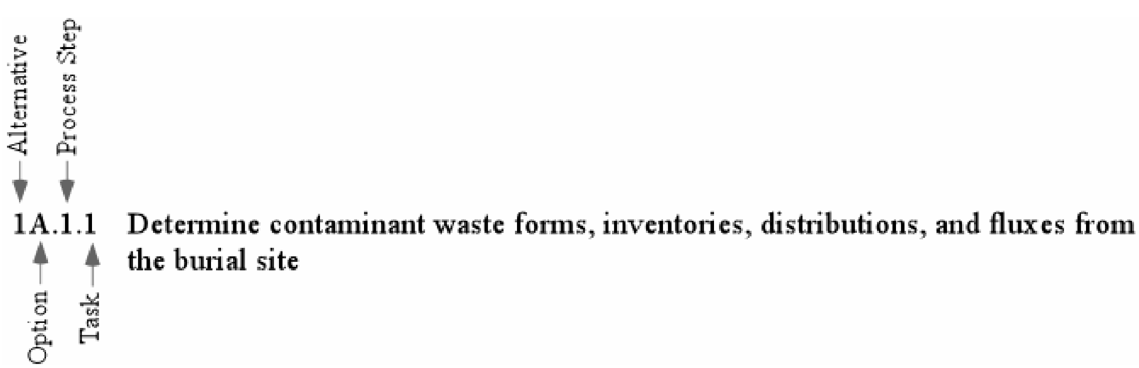


**Figure B-1. Basic format for the task enumeration in the Appendices**

## B.1. Task Listing for the Contain-in-Place Alternative, No Action Option (1A)

### 1A.0 No Action Option—Long-term Monitoring of the Buried Wastes[93]

1A.1. Subsurface Disposal Area (SDA) Characterization

- 1A.1.1. Determine contaminant waste forms, inventories, distributions, and fluxes from the burial site
- 1A.1.2. Complete analysis of historic, current, and planned retrieval activities (e.g., those for Pit 9 and Pit 4 when completed as well as the extraction of organic contamination in the vadose zone or OCVZ (DOE-ID, 1994a))
- 1A.1.3. Complete conceptual site model(s) for the SDA

*Note that process steps 2 through 10 (in Table B-1) are not applicable to this option.*

1A.11. Long-term Stewardship Activities for the SDA

- 1A.11.1. Determine long-term monitoring, maintenance, and institutional controls (e.g., physical and administrative land-use restrictions) needed to ensure that buried contamination will be left in a protective state based upon, in part, future land use decisions and possible failure mode scenarios
- 1A.11.2. Implement long-term monitoring (including sampling and analyses) and institutional controls
- 1A.11.3. Routine maintenance, repair, and replacement
- 1A.11.4. Non-routine maintenance, repair, and replacement

*Note that process steps 12 through 14 (in Table B-1) are not applicable to this option.*

[93] The tasks associated with the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b) and Beryllium Block Grouting (to immobilize $^{14}C$) (Lopez & Schultz, 2004; Lopez, 2004) have been omitted from the task lists because they are common to all alternatives and will be completed before and regardless of what alternative (and option) is selected.

## B.2. Task Listing for the Contain-in-Place Alternative, Surface Barrier Option (1B)

### 1B.0 Contain Buried Wastes in Place Using a Surface Barrier[94]

- 1B.1. Subsurface Disposal Area (SDA) Characterization
  - 1B.1.1. Determine contaminant waste forms, inventories, distributions, and fluxes from the burial site
  - 1B.1.2. Complete analysis of historic, current, and planned retrieval activities (e.g., those for Pit 9 and Pit 4 when completed as well as the extraction of organic contamination in the vadose zone or OCVZ (DOE-ID, 1994a))
  - 1B.1.3. Complete conceptual site model(s) for the SDA
- 1B.2. *In Situ* Thermal Desorption Pretreatment
  - 1B.2.1. Determine performance criteria and requirements for *In Situ* Thermal Desorption based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions
  - 1B.2.2. *In Situ* Thermal Desorption development and treatability testing (including necessary planning and Quality Assurance/Quality Control)
  - 1B.2.3. Prepare site (e.g., add overburden) and install *In Situ* Thermal Desorption equipment
  - 1B.2.4. Perform required *In Situ* Thermal Desorption pretreatment (on any remaining areas with too high levels of volatile organic contaminants)
  - 1B.2.5. Dismantle *In Situ* Thermal Desorption equipment, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)
  - 1B.2.6. Dispose *In Situ* Thermal Desorption equipment under the surface barrier
- 1B.3. *In Situ* Grouting (for Subsurface Stabilization)
  - 1B.3.1. Determine performance criteria and requirements for *In Situ* Grouting based upon relevant performance standards
  - 1B.3.2. *In Situ* Grouting development and treatability testing (including necessary planning and Quality Assurance/Quality Control)
  - 1B.3.3. Install *In Situ* Grouting equipment

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[94] The tasks associated with the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b) and Beryllium Block Grouting (to immobilize $^{14}C$) (Lopez & Schultz, 2004; Lopez, 2004) have been omitted from the task lists because they are common to all alternatives and will be completed before and regardless of what alternative (and option) is selected.

1B.3.4. Grout needed areas to stabilize subsurface (against subsidence) prior to surface barrier installation—it is assumed that an enclosure will not be needed for this process step

1B.3.5. Dismantle *In Situ* Grouting equipment, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)

1B.3.6. Dispose *In Situ* Grouting equipment under the surface barrier

*Note that process step 4 (in Table B-1) is not applicable to this option.*

1B.5. Pad A Reconfiguration

1B.5.1. Install necessary equipment for Pad A reconfiguration

1B.5.2. Retrieve wastes from Pad A

1B.5.3. Segregate/treat retrieved wastes through an external sorting/packaging facility (which is assumed available)

1B.5.4. Temporarily store packaged wastes prior to disposal

1B.5.5. Dispose of Pad A non-TRU wastes by placing the packaged material in a single layer within the central portion of the SDA prior to capping

1B.5.6. Ship Pad A TRU wastes to WIPP

1B.5.7. Dismantle Pad A retrieval equipment, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)

1B.5.8. Dispose contaminated Pad A retrieval equipment under the surface barrier

*Note that process steps 6 through 9 (in Table B-1) are not applicable to this option.*

1B.10. Surface Barrier Selection, Preparation, and Emplacement

1B.10.1. Determine performance criteria and requirements for surface barrier emplacement based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions

1B.10.2. Prepare work plans and safety analyses and obtain necessary permits (including those for borrow area)

1B.10.3. Determine type of barrier required based upon performance criteria, requirements, and other relevant information—the Idaho Site *Preliminary Evaluation of Remedial Alternatives* called for the modified RCRA type "C" cap used in the Idaho Site CERCLA Disposal Facility although an evapotranspiration (ET) cap is currently favored and should be protective

1B.10.4. Prepare SDA for surface barrier installation including grading and construction of necessary containment buildings and structures

1B.10.5. Install surface barrier over the SDA (likely in two phases depending upon closure of the low-level and mixed low-level waste disposal activities) including transporting material from the borrow area

1B.11. Long-term Stewardship Activities for the SDA

1B.11.1. Determine long-term monitoring, maintenance, and institutional controls (e.g., physical and administrative land-use restrictions) needed to ensure that buried contamination will be left in a protective state based upon, in part, future land use decisions and possible failure mode scenarios

1B.11.2. Implement long-term monitoring (including sampling and analyses) and institutional controls

1B.11.3. Routine maintenance, repair, and replacement

1B.11.4. Non-routine maintenance, repair, and replacement

*Note that process steps 12 through 14 (in Table B-1) are not applicable to this option.*

## B.3. *Task Listing for the Contain-in-Place Alternative, In Situ Grouting Option (1C)*

### 1C.0 Contain Buried Wastes in Place Using *In Situ* Grouting (ISG)[95]

- 1C.1. Subsurface Disposal Area (SDA) Characterization
  - 1C.1.1. Determine contaminant waste forms, inventories, distributions, and fluxes from the burial site
  - 1C.1.2. Complete analysis of historic, current, and planned retrieval activities (e.g., those for Pit 9 and Pit 4 when completed as well as the extraction of organic contamination in the vadose zone or OCVZ (DOE-ID, 1994a))
  - 1C.1.3. Complete conceptual site model(s) for the SDA
- 1C.2. *In Situ* Thermal Desorption Pretreatment
  - 1C.2.1. Determine performance criteria and requirements for *In Situ* Thermal Desorption based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions
  - 1C.2.2. *In Situ* Thermal Desorption development and treatability testing (including necessary planning and Quality Assurance/Quality Control)
  - 1C.2.3. Prepare site (e.g., add overburden) and install *In Situ* Thermal Desorption equipment
  - 1C.2.4. Perform required *In Situ* Thermal Desorption pretreatment (on any remaining areas with too high levels of volatile organic contaminants)
  - 1C.2.5. Dismantle *In Situ* Thermal Desorption equipment, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)
  - 1C.2.6. Dispose *In Situ* Thermal Desorption equipment under the surface barrier
- 1C.3. *In Situ* Grouting for Subsurface Stabilization and Contaminant Immobilization
  - 1C.3.1. Determine performance criteria and requirements for *In Situ* Grouting based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions
  - 1C.3.2. *In Situ* Grouting development and treatability testing (including necessary planning and Quality Assurance/Quality Control)
  - 1C.3.3. Install *In Situ* Grouting equipment and enclosure

[95] The tasks associated with the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b) and Beryllium Block Grouting (to immobilize $^{14}C$) (Lopez & Schultz, 2004; Lopez, 2004) have been omitted from the task lists because they are common to all alternatives and will be completed before and regardless of what alternative (and option) is selected.

- 1C.3.4. Grout selected areas (e.g., those containing Rocky Flats Plant wastes) to immobilize subsurface contamination prior to surface barrier installation
- 1C.3.5. Assuming same equipment can be used, dismantle, move, and install In Situ Grouting equipment (but not enclosure) for those areas requiring subsurface stabilization (against subsidence)
- 1C.3.6. Grout needed areas to stabilize subsurface (against subsidence) prior to surface barrier installation
- 1C.3.7. Dismantle *In Situ* Grouting equipment and enclosure, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)
- 1C.3.8. Dispose *In Situ* Grouting equipment and enclosure under the surface barrier

*Note that process step 4 (in Table B-1) is not applicable to this option.*

1C.5. Pad A Reconfiguration

- 1C.5.1. Install necessary equipment for Pad A reconfiguration
- 1C.5.2. Retrieve wastes from Pad A
- 1C.5.3. Segregate/treat retrieved wastes through an external sorting/packaging facility (which is assumed available)
- 1C.5.4. Temporarily store packaged wastes prior to disposal
- 1C.5.5. Dispose of Pad A non-TRU wastes by placing the packaged material in a single layer within the central portion of the SDA prior to capping
- 1C.5.6. Ship Pad A TRU wastes to WIPP
- 1C.5.7. Dismantle Pad A retrieval equipment, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)
- 1C.5.8. Dispose contaminated Pad A retrieval equipment under the surface barrier

*Note that process steps 6 through 9 (in Table B-1) are not applicable to this option.*

1C.10. Surface Barrier Selection, Preparation, and Emplacement

- 1C.10.1. Determine performance criteria and requirements for surface barrier emplacement based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions
- 1C.10.2. Prepare work plans and safety analyses and obtain necessary permits (including those for borrow area)
- 1C.10.3. Determine type of barrier required based upon performance criteria, requirements, and other relevant information—the Idaho Site *Preliminary Evaluation of Remedial Alternatives* called for the modified RCRA type "C" cap used in the Idaho Site CERCLA Disposal Facility although an evapotranspiration (ET) cap is currently favored and should be protective

- 1C.10.4. Prepare SDA for surface barrier installation including grading and construction of necessary containment buildings and structures
- 1C.10.5. Install surface barrier over the SDA (likely in two phases depending upon closure of the low-level and mixed low-level waste disposal activities) including transporting material from the borrow area

1C.11. Long-term Stewardship Activities

- 1C.11.1. Determine long-term monitoring, maintenance, and institutional controls (e.g., physical and administrative land-use restrictions) needed to ensure that buried contamination will be left in a protective state based upon, in part, future land use decisions and possible failure mode scenarios
- 1C.11.2. Implement long-term monitoring (including sampling and analyses) and institutional controls
- 1C.11.3. Routine maintenance, repair, and replacement
- 1C.11.4. Non-routine maintenance, repair, and replacement

*Note that process steps 12 through 14 (in Table B-1) are not applicable to this option.*

## B.4. Task Listing for the Contain-in-Place Alternative, In Situ Vitrification Option (1D)

### 1D.0 Contain Buried Wastes in Place Using *In Situ* Vitrification (ISV)[96]

1D.1. Subsurface Disposal Area (SDA) Characterization

- 1D.1.1. Determine contaminant waste forms, inventories, distributions, and fluxes from the burial site
- 1D.1.2. Complete analysis of historic, current, and planned retrieval activities (e.g., those for Pit 9 and Pit 4 when completed as well as the extraction of organic contamination in the vadose zone or OCVZ (DOE-ID, 1994a))
- 1D.1.3. Complete conceptual site model(s) for the SDA

1D.2. *In Situ* Thermal Desorption Pretreatment

- 1D.2.1. Determine performance criteria and requirements for *In Situ* Thermal Desorption based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions
- 1D.2.2. *In Situ* Thermal Desorption development and treatability testing (including necessary planning and Quality Assurance/Quality Control)
- 1D.2.3. Prepare site (e.g., add overburden) and install *In Situ* Thermal Desorption equipment
- 1D.2.4. Perform required *In Situ* Thermal Desorption pretreatment (on any remaining areas with too high levels of volatile organic contaminants)
- 1D.2.5. Dismantle *In Situ* Thermal Desorption equipment, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)
- 1D.2.6. Dispose *In Situ* Thermal Desorption equipment under the surface barrier

1D.3. *In Situ* Grouting for Subsurface Stabilization and *Specific* Contaminant Immobilization

- 1D.3.1. Determine performance criteria and requirements for *In Situ* Grouting based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions
- 1D.3.2. *In Situ* Grouting development and treatability testing (including necessary planning and Quality Assurance/Quality Control)
- 1D.3.3. Install *In Situ* Grouting equipment and enclosure

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[96] The tasks associated with the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b) and Beryllium Block Grouting (to immobilize $^{14}C$) (Lopez & Schultz, 2004; Lopez, 2004) have been omitted from the task lists because they are common to all alternatives and will be completed before and regardless of what alternative (and option) is selected.

1D.3.4. Grout selected areas (i.e., primarily in the Soil Vault Rows containing $^{14}C$, $^{129}I$, $^{94}Nd$, and $^{99}Tc$ in activated metals) to immobilize selected subsurface contamination prior to surface barrier installation

1D.3.5. Assuming same equipment can be used, dismantle, move, and install *In Situ* Grouting equipment (but not enclosure) to those areas requiring subsurface stabilization against subsidence

1D.3.6. Grout needed areas to stabilize subsurface (against subsidence) prior to surface barrier installation

1D.3.7. Dismantle *In Situ* Grouting equipment and enclosure, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)

1D.3.8. Dispose *In Situ* Grouting equipment and enclosure under the surface barrier

1D.4. *In Situ* Vitrification for Specific Contaminant Immobilization

1D.4.1. Determine performance criteria and requirements for *In Situ* Vitrification based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions

1D.4.2. *In Situ* Vitrification development and treatability testing (including necessary planning and Quality Assurance/Quality Control)

1D.4.3. Prepare site (e.g., add overburden) and install *In Situ* Vitrification equipment (including off-gas and secondary waste stream treatment systems) and enclosure

1D.4.4. Vitrify selected areas (e.g., those containing Rocky Flats Plant wastes) to immobilize subsurface contamination prior to surface barrier installation

1D.4.5. Package and ship secondary TRU wastes to WIPP

1D.4.6. Treat secondary non-TRU wastes and dispose under surface barrier

1D.4.7. Dismantle *In Situ* Vitrification and treatment equipment and enclosure, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)

1D.4.8. Dispose *In Situ* Vitrification and treatment equipment and enclosure under the surface barrier

1D.5. Pad A Reconfiguration

1D.5.1. Install necessary equipment for Pad A reconfiguration

1D.5.2. Retrieve wastes from Pad A

1D.5.3. Segregate/treat retrieved wastes through an external sorting/packaging facility (which is assumed available)

1D.5.4. Temporarily store packaged wastes prior to disposal

1D.5.5. Dispose of Pad A non-TRU wastes by placing the packaged material in a single layer within the central portion of the SDA prior to capping

1D.5.6. Ship Pad A TRU wastes to WIPP

1D.5.7. Dismantle Pad A retrieval equipment, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)

1D.5.8. Dispose contaminated Pad A retrieval equipment under the surface barrier

*Note that process steps 6 through 9 (in Table B-1) are not applicable to this option.*

1D.10. Surface Barrier Selection, Preparation, and Emplacement

1D.10.1. Determine performance criteria and requirements for surface barrier emplacement based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions

1D.10.2. Prepare work plans and safety analyses and obtain necessary permits (including those for borrow area)

1D.10.3. Determine type of barrier required based upon performance criteria, requirements, and other relevant information—the Idaho Site *Preliminary Evaluation of Remedial Alternatives* called for the modified RCRA type "C" cap used in the Idaho Site CERCLA Disposal Facility although an evapotranspiration (ET) cap is currently favored and should be protective

1D.10.4. Prepare SDA for surface barrier installation including grading and construction of necessary containment buildings and structures

1D.10.5. Install surface barrier over the SDA (likely in two phases depending upon closure of the low-level and mixed low-level waste disposal activities) including transporting material from the borrow area

1D.11. Long-term Stewardship Activities

1D.11.1. Determine long-term monitoring, maintenance, and institutional controls (e.g., physical and administrative land-use restrictions) needed to ensure that buried contamination will be left in a protective state based upon, in part, future land use decisions and possible failure mode scenarios

1D.11.2. Implement long-term monitoring (including sampling and analyses) and institutional controls

1D.11.3. Routine maintenance, repair, and replacement

1D.11.4. Non-routine maintenance, repair, and replacement

*Note that process steps 12 through 14 (in Table B-1) are not applicable to this option.*

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# C. Tasks for Alternative 2: Retrieve/Treat/Dispose (2 Options)

# Table of Contents

There are 14 basic process steps that have been identified for the alternatives for dispositioning wastes currently buried in the Subsurface Disposal Area (SDA) at the Idaho Site. These are enumerated in Table B-1. The task lists that are composed of the various process steps in Table B-1 are provided in Appendices A and B. The format of the lists is illustrated in Figure B-1.

**Table B-1. Process Steps Available for Dispositioning SDA Buried Wastes***

| | Alt. 1 | | | | Alt. 2 | |
|---|---|---|---|---|---|---|
| **Process Step** | **1A. No Action** | **1B. Surface Barrier** | **1C. *In Situ* Grouting** | **1D. *In Situ* Vitrification** | **2A. Targeted RFP TRU Waste RTD**** | **2B. Full RFPTRU Waste RTD**** |
| 1. Subsurface Disposal Area (SDA) Characterization | √ | √ | √ | √ | √ | √ |
| 2. *In Situ* Thermal Desorption Pretreatment | | √ | √ | √ | √ | √ |
| 3. *In Situ* Grouting*** | | √ | √√ | √√ | √√ | √√ |
| 4. *In Situ* Vitrification | | | | √ | | |
| 5. Pad A Reconfiguration | | √ | √ | √ | √ | √ |
| 6. Locate, Retrieve, and Segregate Buried Waste | | | | | √ | √ |
| 7. *Ex Situ* Treatment (e.g., Compaction) | | | | | √ | √ |
| 8. Package Retrieved Wastes | | | | | √ | √ |
| 9. Intermediate Storage of Retrieved and Packaged Wastes | | | | | √ | √ |
| 10. Surface Barrier Selection, Preparation, and Emplacement | | √ | √ | √ | √ | √ |
| 11. Long-term Stewardship Activities for the SDA | √ | √ | √ | √ | √ | √ |
| 12. Construct New SDA Disposal Cell | | | | | √ | √ |
| 13. Long-term Stewardship Activities for New SDA Disposal Cell | | | | | √ | √ |
| 14. Off-site Shipment and Disposal at WIPP | | | | | √ | √ |

* Two basic alternatives have been identified for dispositioning the SDA buried wastes: 1) contain the wastes in place or 2) retrieve, treat, and dispose (RTD) the wastes.

** The two options associated with the retrieve, treat, and dispose (RTD) alternative include A) targeted retrieval of Rocky Flats Plant (RFP) TRU wastes or B) full retrieval of Rocky Flats Plant TRU wastes.

*** Two check marks (√) in this column indicate that in situ grouting will potentially be used for both subsurface stabilization and contaminant immobilization.

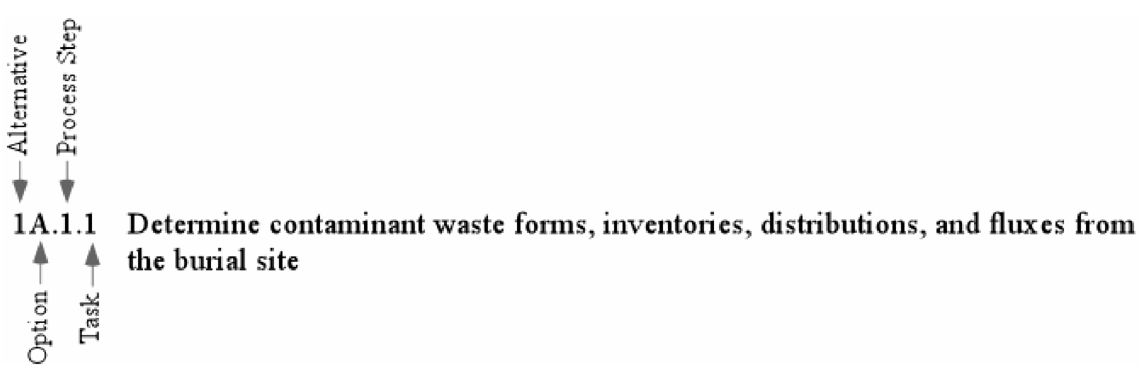


**Figure B-1. Basic format for the task enumeration in the Appendices**

# *C.1. Task Listing for the Retrieve/Treat/Dispose (RTD) Alternative, Targeted Rocky Flats Plant TRU Waste Retrieval Option (2A)*

**2A.0 Retrieve/*Ex Situ* Treat/Package/Transport Targeted Rocky Flats Plant TRU Waste to Waste Isolation Pilot Plant (WIPP)[97]**

2A.1. Subsurface Disposal Area (SDA) Characterization

2A.1.1. Determine contaminant waste forms, inventories, distributions, and fluxes from the burial site

2A.1.2. Complete analysis of historic, current, and planned retrieval activities (e.g., those for Pit 9 and Pit 4 when completed as well as the extraction of organic contamination in the vadose zone or OCVZ (DOE-ID, 1994a))

2A.1.3. Complete conceptual site model(s) for the SDA

2A.2. *In Situ* Thermal Desorption Pretreatment

2A.2.1. Determine performance criteria and requirements for *In Situ* Thermal Desorption based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions

2A.2.2. *In Situ* Thermal Desorption development and treatability testing (including necessary planning and Quality Assurance/Quality Control)

2A.2.3. Prepare site (e.g., add overburden) and install *In Situ* Thermal Desorption equipment

2A.2.4. Perform required *In Situ* Thermal Desorption pretreatment (on any remaining areas with too high levels of volatile organic contaminants)

2A.2.5. Dismantle *In Situ* Thermal Desorption equipment, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)

2A.2.6. Dispose *In Situ* Thermal Desorption equipment under the surface barrier

2A.3. *In Situ* Grouting for Subsurface Stabilization and Contaminant Immobilization

2A.3.1. Determine performance criteria and requirements for *In Situ* Grouting based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions

2A.3.2. *In Situ* Grouting development and treatability testing (including necessary planning and Quality Assurance/Quality Control)

2A.3.3. Install *In Situ* Grouting equipment and enclosure

[97] The tasks associated with the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b) and Beryllium Block Grouting (to immobilize $^{14}C$) (Lopez & Schultz, 2004; Lopez, 2004) have been omitted from the task lists because they are common to all alternatives and will be completed before and regardless of what alternative (and option) is selected.

- 2A.3.4. Grout selected areas (e.g., soil vault rows) to immobilize subsurface contamination prior to surface barrier installation
- 2A.3.5. Assuming same equipment can be used, dismantle, move, and install *In Situ* Grouting equipment (but not enclosure) to those areas requiring stabilization against subsidence
- 2A.3.6. Grout needed areas to stabilize subsurface (against subsidence) prior to surface barrier installation
- 2A.3.7. Dismantle *In Situ* Grouting equipment and enclosure, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)
- 2A.3.8. Dispose *In Situ* Grouting equipment and enclosure under the surface barrier

*Note that process step 4 (in Table B-1) is not applicable to this option.*

2A.5. Pad A Reconfiguration

- 2A.5.1. Install necessary equipment for Pad A reconfiguration
- 2A.5.2. Retrieve wastes from Pad A
- 2A.5.3. Segregate/treat retrieved wastes through an external sorting/packaging facility (which is assumed available)
- 2A.5.4. Temporarily store packaged wastes prior to disposal
- 2A.5.5. Dispose of Pad A non-TRU wastes by placing the packaged material in a single layer within the central portion of the SDA prior to capping
- 2A.5.6. Ship Pad A TRU wastes to WIPP
- 2A.5.7. Dismantle Pad A retrieval equipment, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)
- 2A.5.8. Dispose contaminated Pad A retrieval equipment under the surface barrier

2A.6. Locate Rocky Flats Plant TRU Waste "Hot-Spots" and Retrieve Buried Wastes from these *Targeted* Areas and Segregate into TRU and non-TRU Fractions

- 2A.6.1. Identify appropriate retrieval methods (and assume no additional testing other than that done in previous tests for Pits 4 and 9 is needed)
- 2A.6.2. Determine extent to which buried wastes must be retrieved based on relevant waste acceptance criteria, performance standards, future land use decisions, and possible future legal decisions
- 2A.6.3. Plan and manage retrieval of buried waste from the SDA (including preparation of work plans, safety analyses, and other pertinent reviews and activities as well as obtaining any necessary permits)
- 2A.6.4. Install retrieval equipment for targeted contaminated areas
- 2A.6.5. Retrieve wastes from target areas (noting that spent fuel or analogous materials may be discovered that will have to be handled specially)

2A.6.6. Segregate retrieved wastes into TRU and non-TRU (e.g., low-level and mixed low-level waste) fractions where any spent fuel or analogous material will be segregated further

2A.6.7. Temporarily store retrieved and segregated wastes

2A.6.8. Back fill areas from which wastes have been retrieved (assuming this material will come from the same borrow area used for surface barrier emplacement)

2A.6.9. Dismantle retrieval equipment and facilities, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)

2A.6.10. Dispose retrieval equipment and appropriate facilities under the surface barrier

2A.7. *Ex Situ* Treatment

2A.7.1. Determine *Ex Situ* Treatment requirements and methods based upon relevant performance standards

2A.7.2. Develop necessary *Ex Situ* Treatment technology and perform *t*reatability studies (including necessary planning and Quality Assurance/Quality Control)

2A.7.3. Construct necessary *Ex Situ* Treatment facilities and install equipment

2A.7.4. Perform *Ex Situ* Treatment on retrieved and segregated wastes

2A.7.5. Dismantle *Ex Situ* Treatment equipment and necessary structures, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)

2A.7.6. Dispose *Ex Situ* Treatment equipment and necessary structures under the surface barrier

2A.8. Package Retrieved (and Potentially Treated) Wastes

2A.8.1. Install packaging equipment

2A.8.2. Transfer treated wastes to packaging facility

2A.8.3. Package non-TRU low-level and mixed low-level wastes for on-site storage (assumed to be in the SDA prior to capping)

2A.8.4. Package TRU wastes for shipment to WIPP

2A.8.5. Special Materials will be handled on a case-by-case basis

2A.9. Intermediate Storage of Retrieved and Packaged Wastes

2A.9.1. Construct necessary intermediate storage facilities

2A.9.2. Store wastes prior to disposal (e.g., there is a 225-day wait period following final packaging before a drum can be certified for transport to WIPP)

2A.10. Surface Barrier Selection, Preparation, and Emplacement

- 2A.10.1. Determine performance criteria and requirements for surface barrier emplacement based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions
- 2A.10.2. Prepare work plans and safety analyses and obtain necessary permits (including those for borrow area)
- 2A.10.3. Determine type of barrier required based upon performance criteria, requirements, and other relevant information—the Idaho Site *Preliminary Evaluation of Remedial Alternatives* called for the modified RCRA type "C" cap used in the Idaho Site CERCLA Disposal Facility although an evapotranspiration (ET) cap is currently favored and should be protective
- 2A.10.4. Prepare SDA for surface barrier installation including grading and construction of necessary containment buildings and structures
- 2A.10.5. Install surface barrier over the SDA (likely in two phases depending upon closure of the low-level and mixed low-level waste disposal activities) including transporting material from the borrow area

2A.11. Long-term Stewardship Activities for the SDA

- 2A.11.1. Determine long-term monitoring, maintenance, and institutional controls (e.g., physical and administrative land-use restrictions) needed to ensure that buried contamination will be left in a protective state based upon, in part, future land use decisions and possible failure mode scenarios
- 2A.11.2. Implement long-term monitoring (including sampling and analyses) and institutional controls
- 2A.11.3. Routine maintenance, repair, and replacement
- 2A.11.4. Non-routine maintenance, repair, and replacement

2A.12. Construct New SDA Disposal Cell for Disposal of non-TRU Wastes and Contaminated Soil

- 2A.12.1. Determine performance criteria and requirements for new SDA disposal cell based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions
- 2A.12.2. Construct on-site disposal cell in the SDA including installing a leachate collection system
- 2A.12.3. Dispose of non-TRU Wastes and Contaminated Soil in New SDA Disposal Cell

2A.13. Long-term Stewardship Activities for New SDA Disposal Cell

- 2A.13.1. Determine long-term monitoring, maintenance, and institutional controls (e.g., physical and administrative land-use restrictions) needed to ensure that waste buried in the new SDA disposal cell will be left in a protective state based upon, in part, future land use decisions and possible failure mode scenarios

2A.13.2. Implement long-term monitoring (including sampling and analyses) and institutional controls

2A.13.3. Routine maintenance, repair, and replacement

2A.13.4. Non-routine maintenance, repair, and replacement

2A.14. Off-site Shipment and Disposal at WIPP

2A.14.1. Plan and manage the waste shipments (including carrier/conveyance designation, preparing necessary plans for the route and security, coordinating the shipment with DOE and State/Local Governments, preparing the Hazardous/Radiological Shipment manifests, and performing the transportation Health Physics survey)

2A.14.2. Load TRU Waste Packages into Appropriate Carrier

2A.14.3. Load Appropriate Carrier on Appropriate Conveyance

2A.14.4. Transport TRU Waste to WIPP via road and/or rail

2A.14.5. Off-load TRU waste at WIPP

2A.14.6. Store TRU waste at WIPP

## *C.2. Task Listing for the Retrieve/Treat/Dispose (RTD) Alternative, Full Rocky Flats Plant (RFP) TRU Waste Retrieval Option (2B)*

**2B.0 Fully Retrieve/Treat *Ex Situ*/Package/Transport TRU Waste to the Waste Isolation Pilot Plant (WIPP)[98]**

- 2B.1. Subsurface Disposal Area (SDA) Characterization
  - 2B.1.1. Determine contaminant waste forms, inventories, distributions, and fluxes from the burial site
  - 2B.1.2. Complete analysis of historic, current, and planned retrieval activities (e.g., those for Pit 9 and Pit 4 when completed as well as the extraction of organic contamination in the vadose zone or OCVZ (DOE-ID, 1994a))
  - 2B.1.3. Complete conceptual site model(s) for the SDA
- 2B.2. *In Situ* Thermal Desorption Pretreatment
  - 2B.2.1. Determine performance criteria and requirements for *In Situ* Thermal Desorption based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions
  - 2B.2.2. *In Situ* Thermal Desorption development and treatability testing (including necessary planning and Quality Assurance/Quality Control)
  - 2B.2.3. Prepare site (e.g., add overburden) and install *In Situ* Thermal Desorption equipment
  - 2B.2.4. Perform required *In Situ* Thermal Desorption pretreatment (on any remaining areas with too high levels of volatile organic contaminants)
  - 2B.2.5. Dismantle *In Situ* Thermal Desorption equipment, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)
  - 2B.2.6. Dispose *In Situ* Thermal Desorption equipment under the surface barrier
- 2B.3. *In Situ* Grouting for Subsurface Stabilization and Contaminant Immobilization
  - 2B.3.1. Determine performance criteria and requirements for *In Situ* Grouting based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions
  - 2B.3.2. *In Situ* Grouting development and treatability testing (including necessary planning and Quality Assurance/Quality Control)
  - 2B.3.3. Install *In Situ* Grouting equipment and enclosure

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98 The tasks associated with the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b) and Beryllium Block Grouting (to immobilize $^{14}C$) (Lopez & Schultz, 2004; Lopez, 2004) have been omitted from the task lists because they are common to all alternatives and will be completed before and regardless of what alternative (and option) is selected.

- 2B.3.4. Grout selected areas (e.g., soil vault rows) to immobilize subsurface contamination prior to surface barrier installation
- 2B.3.5. Assuming same equipment can be used, dismantle, move, and install *In Situ* Grouting equipment (but not enclosure) to those areas requiring stabilization against subsidence
- 2B.3.6. Grout needed areas to stabilize subsurface (against subsidence) prior to surface barrier installation
- 2B.3.7. Dismantle *In Situ* Grouting equipment and enclosure, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)
- 2B.3.8. Dispose *In Situ* Grouting equipment and enclosure under the surface barrier

*Note that process step 4 (in Table B-1) is not applicable to this option.*

2B.5. Pad A Reconfiguration

- 2B.5.1. Install necessary equipment for Pad A reconfiguration
- 2B.5.2. Retrieve wastes from Pad A
- 2B.5.3. Segregate/treat retrieved wastes through an external sorting/packaging facility (which is assumed available)
- 2B.5.4. Temporarily store packaged wastes prior to disposal
- 2B.5.5. Dispose of Pad A non-TRU wastes by placing the packaged material in a single layer within the central portion of the SDA prior to capping
- 2B.5.6. Ship Pad A TRU wastes to WIPP
- 2B.5.7. Dismantle Pad A retrieval equipment, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)
- 2B.5.8. Dispose contaminated Pad A retrieval equipment under the surface barrier

2B.6. Locate and Retrieve Buried *Rocky Flats Plant* Waste and Segregate into TRU and non-TRU Fractions—it is assumed that “full” retrieval applies only to Rocky Flats Plant wastes buried in the SDA

- 2B.6.1. Identify appropriate retrieval methods (and assume no additional testing other than that done in previous tests for Pits 4 and 9 is needed)
- 2B.6.2. Determine location of buried *Rocky Flats Plant* wastes that must be retrieved based on relevant waste acceptance criteria, performance standards, future land use decisions, and possible future legal decisions
- 2B.6.3. Plan and manage retrieval of buried waste from the SDA (including preparation of work plans, safety analyses, and other pertinent reviews and activities as well as obtaining any necessary permits)
- 2B.6.4. Install retrieval equipment for areas containing buried *Rocky Flats Plant TRU* waste

2B.6.5. Retrieve *Rocky Flats Plant* wastes from areas containing buried *Rocky Flats Plant TRU* waste (noting that spent fuel or analogous materials may be discovered that will have to be handled specially)

2B.6.6. Segregate retrieved wastes into TRU and non-TRU (e.g., low-level and mixed low-level waste) fractions where any spent fuel or analogous material will be segregated further

2B.6.7. Temporarily store retrieved and segregated wastes

2B.6.8. Back fill areas from which wastes have been retrieved (assuming this material will come from the same borrow area used for surface barrier emplacement)

2B.6.9. Dismantle retrieval equipment and facilities, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)

2B.6.10. Dispose retrieval equipment and appropriate facilities under the surface barrier

2B.7. *Ex Situ* Treatment

2B.7.1. Determine *Ex Situ* Treatment requirements and methods based upon relevant performance standards

2B.7.2. Develop necessary *Ex Situ* Treatment technology *and perform t*reatability studies (including necessary planning and Quality Assurance/Quality Control)

2B.7.3. Construct necessary *Ex Situ* Treatment facilities and install equipment

2B.7.4. Perform *Ex Situ* Treatment on retrieved and segregated wastes

2B.7.5. Dismantle *Ex Situ* Treatment equipment and necessary structures, test for contamination, and decontaminate selected equipment (where remaining, contaminated equipment will be disposed of by placing under surface barrier)

2B.7.6. Dispose *Ex Situ* Treatment equipment under the surface barrier

2B.8. Package Retrieved (and Potentially Treated) Wastes

2B.8.1. Install packaging equipment

2B.8.2. Transfer treated wastes to packaging facility

2B.8.3. Package non-TRU low-level and mixed low-level wastes for on-site storage (assumed to be in the SDA prior to capping)

2B.8.4. Package TRU wastes for shipment to WIPP

2B.8.5. Special Materials will be handled on a case-by-case basis

2B.9. Intermediate Storage of Retrieved and Packaged Wastes

2B.9.1. Construct necessary intermediate storage facilities

2B.9.2. Store wastes prior to disposal (e.g., there is a 225-day wait period following final packaging before a drum can be certified for transport to WIPP)

2B.10. Surface Barrier Selection, Preparation, and Emplacement

2B.10.1. Determine performance criteria and requirements for surface barrier emplacement based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions

2B.10.2. Prepare work plans and safety analyses and obtain necessary permits (including those for borrow area)

2B.10.3. Determine type of barrier required based upon performance criteria, requirements, and other relevant information—the Idaho Site *Preliminary Evaluation of Remedial Alternatives* called for the modified RCRA type "C" cap used in the Idaho Site CERCLA Disposal Facility although an evapotranspiration (ET) cap is currently favored and should be protective

2B.10.4. Prepare SDA for surface barrier installation including grading and construction of necessary containment buildings and structures

2B.10.5. Install surface barrier over the SDA (likely in two phases depending upon closure of the low-level and mixed low-level waste disposal activities) including transporting material from the borrow area

2B.11. Long-term Stewardship Activities for the SDA

2B.11.1. Determine long-term monitoring, maintenance, and institutional controls (e.g., physical and administrative land-use restrictions) needed to ensure that buried contamination will be left in a protective state based upon, in part, future land use decisions and possible failure mode scenarios

2B.11.2. Implement long-term monitoring (including sampling and analyses) and institutional controls

2B.11.3. Maintenance, repair, and replacement

2B.12. Construct New SDA Disposal Cell for Disposal of non-TRU Wastes and Contaminated Soil

2B.12.1. Determine performance criteria and requirements for new SDA disposal cell based upon relevant Waste Acceptance criteria, performance standards, and future land use decisions

2B.12.2. Construct on-site disposal cell in the SDA including installing a leachate collection system

2B.12.3. Dispose of non-TRU Wastes and Contaminated Soil in New SDA Disposal Cell

2B.13. Long-term Stewardship Activities for New SDA Disposal Cell

2B.13.1. Determine long-term monitoring, maintenance, and institutional controls (e.g., physical and administrative land-use restrictions) needed to ensure that waste buried in the new SDA disposal cell will be left in a protective state based upon, in part, future land use decisions and possible failure mode scenarios

2B.13.2. Implement long-term monitoring (including sampling and analyses) and institutional controls

2B.13.3. Routine maintenance, repair, and replacement

2B.13.4. Non-routine maintenance, repair, and replacement

2B.14. Off-site Shipment and Disposal at WIPP

2B.14.1. Plan and manage the waste shipments (including carrier/conveyance designation, preparing necessary plans for the route and security, coordinating the shipment with DOE and State/Local Governments, preparing the Hazardous/Radiological Shipment manifests, and performing the transportation Health Physics survey)

2B.14.2. Load TRU Waste Packages into Appropriate Carrier

2B.14.3. Load Appropriate Carrier on Appropriate Conveyance

2B.14.4. Transport TRU Waste to WIPP via road and/or rail

2B.14.5. Off-load TRU waste at WIPP

2B.14.6. Store TRU waste at WIPP

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# D. Conceptual Site Models for Alternative 1: Contain-in-Place (4 Options)

## List of Figures

This appendix presents conceptual site models for Alternative 1, which involves containing the buried wastes in the Subsurface Disposal Area in-place. That is, no wastes will be retrieved after completion of the on-going vacuum vapor extraction operations to remove volatile organics and the Pit 4 Accelerated Retrieval Project. Conceptual site models[99] can communicate risk-related information to DOE, regulators, and the general public. These models provide (often in block diagram form) pertinent information regarding hazards, pathways, receptors and barriers between known hazards and receptors. The models presented in this appendix follow the general format provided in Appendix C of the DOE-EM memorandum entitled "Guidance to Support Implementation of DOE Policy 455.1 for a Site-Specific Risk-Based End State (RBES) Vision Document," dated September 22, 2003 (DOE-EM, 2004).

[99] According to ASTM International (ASTM, 1995), a conceptual site model is "a written or pictorial representation of an environmental system and the biological, physical, and chemical processes that determine the transport of contaminants from sources through environmental media to environmental receptors within the system."

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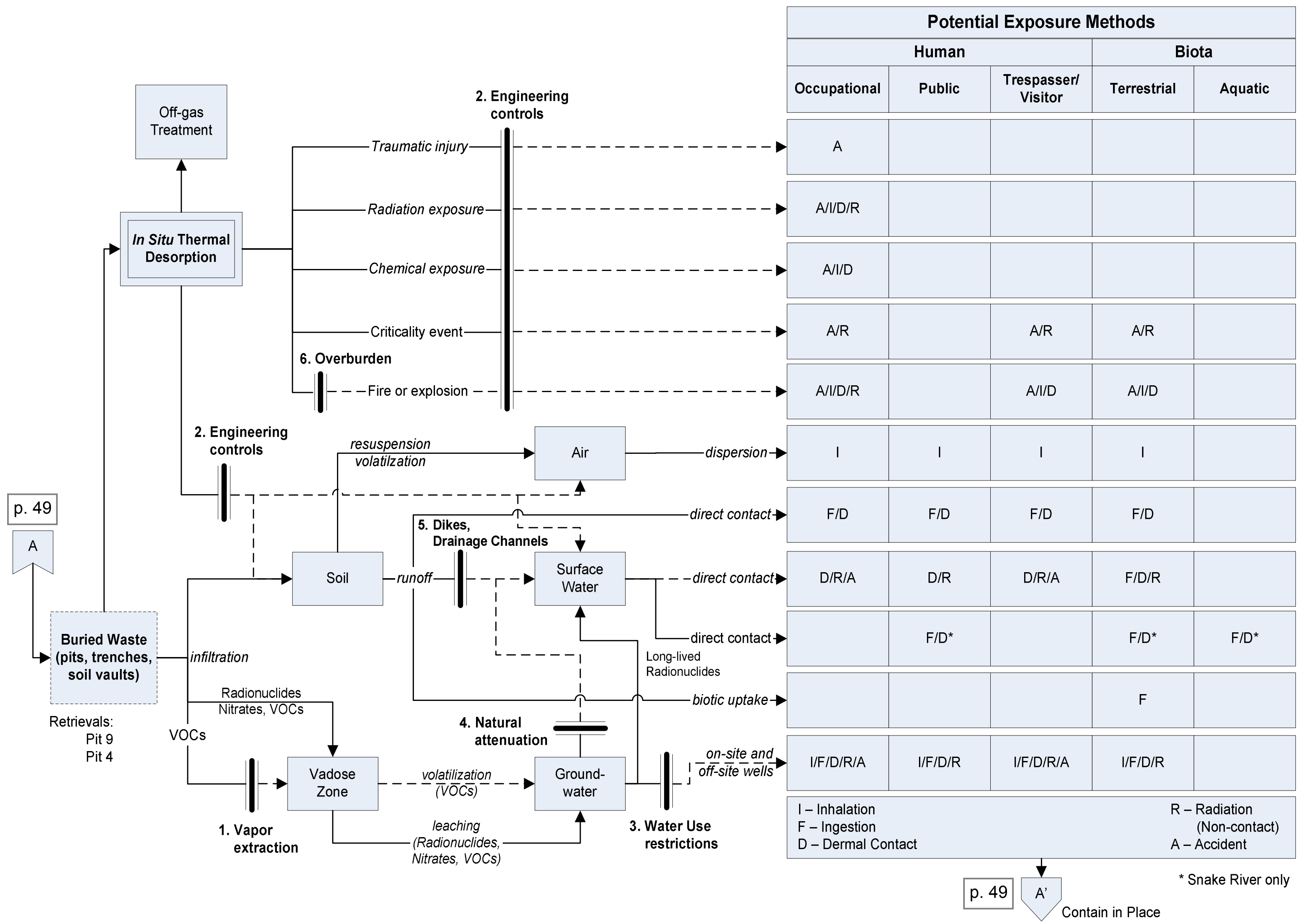


Figure D-1. Conceptual Site Model Representation for *In Situ* Thermal Desorption (ISTD) of the Idaho Site Buried Waste Area

**Narrative for Figure D-1 Conceptual Site Model Representation for *In Situ* Thermal Desorption (ISTD) of the Idaho Site Buried Waste Area**

The following barriers (or steps taken to mitigate impacts) are shown in Figure D-1:

1. A vapor extraction system extending into the vadose zone is being used to mitigate volatile organic constituents migration to the aquifer (DOE-ID, 2004a). Multiple vapor vacuum extraction with treatment units were installed within the Subsurface Disposal Area (SDA) and brought into operation in 1996. Data from monitoring well vapor samples are being used to assess the effectiveness of the remedy and to optimize volatile organic constituent removal.
2. Engineering controls will be in place to reduce worker and general public exposure during operations.
3. An extensive groundwater-monitoring program is in place at the Radioactive Waste Management Complex. Drinking water wells used to supply potable water to the work force are located outside of the SDA and are routinely monitored for water quality (DOE-ID, 2004a).
4. Natural attenuation of volatile organic compounds, nitrates, short-lived radionuclides (e.g., Cs-137, Sr-90, etc.), and some (e.g., immobile) long-lived radionuclides will prevent them from reaching the Snake River via the Snake River plain Aquifer.
5. An extensive surface water management system, including dikes and drainage channels, has been implemented at the SDA to minimize the potential for flooding and releases by way of surface water (DOE-ID, 2004a).
6. A layer of soil will be placed over the area undergoing *in situ* thermal desorption to prevent injury from fire or explosion.

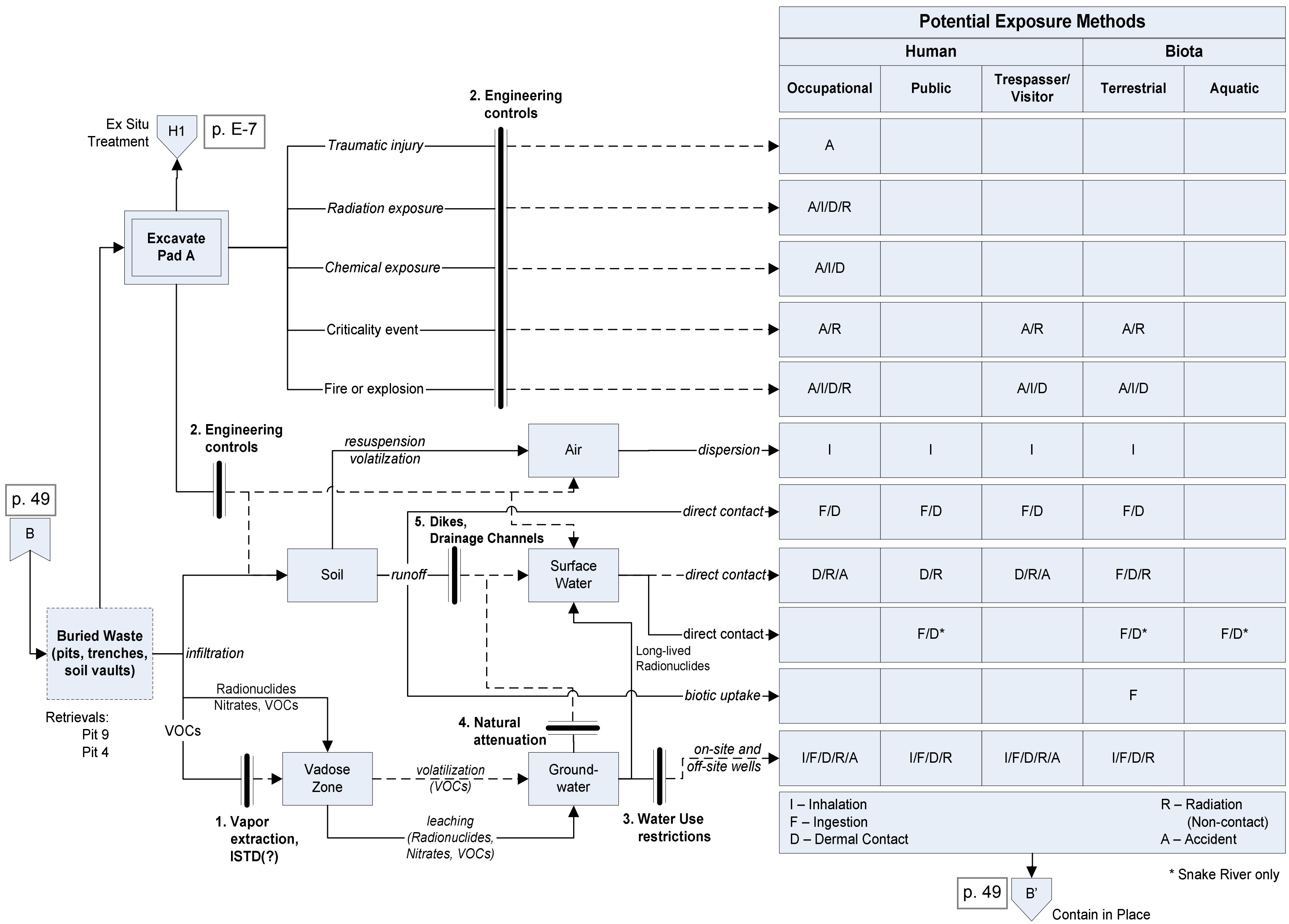


Figure D-2. Conceptual Site Model Representation for the Idaho Site SDA Pad A Reconfiguration

**Narrative for Figure D-2 Conceptual Site Model Representation for Idaho Site SDA Pad A Reconfiguration**

The following barriers (or steps taken to mitigate impacts) are shown in Figure D-2:

1. A vapor extraction system extending into the vadose zone is being used to mitigate volatile organic constituents migration to the aquifer (DOE-ID, 2004a). Multiple vapor vacuum extraction with treatment units were installed within the Subsurface Disposal Area (SDA) and brought into operation in 1996. Data from monitoring well vapor samples are being used to assess the effectiveness of the remedy and to optimize volatile organic constituent removal. It is possible that *in situ* thermal desorption will be required to treat further areas with high concentrations of volatile organic constituents.
2. Engineering controls will be in place to reduce worker and general public exposure during operations.
3. An extensive groundwater-monitoring program is in place at Radioactive Waste Management Complex. Drinking water wells used to supply potable water to the work force are located outside of the SDA and are routinely monitored for water quality (DOE-ID, 2004a).
4. Natural attenuation of volatile organic compounds, nitrates, short-lived radionuclides (e.g., Cs-137, Sr-90, etc.), and some (e.g., immobile) long-lived radionuclides will prevent them from reaching the Snake River via the Snake River plain Aquifer.
5. An extensive surface water management system, including dikes and drainage channels, has been implemented at the SDA to minimize the potential for flooding and releases by way of surface water (DOE-ID, 2004a).

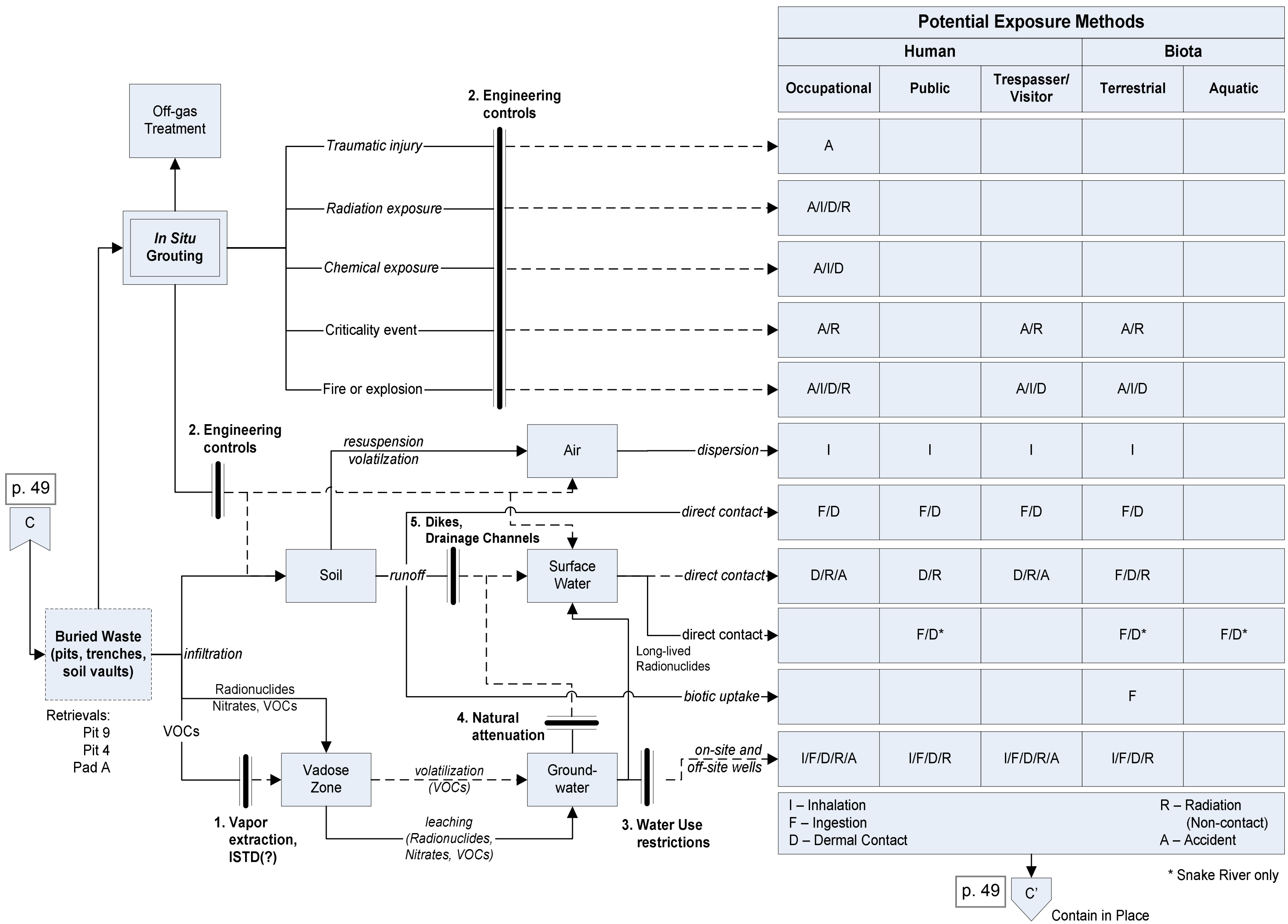


**Figure D-3. Conceptual Site Model Representation for *In Situ* Grouting (ISG)**

**Narrative for Figure D-3 Conceptual Site Model (CSM) Representation for *In Situ* Grouting (ISG)**

The following barriers (or steps taken to mitigate impacts) are shown in Figure D-3:

1. A vapor extraction system extending into the vadose zone is being used to mitigate volatile organic constituents migration to the aquifer (DOE-ID, 2004a). Multiple vapor vacuum extraction with treatment units were installed within the Subsurface Disposal Area (SDA) and brought into operation in 1996. Data from monitoring well vapor samples are being used to assess the effectiveness of the remedy and to optimize volatile organic constituent removal. It is possible that *in situ* thermal desorption will be required to treat further areas with high concentrations of volatile organic constituents.
2. Engineering controls will be in place to reduce worker and general public exposure during operations.
3. An extensive groundwater-monitoring program is in place at Radioactive Waste Management Complex. Drinking water wells used to supply potable water to the work force are located outside of the SDA and are routinely monitored for water quality (DOE-ID, 2004a).
4. Natural attenuation of volatile organic compounds, nitrates, short-lived radionuclides (e.g., Cs-137, Sr-90, etc.), and some (e.g., immobile) long-lived radionuclides will prevent them from reaching the Snake River via the Snake River plain Aquifer.
5. An extensive surface water management system, including dikes and drainage channels, has been implemented at the SDA to minimize the potential for flooding and releases by way of surface water (DOE-ID, 2004a).

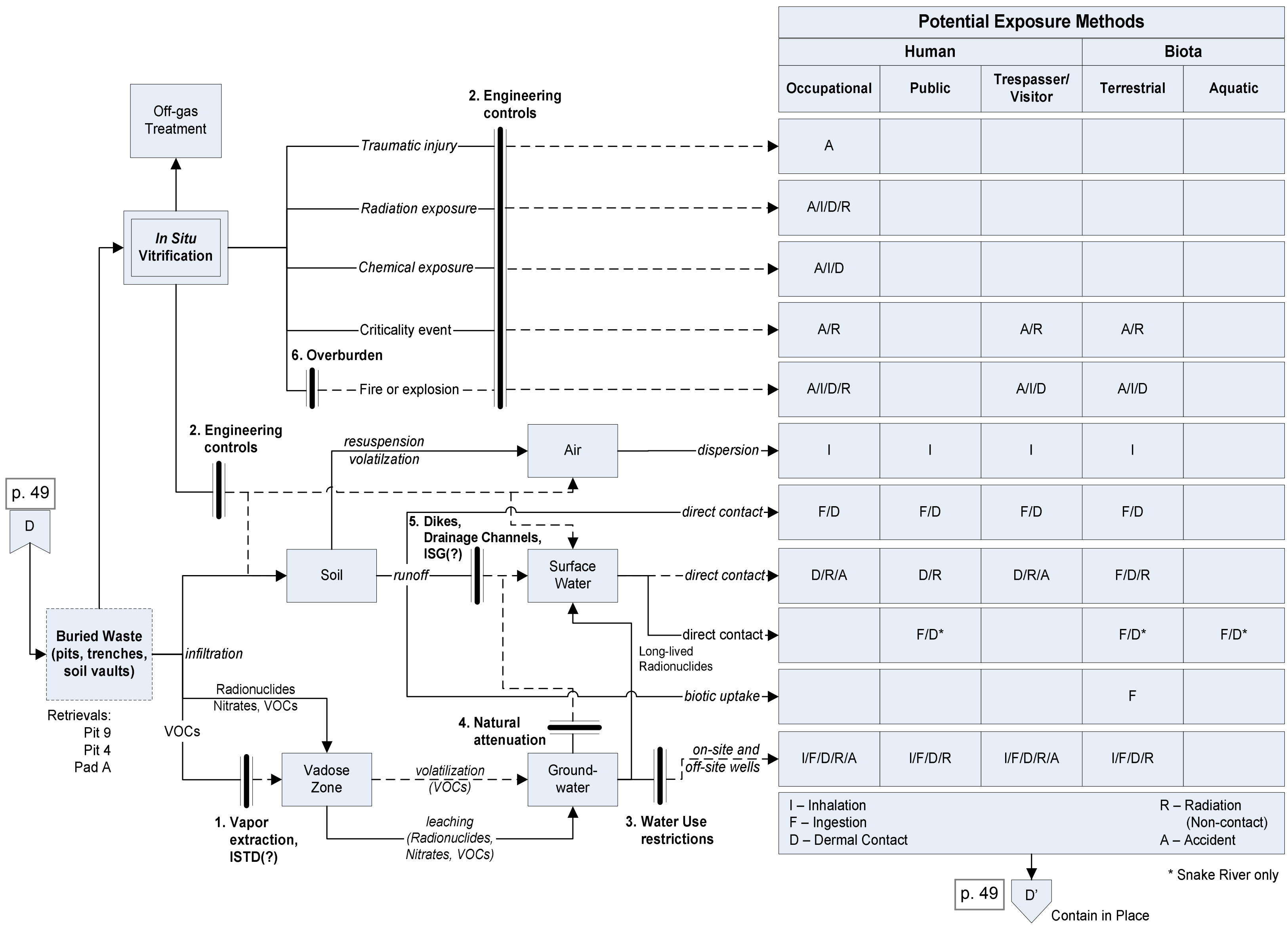


**Figure D-4. Conceptual Site Model Representation for *In Situ* Vitrification (ISV)**

**Narrative for Figure D-4 Conceptual Site Model Representation for *In Situ* Vitrification (ISV)**

The following barriers (or steps taken to mitigate impacts) are shown in Figure D-4:

1. A vapor extraction system extending into the vadose zone is being used to mitigate volatile organic constituents migration to the aquifer (DOE-ID, 2004a). Multiple vapor vacuum extraction with treatment units were installed within the Subsurface Disposal Area (SDA) and brought into operation in 1996. Data from monitoring well vapor samples are being used to assess the effectiveness of the remedy and to optimize volatile organic constituent removal. It is possible that *in situ* thermal desorption (ISTD) will be required to treat further areas with high concentrations of volatile organic constituents.
2. Engineering controls will be in place to reduce worker and general public exposure during operations.
3. An extensive groundwater-monitoring program is in place at Radioactive Waste Management Complex. Drinking water wells used to supply potable water to the work force are located outside of the SDA and are routinely monitored for water quality (DOE-ID, 2004a).
4. Natural attenuation of volatile organic compounds, nitrates, short-lived radionuclides (e.g., Cs-137, Sr-90, etc.), and some (e.g., immobile) long-lived radionuclides will prevent them from reaching the Snake River via the Snake River plain Aquifer.
5. An extensive surface water management system, including dikes and drainage channels, has been implemented at the SDA to minimize the potential for flooding and releases by way of surface water (DOE-ID, 2004a). It is possible that *in situ* grouting (ISG) may be required to immobilize contaminants.
6. A layer of soil will be placed over the area undergoing *in situ* thermal desorption to prevent injury from fire or explosion.

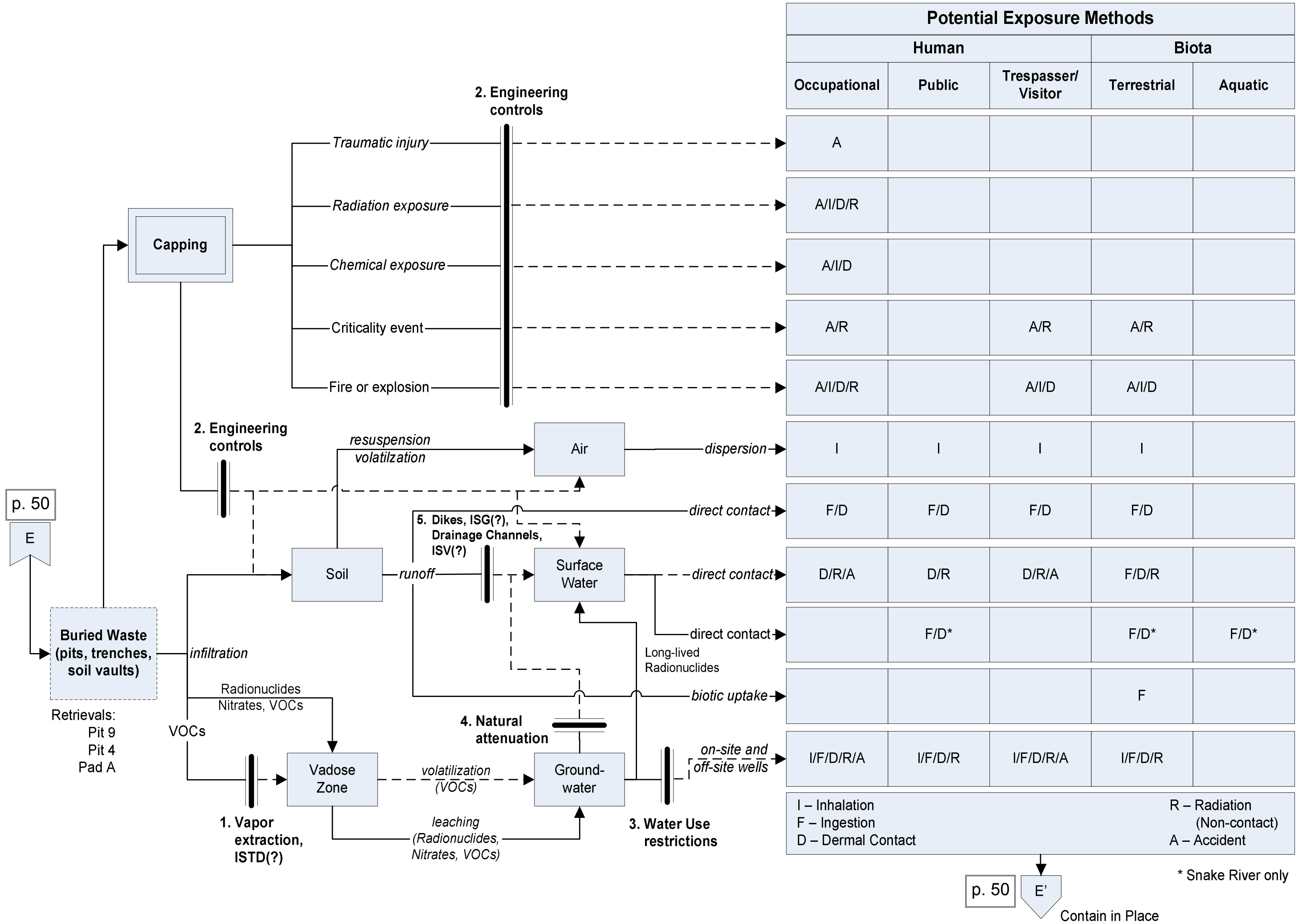


**Figure D-5. Conceptual Site Model Representation for Capping the Idaho Site Buried Waste Area**

**Narrative for Figure D-5 Conceptual Site Model Representation for Capping the Idaho Site Buried Waste Area**

The following barriers (or steps taken to mitigate impacts) are shown in Figure D-5:

1. A vapor extraction system extending into the vadose zone is being used to mitigate volatile organic constituents migration to the aquifer (DOE-ID, 2004a). Multiple vapor vacuum extraction with treatment units were installed within the Subsurface Disposal Area (SDA) and brought into operation in 1996. Data from monitoring well vapor samples are being used to assess the effectiveness of the remedy and to optimize volatile organic constituent removal. It is possible that *in situ* thermal desorption (ISTD) will be required to treat further areas with high concentrations of volatile organic constituents.
2. Engineering controls will be in place to reduce worker and general public exposure during operations.
3. An extensive groundwater-monitoring program is in place at Radioactive Waste Management Complex. Drinking water wells used to supply potable water to the work force are located outside of the SDA and are routinely monitored for water quality (DOE-ID, 2004a).
4. Natural attenuation of volatile organic compounds, nitrates, short-lived radionuclides (e.g., Cs-137, Sr-90, etc.), and some (e.g., immobile) long-lived radionuclides will prevent them from reaching the Snake River via the Snake River plain Aquifer.
5. An extensive surface water management system, including dikes and drainage channels, has been implemented at the SDA to minimize the potential for flooding and releases by way of surface water (DOE-ID, 2004a). It is possible that *in situ* grouting (ISG) or *in situ* vitrification may be required to immobilize contaminants of concern.

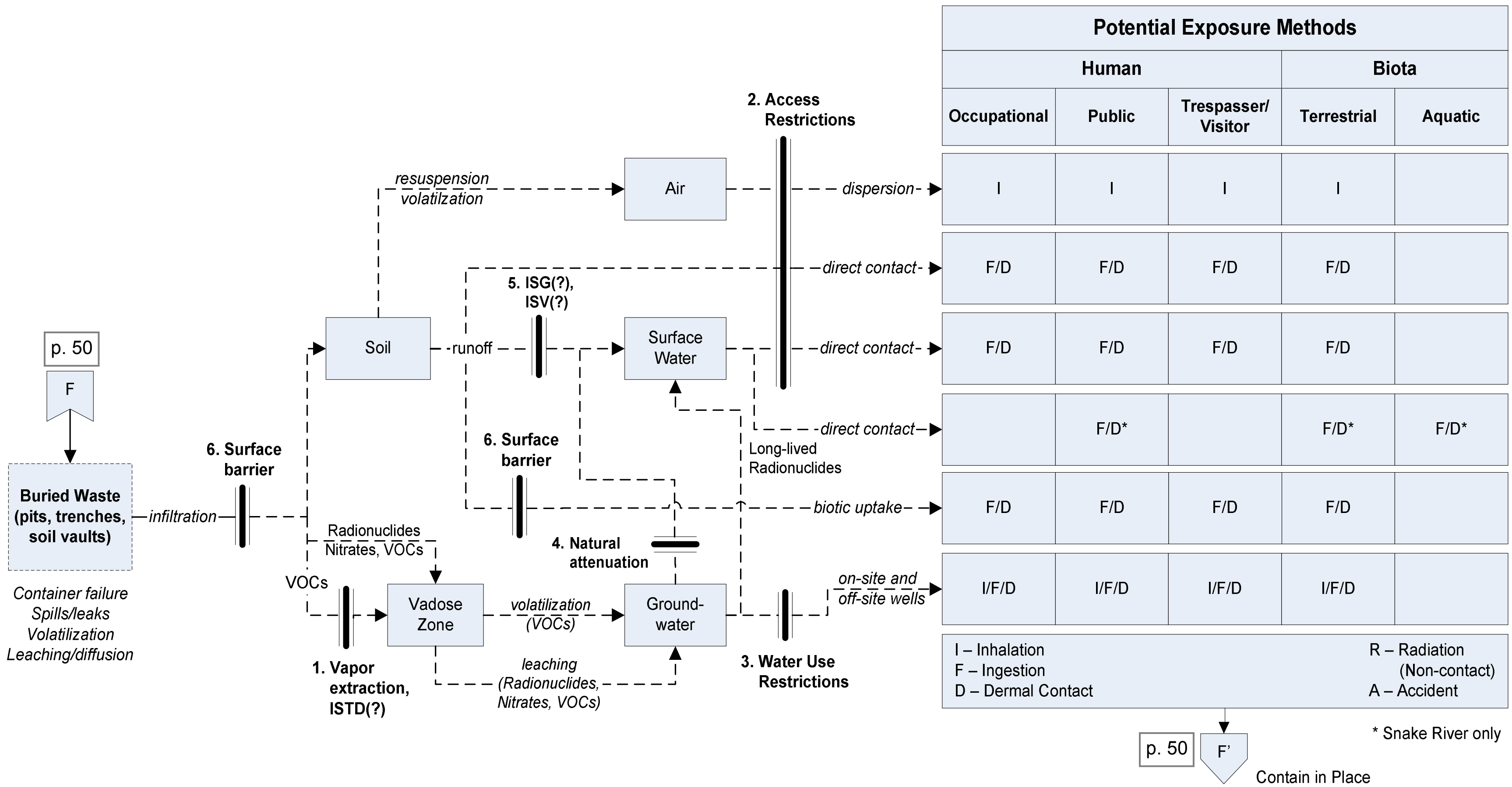


**Figure D-6. Conceptual Site Model Representation for the Idaho Site Buried Waste Area – Potential Protective Post-Capping End State**

**Narrative for Figure D-6 Conceptual Site Model Representation for the Idaho Site Buried Waste Area – Potential Protective Post-Capping End State**

The following barriers (or steps taken to mitigate impacts) are shown in Figure D-6:

1. A vapor extraction system extending into the vadose zone is being used to mitigate volatile organic constituents migration to the aquifer (DOE-ID, 2004a). Multiple vapor vacuum extraction with treatment units were installed within the Subsurface Disposal Area (SDA) and brought into operation in 1996. Data from monitoring well vapor samples are being used to assess the effectiveness of the remedy and to optimize volatile organic constituent removal. It is possible that *in situ* thermal desorption (ISTD) will be required to treat further areas with high concentrations of volatile organic constituents.
2. The Idaho Site has restricted access to prevent intrusion by the public, and the SDA is surrounded by a security fence (DOE-ID, 2004a).
3. An extensive groundwater-monitoring program is in place at Radioactive Waste Management Complex. Drinking water wells used to supply potable water to the work force are located outside of the SDA and are routinely monitored for water quality (DOE-ID, 2004a).
4. Natural attenuation of volatile organic compounds, nitrates, short-lived radionuclides (e.g., Cs-137, Sr-90, etc.), and some (e.g., immobile) long-lived radionuclides will prevent them from reaching the Snake River via the Snake River plain Aquifer.
5. It is possible that *in situ* grouting (ISG) or *in situ* vitrification may be required to immobilize contaminants of concern.
6. A surface barrier will be installed at the SDA to prevent infiltration of water into the burial site.

# E. Conceptual Site Models for Alternative 2: Retrieve/Treat/Dispose (2 Options)

## List of Figures

This appendix presents conceptual site models for Alternative 2, which involves retrieving some fraction of the buried wastes in the Subsurface Disposal Area and treating these wastes for subsequent disposal. Conceptual site models[100] can communicate risk-related information to DOE, regulators, and the general public. These models provide (often in block diagram form) pertinent information regarding hazards, pathways, receptors and barriers between known hazards and receptors. The models presented in this appendix follow the general format provided in Appendix C of the DOE-EM memorandum entitled "Guidance to Support Implementation of DOE Policy 455.1 for a Site-Specific Risk-Based End State (RBES) Vision Document," dated September 22, 2003 (DOE-EM, 2003).

[100] According to ASTM International (ASTM, 1995), a conceptual site model is "a written or pictorial representation of an environmental system and the biological, physical, and chemical processes that determine the transport of contaminants from sources through environmental media to environmental receptors within the system."

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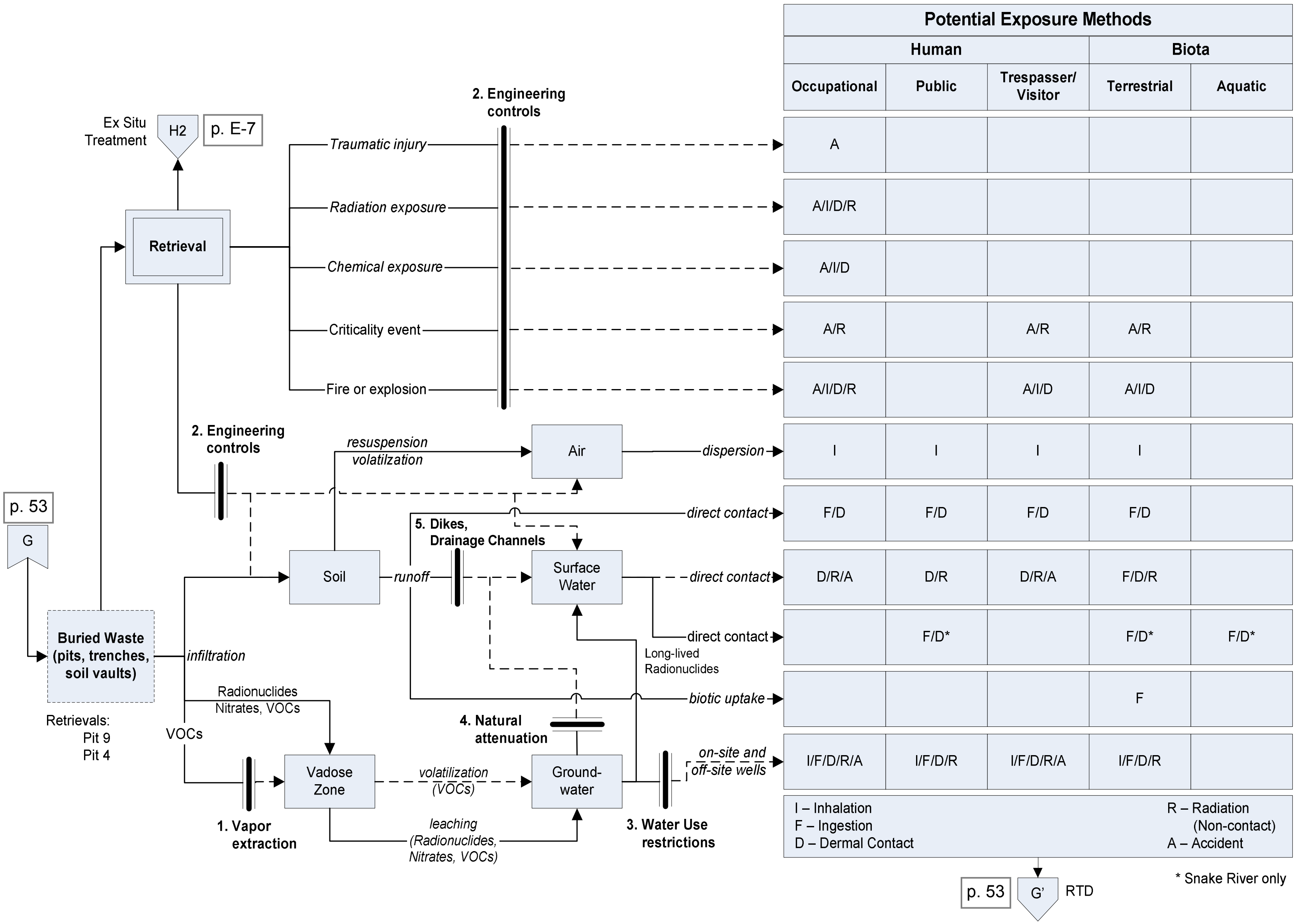


Figure E-1. Conceptual Site Model Representation for Retrieval of the Idaho Site Buried Waste

**Narrative for Figure E-1 Conceptual Site Model Representation for Retrieval of Idaho Site Buried Waste**

The following barriers (or steps taken to mitigate impacts) are shown in Figure E-1:

1. A vapor extraction system extending into the vadose zone is being used to mitigate volatile organic constituents migration to the aquifer (DOE-ID, 2004a). Multiple vapor vacuum extraction with treatment units were installed within the Subsurface Disposal Area (SDA) and brought into operation in 1996. Data from monitoring well vapor samples are being used to assess the effectiveness of the remedy and to optimize volatile organic constituent removal.
2. Engineering controls will be in place to reduce worker and general public exposure during operations.
3. An extensive groundwater-monitoring program is in place at the Radioactive Waste Management Complex. Drinking water wells used to supply potable water to the work force are located outside of the SDA and are routinely monitored for water quality (DOE-ID, 2004a).
4. Natural attenuation of volatile organic compounds, nitrates, short-lived radionuclides (e.g., Cs-137, Sr-90, etc.), and some (e.g., immobile) long-lived radionuclides will prevent them from reaching the Snake River via the Snake River plain Aquifer.
5. An extensive surface water management system, including dikes and drainage channels, has been implemented at the SDA to minimize the potential for flooding and releases by way of surface water (DOE-ID, 2004a).

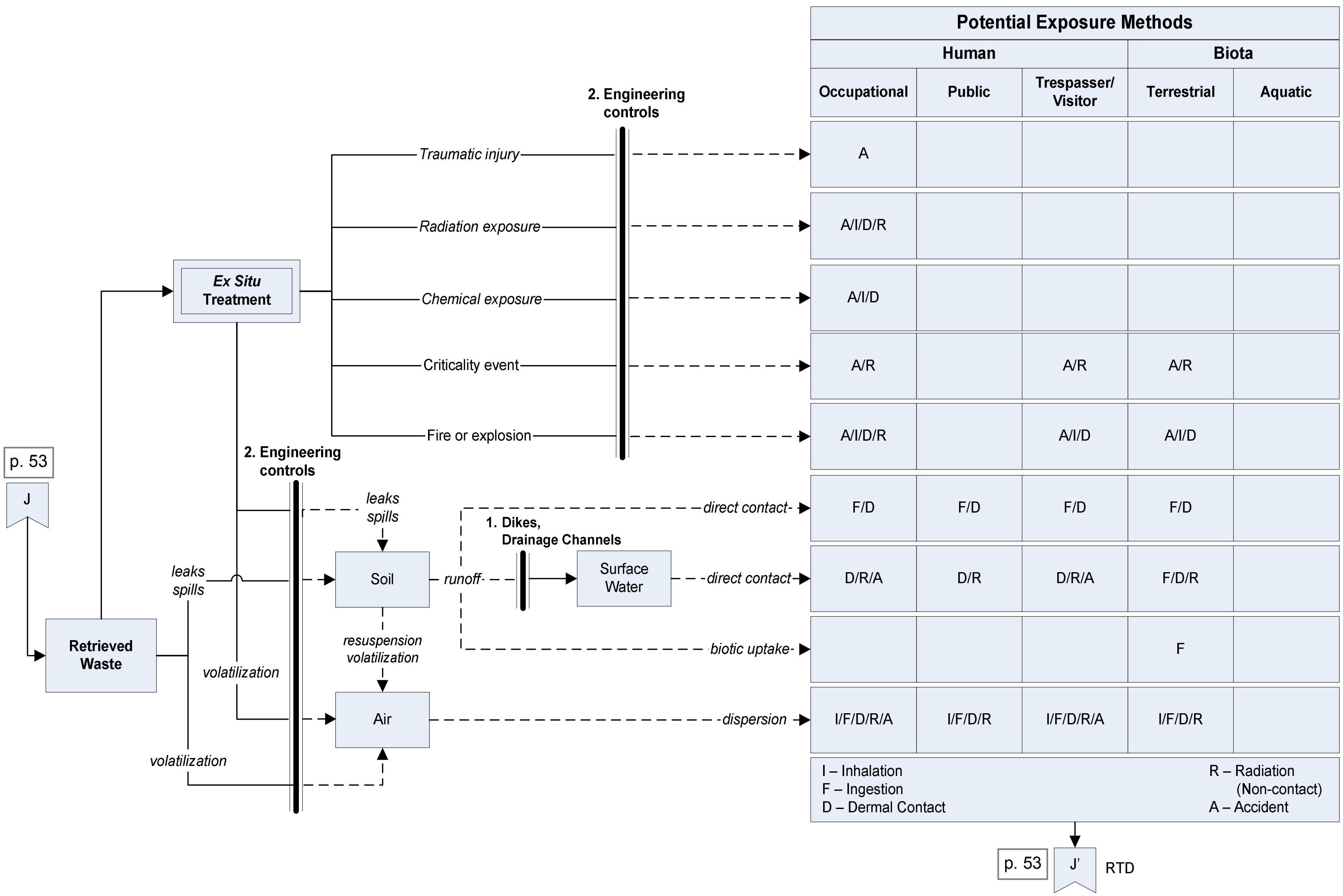


**Figure E-2. Conceptual Site Model Representation for *Ex Situ* Treatment (e.g., Compaction) of Pad A and Buried RFP Wastes—Processing**

**Narrative for Figure E-2 Conceptual Site Model Representation for *Ex Situ* Treatment (e.g., Compaction) of Pad A and Buried RFP Wastes—Processing**

The following barriers (or steps taken to mitigate impacts) are shown in Figure E-2:

1. An extensive groundwater-monitoring program is in place at the Radioactive Waste Management Complex. Drinking water wells used to supply potable water to the work force are located outside of the SDA and are routinely monitored for water quality (DOE-ID, 2004a).
2. Engineering controls will be in place to reduce worker and general public exposure during operations.

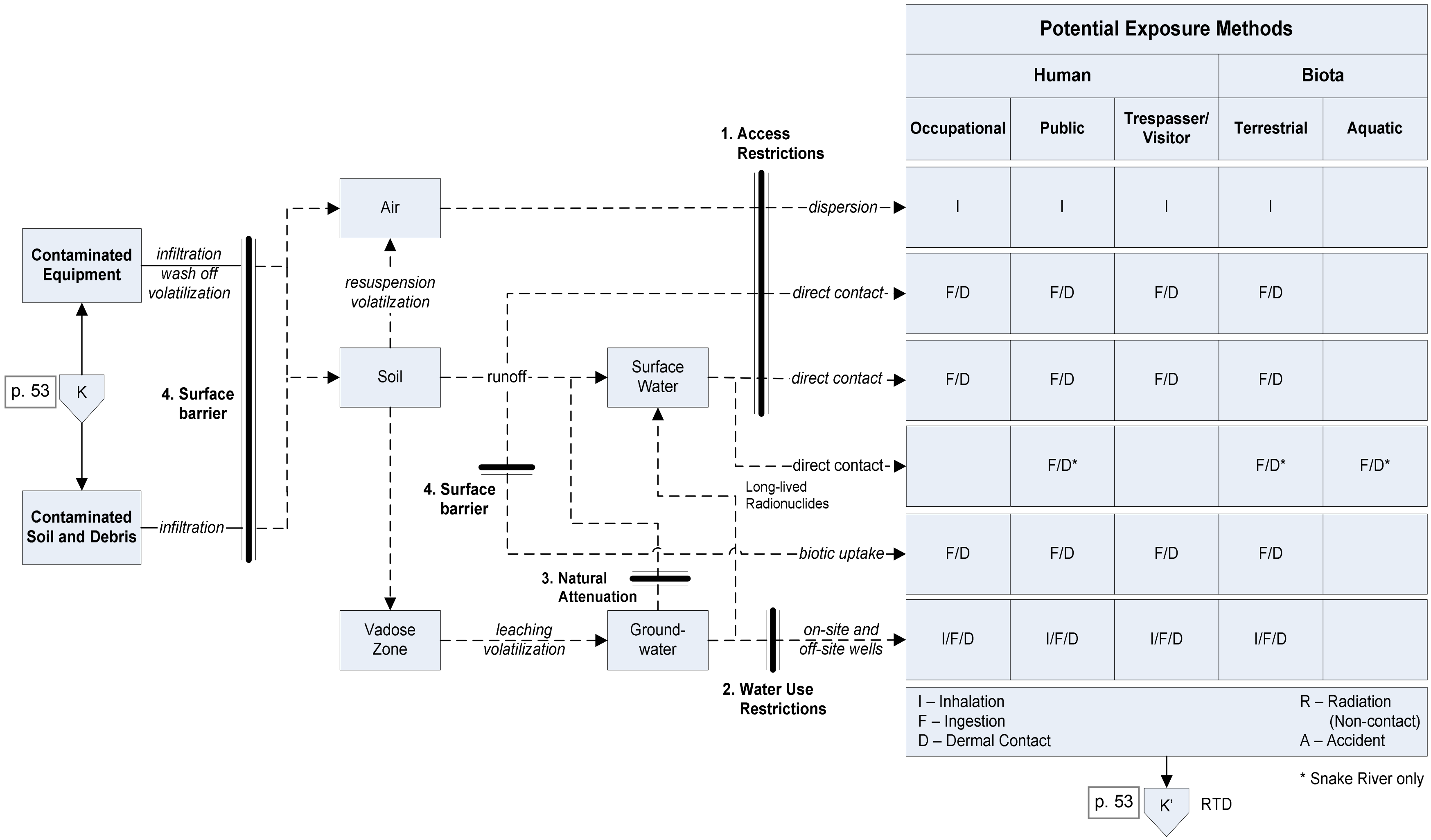


**Figure E-3. Conceptual Site Model Representation for *Ex Situ* Treatment (e.g., Compaction) of Pad A and Buried RFP Wastes—End State (Assuming Equipment Burial and No Decontamination)**

**Narrative for Figure E-3 Conceptual Site Model Representation for *Ex Situ* Treatment (e.g., Compaction) of Pad A and Buried RFP Wastes—End State (Assuming Equipment Burial and No Decontamination)**

The following barriers (or steps taken to mitigate impacts) are shown in Figure E-3:

1. The Idaho Site has restricted access to prevent intrusion by the public, and the Subsurface Disposal Area (SDA) is surrounded by a security fence (DOE-ID, 2004a).
2. An extensive groundwater-monitoring program is in place at Radioactive Waste Management Complex. Drinking water wells used to supply potable water to the work force are located outside of the SDA and are routinely monitored for water quality (DOE-ID, 2004a).
3. Natural attenuation of volatile organic compounds, nitrates, short-lived radionuclides (e.g., Cs-137, Sr-90, etc.), and some (e.g., immobile) long-lived radionuclides will prevent them from reaching the Snake River via the Snake River plain Aquifer.
4. A surface barrier will be installed at the SDA to prevent infiltration of water into the burial site.

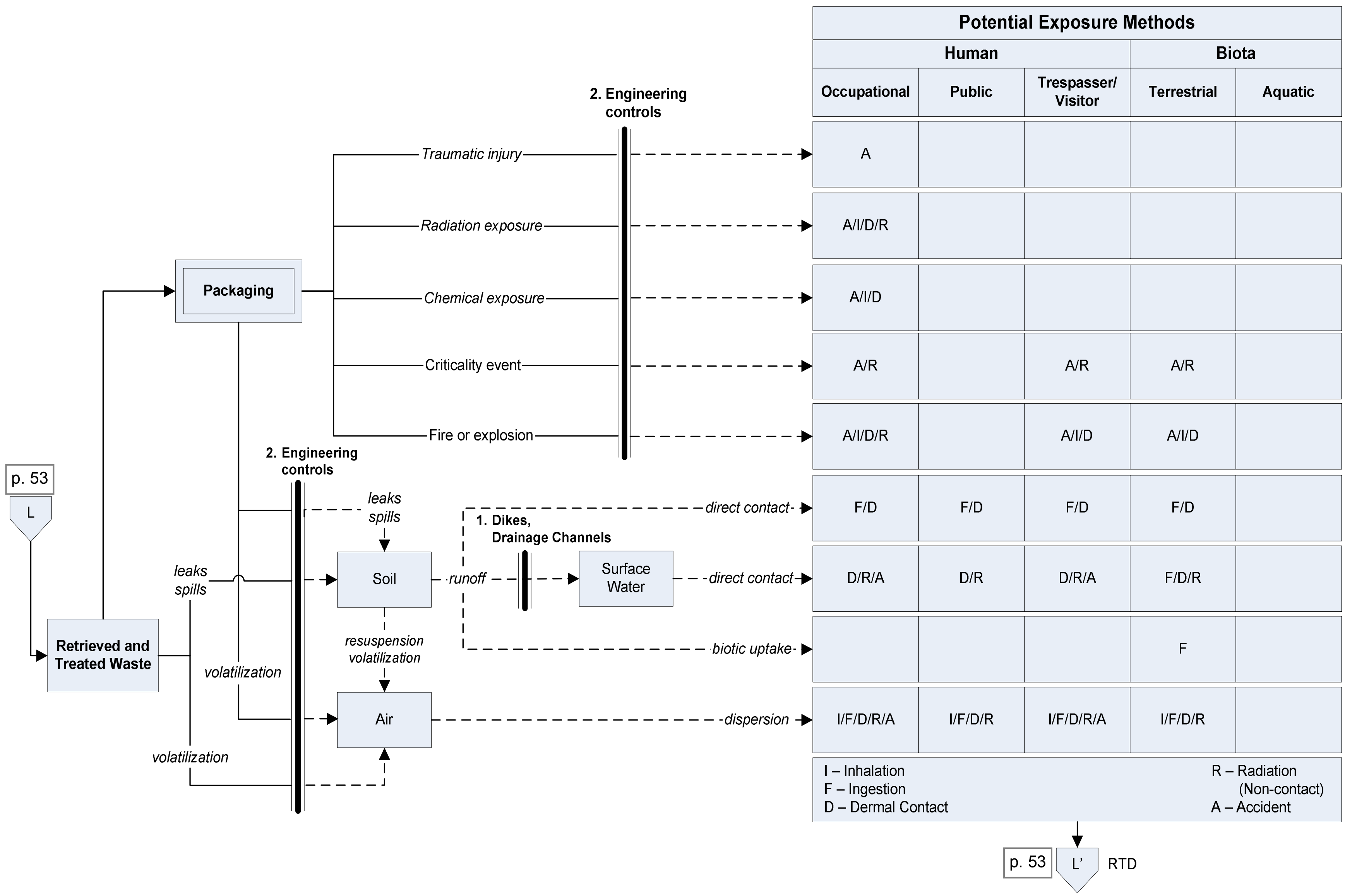


**Figure E-4. Conceptual Site Model Representation for Packaging Retrieved SDA Wastes—Processing**

**Narrative for Figure E-4 Conceptual Site Model Representation for Packaging Retrieved SDA Wastes—Processing**

The following barriers (or steps taken to mitigate impacts) are shown in Figure E-4:

1. An extensive surface water management system, including dikes and drainage channels, has been implemented at the Subsurface Disposal Area to minimize the potential for flooding and releases by way of surface water (DOE-ID, 2004a).
2. Engineering controls will be in place to reduce worker and general public exposure during operations.

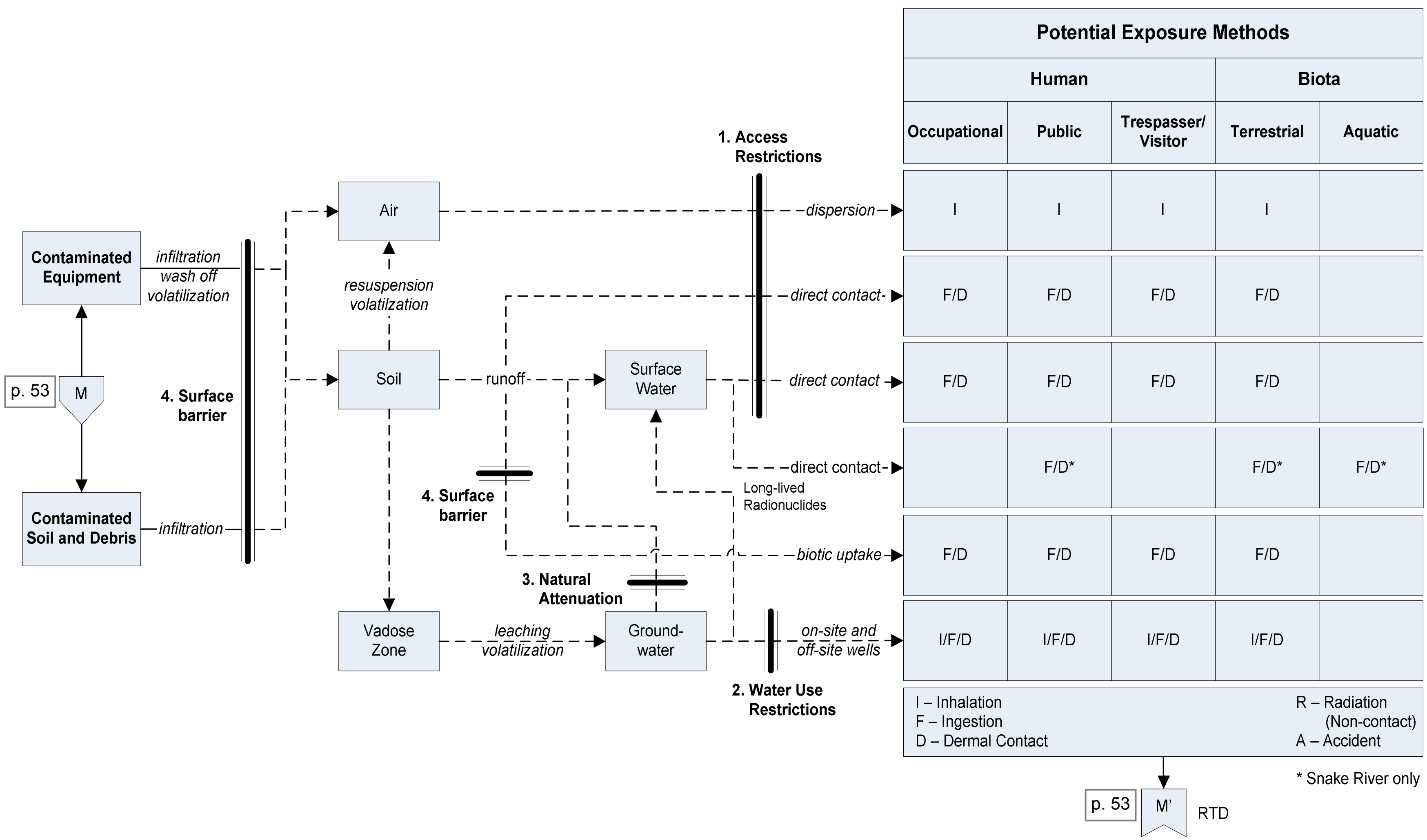


**Figure E-5. Conceptual Site Model Representation for Packaging Retrieved SDA Wastes—End State (Assuming Equipment Burial and No Decontamination)**

**Narrative for Figure E-5 Conceptual Site Model Representation for Packaging Retrieved SDA Wastes—End State (Assuming Equipment Burial and No Decontamination)**

The following barriers (or steps taken to mitigate impacts) are shown in Figure E-5:

1. The Idaho Site has restricted access to prevent intrusion by the public, and the Subsurface Disposal Area (SDA) is surrounded by a security fence (DOE-ID, 2004a).
2. An extensive groundwater-monitoring program is in place at Radioactive Waste Management Complex. Drinking water wells used to supply potable water to the work force are located outside of the SDA and are routinely monitored for water quality (DOE-ID, 2004a).
3. Natural attenuation of volatile organic compounds, nitrates, short-lived radionuclides (e.g., Cs-137, Sr-90, etc.), and some (e.g., immobile) long-lived radionuclides will prevent them from reaching the Snake River via the Snake River plain Aquifer.
4. A surface barrier will be installed at the SDA to prevent infiltration of water into the burial site.

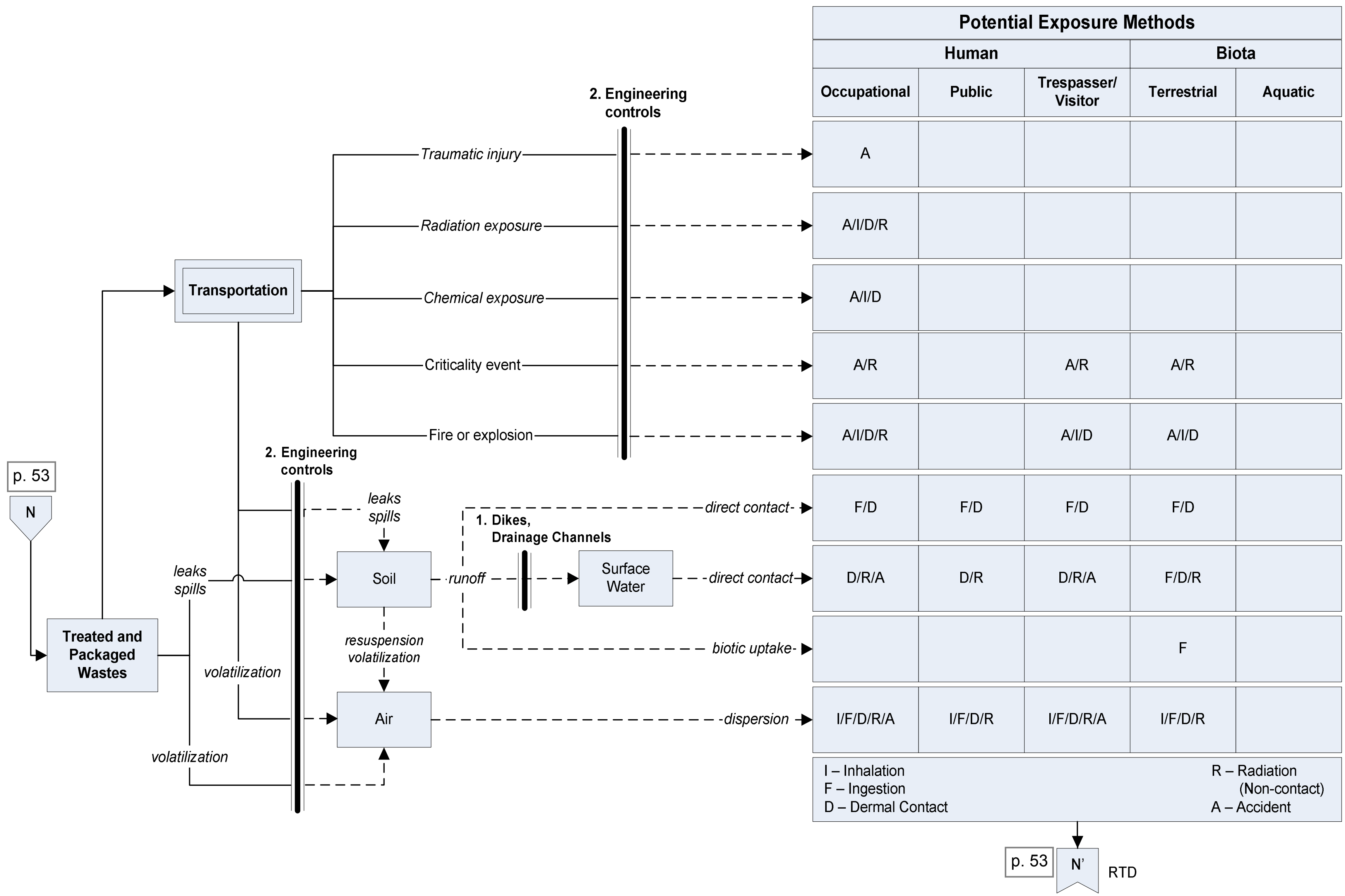


Figure E-6. Conceptual Site Model Representation for Transporting TRU Wastes to WIPP—Transportation

**Narrative for Figure E-6 Conceptual Site Model Representation for Transporting TRU Wastes to WIPP—Transportation**

The following barrier (or steps taken to mitigate impacts) is shown in Figure E-6:

1. An extensive surface water management system, including dikes and drainage channels, has been implemented at the Subsurface Disposal Area to minimize the potential for flooding and releases by way of surface water (DOE-ID, 2004a).
2. Engineering controls will be in place to reduce worker and general public exposure during operations.

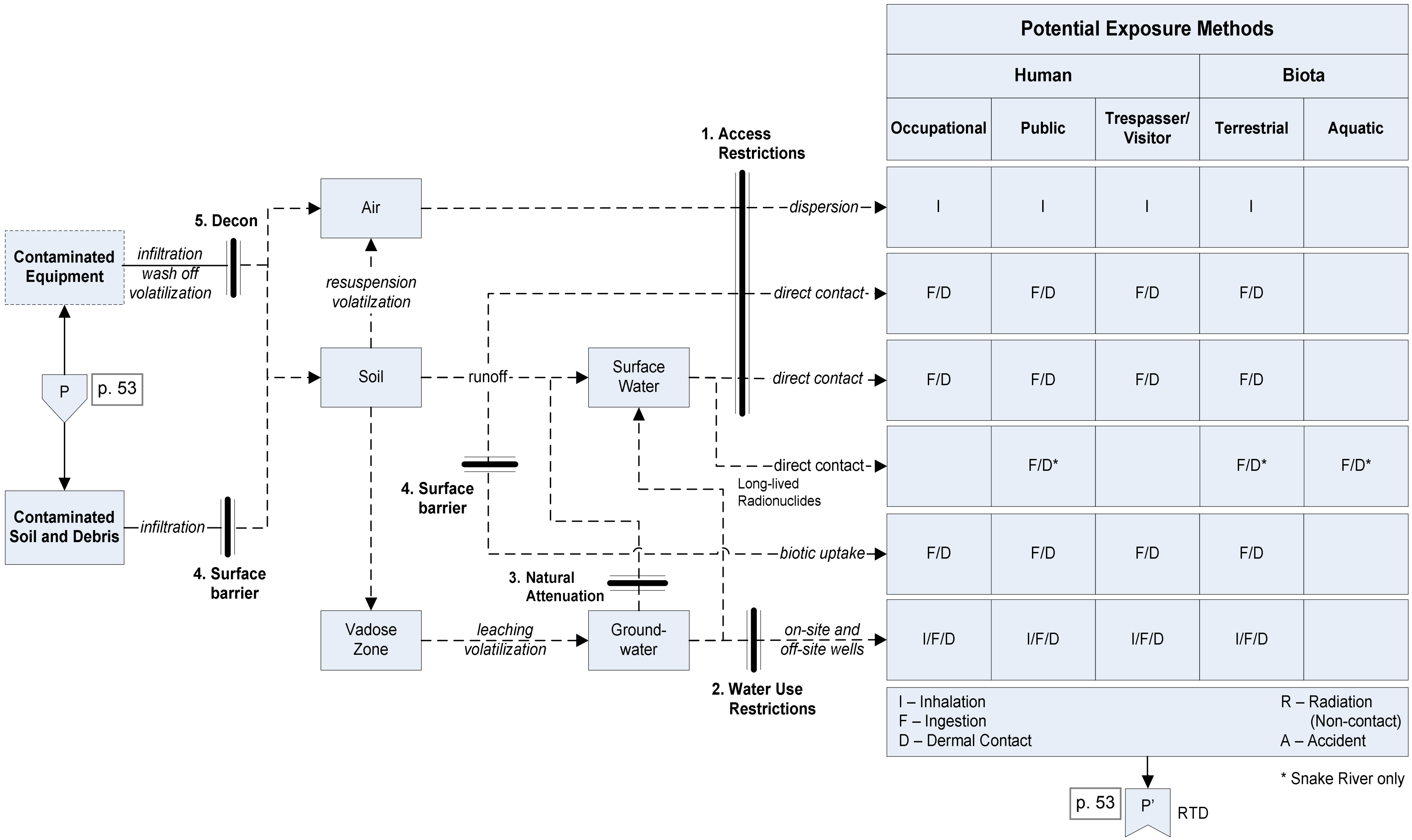


Figure E-7. Conceptual Site Model Representation for Transporting TRU Wastes to WIPP—End State (Assuming Decontamination)

**Narrative for Figure E-7 Conceptual Site Model Representation for Transporting TRU Wastes to WIPP—End State (Assuming Decontamination)**

The following barriers (or steps taken to mitigate impacts) are shown in Figure E-7:

1. The Idaho Site has restricted access to prevent intrusion by the public, and the Subsurface Disposal Area (SDA) is surrounded by a security fence (DOE-ID, 2004a).
2. An extensive groundwater-monitoring program is in place at Radioactive Waste Management Complex. Drinking water wells used to supply potable water to the work force are located outside of the SDA and are routinely monitored for water quality (DOE-ID, 2004a).
3. Natural attenuation of volatile organic compounds, nitrates, short-lived radionuclides (e.g., Cs-137, Sr-90, etc.), and some (e.g., immobile) long-lived radionuclides will prevent them from reaching the Snake River via the Snake River plain Aquifer.
4. A surface barrier will be installed at the SDA to prevent infiltration of water into the burial site.
5. Contaminated equipment will be decontaminated prior to reuse.

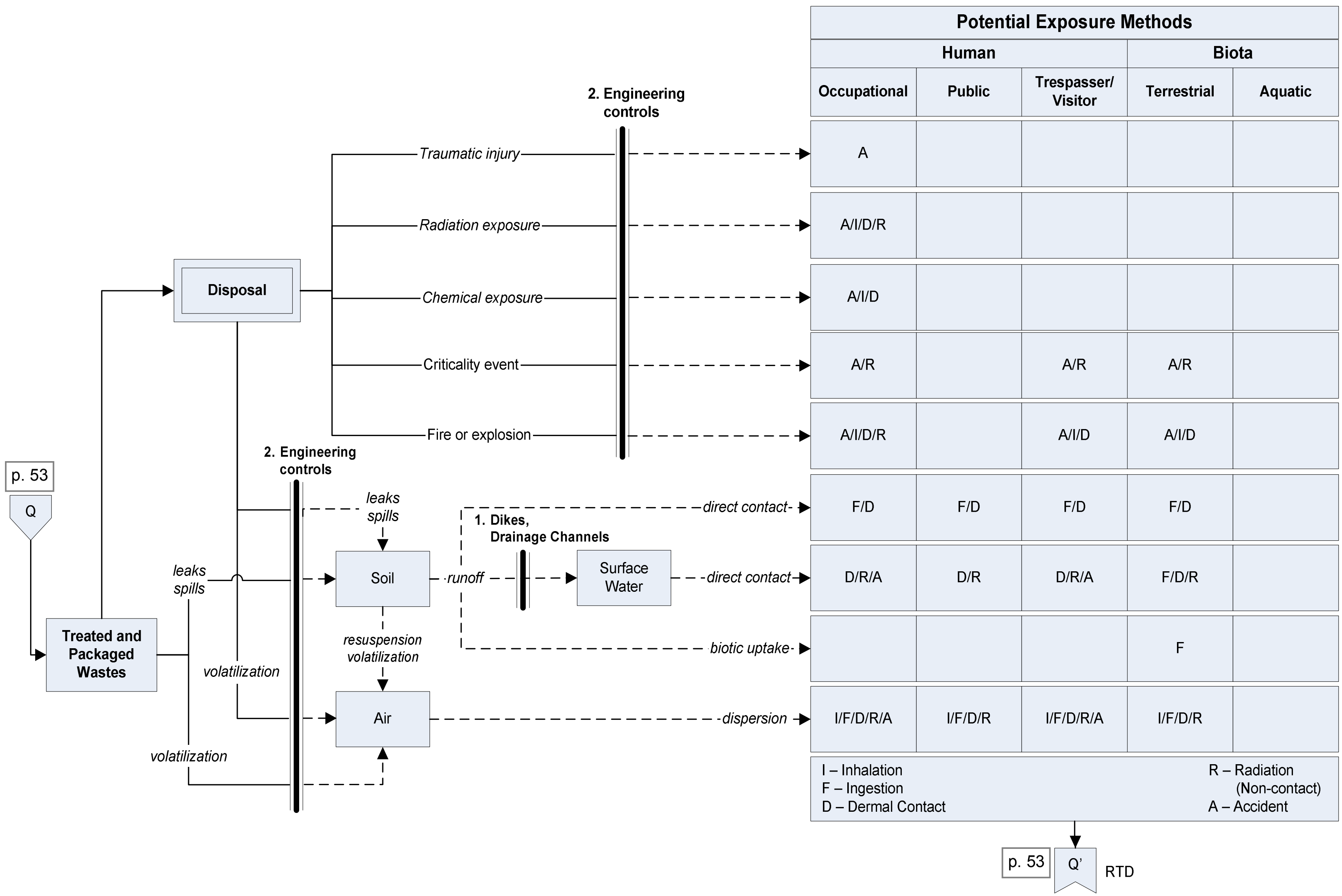


Figure E-8. Conceptual Site Model Representation for Disposal of Retrieved SDA Wastes—Process

**Narrative for Figure E-8 Conceptual Site Model Representation for Disposal of Retrieved SDA Wastes—Process**

The following barrier (or steps taken to mitigate impacts) is shown in Figure E-8:

1. An extensive surface water management system, including dikes and drainage channels, has been implemented at the Subsurface Disposal Area to minimize the potential for flooding and releases by way of surface water (DOE-ID, 2004a).
2. Engineering controls will be in place to reduce worker and general public exposure during operations.

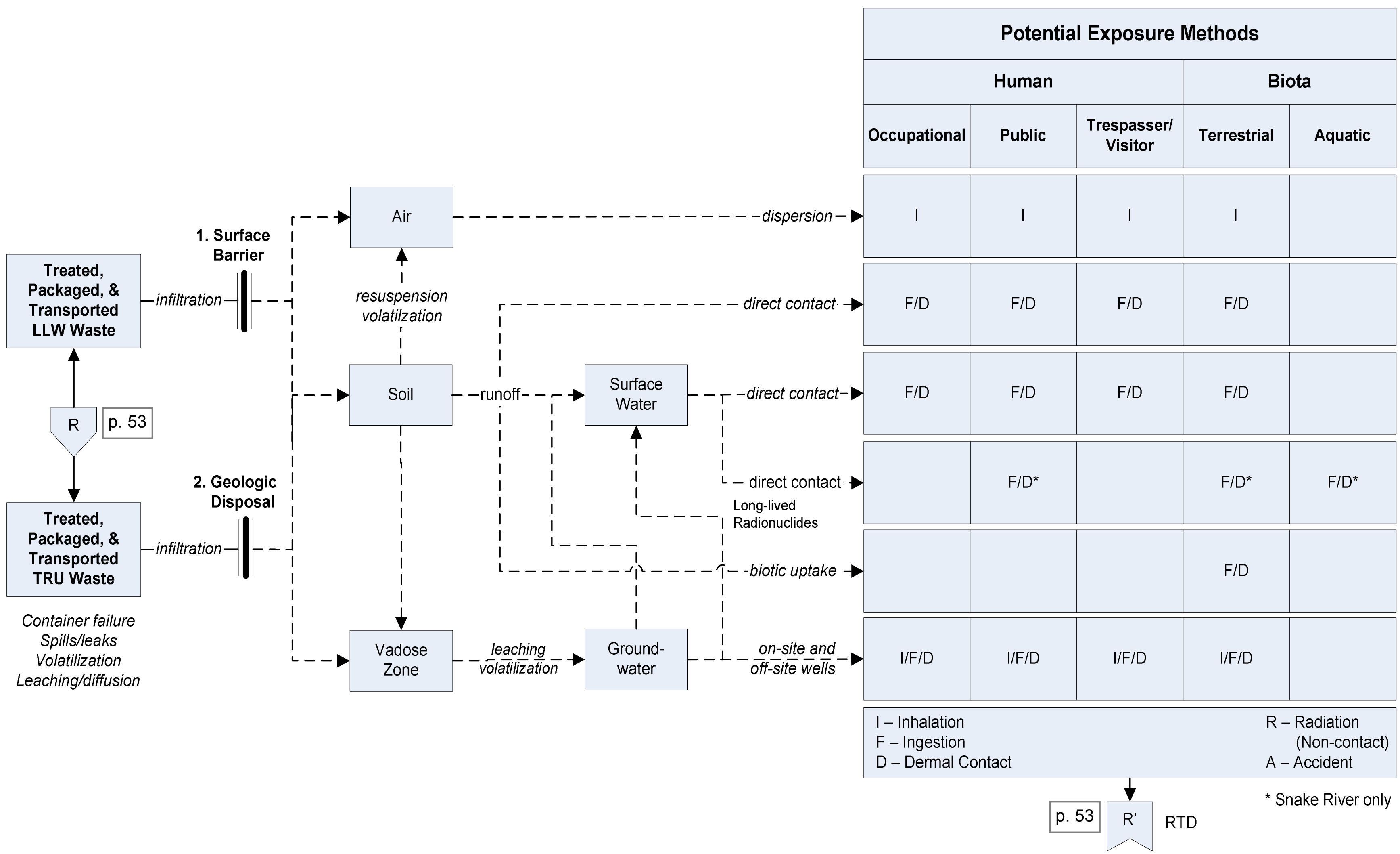


Figure E-9. Conceptual Site Model Representation for Disposal of Retrieved SDA Wastes–Potential Protective Post-Retrieval End State

**Narrative for Figure E-9 Conceptual Site Model Representation for Disposal of Retrieved SDA Wastes–Potential Protective Post-Retrieval End State**

The following barriers (or steps taken to mitigate impacts) are shown in Figure E-9:

1. A surface barrier will be installed at the Subsurface Disposal Area to prevent infiltration of water into the burial site.
2. The retrieved TRU wastes will be packaged and sent to the Waste Isolation Pilot Plant (WIPP) for permanent disposal in a geologic repository.

# F. Definitions for Gap and Hazard Analysis Tables

# Table of Contents



# List of Tables



# List of Additional Information

## F.1. Introduction

Hazard and gap analysis tables are provided as part of this report, which evaluates the various Idaho Site Subsurface Disposal Area (SDA) remedial alternatives. This report provides a *framework* for assessing risks associated with the various remedial alternatives investigated; however, the document will provide neither quantitative risk estimates nor recommendations for remedial alternatives. We must have the ability to categorize, at least qualitatively, the known hazards and gaps pertaining to the remedial alternatives considered. Although we realize that there is not likely to be unanimous agreement on any set of definitions, we must still have a common basis for assessing the tasks in question—this is an attempt to provide such a basis. Furthermore, these definitions allow reviewers to "mean the same thing" when generic terms such as "*low*" or "*high*" are used. It is understood that not everyone would agree with the categorizations provided here; however, because some assessment of the risks must be made (and precise values cannot be placed on the risks or gaps), we have agreed on the descriptions provided. Note that the intent of these reports is to provide a *framework* for assessing risks and not to provide quantitative risk estimates. We are cognizant of the fact that these categories are subject to change as further knowledge is obtained; however, any set of categories must be both defined and consistent to be of use.

## F.2. Hazard Analysis Definitions

The basic format that has been agreed upon for the *hazard analysis* tables is illustrated for the SDA alternatives in Appendix G and Appendix H (i.e., Table G-1 through Table H-2). In these tables, there are a number of columns whose definitions were standardized. These columns are

- Task Frequency
- How likely is it? (Event Probability)
- What is the severity of the consequences?
- Overall contribution to risk

where the other columns are considered self-explanatory.

The "Task Frequency" column indicates the frequency with which a task is performed and the "How likely is it?" or event probability column denotes the overall probability of experiencing an adverse event given performance of the task.[101] Based upon these assumptions, definitions have been provided in Box F-1 for the hazard analysis tables. That is, for *each hazard in a given task in a given process step*, we can categorize both an adverse event probability (i.e., "How likely is it?") and a consequence severity.

[101] The "How likely is it?" or event probability column indicates the likelihood of the adverse event occurring (or the product of the task frequency and the hazard likelihood).

**Box F-1. Definitions for Hazard Analysis Tables**

### Task Frequency

**Frequent:** Occurs very often (e.g., more than once per quarter for long-duration tasks) or continuously.

**Anticipated:** Occurs several times (e.g., on the average of once per year) over the project lifetime or occurs infrequently but with long duration.

**Occasional:** Occurs sporadically or at a well-defined time (e.g., start-up or closure) or has a remote possibility of occurrence.

**Unlikely:** One can reasonably assume that this will not occur, but its occurrence is not impossible.

### How likely is it? (Event Probability)

**Probable:** Very likely to occur (e.g., more than 50 times out of 100) during task execution.

**Possible:** Expected to occur (e.g., between 1 time out of 100 and 50 times out of 100) during task execution.

**Unlikely:** One can reasonably assume that this hazard will not transpire (e.g., less than one chance out of 100), but its occurrence is not impossible.

### Consequence Severity[102]

**Severe:** Loss of ability to satisfy applicable and relevant design and performance criteria and protect human health (both worker and general public) and the environment (both on- and off-site). Likely to result in death or permanent disability including that from latent cancer effects to a large group of people (e.g., greater than 25 and greater than 5, respectively). Loss of major or safety-critical system or equipment. Major property or facility damage (e.g., greater than $1 million). Severe environmental damage (e.g., significant loss of protected or endangered species habitat). Severe security failure (e.g., loss of material with potential "dirty bomb" applicability).[103]

**Critical:** Significantly degraded performance versus applicable and relevant design and performance criteria and the ability to protect human health (both worker and the general public) and the environment (both on- and off-site). Likely to result in traumatic injury, illness, and/or disability requiring medical treatment to a moderate-sized group of people (e.g., 10 to 25 and 2 to 5 for injuries and deaths, respectively). Significantly degraded performance of major or safety-critical system or equipment. Significant property damage (of less than $1 million) requiring repairs and replacement and/or environmental damage requiring treatment. Breach of security (e.g., potential loss of control over material with potential "dirty bomb" applicability).[103]

**Marginal:** Some degraded performance versus applicable and relevant design and/or performance criteria or reduced ability to protect human health (both worker and the general public) as well as the environment (both on- and off-site). Minor damage to equipment, facilities, property, or environment that does not require immediate action. Injury or illness likely to result and will be limited to a small group of people (e.g., less than 10 and less than 2 for injuries and deaths, respectively). Minimal breach of or threat to security.[103]

### Risk Level (Overall Contribution to Risk)

**High:** The hazard associated with the alternative has the potential for major on-site and off-site impacts to large numbers of persons or with the potential for major impacts to the environment or national security. There is a high risk of fatality due to traumatic injury or a high probability (e.g., more than one in $10^4$) of a latent cancer to either on- or off-site personnel. Highly contaminated area of greater than 10 $mi^2$.

**Significant:** The hazard associated with the alternative represents considerable potential on-site impacts to human health or the environment, but at most only minor off-site impacts to human health, the environment, or national security. There is a risk of traumatic injury or a moderate probability (e.g., between one chance in $10^6$ and one in $10^4$) of a latent cancer to either on- or off-site personnel. Contaminated area of between 1 and 10 $mi^2$.

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102 Direct injuries and deaths are taken into account; psychological damage, economic loss, and stigma are not considered.

103 It is recognized that this report primarily concerns human health; however, those tasks that involve risks to facilities and property, the environment, and site security will also be noted where appropriate.

**Box F-1. Definitions for Hazard Analysis Tables**

| |
|---|
| **Low:** The hazard associated with the alternative presents only minor on-site and negligible off-site impacts to human health, the environment, or national security. There is negligible risk of injury (which can result in no more than a first-aid treatment case) or a low probability (e.g., less than one chance in $10^6$) of a latent cancer developing in either on- or off-site personnel. Impacted area of less than 1 $mi^2$. |

Definitions of generic terms, such as those used in Box F-1, can be broadly interpreted. So, our use of terms such as "critical" depends upon our philosophic stance. For example, for certain groups, *any release* of radioactive or chemical wastes would be considered critical. For other groups, unless there was some damage to people or the environment, it would not be deemed critical. Consequently, because we are dealing with these issues from a technical perspective, we are not considering the political or psychological impact of a given hazard. So for the “consequence severity” category, “Marginal” would be used for injuries or deaths to small groups, say less than 10 and less than 2 for injuries and deaths, respectively. For “Critical” we would use injuries or deaths to larger groups, say 10 to 25 and 2 to 5, respectively. For “Severe” we would use injuries or deaths to large groups, say greater than 25 and greater than 5, respectively. We recognize that these numbers are subjective, but we need numbers so that we all mean the same thing when we use a generic term from Box F-1. Those with a different philosophical view can use transforms to change the meanings but with a note that this has been done. We also recognize that these numbers are only estimates because a rigorous risk analysis has not yet been done and is outside the scope of this report.

However, the purpose of this exercise is to estimate (and possibly rank order) the contributions to the overall risk for a given alternative of the various process steps (which are comprised of tasks with associated hazards). For example, the *in situ* thermal desorption (ISTD) process step indicated in Table G-2 is comprised of six (6) tasks—each of which may have multiple known hazards (as indicated in the “What can go wrong” or failure mode event column). Therefore, a possible, initial step might be to estimate the contribution of a given hazard to overall process step risk and then “roll up” (and possibly rank order) the process steps risks for a given alternative. However, to determine the contribution to the overall process step risk for a given hazard would require

1) determining the risks for all hazards for tasks within a given process step,
2) aggregating the risks[104] to derive an overall risk for the process step, and finally
3) determining the contribution from each hazard to the overall process step risk.

We believe that the resources and/or the level of detail are not available to complete these required tasks in what theoretically would be the desired scientific manner. Therefore, the overall risk from a given hazard will instead be estimated based on expert opinion using a risk-assessment matrix type analysis. That is, given an event probability (e.g., in the “How likely is it?” column) and consequence severity, a risk-assessment matrix can be defined[105] that

[104] We recognize that the risks could be synergistic or antagonistic; however, for simplicity we will assume that the risks are additive.

[105] The primary reference for the hazard categorization is: “Review of the Army's Technical Guides on Assessing and Managing Chemical Hazards to Deployed Personnel,” Subcommittee on the Toxicological Risks to Deployed Military Personnel, Committee on Toxicology, National Research Council, 2004.

translates the products of these factors to corresponding overall risk levels given in the "Overall Contribution to Risk" column, which are defined in Box F-1. Our proposed scheme is illustrated in Table F-1; where the definitions of *High*, *Significant*, and *Low* are provided in Box F-1.

**Table F-1. Example Risk-Assessment Matrix**

| | | How likely is it? (Event Probability) | | |
|---|---|---|---|---|
| | | **Probable** | **Possible** | **Unlikely** |
| **Severity** | **Severe** | High | Significant | Low |
| | **Critical** | Significant | Significant | Low |
| | **Marginal** | Low | Low | Low |

Thus for each hazard associated with a given alternative/process step/task triplet, we can define a risk based upon the consequence severity and event probability information in Table F-1. We also need a way to take the information in the individual hazard tables (provided in Appendix G and Appendix H) and "roll up" this information for multiple hazards into a single metric representing the overall contribution to alternative risk for a given process step.[106] For simplicity, it is assumed that the minimum risk contribution for a given process step cannot be less than the maximum risk for any hazard for any task in that process step. Furthermore, assuming independence, the maximum risk contribution for a given process step cannot be more than the sum of risk over all hazards.

Because the risk levels (i.e., *high*, *significant*, and *low* from Box F-1) that we require to roll-up into a single metric can be considered as primarily categorical variables[107], there is no simple, mathematical expression that can be derived for use here. Instead the following *criteria* will be used to roll-up the risk information into a single overall contribution to risk metric:

1. If a process step has at least one hazard that is considered *high* risk, then that process step is considered *high* risk in terms of its contribution to the overall risk.

   There may be a subsequent attempt to rank-order the high risk hazards; however, this will be by its very nature subjective because of the many assumptions already made. For example, one rank-ordering would place the potential for human health effects first (based upon numbers of people impacted, death versus injury, immediate versus latent, off-site versus on-site, etc.) followed by ecological risk, then national security and finally property damage. After we complete the analysis,

[106] We can adopt a process analogous to the Welch-Satterthwaite method for estimating degrees of freedom corresponding to adding a set of variances in quadrature, each having unique degrees of freedom. The resulting degrees of freedom estimate (associated with the total variance) is bounded by the maximum of the individual degrees of freedom and the sum of all.

[107] We have, in part, relied upon definitions (i.e., $10^{-4}$ to $10^{-6}$) analogous to those used in CERCLA indicating acceptable "excess upper bound lifetime cancer risk[s] to an individual" (per 40 CFR Part 300.430). Thus, again we must agree on what we consider "acceptable" levels of risk, especially for things other than cancer risks. This is especially important because neither the information nor time exists to develop a quantitative risk estimate for each hazard. Thus our definitions are inherently categorical in nature; however, they should represent our best estimates of risks analogous to $10^{-4}$ to $10^{-6}$.

we shall rank order the risks based upon expert opinion and the value judgment of the individual expert. If there is not at least a majority agreement, then the individual rank-ordering will be given with a description of the drivers for their choices.

2. If a process step has only hazards that are considered *low* risk, then the contribution to overall risk from that process step is also *low* risk. This is akin to what should be done when considering cumulative radiological dose estimates.
3. If a process step has hazards that are considered as *significant* to overall risk, then the minimum risk contribution must also be *significant*. There is a *high* contribution to overall risk from a process step if ten (10) hazards in a process step are deemed *significant*. This is based upon the fact that the best information that we are likely to find for our analyses is on an order of magnitude. For reasons similar to those in Criterion #2 above, the number of low-risk hazards does not factor into this assessment.

These metrics indicating the overall contribution to risk for a given process step are determined and entered into Table 4 for the remedial alternatives considered.

## F.3. Gap Analysis Definitions

We must also explore the information that is available concerning the necessary tasks, process steps, and alternatives and how important each is or will be to protecting human health and the environment. To that end, a set of gap analysis tables have been provided in Appendix I and Appendix J that are analogous to the hazard analysis tables in Appendix G and Appendix H. In the gap analysis tables in Appendix I and Appendix J, a number of column heading definitions were standardized to the point that was possible and reasonable. These columns are

- How important [is the gap]?
- How large a gap?

where other columns are considered self-explanatory. It is realized that there is not likely to be unanimous agreement on any set of definitions for the gap analysis tables; nonetheless, we again require a common basis for assessing the tasks in question.

A set of definitions for the two aforementioned columns is provided in Box F-2. The gaps are considered important because of their ability to jeopardize human health, the environment, and/or security. Using the definitions in Table F-2 would allow us to roll-up the gap information in a manner similar to that for the hazard analysis. It should be noted that there is not necessarily a one-to-one correspondence between the hazards in the hazards analysis tables and the gaps in the gap analysis tables.

**Box F-2. Definitions for Gap Analysis Tables**

## How Important (a Gap)?

**Critical:** Lack of this piece of knowledge is sufficient to provide a high degree of uncertainty in the ability to assess the threat to human health (both worker and the general public), the environment (both on-site and off-site), and/or security; i.e., result in a critical or severe hazard (as defined in Box F-1).

**Important:** Possession of this knowledge is important to the ability to assess the threat to human health (both worker and the general public), the environment (both on-site and off-site), and/or security. Other information must be lacking to the ability to assess the threat to human health and the environment.

**Inconsequential:** This knowledge may have localized significance to non-safety-related activities (including routine maintenance, repair, etc.).

## Low large a Gap? (Magnitude of Gap or Level of Knowledge)

**Large:** Little is known or can be reasonably inferred concerning this piece of information (from other sources of information).

**Intermediate:** Incomplete information is available concerning this piece of information or can only be inferred from other data not necessarily directly related to the missing piece of information.

**Small:** Complete or nearly complete information is available concerning this piece of information or an adequate, well-known analogue can be established.

**Table F-2. Example Information Contribution-Assessment Matrix**

| | | How large a Gap? | | |
|---|---|---|---|---|
| | | **Large** | **Intermediate** | **Small** |
| **Importance** | **Critical** | Safety Critical | Safety Significant | Safety Insignificant |
| | **Important** | Safety Significant | Safety Significant | Safety Insignificant |
| | **Inconsequential** | Safety Insignificant | Safety Insignificant | Safety Insignificant |

# G. Hazard Analysis Tables for Alternative 1: Contain in Place (4 Options)

## List of Tables

This appendix contains the hazard analysis tables for Alternative 1, which involves containing the buried wastes in the Subsurface Disposal Area in-place. That is, no wastes will be retrieved after completion of the on-going vacuum vapor extraction operations to remove volatile organics and the Pit 4 Accelerated Retrieval Project. These hazard tables provide the following information for each tasks associated with a remedial alternative:

- Task Frequency
- How likely is it? (Event Probability)
- What is the severity of the consequences?
- Overall contribution to risk

The definitions in Box F-1 are used to characterize this information. Although we realize that there is not likely to be unanimous agreement on any set of definitions, we must have a common basis for assessing the tasks in question—this is an attempt to provide such a basis. Furthermore, these definitions allow the authors and reviewers to "mean the same thing" when generic terms such as "*low*" or "*high*" are used. It is understood that not everyone would agree with the categorizations provided here; however, because some assessment of the risks must be made (and precise values cannot be placed on the risks or gaps), we have agreed on the descriptions provided. Note that the intent of these reports is to provide a *framework* for assessing risks and not to provide quantitative risk estimates. We are cognizant of the fact that these categories are subject to change as further knowledge is obtained; however, any set of categories must be both defined and consistent to be of use.

**Box F-1. Definitions for Hazard Analysis Tables**

## Task Frequency

**Frequent:** Occurs very often (e.g., more than once per quarter for long-duration tasks) or continuously.

**Anticipated:** Occurs several times (e.g., on the average of once per year) over the project lifetime or occurs infrequently but with long duration.

**Occasional:** Occurs sporadically or at a well-defined time (e.g., start-up or closure) or has a remote possibility of occurrence.

**Unlikely:** One can reasonably assume that this will not occur, but its occurrence is not impossible.

## How likely is it? (Event Probability)

**Probable:** Very likely to occur (e.g., more than 50 times out of 100) during task execution.

**Possible:** Expected to occur (e.g., between 1 time out of 100 and 50 times out of 100) during task execution.

**Unlikely:** One can reasonably assume that this hazard will not transpire (e.g., less than one chance out of 100), but its occurrence is not impossible.

## Consequence Severity

**Severe:** Loss of ability to satisfy applicable and relevant design and performance criteria and protect human health (both worker and general public) and the environment (both on- and off-site). Likely to result in death or permanent disability including that from latent cancer effects to a large group of people (e.g., greater than 25 and greater than 5, respectively). Loss of major or safety-critical system or equipment. Major property or facility damage (e.g., greater than $1 million). Severe environmental damage (e.g., significant loss of protected or endangered species habitat). Severe security failure (e.g., loss of material with potential “dirty bomb” applicability).

**Critical:** Significantly degraded performance versus applicable and relevant design and performance criteria and the ability to protect human health (both worker and the general public) and the environment (both on- and off-site). Likely to result in traumatic injury, illness, and/or disability requiring medical treatment to a moderate-sized group of people (e.g., 10 to 25 and 2 to 5 for injuries and deaths, respectively). Significantly degraded performance of major or safety-critical system or equipment. Significant property damage (of less than $1 million) requiring repairs and replacement and/or environmental damage requiring treatment. Breach of security (e.g., potential loss of control over material with potential “dirty bomb” applicability).

**Marginal:** Some degraded performance versus applicable and relevant design and/or performance criteria or reduced ability to protect human health (both worker and the general public) as well as the environment (both on- and off-site). Minor damage to equipment, facilities, property, or environment that does not require immediate action. Injury or illness likely to result and will be limited to a small group of people (e.g., less than 10 and less than 2 for injuries and deaths, respectively). Minimal breach of or threat to security.

## Risk Level (Overall Contribution to Risk)

**High:** The hazard associated with the alternative has the potential for major on-site and off-site impacts to large numbers of persons or with the potential for major impacts to the environment or national security. There is a high risk of fatality due to traumatic injury or a high probability (e.g., more than one in $10^4$) of a latent cancer to either on- or off-site personnel. Highly contaminated area of greater than 10 $mi^2$.

**Significant:** The hazard associated with the alternative represents considerable potential on-site impacts to human health or the environment, but at most only minor off-site impacts to human health, the environment, or national security. There is a risk of traumatic injury or a moderate probability (e.g., between one chance in $10^6$ and one in $10^4$) of a latent cancer to either on- or off-site personnel. Contaminated area of between 1 and 10 $mi^2$.

**Low:** The hazard associated with the alternative presents only minor on-site and negligible off-site impacts to human health, the environment, or national security. There is negligible risk of injury (which can result in no more than a first-aid treatment case) or a low probability (e.g., less than one chance in $10^6$) of a latent cancer developing in either on- or off-site personnel. Impacted area of less than 1 $mi^2$.

**Table G-1. Hazard Evaluation for Contain-in-Place Alternative, No Action Option (1A): Long-term Monitoring of Buried Wastes**

| **1A.1 SUBSURFACE DISPOSAL AREA (SDA) CHARACTERIZATION** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 1A.1.1<br>Determine waste forms, inventories, distributions, fluxes** | Occasional* | • Construction-related traumatic injury<br>• Radiological uptake via dust inhalation<br>• Toxic VOC uptake via inhalation<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Possible<br>• Unlikely<br>• Possible<br>• Possible<br>• Possible | • Critical<br>• Critical<br>• Critical<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Judgment and similar activity | •Significant<br>•Low<br>•Significant<br>•Low<br>•Significant |
| 1A.1.2<br>Complete analysis of historic retrieval activities** | Occasional* | • Office hazards not considered*** | • Not considered | • Not considered | • Not considered | Judgment and similar activity | •Not considered |
| 1A.1.3<br>Complete conceptual site model(s) for the SDA | Occasional* | • Office hazards not considered*** | • Not considered | • Not considered | • Not considered | Judgment and similar activity | •Not considered |
| **TASKS 1A.2 THROUGH 1A.10 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | | | |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.

** There is an on-going integrated probing project in the SDA to identify the extent of contamination. This is will include site preparation, surveys and mapping, probehole installation and testing, and sampling and data collection (Miller, 2003).

*** There are hazards associated with the Pit 4 Accelerated Retrieval (DOE-ID, 2004) and Beryllium Block Grouting (Lopez & Schultz, 2004; Lopez, 2004) Projects. However, the tasks associated with these projects have been omitted because they are common to all alternatives and will be completed before and regardless of what remedial alternative is selected.

**** Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not usually considered significant nor do they relate to chemical or radioactive exposure and thus are not considered in this report.

**Table G-1. Hazard Evaluation for Contain-in-Place Alternative, No Action Option (1A): Long-term Monitoring of Buried Wastes—Continued**

| 1A.11 LONG-TERM STEWARDSHIP ACTIVITIES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 1A.11.1<br>Determine long-term monitoring and institutional controls needed | Occasional* | • Office hazards not considered* | • Not considered | • Not considered | • Not considered | Judgment and similar activity | • Not considered |
| 1A.11.2<br>Implement monitoring and institutional controls | Occasional* | • Construction-related traumatic injury<br>• Radiological uptake via dust inhalation<br>• Toxic VOC uptake via inhalation<br>• Dose from external radiation<br>• Heat stress or hypothermia<br>• Failure of Long-Term Stewardship | • Possible<br>• Unlikely<br>• Possible<br>• Probable<br>• Possible<br>• Probable | • Critical<br>• Critical<br>• Critical<br>• Marginal<br>• Critical<br>• Severe | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Public | Judgment and unlined landfill experience | • Significant<br>• Low<br>• Significant<br>• Low<br>• Significant<br>• High |
| 1A.11.3<br>Routine maintenance, repair, and replacement | Anticipated | • Maintenance-related traumatic injury<br>• Radiological uptake via dust inhalation<br>• Toxic VOC uptake via inhalation<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Unlikely<br>• Possible<br>• Unlikely<br>• Possible | • Critical<br>• Critical<br>• Marginal<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Judgment and unlined landfill experience | • Low<br>• Low<br>• Low<br>• Low<br>• Significant |
| 1A.11.4<br>Non-routine maintenance, repair, and replacement | Occasional | • Maintenance-related traumatic injury<br>• Radiological uptake via dust inhalation<br>• Toxic VOC uptake via inhalation<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Possible<br>• Possible<br>• Possible<br>• Unlikely<br>• Possible | • Critical<br>• Critical<br>• Marginal<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Judgment and unlined landfill experience | • Significant<br>• Significant<br>• Low<br>• Low<br>• Significant |
| **TASKS 1A.12 THROUGH 1A.14 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | | | |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.

** Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not usually considered significant nor do they relate to chemical or radioactive exposure and thus are not considered in this report.

**Table G-2. Hazard Evaluation for Contain-in-Place Alternative, Surface Barrier Option (1B)**

**1B.1 SUBSURFACE DISPOSAL AREA (SDA) CHARACTERIZATION**

| Task | Task Frequency | What can go wrong? (Failure mode event) | How likely is it? (Event probability) | What is the severity of the consequences? | Who is the impacted population? | What is the risk evaluation basis? | Overall Contribution to Risk |
|---|---|---|---|---|---|---|---|
| *No change from Alternative 1A: For details, please refer to Table G-1 for 1A.1 Subsurface Disposal Area (SDA) Characterization* | | | | | | | |

**1B.2 *IN SITU* THERMAL DESORPTION PRETREATMENT (ISTD)**

| Task | Task Frequency | What can go wrong? (Failure mode event) | How likely is it? (Event probability) | What is the severity of the consequences? | Who is the impacted population? | What is the risk evaluation basis? | Overall Contribution to Risk |
|---|---|---|---|---|---|---|---|
| 1B.2.1 Performance criteria | Occasional* | • Office hazards are not considered** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 1B.2.2 Development and treatability testing*** | Occasional* | • Usual and customary laboratory hazards<br>• Dose from radioactive laboratory samples<br>• Pipe failure resulting in burns<br>• Heat stress or hypothermia during field treatability testing | • Unlikely<br>• Possible<br>• Unlikely<br>• Possible | • Marginal<br>• Marginal<br>• Critical<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience, Study Work Plan, and PDSA**** | • Low<br>• Low<br>• Low<br>• Significant |
| 1B.2.3 Prepare site and install equipment | Occasional* | • Traumatic injury during overburden installation<br>• Traumatic injury during construction<br>• Burn injury during welding<br>• Heat stress or hypothermia | • Unlikely<br>• Unlikely<br>• Unlikely<br>• Possible | • Critical<br>• Critical<br>• Critical<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA**** | • Low<br>• Low<br>• Low<br>• Significant |
| 1B.2.4 Perform required ISTD pretreatment | Anticipated | • Underground drum explosion<br>• Vacuum failure resulting in radiological dose<br>• Vacuum failure resulting in toxic VOC uptake<br>• Burns from high temperature off-gas system<br>• Dose from external radiation<br>• Uncovering high radiation source (subsidence) | • Unlikely<br>• Unlikely<br>• Unlikely<br>• Unlikely<br>• Probable<br>• Unlikely | • Marginal<br>• Marginal<br>• Marginal<br>• Severe<br>• Marginal<br>• Severe | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA**** | • Low<br>• Low<br>• Low<br>• Low<br>• Low<br>• Low |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.

** Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not usually considered significant nor do they relate to chemical or radioactive exposure and thus are not considered in this report.

*** *In Situ* Thermal Desorption treatability testing includes both laboratory and field testing (DOE-ID, 1999a).

**** The "Study Work Plan" is the Operable Unit 7-13/14 In Situ Thermal Desorption Treatability Study Work Plan (DOE-ID, 1999a) and PDSA is the Feasibility Study Preliminary Documented Safety Analysis (PDSA) for *In Situ* Thermal Desorption in the Subsurface Disposal Area (Abbott, 2003).

## Table G-2. Hazard Evaluation for Contain-in-Place Alternative, Surface Barrier Option (1B)

| 1B.2 *IN SITU* THERMAL DESORPTION PRETREATMENT (ISTD)—CONTINUED | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 1B.2.5 Dismantle/decon ISTD equipment | Occasional* | • Construction-related traumatic injury<br>• Radiological exposure during dismantling<br>• Toxic chemical exposure during dismantling<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Possible<br>• Possible<br>• Possible<br>• Probable<br>• Possible | • Critical<br>• Critical<br>• Marginal<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience | • Significant<br>• Significant<br>• Low<br>• Low<br>• Significant |
| 1B.2.6 Dispose ISTD equipment | Occasional* | • Construction-related traumatic injury** | • Possible | • Critical | • Worker | Previous, similar experience | • Significant |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** Other hazards are related to surface barrier emplacement. Said hazards are the same as those for 1B.10 Surface Barrier Selection, Preparation, and Emplacement, Table G-2.

**Table G-2. Hazard Evaluation for Contain-in-Place Alternative, Surface Barrier Option (1B)—Continued**

| 1B.3 *IN SITU* GROUTING (ISG) FOR SUBSURFACE STABILIZATION | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 1B.3.1 Performance criteria | Occasional* | • Office hazards are not considered** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 1B.3.2 Development and treatability testing*** | Occasional* | • Usual and customary laboratory hazards<br>• Direct contact and resulting exposure to simulated waste materials<br>• Heat stress or hypothermia during field treatability testing<br>• High noise levels and resulting hearing damage | • Unlikely<br>• Possible<br>• Possible<br>• Probable | • Marginal<br>• Marginal<br>• Critical<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience, HASP, and PDSA**** | • Low<br>• Low<br>• Significant<br>• Low |
| 1B.3.3 Install ISG equipment | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Drill penetrates pressurized cylinder or one containing hydrogen resulting in explosion<br>• Leak in drill shroud or filter releasing hazardous material<br>• High noise levels and resulting hearing damage | • Unlikely<br>• Unlikely<br>• Probable<br>• Probable | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA**** | • Low<br>• Low<br>• Low<br>• Low |
| 1B.3.4 Grout needed areas for subsurface stabilization | Anticipated | • Failure of high-pressure grout system resulting in projectiles or grout release and injuries<br>• Inadvertent criticality from fissile material<br>• Dose from external radiation<br>• Highly contaminated grout returns to surface<br>• Failure of containment system results in exposure to hazardous contaminants | • Probable<br>• Unlikely<br>• Probable<br>• Unlikely<br>• Possible | • Severe<br>• Severe<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA**** | • High<br>• Low<br>• Low<br>• Low<br>• Low |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not usually considered significant nor do they relate to chemical or radioactive exposure and thus are not considered in this report.
*** *In Situ* Grouting treatability testing includes both laboratory and field testing (Miller, 2001; Abbott & Santee, 2004).
**** The HASP is the *Health and Safety Plan* for the *In Situ* Grouting Treatability Study (Miller, 2001) and PDSA is the Feasibility Study *Preliminary Documented Safety Analysis* (PDSA) for *In Situ* Grouting (ISG) in the Subsurface Disposal Area (Abbott & Santee, 2004).

**Table G-2. Hazard Evaluation for Contain-in-Place Alternative, Surface Barrier Option (1B)—Continued**

| Task | Task Frequency | What can go wrong? (Failure mode event) | How likely is it? (Event probability) | What is the severity of the consequences? | Who is the impacted population? | What is the risk evaluation basis? | Overall Contribution to Risk |
|---|---|---|---|---|---|---|---|
| **1B.3 *IN SITU* GROUTING (ISG) FOR SUBSURFACE STABILIZATION—CONTINUED** | | | | | | | |
| 1B.3.5 Dismantle/decon ISG equipment | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Construction-related traumatic injury<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Probable<br>• Possible | • Marginal<br>• Critical<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA** | • Low<br>• Significant<br>• Low<br>• Significant |
| 1B.3.6 Dispose ISG equipment | Occasional* | • Construction-related traumatic injury*** | • Possible | • Critical | • Worker | Previous, similar experience | • Significant |
| **1B.4 *IN SITU* VITRIFICATION (ISV) IS NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | | | |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** The HASP is the Health and Safety Plan for the In Situ Grouting Treatability Study (Miller, 2001) and PDSA is the Feasibility Study Preliminary Documented Safety Analysis (PDSA) for In Situ Grouting (ISG) in the Subsurface Disposal Area (Abbott & Santee, 2004)
*** Other hazards are related to surface barrier emplacement. Said hazards are the same as those for 1B.10 Surface Barrier Selection, Preparation, and Emplacement, Table G-2.

**Table G-2. Hazard Evaluation for Contain-in-Place Alternative, Surface Barrier Option (1B)—Continued**

| 1B.5 PAD A RECONFIGURATION | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 1B.5.1<br>Install necessary equipment | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• High noise levels and resulting hearing damage<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Possible | • Marginal<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker | Previous, similar experience and HASP** | • Low<br>• Low<br>• Significant |
| 1B.5.2<br>Retrieve wastes from Pad A | Occasional | • Disturb waste area resulting in airborne radiological/toxic chemical inhalation exposure<br>• Radiological/toxic chemical inhalation exposure from direct contact with waste containers<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling<br>• Heat stress or hypothermia | • Probable<br>• Possible<br>• Probable<br>• Possible | • Marginal<br>• Marginal<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and HASP** | • Low<br>• Low<br>• Low<br>• Significant |
| 1B.5.3<br>Segregate/treat retrieved wastes | Occasional | • Radiological/toxic chemical inhalation exposure from direct contact with waste containers or during decontamination procedure<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling<br>• Overpressurization from compacting a compressed gas cylinder with resulting release and exposure<br>• Heat stress or hypothermia | • Possible<br>• Probable<br>• Unlikely<br>• Possible | • Marginal<br>• Marginal<br>• Critical<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience, Pit 9 HazID, and HASP** | • Low<br>• Low<br>• Low<br>• Significant |
| 1B.5.4<br>Store packaged wastes | Anticipated | • Radiological/toxic chemical inhalation exposure from direct contact with waste containers<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling | • Possible<br>• Probable | • Marginal<br>• Marginal | • Worker<br>• Worker | Previous, similar experience and HASP** | • Low<br>• Low |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** The HASP is the *Health and Safety Plan* for the Pit 4 Accelerated Retrieval Project (Wooley, 2004a) and the "Pit 9 HazID" is the Hazard Identification Document for Stage III of the Pit 9 (or OU 7-10) Project during which wastes were retrieved (INEEL, 2003b).

## Table G-2. Hazard Evaluation for Contain-in-Place Alternative, Surface Barrier Option (1B)—Continued

| 1B.5 PAD A RECONFIGURATION—CONTINUED | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 1B.5.5 Dispose non-TRU wastes under cap | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Radiological/toxic chemical inhalation exposure from direct contact with waste containers | • Unlikely<br>• Unlikely | • Marginal<br>• Marginal | • Worker<br>• Worker | Previous, similar experience | • Low<br>• Low |
| 1B.5.6 Ship TRU wastes to WIPP** | Unlikely | • WIPP hazards*** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 1B.5.7 Dismantle/decon equipment | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Construction-related traumatic injury<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Probable<br>• Possible | • Marginal<br>• Critical<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience | • Low<br>• Significant<br>• Low<br>• Significant |
| 1B.5.8 Dispose retrieval equipment | Occasional* | • Construction-related traumatic injury**** | • Possible | • Critical | • Worker | Previous, similar experience | • Significant |
| **TASKS 1B.6 THROUGH 1B.9 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | | | |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.

** The wastes in Pad A reside abovegrade on an asphalt pad; therefore, these wastes are not buried. Furthermore, it is unlikely that any of the Pad A wastes will be found to be TRU wastes.

*** These hazards are related to shipment of any transuranic (TRU) wastes discovered in Pad A to WIPP for ultimate disposal. Said hazards are the same as those for 2A.14 Off-site Shipment and Disposal at WIPP, Table G-1.

**** Other hazards are related to surface barrier emplacement. Said hazards are the same as those for 1B.10 Surface Barrier Selection, Preparation, and Emplacement, Table G-2.

**Table G-2. Hazard Evaluation for Contain-in-Place Alternative, Surface Barrier Option (1B)—Continued**

| **1B.10 SURFACE BARRIER SELECTION, PREPARATION, AND EMPLACEMENT** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 1B.10.1 Performance criteria | Occasional* | • Office hazards are not considered** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 1B.10.2 Work plans and safety analyses | Occasional* | • Office hazards are not considered** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 1B.10.3 Determine type of barrier | Occasional* | • Office hazards are not considered** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 1B.10.4 Prepare SDA for surface barrier installation | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Unintentionally uncovering high radiation source during grading and resulting exposure<br>• Injuries from construction-related activities<br>• High noise levels and resulting hearing damage<br>• Heat stress or hypothermia | • Probable<br>• Unlikely<br>• Possible<br>• Possible<br>• Possible | • Marginal<br>• Severe<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience | • Low<br>• Low<br>• Low<br>• Low<br>• Low |
| 1B.10.5 Install surface barrier over the SDA*** | Occasional | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Injuries from construction-related activities including borrow soil transport<br>• High noise levels and resulting hearing damage | • Probable<br>• Probable<br>• Possible | • Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker | Previous, similar experience | • Low<br>• Low<br>• Low |
| **1B.11 LONG-TERM STEWARDSHIP ACTIVITIES** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1A: For details, please refer to Table G-1 for 1A.11 Long-term Stewardship Activities* | | | | | | | |
| **TASKS 1B.12 THROUGH 1B.14 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | | | |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not usually considered significant nor do they relate to chemical or radioactive exposure and thus are not considered in this report.
*** The SDA surface barrier may be installed in two stages because of on-going low-level waste disposal operations.

**Table G-3. Hazard Evaluation for Contain-in-Place Alternative, *In Situ* Grouting Option (1C)[108]**

| 1C.1 SUBSURFACE DISPOSAL AREA (SDA) CHARACTERIZATION | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1A: For details, please refer to Table G-1 for 1A.1 Subsurface Disposal Area (SDA) Characterization* | | | | | | | |
| **1C.2 *IN SITU* THERMAL DESORPTION PRETREATMENT (ISTD)** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1B: For details, please refer to Table G-2 for 1B.2 In Situ Thermal Desorption (ISTD) Pretreatment* | | | | | | | |
| **1C.3 *IN SITU* GROUTING FOR SUBSURFACE STABILIZATION AND CONTAMINANT IMMOBILIZATION** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 1C.3.1 Performance criteria | Occasional* | • Office hazards are not considered** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 1C.3.2 Development and treatability testing | Occasional* | • Usual and customary laboratory hazards<br>• Direct contact and resulting exposure to simulated waste materials<br>• Heat stress or hypothermia during field testing<br>• High noise levels and resulting hearing damage | • Unlikely<br>• Possible<br>• Possible<br>• Possible | • Marginal<br>• Marginal<br>• Critical<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience, HASP, and PDSA*** | • Low<br>• Low<br>• Significant<br>• Low |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not usually considered significant nor do they relate to chemical or radioactive exposure and thus are not considered in this report.
** The HASP is the Health and Safety Plan for the *In Situ* Grouting Treatability Study (Miller, 2001), and the PDSA is the Feasibility Study Preliminary Documented Safety Analysis (PDSA) for *In Situ* Grouting in the Subsurface Disposal Area (Abbott & Santee, 2004).

108 The primary difference between this option and that represented by 1B Surface Barrier Option is that *in situ* grouting will be used for both contaminant immobilization and subsurface stabilization.

**Table G-3. Hazard Evaluation for Contain-in-Place Alternative, *In* Situ Grouting Option (1C)—Continued**

| **1C.3** | ***IN SITU* GROUTING FOR SUBSURFACE STABILIZATION AND CONTAMINANT IMMOBILIZATION--CONTINUED** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 1C.3.3 Install ISG equipment and enclosure | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Drill penetrates pressurized cylinder or one containing hydrogen resulting in explosion<br>• Injuries from other construction-related activities<br>• Leak in drill shroud or filter releasing hazardous material<br>• High noise levels and resulting hearing damage | • Unlikely<br>• Unlikely<br>• Unlikely<br>• Probable<br>• Possible | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA* | • Low<br>• Low<br>• Low<br>• Low<br>• Low |
| 1C.3.4 Grout needed areas for contaminant stabilization | Anticipated | • Failure of high-pressure grout system resulting in projectiles or grout release and injuries<br>• Inadvertent criticality from fissile material<br>• Dose from external radiation<br>• Highly contaminated grout returns to surface<br>• Failure of containment system results in exposure to hazardous contaminants | • Probable<br>• Unlikely<br>• Probable<br>• Unlikely<br>• Probable | • Severe<br>• Severe<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA* | • High<br>• Low<br>• Low<br>• Low<br>• Low |
| 1C.3.5 Dismantle, move, and install ISG equipment | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Drill penetrates pressurized cylinder or one containing hydrogen resulting in explosion<br>• Leak in drill shroud or filter releasing hazardous material<br>• High noise levels and resulting hearing damage | • Unlikely<br>• Unlikely<br>• Probable<br>• Possible | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA* | • Low<br>• Low<br>• Low<br>• Low |
| 1C.3.6 Grout needed areas for subsurface stabilization | Anticipated | • Failure of high-pressure grout system resulting in projectiles or grout release and injuries<br>• Inadvertent criticality from fissile material<br>• Dose from external radiation<br>• Highly contaminated grout returns to surface<br>• Failure of containment system results in exposure to hazardous contaminants | • Probable<br>• Unlikely<br>• Probable<br>• Unlikely<br>• Possible | • Severe<br>• Severe<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA* | • High<br>• Low<br>• Low<br>• Low<br>• Low |

* “Occasional” in this context refers to an activity that is conducted a single time, however, over a long period of time.
** The PDSA is the Feasibility Study *Preliminary Documented Safety Analysis* (PDSA) for *In Situ* Grouting (ISG) in the Subsurface Disposal Area (Abbott & Santee, 2004).

### Table G-3. Hazard Evaluation for Contain-in-Place Alternative, *In* Situ Grouting Option (1C)—Continued

| **1C.3 *IN SITU* GROUTING FOR SUBSURFACE STABILIZATION AND CONTAMINANT IMMOBILIZATION--CONTINUED** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 1C.3.7 Dismantle/decon ISG equipment and enclosure | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Construction-related traumatic injury<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Probable<br>• Possible | • Marginal<br>• Critical<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA** | • Low<br>• Significant<br>• Low<br>• Significant |
| 1C.3.8 Dispose ISG equipment | Occasional* | • Construction-related traumatic injury*** | • Possible | • Critical | • Worker | Previous, similar experience | • Significant |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** The PDSA is the Feasibility Study *Preliminary Documented Safety Analysis* (PDSA) for *In Situ* Grouting (ISG) in the Subsurface Disposal Area (Abbott & Santee, 2004).
*** Other hazards are related to surface barrier emplacement. Said hazards are the same as those for 1B.10 Surface Barrier Selection, Preparation, and Emplacement, Table G-2.

**Table G-3. Hazard Evaluation for Contain-in-Place Alternative, *In* Situ Grouting Option (1C)—Continued**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1C.4 *IN SITU* VITRIFICATION (ISV) IS NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | | | |
| **1C.5 PAD A RECONFIGURATION** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1B: For details, please refer to Table G-2 for 1B.5 Pad A Reconfiguration* | | | | | | | |
| **TASKS 1C.6 THROUGH 1C.9 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | | | |
| **1C.10 SURFACE BARRIER SELECTION, PREPARATION, AND EMPLACEMENT** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1B: For details, please refer to Table G-2 for 1B.10 Surface Barrier Selection, Preparation, and Emplacement* | | | | | | | |
| **1C.11 LONG-TERM STEWARDSHIP ACTIVITIES** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1A: For details, please refer to Table G-1 for 1A.11 Long-term Stewardship Activities* | | | | | | | |
| **TASKS 1C.12 THROUGH 1C.14 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | | | |

## Table G-4. Hazard Evaluation for Contain-in-Place Alternative, *In Situ* Vitrification Option (1D)

**1D.1 SUBSURFACE DISPOSAL AREA (SDA) CHARACTERIZATION**

| Task | Task Frequency | What can go wrong? (Failure mode event) | How likely is it? (Event probability) | What is the severity of the consequences? | Who is the impacted population? | What is the risk evaluation basis? | Overall Contribution to Risk |
|---|---|---|---|---|---|---|---|
| *No change from Alternative 1A: For details, please refer to Table G-1 for 1A.1 Subsurface Disposal Area (SDA) Characterization* | | | | | | | |

**1D.2 *IN SITU* THERMAL DESORPTION PRETREATMENT (ISTD)**

| Task | Task Frequency | What can go wrong? (Failure mode event) | How likely is it? (Event probability) | What is the severity of the consequences? | Who is the impacted population? | What is the risk evaluation basis? | Overall Contribution to Risk |
|---|---|---|---|---|---|---|---|
| *No change from Alternative 1B: For details, please refer to Table G-2 for 1B.2 In Situ Thermal Desorption (ISTD) Pretreatment* | | | | | | | |

**1D.3 *IN SITU* GROUTING FOR SUBSURFACE STABILIZATION AND *SPECIFIC* CONTAMINANT IMMOBILIZATION**

| Task | Task Frequency | What can go wrong? (Failure mode event) | How likely is it? (Event probability) | What is the severity of the consequences? | Who is the impacted population? | What is the risk evaluation basis? | Overall Contribution to Risk |
|---|---|---|---|---|---|---|---|
| 1D.3.1 Performance criteria | Occasional* | • Office hazards not considered** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 1D.3.2 Development and treatability testing | Occasional* | • Usual and customary laboratory hazards<br>• Direct contact and resulting exposure to simulated waste materials<br>• Heat stress or hypothermia during field testing<br>• High noise levels and resulting hearing damage | • Unlikely<br>• Possible<br>• Possible<br>• Probable | • Marginal<br>• Marginal<br>• Critical<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience, HASP, and PDSA*** | • Low<br>• Low<br>• Significant<br>• Low |
| 1D.3.3 Install ISG equipment and enclosure | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Drill penetrates pressurized cylinder or one containing hydrogen resulting in explosion<br>• Leak in drill shroud or filter releasing hazardous material<br>• Injuries from construction-related activities<br>• Direct radiation exposure<br>• High noise levels and resulting hearing damage | • Unlikely<br>• Unlikely<br>• Probable<br>• Unlikely<br>• Probable<br>• Possible | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA*** | • Low<br>• Low<br>• Low<br>• Low<br>• Low<br>• Low |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not usually considered significant and thus are not considered in this report.
*** The HASP is the Health and Safety Plan for the *In Situ* Grouting Treatability Study (Miller, 2001), and the PDSA is the Feasibility Study Preliminary Documented Safety Analysis (PDSA) for *In Situ* Grouting in the Subsurface Disposal Area (Abbott & Santee, 2004).

## Table G-4. Hazard Evaluation for Contain-in-Place Alternative, In Situ Vitrification Option (1D)—Continued

| **1D.3 *IN SITU* GROUTING FOR SUBSURFACE STABILIZATION AND SPECIFIC CONTAMINANT IMMOBILIZATION--CONTINUED** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 1D.3.4 Grout needed areas for contaminant stabilization | Anticipated | • Failure of high-pressure grout system resulting in projectiles or grout release and injuries<br>• Inadvertent criticality from fissile material<br>• Dose from external radiation<br>• Highly contaminated grout returns to surface<br>• Failure of containment system results in exposure to hazardous contaminants | • Probable<br>• Unlikely<br>• Probable<br>• Unlikely<br>• Probable | • Severe<br>• Severe<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA** | • High<br>• Low<br>• Low<br>• Low<br>• Low |
| 1D.3.5 Dismantle, move, and install ISG equipment | Occasional | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Drill penetrates pressurized cylinder or one containing hydrogen resulting in explosion<br>• Leak in drill shroud or filter releasing hazardous material<br>• High noise levels and resulting hearing damage | • Unlikely<br>• Unlikely<br>• Probable<br>• Probable<br>• Possible | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA** | • Low<br>• Low<br>• Low<br>• Low<br>• Low |
| 1D.3.6 Grout needed areas for subsurface stabilization | Anticipated | • Failure of high-pressure grout system resulting in projectiles or grout release and injuries<br>• Inadvertent criticality from fissile material<br>• Dose from external radiation<br>• Highly contaminated grout returns to surface<br>• Failure of containment system results in exposure to hazardous contaminants | • Probable<br>• Unlikely<br>• Probable<br>• Unlikely<br>• Probable | • Severe<br>• Severe<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA** | • High<br>• Low<br>• Low<br>• Low<br>• Low |
| 1D.3.7 Dismantle/decon ISG equipment and enclosure | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Construction-related traumatic injury<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Probable<br>• Possible | • Marginal<br>• Critical<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA** | • Low<br>• Significant<br>• Low<br>• Significant |
| 1D.3.8 Dispose ISG equipment | Occasional* | • Construction-related traumatic injury*** | • Possible | • Critical | • Worker | Previous, similar experience | • Significant |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** The PDSA is the Feasibility Study *Preliminary Documented Safety Analysis* (PDSA) for *In Situ* Grouting (ISG) in the Subsurface Disposal Area (Abbott & Santee, 2004).
*** Other hazards are related to surface barrier emplacement. Said hazards are the same as those for 1B.10 Surface Barrier Selection, Preparation, and Emplacement, Table G-2.

**Table G-4. Hazard Evaluation for Contain-in-Place Alternative, *In* Situ Vitrification Option (1D)—Continued**

| **1D.4 *IN SITU* VITRIFICATION (ISV) FOR CONTAMINANT IMMOBILIZATION** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 1D.4.1 Performance criteria | Occasional* | • Office hazards not considered** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 1D.4.2 Development and treatability testing*** | Occasional* | • Usual and customary laboratory hazards<br>• Direct contact and exposure to simulated waste materials<br>• Disturb surface during dynamic drum disruption resulting in airborne radiological/toxic chemical inhalation exposure<br>• Exposure to VOCs released during operations<br>• Injuries and exposure to radiological /toxic chemicals resulting from melt expulsion<br>• Exposure to radiological /toxic chemicals resulting from off-gas hood or ventilation system failure<br>• Heat stress or hypothermia<br>• High noise levels and resulting hearing damage | • Unlikely<br>• Possible<br>• Unlikely<br>• Possible<br>• Unlikely<br>• Unlikely<br>• Possible<br>• Possible | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal<br>• Marginal<br>• Marginal<br>• Critical<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience, Work Study Plan, and PDSA**** | • Low<br>• Low<br>• Low<br>• Low<br>• Low<br>• Low<br>• Significant<br>• Low |
| 1D.4.3 Install ISV equipment and enclosure | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• High noise levels and resulting hearing damage<br>• Injuries from construction-related activities<br>• Dose from external radiation | • Unlikely<br>• Possible<br>• Unlikely<br>• Probable | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA**** | • Low<br>• Low<br>• Low<br>• Low |
| 1D.4.4 Vitrify selected areas for subsurface stabilization | Anticipated | • Steam pressurization resulting in airborne radiological/toxic chemical inhalation exposure<br>• Failure to incorporate radiological/toxic chemical contaminants in vitreous layer and subsequent migration<br>• Disturb surface during dynamic drum disruption resulting in airborne radiological/toxic chemical inhalation exposure<br>• Exposure to VOCs released during operations | • Unlikely<br>• Unlikely<br>• Unlikely<br>• Possible | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Public<br>• Worker<br>• Worker | Previous, similar experience and PDSA**** | • Low<br>• Low<br>• Low<br>• Low |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not usually considered significant nor do they relate to chemical or radioactive exposure and thus are not considered in this report.
*** A part of the *In Situ* Vitrification treatability study was planned for a corner of Pit 4 (Santee, 2003) and would present many of the same hazards as that for the planned SDA work.
**** The "Work Study Plan" is the In Situ Vitrification Treatability Study Work Plan (Farnsworth et al., 1999), and the PDSA is the Feasibility Study *Preliminary Documented Safety Analysis* (PDSA) for *In Situ* Vitrification (ISV) in the Subsurface Disposal Area (Santee, 2003).

**Table G-4. Hazard Evaluation for Contain-in-Place Alternative, *In* Situ Vitrification Option (1D)—Continued**

| **1D.4 *IN SITU* VITRIFICATION (ISV) FOR CONTAMINANT IMMOBILIZATION—CONTINUED** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 1D.4.4 (Cont'd) Vitrify selected areas for subsurface stabilization | Anticipated | • Injuries and exposure to radiological /toxic chemicals from fire, deflagration, detonation, or melt expulsion<br>• Exposure to radiological /toxic chemicals resulting from off-gas hood or ventilation system failure<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Probable<br>• Unlikely<br>• Probable<br>• Possible | • Severe<br>• Marginal<br>• Marginal<br>• Critical | • Worker Public<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience, (DOE, 1996; INEEL, 2004b), and PDSA** | • High<br>• Low<br>• Low<br>• Significant |
| 1D.4.5 Manage secondary TRU wastes (WIPP) | Occasional | • No *additional* hazards*** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 1D.4.6 Manage secondary non-TRU wastes (Idaho Site) | Occasional | • Radiological/toxic chemical inhalation exposure from direct contact with waste containers | • Unlikely | • Marginal | • Worker | Previous, similar experience | • Low |
| 1D.4.7 Dismantle/decon ISV equipment and enclosure | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Construction-related traumatic injury<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Possible<br>• Possible | • Marginal<br>• Critical<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and PDSA** | • Low<br>• Significant<br>• Low<br>• Significant |
| 1D.4.8 Dispose ISV equipment under cap | Occasional* | • Construction-related traumatic injury**** | • Possible | • Critical | • Worker | Previous, similar experience | • Significant |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** The PDSA is the Feasibility Study *Preliminary Documented Safety Analysis* (PDSA) for *In Situ* Vitrification (ISV) in the Subsurface Disposal Area (Santee, 2003).
*** Other hazards are related to shipment of transuranic wastes to WIPP for ultimate disposal. Said hazards are the same as those for 2A.14 Off-site Shipment and Disposal at WIPP, Table G-1.
**** Other hazards are related to surface barrier emplacement. Said hazards are the same as those for 1B.10 Surface Barrier Selection, Preparation, and Emplacement, Table G-2.

**Table G-4. Hazard Evaluation for Contain-in-Place Alternative, *In* Situ Vitrification Option (1D)—Continued**

| **1D.5 PAD A RECONFIGURATION** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1B: For details, please refer to Table G-2 for 1B.5 Pad A Reconfiguration* | | | | | | | |
| **TASKS 1D.6 THROUGH 1D.9 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | | | |
| **1D.10 SURFACE BARRIER SELECTION, PREPARATION, AND EMPLACEMENT** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1B: For details, please refer to Table G-2 for 1B.10 Surface Barrier Selection, Preparation, and Emplacement* | | | | | | | |
| **1D.11 LONG-TERM STEWARDSHIP ACTIVITIES** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1A: For details, please refer to Table G-1 for 1A.11 Long-term Stewardship Activities* | | | | | | | |
| **TASKS 1D.12 THROUGH 1D.14 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | | | |

# H. Hazard Analysis Tables for Alternative 2: Retrieve/Treat/Dispose (2 Options)

## List of Tables

This appendix contains the hazard analysis tables for Alternative 2, which involves retrieving some fraction of the buried wastes in the Subsurface Disposal Area and treating these wastes for subsequent disposal. These hazard tables provide the following information for each tasks associated with a remedial alternative:

- Task Frequency
- How likely is it? (Event Probability)
- What is the severity of the consequences?
- Overall contribution to risk

The definitions in Box F-1 are used to characterize this information. Although we realize that there is not likely to be unanimous agreement on any set of definitions, we must have a common basis for assessing the tasks in question—this is an attempt to provide such a basis. Furthermore, these definitions allow the authors and reviewers to "mean the same thing" when generic terms such as "*low*" or "*high*" are used. It is understood that not everyone would agree with the categorizations provided here; however, because some assessment of the risks must be made (and precise values cannot be placed on the risks or gaps), we have agreed on the descriptions provided. Note that the intent of these reports is to provide a *framework* for assessing risks and not to provide quantitative risk estimates. We are cognizant of the fact that these categories are subject to change as further knowledge is obtained; however, any set of categories must be both defined and consistent to be of use.

**Box F-1. Definitions for Hazard Analysis Tables**

## Task Frequency

**Frequent:** Occurs very often (e.g., more than once per quarter for long-duration tasks) or continuously.

**Anticipated:** Occurs several times (e.g., on the average of once per year) over the project lifetime or occurs infrequently but with long duration.

**Occasional:** Occurs sporadically or at a well-defined time (e.g., start-up or closure) or has a remote possibility of occurrence.

**Unlikely:** One can reasonably assume that this will not occur, but its occurrence is not impossible.

## How likely is it? (Event Probability)

**Probable:** Very likely to occur (e.g., more than 50 times out of 100) during task execution.

**Possible:** Expected to occur (e.g., between 1 time out of 100 and 50 times out of 100) during task execution.

**Unlikely:** One can reasonably assume that this hazard will not transpire (e.g., less than one chance out of 100), but its occurrence is not impossible.

## Consequence Severity

**Severe:** Loss of ability to satisfy applicable and relevant design and performance criteria and protect human health (both worker and general public) and the environment (both on- and off-site). Likely to result in death or permanent disability including that from latent cancer effects to a large group of people (e.g., greater than 25 and greater than 5, respectively). Loss of major or safety-critical system or equipment. Major property or facility damage (e.g., greater than $1 million). Severe environmental damage (e.g., significant loss of protected or endangered species habitat). Severe security failure (e.g., loss of material with potential "dirty bomb" applicability).

**Critical:** Significantly degraded performance versus applicable and relevant design and performance criteria and the ability to protect human health (both worker and the general public) and the environment (both on- and off-site). Likely to result in traumatic injury, illness, and/or disability requiring medical treatment to a moderate-sized group of people (e.g., 10 to 25 and 2 to 5 for injuries and deaths, respectively). Significantly degraded performance of major or safety-critical system or equipment. Significant property damage (of less than $1 million) requiring repairs and replacement and/or environmental damage requiring treatment. Breach of security (e.g., potential loss of control over material with potential "dirty bomb" applicability).

**Marginal:** Some degraded performance versus applicable and relevant design and/or performance criteria or reduced ability to protect human health (both worker and the general public) as well as the environment (both on- and off-site). Minor damage to equipment, facilities, property, or environment that does not require immediate action. Injury or illness likely to result and will be limited to a small group of people (e.g., less than 10 and less than 2 for injuries and deaths, respectively). Minimal breach of or threat to security.

## Risk Level (Overall Contribution to Risk)

**High:** The hazard associated with the alternative has the potential for major on-site and off-site impacts to large numbers of persons or with the potential for major impacts to the environment or national security. There is a high risk of fatality due to traumatic injury or a high probability (e.g., more than one in $10^4$) of a latent cancer to either on- or off-site personnel. Highly contaminated area of greater than 10 $mi^2$.

**Significant:** The hazard associated with the alternative represents considerable potential on-site impacts to human health or the environment, but at most only minor off-site impacts to human health, the environment, or national security. There is a risk of traumatic injury or a moderate probability (e.g., between one chance in $10^6$ and one in $10^4$) of a latent cancer to either on- or off-site personnel. Contaminated area of between 1 and 10 $mi^2$.

**Low:** The hazard associated with the alternative presents only minor on-site and negligible off-site impacts to human health, the environment, or national security. There is negligible risk of injury (which can result in no more than a first-aid treatment case) or a low probability (e.g., less than one chance in $10^6$) of a latent cancer developing in either on- or off-site personnel. Impacted area of less than 1 $mi^2$.

**Table H-1. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Targeted RFP TRU Waste Retrieval Option (2A)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2A.1 SUBSURFACE DISPOSAL AREA (SDA) CHARACTERIZATION** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1A: For details, please refer to Table G-1 for 1A.1 Subsurface Disposal Area (SDA) Characterization* | | | | | | | |
| **2A.2 *IN SITU* THERMAL DESORPTION PRETREATMENT (ISTD)** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1B: For details, please refer to Table G-2 for 1B.2 In Situ Thermal Desorption (ISTD) Pretreatment* | | | | | | | |
| **2A.3 *IN SITU* GROUTING FOR SUBSURFACE STABILIZATION AND CONTAMINANT IMMOBILIZATION** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1C: For details, please refer to Table G-3 for 1C.3 In Situ Grouting for Subsurface Stabilization and Contaminant Immobilization* | | | | | | | |
| **2A.4 *IN SITU* VITRIFICATION (ISV) IS NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | | | |
| **2A.5 PAD A RECONFIGURATION** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1B: For details, please refer to Table G-2 for 1B.5 Pad A Reconfiguration* | | | | | | | |

**Table H-1. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Targeted RFP TRU Waste Retrieval Option (2A)—Continued**

| 2A.6 LOCATE AND RETRIEVE TARGETED RFP BURIED TRU WASTE AND SEGREGATE INTO TRU AND NON-TRU FRACTIONS | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 2A.6.1 Identify retrieval methods | Occasional* | • No *additional* hazards** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 2A.6.2 Determine extent of retrieval | Occasional* | • Office hazards not considered*** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 2A.6.3 Plan/manage retrieval | Occasional* | • Office hazards not considered*** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 2A.6.4 Install retrieval equipment and enclosures | Occasional* | • Overburden removal resulting in airborne radiological/ toxic chemical inhalation exposure<br>• Contaminated soil removal resulting in radiological/ toxic chemical exposure<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling<br>• High noise levels and resulting hearing damage<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Possible<br>• Probable<br>• Probable<br>• Possible<br>• Probable<br>• Possible | • Marginal<br>• Critical<br>• Marginal<br>• Marginal<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience, Pit 4 Plan, HASP, and Pit 9 HazID **** | • Low<br>• Significant<br>• Low<br>• Low<br>• Low<br>• Significant |
| 2A.6.5 Retrieve wastes from target areas | Anticipated | • Disturb waste area and failure of dust suppression resulting in airborne radiological/toxic chemical inhalation exposure<br>• Radiological/toxic chemical inhalation exposure from contact with waste containers<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling<br>• Off-gas treatment system failure resulting in radiological/toxic chemical release | • Unlikely<br>• Unlikely<br>• Possible<br>• Unlikely | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker Public | Previous, similar experience, Pit 4 Plan, HASP, and Pit 9 HazID**** | • Low<br>• Low<br>• Low<br>• Low |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.

** There are hazards associated with the Pit 9 retrieval study that has already been completed (Snook, 2004) and the active Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b), but these are not considered here as the Pit 4 Accelerated Retrieval Project is being carried out regardless of the alternative selected for the SDA buried wastes.

*** The areas will likely be targeted using process and historical knowledge as well as the results of the Integrated Probing Project whose risks were indicated in 1A.1 Subsurface Disposal Area (SDA) Characterization, Table G-1. Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not usually considered significant nor do they relate to chemical or radioactive exposure and thus are not considered in this report.

**** "Pit 4 Plan" refers to the Removal Action Plan for the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b), HASP is the Health and Safety Plan for the Pit 4 Accelerated Retrieval Project (Wooley, 2004a), and "Pit 9 HazID" is the Hazard Identification Document for the Pit 9 Stage III Project (INEEL, 2003b), which involved excavation.

**Table H-1. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Targeted RFP TRU Waste Retrieval Option (2A)—Continued**

| 2A.6 LOCATE AND RETRIEVE TARGETED RFP BURIED TRU WASTE AND SEGREGATE INTO TRU AND NON-TRU FRACTIONS —CONTINUED | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 2A.6.5 (Cont'd) Retrieve wastes from target areas | Anticipated | • Containment/ventilation system failure and resulting exposure to radiological and toxic substances<br>• Large sloughing event resulting in airborne release of contaminated waste zone materials<br>• Pit subsidence external to retrieval facility<br>• Undesired criticality during operations<br>• Fire or explosion during operations<br>• Loaded tote-bin is dropped (outside confinement area) releasing radioactive material<br>• Cave-in occurs during excavation operation and buries a worker<br>• Worker slips and falls into excavation site<br>• Back-hoe falls into excavation site<br>• Uncovering high radiation source during retrieval<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Probable<br>• Unlikely<br>• Unlikely<br>• Probable<br>• Possible<br>• Unlikely<br>• Unlikely<br>• Unlikely<br>• Unlikely<br>• Unlikely | • Marginal<br>• Critical<br>• Marginal<br>• Severe<br>• Critical<br>• Critical<br>• Severe<br>• Marginal<br>• Marginal<br>• Severe<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience, Pit 4 Plan, HASP, Pit 9 HazID, and OSHA | • Low<br>• Significant<br>• Low<br>• Low<br>• Low<br>• Significant<br>• Significant<br>• Low<br>• Low<br>• Low<br>• Low<br>• Low |
| 2A.6.6 Segregate retrieved wastes | Occasional | • Radiological/toxic chemical inhalation exposure from contact with waste containers<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling<br>• Off-gas treatment system failure resulting in radiological/toxic chemical release<br>• Containment/ventilation system failure and resulting exposure to radiological and toxic substances | • Unlikely<br>• Possible<br>• Unlikely<br>• Unlikely | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker Public<br>• Worker | Previous, similar experience, Pit 4 Plan, HASP, and Pit 9 HazID*** | • Low<br>• Low<br>• Low<br>• Low |
| 2A.6.7 Temporary waste storage | Anticipated | • Radiological/toxic chemical inhalation exposure from contact with waste containers<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling | • Unlikely<br>• Possible | • Marginal<br>• Marginal | • Worker<br>• Worker | Previous, similar experience | • Low<br>• Low |

* The "Pit 4 Plan" refers to the Removal Action Plan for the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b), the HASP is the Health and Safety Plan (HASP) for the Pit 4 Accelerated Retrieval Project (Wooley, 2004a), the "Pit 9 HazID" refers to the Hazard Identification Document for the Pit 9 Stage III Project (INEEL, 2003b), which involved excavation, and OSHA refers to the OSHA Excavations Manual 2226 (DOL, 2002).

**Table H-1. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Targeted RFP TRU Waste Retrieval Option (2A)—Continued**

**2A.6 LOCATE AND RETRIEVE TARGETED RFP BURIED TRU WASTE AND SEGREGATE INTO TRU AND NON-TRU FRACTIONS —CONTINUED**

| Task | Task Frequency | What can go wrong? (Failure mode event) | How likely is it? (Event probability) | What is the severity of the consequences? | Who is the impacted population? | What is the risk evaluation basis? | Overall Contribution to Risk |
|---|---|---|---|---|---|---|---|
| 2A.6.8 Backfill retrieval areas | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Injuries from construction-related activities including borrow soil transport<br>• High noise levels and resulting hearing damage<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Probable<br>• Probable<br>• Possible | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience | • Low<br>• Low<br>• Low<br>• Low<br>• Significant |
| 2A.6.9 Dismantle/decon retrieval equipment and facilities | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Injuries from construction-related activities<br>• High noise levels and resulting hearing damage<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Probable<br>• Probable<br>• Possible | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience | • Low<br>• Low<br>• Low<br>• Low<br>• Significant |
| 2A.6.10 Dispose of equipment under cap | Occasional* | • Construction-related traumatic injury** | • Possible | • Critical | • Worker | Previous, similar experience | • Significant |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** Other hazards are related to surface barrier emplacement. Said hazards are the same as those for 1B.10 Surface Barrier Selection, Preparation, and Emplacement, Table G-2.

**Table H-1. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Targeted RFP TRU Waste Retrieval Option (2A)—Continued**

| 2A.7 *EX SITU* TREATMENT (E.G., COMPACTION) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 2A.7.1 Performance criteria | Occasional* | • Office hazards not considered** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 2A.7.2 Development and treatability testing | Occasional* | • Direct contact and resulting exposure to simulated waste materials<br>• Heat stress or hypothermia<br>• High noise levels and resulting hearing damage | • Possible<br>• Possible<br>• Possible | • Marginal<br>• Critical<br>• Marginal | • Worker<br>• Worker<br>• Worker | Previous, similar experience | • Low<br>• Significant<br>• Low |
| 2A.7.3 Construction and equipment installation | Occasional* | • Injuries from construction-related activities including pinch points, struck by, and drum handling<br>• High noise levels and resulting hearing damage<br>• Dose from external radiation | • Probable<br>• Probable<br>• Unlikely | • Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker | Previous, similar experience | • Low<br>• Low<br>• Low |
| 2A.7.4 Perform needed *ex situ* treatment | Anticipated | • Containment/ventilation system failure and resulting exposure to radiological and toxic substances<br>• Overpressurization while compacting pressurized container resulting in radiological/toxic chemical exposure<br>• Off-gas treatment system failure resulting in radiological/toxic chemical release<br>• Undesired criticality during operations<br>• Fire or explosion during operation<br>• High noise levels and resulting hearing damage<br>• Dose from external radiation | • Probable<br>• Possible<br>• Unlikely<br>• Unlikely<br>• Unlikely<br>• Probable<br>• Unlikely | • Marginal<br>• Critical<br>• Marginal<br>• Severe<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker Public<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and Pit 9 HazID*** | • Low<br>• Significant<br>• Low<br>• Low<br>• Low<br>• Low<br>• Low |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not usually considered significant nor do they relate to chemical or radioactive exposure and thus are not considered in this report.
*** The "Pit 9 HazID" refers to the Hazard Identification Document for the Pit 9 Stage III Project (INEEL, 2003b), which involved excavation and some treatment activities.

**Table H-1. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Targeted RFP TRU Waste Retrieval Option (2A)—Continued**

| **2A.7 *EX SITU* TREATMENT (E.G., COMPACTION)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 2A.7.5 Dismantle/decon equipment | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Construction-related traumatic injury<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Probable<br>• Possible | • Marginal<br>• Critical<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience | • Low<br>• Significant<br>• Low<br>• Significant |
| 2A.7.6 Dispose equipment | Occasional* | • Construction-related traumatic injury** | • Possible | • Critical | • Worker | Previous, similar experience | • Significant |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** Other hazards are related to surface barrier emplacement. Said hazards are the same as those for 1B.10 Surface Barrier Selection, Preparation, and Emplacement, Table G-2.

**Table H-1. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Targeted RFP TRU Waste Retrieval Option (2A)—Continued**

| **2A.8 PACKAGE RETRIEVED (AND POTENTIALLY TREATED) WASTES** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 2A.8.1 Equipment installation | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling<br>• High noise levels and resulting hearing damage<br>• Dose from external radiation | • Unlikely<br>• Probable<br>• Probable<br>• Unlikely | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience | • Low<br>• Low<br>• Low<br>• Low |
| 2A.8.1 Waste transfer | Anticipated | • High noise levels and resulting hearing damage<br>• Direct contact and resulting exposure to waste materials | • Probable<br>• Unlikely | • Marginal<br>• Marginal | • Worker<br>• Worker | Previous, similar experience | • Low<br>• Low |
| 2A.8.3 Package non-TRU wastes (SDA) | Anticipated | • Containment/ventilation system failure and resulting exposure to radiological and toxic substances<br>• Off-gas treatment system failure resulting in radiological/toxic chemical release<br>• Undesired criticality during operations<br>• Direct contact and resulting exposure to waste materials | • Probable<br>• Unlikely<br>• Unlikely<br>• Possible | • Marginal<br>• Marginal<br>• Severe<br>• Marginal | • Worker<br>• Worker Public<br>• Worker<br>• Worker | Previous, similar experience and Pit 9 HazID** | • Low<br>• Low<br>• Low<br>• Low |
| 2A.8.4 Package TRU wastes (WIPP) | Anticipated | • Containment/ventilation system failure and resulting exposure to radiological and toxic substances<br>• Off-gas treatment system failure resulting in radiological/toxic chemical release<br>• Undesired criticality during operations<br>• Direct contact and resulting exposure to waste materials | • Probable<br>• Unlikely<br>• Unlikely<br>• Possible | • Marginal<br>• Marginal<br>• Severe<br>• Marginal | • Worker<br>• Worker Public<br>• Worker<br>• Worker | Previous, similar experience and Pit 9 HazID** | • Low<br>• Low<br>• Low<br>• Low |
| 2A.8.5 Handle special materials | Unlikely | • Containment/ventilation system failure and resulting exposure to radiological and toxic substances<br>• Off-gas treatment system failure resulting in radiological/toxic chemical release<br>• Undesired criticality during operations<br>• Direct contact and resulting exposure to waste materials<br>• Dose from external radiation (non-waste) | • Possible<br>• Unlikely<br>• Unlikely<br>• Possible<br>• Unlikely | • Severe<br>• Severe<br>• Severe<br>• Critical<br>• Marginal | • Worker<br>• Worker Public<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and Pit 9 HazID** | • Significant<br>• Low<br>• Low<br>• Significant<br>• Low |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** The "Pit 9 HazID" refers to the Hazard Identification Document for the Pit 9 Stage III Project (INEEL, 2003b), which involved excavation and some treatment activities.

**Table H-1. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Targeted RFP TRU Waste Retrieval Option (2A)—Continued**

**2A.9 INTERMEDIATE STORAGE OF RETRIEVED AND PACKAGED WASTES**

| Task | Task Frequency | What can go wrong? (Failure mode event) | How likely is it? (Event probability) | What is the severity of the consequences? | Who is the impacted population? | What is the risk evaluation basis? | Overall Contribution to Risk |
|---|---|---|---|---|---|---|---|
| 2A.9.1 Construct storage facilities | Occasional | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling<br>• High noise levels and resulting hearing damage<br>• Dose from external radiation | • Unlikely<br>• Probable<br>• Possible<br>• Unlikely | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience | • Low<br>• Low<br>• Low<br>• Low |
| 2A.9.2 Store wastes | Anticipated | • Containment/ventilation system failure and resulting exposure to radiological and toxic substances | • Unlikely | • Marginal | • Worker Public | Previous, similar experience and Pit 9 HazID* | • Low |

**2A.10 SURFACE BARRIER SELECTION, PREPARATION, AND EMPLACEMENT**

| Task | Task Frequency | What can go wrong? (Failure mode event) | How likely is it? (Event probability) | What is the severity of the consequences? | Who is the impacted population? | What is the risk evaluation basis? | Overall Contribution to Risk |
|---|---|---|---|---|---|---|---|
| *No change from Alternative 1B: For details, please refer to Table G-2 for 1B.10 Surface Barrier Selection, Preparation, and Emplacement* | | | | | | | |

* The "Pit 9 HazID" refers to the Hazard Identification Document for the Pit 9 Stage III Project (INEEL, 2003b), which involved excavation and some treatment activities.

**Table H-1. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Targeted RFP TRU Waste Retrieval Option (2A)—Continued**

| 2A.11 LONG-TERM STEWARDSHIP ACTIVITIES FOR THE SDA | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 2A.11.1<br>Determine long-term monitoring and institutional controls needed | Occasional* | • Office hazards not considered* | • Not considered | • Not considered | • Not considered | Judgment and similar activity | • Not considered |
| 2A.11.2<br>Implement monitoring and institutional controls | Occasional* | • Construction-related traumatic injury<br>• Radiological uptake via dust inhalation<br>• Toxic VOC uptake via inhalation<br>• Dose from external radiation<br>• Heat stress or hypothermia<br>• Failure of Long-Term Stewardship | • Possible<br>• Unlikely<br>• Possible<br>• Probable<br>• Possible<br>• Probable | • Critical<br>• Critical<br>• Critical<br>• Marginal<br>• Critical<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Public | Judgment and unlined landfill experience | • Significant<br>• Low<br>• Significant<br>• Low<br>• Significant<br>• High |
| 2A.11.3<br>Routine maintenance, repair, and replacement | Anticipated | • Maintenance-related traumatic injury<br>• Radiological uptake via dust inhalation<br>• Toxic VOC uptake via inhalation<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Unlikely<br>• Possible<br>• Unlikely<br>• Possible | • Critical<br>• Critical<br>• Marginal<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Judgment and unlined landfill experience | • Low<br>• Low<br>• Low<br>• Low<br>• Significant |
| 2A.11.4<br>Non-routine maintenance, repair, and replacement | Occasional | • Maintenance-related traumatic injury<br>• Radiological uptake via dust inhalation<br>• Toxic VOC uptake via inhalation<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Possible<br>• Possible<br>• Possible<br>• Unlikely<br>• Possible | • Critical<br>• Critical<br>• Marginal<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Judgment and unlined landfill experience | • Significant<br>• Significant<br>• Low<br>• Low<br>• Significant |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.

** Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not usually considered significant nor do they relate to chemical or radioactive exposure and thus are not considered in this report.

**Table H-1. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Targeted RFP TRU Waste Retrieval Option (2A)—Continued**

| 2A.12 CONSTRUCT NEW SDA DISPOSAL CELL FOR DISPOSAL OF NON-TRU WASTES AND CONTAMINATED SOIL | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 2A.12.1 Performance criteria | Occasional* | • Office hazards not considered** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 2A.12.2 SDA disposal cell construction | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Injuries from construction-related activities especially from heavy equipment operation<br>• Large sloughing event resulting in airborne release of contaminated waste zone materials<br>• Cave-in occurs during excavation operation and buries a worker<br>• High noise levels and resulting hearing damage<br>• Uncovering high radiation source during excavation<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Possible<br>• Possible<br>• Possible<br>• Unlikely<br>• Unlikely<br>• Unlikely | • Marginal<br>• Critical<br>• Marginal<br>• Severe<br>• Marginal<br>• Severe<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience, HASP, and OSHA*** | • Low<br>• Significant<br>• Low<br>• Significant<br>• Low<br>• Low<br>• Low<br>• Low |
| 2A.12.3 Non-TRU waste and soil disposal | Frequent | • Radiological exposure from proximity to waste containers<br>• Toxic chemical exposure from proximity to waste containers<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling<br>• High noise levels and resulting hearing damage<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Possible<br>• Probable<br>• Unlikely<br>• Unlikely | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience and ICDF HASP*** | • Low<br>• Low<br>• Low<br>• Low<br>• Low<br>• Low |

| 2A.13 LONG-TERM STEWARDSHIP ACTIVITIES FOR THE NEW SDA DISPOSAL CELL | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No significant change from Alternative 1A: For details, please refer to Table H-1 for 2A.11 Long-term Stewardship Activities* | | | | | | | |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not usually considered significant and thus are not considered in this report.
*** HASP is the Health and Safety Plan for *construction* of the CERCLA Disposal Facility (ICDF) (INEEL, 2001) and OSHA is the OSHA Excavations Manual 2226 (DOL, 2002). The ICDF HASP refers to the Health and Safety Plan for operation of the Idaho Site CERCLA Disposal Facility (ICDF) (INEEL, 2003c).

**Table H-1. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Targeted RFP TRU Waste Retrieval Option (2A)—Continued**

| **2A.14 OFF-SITE SHIPMENT AND DISPOSAL AT WIPP** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 2A.14.1 Plan & manage shipments | Anticipated | • Office hazards not considered* | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 2A.14.2 Load waste packages onto carrier | Frequent | • Contact and resulting exposure to waste materials<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling<br>• Dose from external radiation (only if package does not meet shipping requirements) | • Possible<br>• Possible<br>• Unlikely | • Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker | Previous, similar experience | • Low<br>• Low<br>• Low |
| 2A.14.3 Load carrier onto conveyance | Frequent | • Injuries from heavy equipment operation<br>• Proximity to waste materials resulting in exposure<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Probable<br>• Possible<br>• Unlikely<br>• Unlikely | • Critical<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience | • Significant<br>• Low<br>• Low<br>• Low |
| 2A.14.4 Transport via road or rail | Frequent | • Vehicular accident resulting in high temperature fire, container/carrier breach, and exposure<br>• Intentional sabotage resulting in high temperature fire, container/carrier breach, and exposure | • Possible<br>• Unlikely | • Critical<br>• Critical | • Worker Public<br>• Worker Public | Previous, similar experience | • Significant<br>• Low |
| 2A.14.5 Off-load waste at WIPP | Frequent | • Crane/waste hoist failure or forklift accident resulting in breach of waste container and exposure to waste materials<br>• Natural event (e.g., seismic or tornado) resulting in waste container breach and exposure<br>• Intentional sabotage resulting in high temperature fire, container/carrier breach, exposure, and other injuries | • Possible<br>• Unlikely<br>• Unlikely | • Marginal<br>• Marginal<br>• Severe | • Worker<br>• Worker Public<br>• Worker Public | Previous, similar experience and WIPP CH DSA** | • Low<br>• Low<br>• Low |
| 2A.14.6 TRU Waste at WIPP | Frequent | • Drop of waste container by forklift operator resulting in breach of waste container and exposure to waste materials<br>• Underground roof cave-in resulting in worker injury and/or exposure to waste materials (if container is breached) | • Unlikely<br>• Unlikely | • Marginal<br>• Severe | • Worker<br>• Worker | Previous, similar experience and WIPP CH DSA** | • Low<br>• Significant |

* Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not usually considered significant nor do they relate to chemical or radioactive exposure and thus are not considered in this report.
** "WIPP CH DSA" refers to the Documented Safety Analysis for Contact-Handled TRU wastes at the Waste Isolation Pilot Plant (DOE, 2004).

**Table H-2. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Full Rocky Flats Plant TRU Waste Retrieval Option (2B)**

| **2B.1 SUBSURFACE DISPOSAL AREA (SDA) CHARACTERIZATION** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1A: For details, please refer to Table G-1 for 1A.1 Subsurface Disposal Area (SDA) Characterization* | | | | | | | |
| **2B.2 *IN SITU* THERMAL DESORPTION PRETREATMENT (ISTD)** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1B: For details, please refer to Table G-2 for 1B.2 In Situ Thermal Desorption (ISTD) Pretreatment* | | | | | | | |
| **2B.3 *IN SITU* GROUTING FOR SUBSURFACE STABILIZATION AND CONTAMINANT IMMOBILIZATION** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1C: For details, please refer to Table G-3 for 1C.3 In Situ Grouting for Subsurface Stabilization and Contaminant Immobilization* | | | | | | | |
| **2B.4 *IN SITU* VITRIFICATION (ISV) IS NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | | | |
| **2B.5 PAD A RECONFIGURATION** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1B: For details, please refer to Table G-2 for 1B.5 Long-term Stewardship Activities* | | | | | | | |

**Table H-2. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Full Rocky Flats Plant TRU Waste Retrieval Option (2B)—Continued**

| **2B.6** | **LOCATE AND RETRIEVE *ROCKY FLATS PLANT* BURIED TRU WASTE AND SEGREGATE INTO TRU AND NON-TRU FRACTIONS** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 2B.6.1 Identify retrieval methods | Occasional* | • No *additional* hazards** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 2B.6.2 Determine extent of retrieval | Occasional | • Office hazards not considered*** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 2B.6.3 Plan/manage retrieval | Occasional* | • Office hazard not considered*** | • Not considered | • Not considered | • Not considered | Previous, similar experience | • Not considered |
| 2B.6.4 Install retrieval equipment and enclosures | Occasional | • Overburden removal resulting in airborne radiological/ toxic chemical inhalation exposure<br>• Potentially contaminated soil removal resulting radiological/toxic chemical exposure<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling<br>• High noise levels and resulting hearing damage<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Possible<br>• Probable<br>• Probable<br>• Probable<br>• Probable<br>• Possible | • Marginal<br>• Critical<br>• Marginal<br>• Marginal<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience, Pit 4 Plan, HASP, and Pit 9 HazID**** | • Low<br>• Significant<br>• Low<br>• Low<br>• Low<br>• Significant |
| 2B.6.5 Retrieve buried RFP TRU wastes | Anticipated | • Disturb waste area and failure of dust suppression resulting in airborne radiological/toxic chemical inhalation exposure<br>• Radiological/toxic chemical inhalation exposure from contact with waste containers<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling<br>• Off-gas treatment system failure resulting in radiological/toxic chemical release | • Unlikely<br>• Unlikely<br>• Possible<br>• Unlikely | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker Public | Previous, similar experience, Pit 4 Plan, HASP, and Pit 9 HazID**** | • Low<br>• Low<br>• Low<br>• Low |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.

** There are hazards associated with the Pit 9 retrieval study that has already been completed (Snook, 2004) and the active Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b), but these are not considered here as the Pit 4 Accelerated Retrieval Project is being carried out regardless of the alternative selected for the SDA buried wastes.

*** The areas containing RFP TRU wastes will likely be determined using process and historical knowledge and the results of the Integrated Probing Project whose risks were indicated in 1A.1 Subsurface Disposal Area (SDA) Characterization, Table G-1. Office hazards (e.g., carpal tunnel syndrome, tripping, slipping, etc.) are not considered.

**** The "Pit 4 Plan" refers to the Removal Action Plan for the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b), the HASP is the Health and Safety Plan (HASP) for the Pit 4 Accelerated Retrieval Project (Wooley, 2004b), and the "Pit 9 HazID" refers to the Hazard Identification Document for the Pit 9 Stage III Project (INEEL, 2003b), which involved excavation.

**Table H-2. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Full Rocky Flats Plant TRU Waste Retrieval Option (2B)—Continued**

| **2B.6 LOCATE AND RETRIEVE *ROCKY FLATS PLANT* BURIED TRU WASTE AND SEGREGATE INTO TRU AND NON-TRU FRACTIONS—CONTINUED** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 2B.6.5 (Cont'd) Retrieve buried RFP TRU wastes | Anticipated | • Containment/ventilation system failure and resulting exposure to radiological and toxic substances<br>• Large sloughing event resulting in airborne release of contaminated waste zone materials<br>• Pit subsidence external to retrieval facility<br>• Undesired criticality during operations<br>• Fire or explosion during operations<br>• Loaded tote-bin is dropped (outside confinement area) releasing radioactive material<br>• Cave-in occurs during excavation operation and buries a worker<br>• Worker slips and falls into excavation site<br>• Back-hoe falls into excavation site<br>• Uncovering high radiation source during retrieval<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Probable<br>• Unlikely<br>• Unlikely<br>• Probable<br>• Possible<br>• Unlikely<br>• Unlikely<br>• Unlikely<br>• Unlikely<br>• Unlikely | • Marginal<br>• Critical<br>• Marginal<br>• Severe<br>• Critical<br>• Critical<br>• Severe<br>• Marginal<br>• Marginal<br>• Severe<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience, Pit 4 Plan, HASP, Pit 9 HazID, and OSHA* | • Low<br>• Significant<br>• Low<br>• Low<br>• Low<br>• Significant<br>• Significant<br>• Low<br>• Low<br>• Low<br>• Low<br>• Low |
| 2B.6.6 Segregate retrieved wastes | Occasional | • Radiological/toxic chemical inhalation exposure from contact with waste containers<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling<br>• Off-gas treatment system failure resulting in radiological/toxic chemical release<br>• Containment/ventilation system failure and resulting exposure to radiological and toxic substances | • Unlikely<br>• Possible<br>• Unlikely<br>• Unlikely | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal | • Worker<br>• Worker<br>• Worker Public<br>• Worker | Previous, similar experience, Pit 4 Plan, HASP, and Pit 9 HazID* | • Low<br>• Low<br>• Low<br>• Low |
| 2B.6.7 Temporary waste storage | Anticipated | • Radiological/toxic chemical inhalation exposure from contact with waste containers<br>• Injuries from construction-related activities including pinch points, struck by, and drum handling | • Unlikely<br>• Possible | • Marginal<br>• Marginal | • Worker<br>• Worker | Previous, similar experience | • Low<br>• Low |

* The "Pit 4 Plan" refers to the Removal Action Plan for the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b), the HASP is the Health and Safety Plan (HASP) for the Pit 4 Accelerated Retrieval Project (Wooley, 2004b), the "Pit 9 HazID" refers to the Hazard Identification Document for the Pit 9 Stage III Project (INEEL, 2003b), which involved excavation, and OSHA refers to the OSHA Excavations Manual 2226 (DOL, 2002).

**Table H-2. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Full Rocky Flats Plant TRU Waste Retrieval Option (2B)—Continued**

| **2B.6 LOCATE AND RETRIEVE *ROCKY FLATS PLANT* BURIED TRU WASTE AND SEGREGATE INTO TRU AND NON-TRU FRACTIONS—CONTINUED** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| 2B.6.8 Backfill retrieval areas | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Injuries from construction-related activities including borrow soil transport<br>• High noise levels and resulting hearing damage<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Possible<br>• Probable<br>• Possible | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience | • Low<br>• Low<br>• Low<br>• Low<br>• Significant |
| 2B.6.9 Dismantle/decon retrieval equipment and facilities | Occasional* | • Disturb surface resulting in airborne radiological/toxic chemical inhalation exposure<br>• Injuries from construction-related activities<br>• High noise levels and resulting hearing damage<br>• Dose from external radiation<br>• Heat stress or hypothermia | • Unlikely<br>• Possible<br>• Possible<br>• Probable<br>• Possible | • Marginal<br>• Marginal<br>• Marginal<br>• Marginal<br>• Critical | • Worker<br>• Worker<br>• Worker<br>• Worker<br>• Worker | Previous, similar experience | • Low<br>• Low<br>• Low<br>• Low<br>• Significant |
| 2B.6.10 Dispose of retrieval equipment under cap | Occasional* | • Construction-related traumatic injury** | • Possible | • Critical | • Worker | Previous, similar experience | • Significant |

* "Occasional" in this context refers to an activity that is conducted a single time, however, over a long period of time.
** Other hazards are related to surface barrier emplacement. Said hazards are the same as those for 1B.10 Surface Barrier Selection, Preparation, and Emplacement, Table G-2.

**Table H-2. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Full Rocky Flats Plant TRU Waste Retrieval Option (2B)—Continued**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **2B.7 *EX SITU* TREATMENT (E.G., COMPACTION)** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 2A: For details, please refer to Table H-1 for 2A.7 Ex Situ Treatment (e.g., Compaction)* | | | | | | | |
| **2B.8 PACKAGE RETRIEVED (AND POTENTIALLY TREATED) WASTES** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 2A: For details, please refer to Table H-1 for 2A.8 Package Retrieved (and Potentially Treated) Wastes* | | | | | | | |
| **2B.9 INTERMEDIATE STORAGE OF RETRIEVED AND PACKAGED WASTES** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 2A: For details, please refer to Table H-1 for 2A.9 Intermediate Storage of Retrieved and Packaged Wastes* | | | | | | | |
| **2B.10 SURFACE BARRIER SELECTION, PREPARATION, AND EMPLACEMENT** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 1B: For details, please refer to Table G-2 for 1B.10 Surface Barrier Selection, Preparation, and Emplacement* | | | | | | | |
| **2B.11 LONG-TERM STEWARDSHIP ACTIVITIES FOR THE SDA** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No significant change from Alternative 1A: For details, please refer to Table H-1 for 2A.11 Long-term Stewardship Activities for the SDA* | | | | | | | |

**Table H-2. Hazard Evaluation for Retrieve/Treat/Dispose Alternative, Full Rocky Flats Plant TRU Waste Retrieval Option (2B)—Continued**

| **2B.12 CONSTRUCT NEW SDA DISPOSAL CELL FOR DISPOSAL OF NON-TRU WASTES AND CONTAMINATED SOIL** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 2A: For details, please refer to Table H-1 for 2A.12Construct New SDA Disposal Cell for Disposal of Non-TRU Wastes and Contaminated Soil* | | | | | | | |
| **2B.13 LONG-TERM STEWARDSHIP ACTIVITIES FOR THE NEW SDA DISPOSAL CELL** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No significant change from Alternative 1A: For details, please refer to Table H-1 for 2A.11 Long-term Stewardship Activities for the SDA* | | | | | | | |
| **2B.14 OFF-SITE SHIPMENT AND DISPOSAL AT WIPP** | | | | | | | |
| **Task** | **Task Frequency** | **What can go wrong? (Failure mode event)** | **How likely is it? (Event probability)** | **What is the severity of the consequences?** | **Who is the impacted population?** | **What is the risk evaluation basis?** | **Overall Contribution to Risk** |
| *No change from Alternative 2A: For details, please refer to Table H-1 for 2A.14 Off-site Shipment and Disposal at WIPP* | | | | | | | |

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# I. Gap Analysis Tables for Alternative 1: Contain in Place (4 Options)

## List of Tables

**Box F-2. Definitions for Gap Analysis Tables**

## How Important (a Gap)?

**Critical:** Lack of this piece of knowledge is sufficient to provide a high degree of uncertainty in the ability to assess the threat to human health (both worker and the general public), the environment (both on-site and off-site), and/or security; i.e., result in a critical or severe hazard (as defined in Box F-1).

**Important:** Possession of this knowledge is important to the ability to assess the threat to human health (both worker and the general public), the environment (both on-site and off-site), and/or security. Other information must be lacking to the ability to assess the threat to human health and the environment.

**Inconsequential:** This knowledge may have localized significance to non-safety-related activities (including routine maintenance, repair, etc.).

## Low large a Gap? (Magnitude of Gap or Level of Knowledge)

**Large:** Little is known or can be reasonably inferred concerning this piece of information (from other sources of information).

**Intermediate:** Incomplete information is available concerning this piece of information or can only be inferred from other data not necessarily directly related to the missing piece of information.

**Small:** Complete or nearly complete information is available concerning this piece of information or an adequate, well-known analogue can be established.

**Table I-1. Gap Analysis for Contain-in-Place Alternative, No Action Option (1A): Long-term Monitoring of Buried Wastes**

| **1A.1 SUBSURFACE DISPOSAL AREA (SDA) CHARACTERIZATION** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 1A.1.1 Determine contaminant waste forms, inventories, distributions, and fluxes | • Potential for facilitated plutonium transport through the vadose zone<br>• Presence and location of spent fuel or similar high-activity material<br>• Saturated zone contaminant transport properties and model validity<br>• Vadose zone contaminant transport properties and model validity<br>• Geospatial distribution of waste and waste forms<br>• Physical and chemical forms<br>• Release mechanisms and rates<br>• Infiltration rate into burial site<br>• Locations to insert probes to determine extent of contaminant migration | • Critical<br>• Critical<br>• Important<br>• Important<br>• Critical<br>• Inconsequential**<br>• Inconsequential**<br>• Inconsequential**<br>• Important | • Large<br>• Large<br>• Intermediate<br>• Large<br>• Large<br>• Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | • (Batcheller, 2004)<br>• STRE, PERA, (Holdren, 2004)<br>• (INEEL, 2004c)<br>• (INEEL, 2004c)<br>• ABRA<br>• ABRA<br>• ABRA<br>• ABRA<br>• (Miller, 2003; Salomon, 2003) | The gaps in knowledge, particularly those relating to the presence and location of spent fuel (or analogous) material and possible facilitated plutonium transport, are high risk/large gap that can lead to significant risks to workers and the general public. |
| 1A.1.2 Complete analysis of historic, current, and planned retrieval activities | • Pit 4 Accelerated Retrieval Project<br>• Extraction of organic contaminants in the vadose zone (OCVZ)***<br>• On-going low-level and mixed low-level waste disposal operations | • Inconsequential<br>• Important<br>• Inconsequential | • Large<br>• Large<br>• Intermediate | • (DOE-ID, 2004b; Wooley, 2004a)<br>• (DOE-ID, 1994a; Housley, 2004)<br>• IRA, ABRA | The tasks related to Pit 4 and OCVZ tend to reduce risks further and thus can be omitted to provide a reasonable bounding case; however, there are on-going low-level and mixed low-level waste disposal activities that will increase the inventory. |
| 1A.1.3 Complete SDA conceptual site models | • Contaminant transport pathways<br>• Exposure methods<br>• Residential and worker scenarios | • Critical<br>• Critical<br>• Important | • Small<br>• Small<br>• Intermediate | IRA, ABRA, RBES | One important gap is whether the acute well-drilling, intruder scenario (i.e., the only scenario evaluated by Idaho Site personnel) is the only important scenario. |
| **TASKS 1A.2 THROUGH 1A.10 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | |

* STRE is the *Short-term Risk Evaluation* for Operable Unit 7-13/14 (Schofield, 2002), IRA is the *Interim Risk Assessment* and Contaminant Screening for Waste Area Group 7 (which includes the SDA) Remedial Investigation (Becker et al., 1998), PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik et al., 2002), ABRA is the *Ancillary Basis for Risk Analysis* of the SDA (Holdren et al., 2002), and RBES is the Draft Idaho Site Risk-Based End State Vision document (DOE-ID, 2004a).

** These gaps are considered to have a small impact on the overall task because reasonable assumptions (e.g., solubility-limited releases) can be made to provide reasonably conservative estimates for the contaminant fluxes from the burial site.

*** Since 1996, soil vapor extraction has been employed to remove organic contamination in the vadose zone (OCVZ) below the Subsurface Disposal Area (SDA). The vadose zone has been contaminated by volatile organic compounds migrating from the buried wastes (Housley & Sondrup, 2004).

**Table I-1. Gap Analysis for Contain-in-Place Alternative, No Action Option (1A): Long-term Monitoring of Buried Wastes—Continued**

| Task | What information is missing? | How important? | How large a gap? | Sources* | Comments |
|---|---|---|---|---|---|
| **1A.11 LONG-TERM STEWARDSHIP ACTIVITIES** | | | | | |
| 1A.11.1 Determine long-term monitoring and institutional controls needed | • Future land use scenarios and population pressures<br>• Maintenance requirements for the physical site<br>• Current and future regulatory, permitting, funding, and authority issues<br>• What incentives and procedures are needed to ensure longevity of protective state?<br>• Types of institutional controls (e.g., use restrictions, notification measures, etc.) that are necessary and enforceable<br>• Types of environmental monitoring needed<br>• How current and future risks will be assessed | • Important<br>• Important<br>• Important<br>• Important<br>• Important<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Large<br>• Large<br>• Intermediate<br>• Intermediate<br>• Intermediate | • RBES<br>• (Kratina, 2002)<br>• (C-H, 1995)<br>• (C-H, 1995)<br>• (C-H, 1995)<br>• (C-H, 1995)<br>• (C-H, 1995) | There is likely to be great uncertainty in how the issues of implementing legacy management for the SDA. Some degree of flexibility should be built into the controls as conditions (e.g., due to contaminant migration) are bound to change unexpectedly in the future. There must also be consideration of public acceptance of the controls selected as well as any actions (e.g., groundwater use restrictions) that might be needed outside the Idaho Site boundary. |
| 1A.11.2 Implement long-term monitoring and institutional controls | • Efficacy of environmental monitoring and institutional controls over time<br>• Changes in site conditions, regulations, funding mechanisms, contaminant distributions, etc.<br>• Geospatial and temporal distribution of wastes and waste forms | • Critical<br>• Important<br>• Critical | • Intermediate<br>• Large<br>• Large | • (C-H, 1995)<br>• (C-H, 1995)<br>• Judgment | The primary consideration is how to provide incentives and procedures to assure the efficacy of the monitoring and controls with changing site and regulatory conditions. |
| 1A.11.3 Routine maintenance, repair, and replacement | • What procedures, expertise/staffing level, funding, materials, etc. will be required for routine maintenance | • Important | • Intermediate | • Judgment | Usual and customary practices for defining the level of staffing and expertise necessary should provide reasonable estimates for this information. |
| 1A.11.4 Non-routine maintenance, repair, and replacement | • What procedures, expertise/staffing level, funding, materials, etc. will be required for non-routine maintenance | • Important | • Large | • Judgment | It will be difficult to provide reasonable estimates for this information because of the unexpected nature of these operations. |
| **TASKS 1A.12 THROUGH 1A.14 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | |

* The RBES is the Draft Idaho Site Risk-Based End State Vision document (DOE-ID, 2004b) and "C-H, 1995" is (Clancy-Hepburn, 1995).

## Table I-2. Gap Analysis for Contain-in-Place Alternative, Surface Barrier Option (1B)

| **1B.1 SUBSURFACE DISPOSAL AREA (SDA) CHARACTERIZATION** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1A: For details, please refer to Table I-1 for 1A.1 Subsurface Disposal Area (SDA) Characterization* | | | | | |

| **1B.2 *IN SITU* THERMAL DESORPTION (ISTD) PRETREATMENT** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 1B.2.1 Performance criteria | • The types of wastes and contaminant inventory that will need to be treated<br>• Applicable or Relevant and Appropriate Requirements (ARARs)<br>• Results from organic contamination in the vadose zone (OCVZ) extraction | • Important<br>• Important<br>• Critical | • Intermediate<br>• Intermediate<br>• Intermediate | • ABRA, Study Work Plan<br>• PERA, Study Work Plan, (Holdren, 2004)<br>• (DOE-ID, 1994a; Housley, 2004) | There is reasonably complete information concerning what was buried in the SDA; however, the distributions of contaminants are less well known as are the requirements that the site must satisfy. Furthermore, the extraction of volatile organic contaminants from the vadose zone (DOE-ID, 1994a; Housley, 2004) may make this process step unnecessary. |
| 1B.2.2 Development and treatability testing | • Changes that will have to be made to the study based upon intermediate results<br>• The data and other information that will be obtained from the study<br>• The residuals that will be produced and how they will have to be treated<br>• Demonstration that ISTD pretreatment will not cause further contamination (due to increased contaminant mobility) | • Important<br>• Important<br>• Important<br>• Critical | • Large<br>• Large<br>• Intermediate<br>• Intermediate | Judgment, (Vinegar, 1997; Baker, 2002) | One cannot know what will be obtained from the study; however, there have been at least eight previous tests and applications of this technology (DOE-ID, 1999a; Vinegar, 1997; Baker, 2002) from which information can be drawn. There is a concern that further contamination may result from the application of this technology due to increased contaminant mobility. |
| 1B.2.3 Prepare site and install equipment | • Area and depth needed to treat the organic wastes buried in the SDA<br>• Geospatial distribution of wastes and waste forms | • Important<br>• Critical | • Intermediate<br>• Large | ABRA, Study Work Plan | There is reasonably complete information concerning what was buried in the SDA; however, the distributions of contaminants are less well known. |
| 1B.2.4 Perform required ISTD pretreatment | • Area and depth needed to treat the organic wastes buried in the SDA<br>• Resources required to complete pretreatment of the SDA<br>• Time (and worker hours) needed to complete pretreatment | • Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | • ABRA, Study Work Plan<br>• Judgment, PERA<br>• PERA, Study Work Plan | There is reasonably complete information concerning what was buried in the SDA; however, the distributions of contaminants are less well known. |

* ABRA is the *Ancillary Basis for Risk Analysis* of the Subsurface Disposal Area (SDA) (Holdren et al., 2002), "Study Work Plan" is the OU 7-13/14 ISTD Treatability Study Work Plan (DOE-ID, 1999a), and PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik et al., 2002).

**Table I-2. Gap Analysis for Contain-in-Place Alternative, Surface Barrier Option (1B)—Continued**

| **1B.2 *IN SITU* THERMAL DESORPTION PRETREATMENT (ISTD)—CONTINUED** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| 1B.2.5<br>Dismantle/decon ISTD equipment | • Resources and equipment required to complete dismantling operations<br>• Time (and worker hours) needed to complete dismantling operations<br>• Level to which equipment and secondary wastes have been contaminated | • Inconsequential<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment | Much of the risk associated with this task is based upon how long the dismantling operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) must be used. |
| 1B.2.6<br>Dispose ISTD equipment under cap | • Site/volume availability for contaminated equipment/material disposal<br>• Need for interim storage of contaminated equipment/material to be interred<br>• Resources and equipment required to complete internment operations<br>• Time (and worker hours) needed to complete internment operations | • Important<br>• Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | Judgment | An appropriate site must be made available to receive the contaminated material and equipment from the dismantling operations, and interim storage may be required for said material/equipment until the site is available. Much of the risk associated with this task is based upon how long the internment operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) will be required. |

| **1B.3 *IN SITU* GROUTING (ISG) FOR SUBSURFACE STABILIZATION** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 1B.3.1<br>Performance criteria | • Areas and extent to which the subsurface must be stabilized against subsidence<br>• Compaction and loading limits on subsurface | • Important<br>• Important | • Intermediate<br>• Intermediate | ABRA, (INEEL, 2004d; DOE-ID, 1999c) | Much of the risk associated with this task is based upon how long the *in situ* grouting operation will take and what kind of equipment must be used. |
| 1B.3.2<br>Development and treatability testing | • Changes that will have to be made to the study based upon intermediate results<br>• The data and other information that will be obtained from the study | • Important<br>• Important | • Intermediate<br>• Intermediate | • Judgment<br>• Judgment (INEEL, 2004d; Loomis, 1995, 1996, 1998) | One cannot know what will be obtained from the grouting treatability studies; however, there have been previous tests and applications of this technology (INEEL, 2004d; Loomis, 1995; Loomis, 1996; Loomis, 1998) from which relevant information can be drawn. |
| 1B.3.3<br>Prepare site and install equipment | • Area needed to be grouted to stabilize the subsurface against subsidence | • Important | • Intermediate | • ABRA, (INEEL, 2004d; DOE-ID, 1999c) | Much of the risk associated with this task is based upon how long the *in situ* grouting operation will take and what kind of equipment must be used. |

* ABRA is the *Ancillary Basis for Risk Analysis* of the Subsurface Disposal Area (SDA) (Holdren et al., 2002).

**Table I-2. Gap Analysis for Contain-in-Place Alternative, Surface Barrier Option (1B)—Continued**

| **1B.3 *IN SITU* GROUTING (ISG) FOR SUBSURFACE STABILIZATION—CONTINUED** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 1B.3.4<br>Grout needed areas for subsurface stabilization | • Areas that must be grouted to prevent subsidence<br>• Resources required to complete needed *in situ* grouting in the SDA<br>• Time (and worker hours) needed to complete grouting | • Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | • ABRA, (INEEL, 2004d)<br>• Judgment, PERA<br>• PERA, (INEEL, 2004d; Loomis, 1995, 1996, 1998) | There is some information concerning those areas with drums that may contain voids or areas where waste was emplaced in such a way as to likely leave voided areas. |
| 1B.3.5<br>Dismantle/decon ISG equipment | • Resources and equipment required to complete dismantling operations<br>• Time (and worker hours) needed to complete dismantling operations<br>• Level to which equipment and secondary wastes have been contaminated | • Inconsequential<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment | Much of the risk associated with this task is based upon how long the dismantling operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) must be used. |
| 1B.3.6<br>Dispose ISG equipment under cap | • Site/volume availability for contaminated equipment/material disposal<br>• Need for interim storage of contaminated equipment/material to be interred<br>• Resources and equipment required to complete internment operations<br>• Time (and worker hours) needed to complete internment operations | • Important<br>• Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | Judgment | An appropriate site must be identified and made available to receive the contaminated material and equipment from the dismantling operations, and interim storage may be required for contaminated material/equipment until the site is available. Much of the risk associated with this task is based upon how long the internment operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) will be required. |
| **1B.4 *IN SITU* VITRIFICATION (ISV) IS NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | |

* ABRA is the *Ancillary Basis for Risk Analysis* of the Subsurface Disposal Area (SDA) (Holdren et al., 2002), and PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik et al., 2002).

**Table I-2. Gap Analysis for Contain-in-Place Alternative, Surface Barrier Option (1B)—Continued**

| **1B.5 PAD A RECONFIGURATION** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 1B.5.1 Install necessary equipment | • No *known* gaps | • Not applicable | • Not applicable | • ARP, GEM | Pad A is an aboveground waste storage site containing wastes retrieved during past studies and is thus well characterized. |
| 1B.5.2 Retrieve wastes from Pad A | • Resources and equipment required to complete retrieval operations<br>• Time (and worker hours) needed to complete retrieval operations<br>• Amount and degree to which surrounding soil is contaminated<br>• Level to which equipment and any secondary wastes were contaminated | • Important<br>• Important<br>• Important<br>• Important | • Large<br>• Intermediate<br>• Intermediate<br>• Intermediate | Judgment, ARP, GEM | Much of the risk associated with this task is based upon how long the retrieval operations will take and what kind of equipment must be used. Any information obtained from operations in the Transuranic Storage Area (TSA) should be applicable to Pad A operations. |
| 1B.5.3 Segregate/treat wastes through an external sorting/packaging facility | • Resources and equipment required to complete treatment operations<br>• Time (and worker hours) needed to complete treatment operations<br>• State of the retrieved waste containers | • Important<br>• Important<br>• Critical | • Intermediate<br>• Large<br>• Intermediate | Judgment, ARP, GEM | The risk associated with this task depends primarily on the duration of the handling and treatment tasks as well as the integrity of the waste containers upon removal from Pad A. |
| 1B.5.4 Temporarily store packaged wastes | • The quantities and forms of waste that will have to be stored<br>• The types of waste that will have to be stored<br>• The lengths of time that the wastes will have to be stored | • Important<br>• Important<br>• Important | • Small<br>• Small<br>• Large | Judgment, ARP, GEM | The wastes in Pad A are low-level and come from past retrieval activities. Depending upon what is discovered during retrieval, some of the wastes may be treated and packaged. Thus the types of wastes that must be stored will be well known; however, the storage duration will be dependent upon a number of regulatory and other factors. |
| 1B.5.5 Dispose of Pad A non-TRU wastes in SDA | • The fraction of retrieved wastes that will be non-TRU wastes<br>• Site/volume available for retrieved wastes<br>• Resources and equipment required to complete internment operations<br>• Time (and worker hours) needed to complete internment operations | • Important<br>• Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | Judgment, ARP, GEM | An appropriate site must be identified and made available to receive the contaminated material and equipment from the dismantling operations, and interim storage may be required for contaminated material/equipment until the site is available. For example, there are on-going low-level waste disposal operations in the SDA in Pits 17-20; one or more of these pits may be available for disposal purposes. |
| 1B.5.6 Ship Pad A TRU wastes to WIPP | • The fraction of retrieved wastes that will be TRU wastes<br>• No *additional* gaps* | • Important<br>• Not applicable | • Intermediate<br>• Not applicable | Judgment, ARP, GEM | The major gap in information related to this task is the amount of TRU wastes that will be found in Pad A; the handling and disposal tasks are fairly well known. |

* ARP is the *Accelerated Retrieval Project* (ARP) for Pit 4 (DOE-ID, 2004b) and GEM is the *Glovebox Excavator Method (GEM)* for waste retrieval in Pit 9 (DOE-ID, 2004c).
** Other gaps in information are related to shipment of transuranic (TRU) wastes to WIPP for ultimate disposal and are handled elsewhere.

**Table I-2. Gap Analysis for Contain-in-Place Alternative, Surface Barrier Option (1B)—Continued**

| **1B.5 PAD A RECONFIGURATION—CONTINUED** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 1B.5.7<br>Dismantle/decon Pad A retrieval equipment | • Resources and equipment required to complete dismantling operations<br>• Time (and worker hours) needed to complete dismantling operations<br>• Level to which equipment and secondary wastes have been contaminated | • Inconsequential<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment, ARP, GEM | Much of the risk associated with this task is based upon how long the dismantling operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) must be used. |
| 1B.5.8<br>Dispose Pad A retrieval equipment under cap | • Site/volume availability for contaminated equipment/material disposal<br>• Need for interim storage of contaminated equipment/material to be interred<br>• Resources and equipment required to complete internment operations<br>• Time (and worker hours) needed to complete internment operations | • Important<br>• Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | Judgment, ARP, GEM | An appropriate site must be identified and made available to receive the contaminated equipment from the dismantling operations, and interim storage may be required for contaminated equipment until the site is available. Much of the risk associated with this task is based upon how long the internment operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) will be required. |
| **TASKS 1B.6 THROUGH 1B.9 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | |
| **1B.10 SURFACE BARRIER SELECTION, PREPARATION, AND EMPLACEMENT** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 1B.10.1<br>Performance criteria | • Regulatory and other including site-specific requirements that must be met<br>• Performance measurements available to assess performance versus criteria<br>• Land-use scenarios | • Important<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | • Judgment, (Mattson, 2004)<br>• Judgment, (Mattson, 2004)<br>• Judgment, (DOE, 2003) | The specific regulations that will have to be satisfied by the surface barrier are unknown at the present. |
| 1B.10.2<br>Prepare work plans and safety analyses | • Presence and locations of spent fuel or similar high-activity material<br>• Burial site and container states as well as waste forms | • Critical<br>• Important | • Large<br>• Intermediate | • Judgment, STRE, PERA, (Holdren, 2004)<br>• Judgment, ABRA | It is standard procedure to mitigate known hazards when necessary to protect workers and much of this will not change based upon the waste inventory. One difference involves the discovery of high activity wastes, which require special handling. |

* ARP is the *Accelerated Retrieval Project* (ARP) for a designated area in Pit 4 (DOE-ID, 2004b), GEM is the *Glovebox Excavator Method (GEM)* for waste retrieval in Pit 9 (DOE-ID, 2004c), STRE is the *Short-term Risk Evaluation* for Operable Unit 7-13/14 (Schofield, 2002), PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik, 2002), and ABRA is the *Ancillary Basis for Risk Analysis* of the Subsurface Disposal Area (SDA) (Holdren, 2002).

** Other gaps in information are related to shipment of transuranic (TRU) wastes to WIPP for ultimate disposal and are handled elsewhere.

**Table I-2. Gap Analysis for Contain-in-Place Alternative, Surface Barrier Option (1B)—Continued**

| **1B.10 SURFACE BARRIER SELECTION, PREPARATION, AND EMPLACEMENT—CONTINUED** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 1B.10.3 Determine type of barrier required | • Burial site/local conditions that promote contaminant release and migration<br>• Specific performance criteria that must be satisfied | • Important<br>• Important | • Intermediate<br>• Intermediate | Judgment, (Mattson, 2004) | It is likely that an evapotranspiration (ET) type of cap will satisfy the requirements foreseen for the SDA engineered barrier. |
| 1B.10.4 Prepare SDA for surface barrier installation | • Resources and equipment required to complete preparation (e.g., grading)<br>• Time (and worker hours) needed to complete preparation<br>• Types of active systems (e.g., leachate collection) needed | • Important<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment, (Mattson, 2004) | There is likely to be significant preparation (e.g., grading, excavation, etc.) that will be needed prior to surface barrier installation. |
| 1B.10.5 Install surface barrier over the SDA | • Resources and equipment required to complete installation<br>• Time (and worker hours) needed to complete installation<br>• Availability/location of borrow material<br>• State of low-level waste disposal activities (in Pits 17-20) | • Important<br>• Important<br>• Critical<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | • Judgment, (Mattson, 2004)<br>• Judgment, (Mattson, 2004)<br>• Judgment, PERA<br>• Judgment, ABRA | There is a substantial quantity of borrow material that will be needed to complete the surface barrier. If material from the spreading areas (which are less than one mile from the SDA) can be used, this will reduce the travel distance considerably with the risks. There are also on-going low-level waste disposal activities in the SDA that may require the surface barrier installation to be carried out in stages. |
| **1B.11 LONG-TERM STEWARDSHIP ACTIVITIES** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1A: For details, please refer to Table I-1 for 1A.11 Long-term Stewardship Activities* | | | | | |
| **TASKS 1B.12 THROUGH 1B.14 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | |

* PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik, 2002), and ABRA is the *Ancillary Basis for Risk Analysis* of the Subsurface Disposal Area (SDA) (Holdren, 2002).

**Table I-3. Gap Analysis for Contain-in-Place Alternative, *In Situ* Grouting Option (1C)**

| **1C.1 SUBSURFACE DISPOSAL AREA (SDA) CHARACTERIZATION** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1A: For details, please refer to Table I-1 for 1A.1 Subsurface Disposal Area (SDA) Characterization* | | | | | |
| **1C.2 *IN SITU* THERMAL DESORPTION PRETREATMENT (ISTD)** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1B: For details, please refer to Table I-2 for 1B.2 In Situ Thermal Desorption (ISTD) Pretreatment* | | | | | |
| **1C.3 *IN SITU* GROUTING (ISG) FOR SUBSURFACE STABILIZATION AND CONTAMINANT IMMOBILIZATION** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 1C.3.1<br>Performance criteria | • Geospatial distribution of wastes and waste forms<br>• Applicable or Relevant and Appropriate Requirements (ARARs)<br>• Results from the Pit 4 Accelerated Retrieval Project<br>• Projected treatment endpoint for organic contamination in the vadose zone<br>• Future land-use decisions | • Critical<br>• Important<br>• Important<br>• Inconsequential<br>• Critical | • Large<br>• Intermediate<br>• Intermediate<br>• Large<br>• Intermediate | • ABRA, Study Work Plan<br>• PERA, Study Work Plan, (Holdren, 2004)<br>• (DOE-ID, 2004b)<br>• DOE-ID, 1994a; Housley, 2004)<br>• RBES | The treatment or stabilization requirements will be based upon historic as well as on-going project information, relevant regulations, and other considerations such as worker health. For example, there is reasonably complete information concerning what was buried in the SDA; however, the distributions of contaminants are less well known as are the requirements that the site must satisfy in the future, which are a function of future land-use decisions. |
| 1C.3.2<br>Development and treatability testing | • Changes that will have to be made to the study based upon intermediate results<br>• The data and other information that will be obtained from the study | • Important<br>• Important | • Large<br>• Large | (INEEL, 2004d; Loomis, 1995, 1996, 1998) | One cannot know the results of future *in situ* grouting treatability studies; however, there have been previous tests and applications of this technology (INEEL, 2004d; Loomis, 1995; Loomis, 1996; Loomis, 1998). |
| 1C.3.3<br>Install ISG equipment and enclosure | • Optimal location to install enclosure during grouting operations<br>• Areas/extent to which grouting needed<br>• Enclosure and subsurface conditions sufficient to prevent contaminated grout from surfacing outside enclosure | • Important<br>• Important<br>• Critical | • Intermediate<br>• Intermediate<br>• Intermediate | (INEEL, 2004d; Loomis, 1995, 1996, 1998) | There have been previous tests and applications of this technology (INEEL, 2004d; Loomis, 1995; Loomis, 1996; Loomis, 1998) from which information can be drawn concerning the ability to control such events. |

* ABRA is the *Ancillary Basis for Risk Analysis* of the Subsurface Disposal Area (SDA) (Holdren, 2002), "Study Work Plan" is the OU 7-13/14 In Situ Grouting Treatability Study Work Plan (DOE-ID, 1999c), PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik, 2002), and RBES is the DRAFT *Risk-Based End State* Vision for the Idaho Site (DOE-ID, 2004a).

## Table I-3. Gap Analysis for Contain-in-Place Alternative, *In Situ* Grouting Option (1C)—Continued

**1C.3 *IN SITU* GROUTING (ISG) FOR SUBSURFACE STABILIZATION AND CONTAMINANT IMMOBILIZATION —CONTINUED**

| Task | What information is missing? | How important? | How large a gap? | Sources* | Comment |
|---|---|---|---|---|---|
| 1C.3.4<br>Grout needed areas for contaminant stabilization | • Area and depth needed to immobilize the contaminants of concern in the SDA<br>• Resources required to complete needed *in situ* grouting in the SDA<br>• Time (and worker hours) needed to complete grouting | • Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | • ABRA, (INEEL, 2004d)<br>• Judgment, PERA<br>• Judgment, PERA | There is reasonably complete information concerning what was buried in the SDA; however, the distributions of the contaminants are less well known. |
| 1C.3.5<br>Dismantle, move, and install ISG equipment | • Resources and equipment required to complete dismantling operations<br>• Time (and worker hours) needed to complete dismantling operations<br>• Level to which equipment and secondary wastes have been contaminated | • Inconsequential<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment | Much of the risk associated with this task is based upon how long the dismantling and moving operations will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) must be used. |
| 1C.3.6<br>Grout needed areas for subsurface stabilization | • Areas that must be grouted to prevent subsidence<br>• Resources required to complete needed *in situ* grouting in the SDA<br>• Time (and worker hours) needed to complete *in situ* grouting | • Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | • ABRA, (INEEL, 2004d)<br>• Judgment, PERA<br>• PERA, (INEEL, 2004d; Loomis, 1995, 1996, 1998) | There is some information concerning those areas with drums that may contain voids or areas where waste was emplaced in such a way as to likely leave voided areas. |
| 1C.3.7<br>Dismantle/decon ISG equipment and enclosure | • Resources and equipment required to complete dismantling operations<br>• Time (and worker hours) needed to complete dismantling operations<br>• Level to which equipment and secondary wastes have been contaminated | • Inconsequential<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment | Much of the risk associated with this task is based upon how long the dismantling operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) must be used. |

* ABRA is the *Ancillary Basis for Risk Analysis* of the Subsurface Disposal Area (SDA) (Holdren, 2002), PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik, 2002), and RBES is the DRAFT *Risk-Based End State* Vision for the Idaho Site (DOE-ID, 2004a).

**Table I-3. Gap Analysis for Contain-in-Place Alternative, *In Situ* Grouting Option (1C)—Continued**

| Task | What information is missing? | How important? | How large a gap? | Sources | Comment |
|---|---|---|---|---|---|
| **1C.3 *IN SITU* GROUTING (ISG) FOR SUBSURFACE STABILIZATION AND CONTAMINANT IMMOBILIZATION —CONTINUED** | | | | | |
| 1C.3.8 Dispose ISG equipment | • Site/volume availability for contaminated equipment/material disposal<br>• Need for interim storage of contaminated equipment/material to be interred<br>• Resources and equipment required to complete internment operations<br>• Time (and worker hours) needed to complete internment operations | • Important<br>• Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | • Judgment | An appropriate site must be identified and made available to receive the contaminated material and equipment from the dismantling operations, and interim storage may be required for contaminated material/equipment until the site is available. Much of the risk associated with this task is based upon how long the internment operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) will be required. |
| **1C.4 *IN SITU* VITRIFICATION (ISV) IS NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | |
| **1C.5 PAD A RECONFIGURATION** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1B: For details, please refer to Table I-2 for 1B.5 Pad A Reconfiguration* | | | | | |
| **TASKS 1C.6 THROUGH 1C.9 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | |
| **1C.10 SURFACE BARRIER SELECTION, PREPARATION, AND EMPLACEMENT** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1B: For details, please refer to Table I-2 for 1B.10 Surface Barrier Selection, Preparation, and Emplacement* | | | | | |
| **1C.11 LONG-TERM STEWARDSHIP ACTIVITIES** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1A: For details, please refer to Table I-1 for 1A.11 Long-term Stewardship Activities* | | | | | |
| **TASKS 1C.12 THROUGH 1C.14 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | |

## Table I-4. Gap Analysis for Contain-in-Place Alternative, *In Situ* Vitrification Option (1D)

**1D.1 SUBSURFACE DISPOSAL AREA (SDA) CHARACTERIZATION**

| Task | What information is missing? | How important? | How large a gap? | Sources | Comment |
|---|---|---|---|---|---|
| *No change from Alternative 1A: For details, please refer to Table I-1 for 1A.1 Subsurface Disposal Area (SDA) Characterization* | | | | | |

**1D.2 *IN SITU* THERMAL DESORPTION PRETREATMENT (ISTD)**

| Task | What information is missing? | How important? | How large a gap? | Sources | Comment |
|---|---|---|---|---|---|
| *No change from Alternative 1B: For details, please refer to Table I-2 for 1B.2 In Situ Thermal Desorption (ISTD) Pretreatment* | | | | | |

**1D.3 *IN SITU* GROUTING (ISG) FOR SUBSURFACE STABILIZATION AND *SPECIFIC* CONTAMINANT IMMOBILIZATION**

| Task | What information is missing? | How important? | How large a gap? | Sources* | Comment |
|---|---|---|---|---|---|
| 1D.3.1<br>Performance criteria | • Geospatial distribution of wastes and waste forms<br>• Applicable or Relevant and Appropriate Requirements (ARARs)<br>• Results from the Pit 4 Accelerated Retrieval Project<br>• Projected treatment endpoint for organic contamination in the vadose zone<br>• Future land-use decisions | • Critical<br>• Important<br>• Important<br>• Inconsequential<br>• Critical | • Large<br>• Intermediate<br>• Intermediate<br>• Large<br>• Intermediate | • ABRA, (INEEL, 2004d)<br>• PERA, (Holdren, 2004; INEEL, 2004d)<br>• (DOE-ID, 2004b)<br>• (DOE-ID, 1994a; Housley, 2004)<br>• RBES | The treatment or stabilization requirements will be based upon historic as well as on-going project information, relevant regulations, and other considerations such as worker health. For example, there is reasonably complete information concerning what was buried in the SDA; however, the distributions of contaminants are less well known as are the requirements that the site must satisfy in the future, which are a function of future land-use decisions. |
| 1D.3.2<br>Development and treatability testing | • Changes that will have to be made to the study based upon intermediate results<br>• The data and other information that will be obtained from the study | • Important<br>• Important | • Large<br>• Large | Judgment (INEEL, 2004d; Loomis, 1995, 1996, 1998) | One cannot know the results of future *in situ* grouting treatability studies; however, there have been previous tests and applications of this technology (INEEL, 2004d; Loomis, 1995; Loomis, 1996; Loomis, 1998) from which relevant information can be drawn. |
| 1D.3.3<br>Install ISG equipment and enclosure | • Optimal location to install enclosure during grouting operations<br>• Areas/extent to which grouting is needed<br>• Enclosure and subsurface conditions sufficient to prevent contaminated grout from surfacing outside enclosure | • Important<br>• Important<br>• Critical | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment (INEEL, 2004d; Loomis, 1995, 1996, 1998) | There have been previous tests and applications of this technology (INEEL, 2004d; Loomis, 1995; Loomis, 1996; Loomis, 1998) from which information can be drawn concerning the ability to control such events. |

* ABRA is the *Ancillary Basis for Risk Analysis* of the Subsurface Disposal Area (SDA) (Holdren, 2002), PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik, 2002), and RBES is the DRAFT *Risk-Based End State* Vision for the Idaho Site (DOE-ID, 2004a).

**Table I-4. Gap Analysis for Contain-in-Place Alternative, *In Situ* Vitrification Option (1D)—Continued**

| **1D.3 *IN SITU* GROUTING (ISG) FOR SUBSURFACE STABILIZATION AND *SPECIFIC* CONTAMINANT IMMOBILIZATION —CONTINUED** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 1D.3.4<br>Grout needed areas for contaminant stabilization | • Area and depth needed to immobilize the contaminants of concern in the SDA<br>• Resources required to complete needed *in situ* grouting in the SDA<br>• Time (and worker hours) needed to complete grouting | • Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | • ABRA, (INEEL, 2004d)<br>• Judgment, PERA<br>• Judgment, PERA | There is reasonably complete information concerning what was buried in the SDA; however, the distributions of the contaminants are less well known. |
| 1D.3.5<br>Dismantle, move, and install ISG equipment | • Resources and equipment required to complete dismantling operations<br>• Time (and worker hours) needed to complete dismantling operations<br>• Level to which equipment and secondary wastes have been contaminated | • Inconsequential<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment | Much of the risk associated with this task is based upon how long the dismantling and moving operations will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) must be used. |
| 1D.3.6<br>Grout needed areas for subsurface stabilization | • Areas that must be grouted to prevent subsidence<br>• Resources required to complete needed *in situ* grouting in the SDA<br>• Time (and worker hours) needed to complete *in situ* grouting | • Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | • ABRA, (INEEL, 2004d)<br>• Judgment, PERA<br>• PERA, (INEEL, 2004d; Loomis, 1995, 1996, 1998) | There is some information concerning those areas with drums that may contain voids or areas where waste was emplaced in such a way as to likely leave voided areas. |
| 1D.3.7<br>Dismantle/decon ISG equipment and enclosure | • Resources and equipment required to complete dismantling operations<br>• Time (and worker hours) needed to complete dismantling operations<br>• Level to which equipment and secondary wastes have been contaminated | • Inconsequential<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment | Much of the risk associated with this task is based upon how long the dismantling operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) must be used. |
| 1D.3.8<br>Dispose ISG equipment | • Site/volume availability for contaminated equipment/material disposal<br>• Need for interim storage of contaminated equipment/material to be interred<br>• Resources and equipment required to complete internment operations<br>• Time (and worker hours) needed to complete internment operations | • Important<br>• Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | Judgment | An appropriate site must be identified and made available to receive the contaminated material and equipment from the dismantling operations, and interim storage may be required for contaminated material/equipment until the site is available. |

* ABRA is the *Ancillary Basis for Risk Analysis* of the SDA (Holdren, 2002) and PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik, 2002).

**Table I-4. Gap Analysis for Contain-in-Place Alternative, *In Situ* Vitrification Option (1D)—Continued**

| 1D.4 *IN SITU* VITRIFICATION (ISV) FOR CONTAMINANT IMMOBILIZATION | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 1D.4.1<br>Performance criteria | • Geospatial distribution of wastes and waste forms<br>• Applicable or Relevant and Appropriate Requirements (ARARs)<br>• Results from the Pit 4 Accelerated Retrieval Project<br>• Future land-use decisions | • Critical<br>• Important<br>• Important<br>• Critical | • Large<br>• Intermediate<br>• Intermediate<br>• Intermediate | • ABRA, (Farnsworth, 1999)<br>• PERA, (Holdren, 2004; Farnsworth, 1999)<br>• (DOE-ID, 2004b)<br>• RBES | The immobilization requirements will be based upon historic and on-going project information, relevant regulations, and other considerations such as worker health. For example, there is reasonably complete information concerning what was buried in the SDA; however, the distributions of contaminants are less well known as are the future requirements that the site must satisfy, which are a function of future land-use decisions. |
| 1D.4.2<br>Development and treatability testing | • Changes that will have to be made to the study based upon intermediate results<br>• The data and other information that will be obtained from the study | • Important<br>• Important | • Large<br>• Large | Judgment (Farnsworth, 1999) | One cannot know the results of future *in situ* vitrification treatability studies; however, there have been previous tests and applications of this technology (Farnsworth, 1999) from which relevant information can be drawn. |
| 1D.4.3<br>Install ISV equipment and enclosure | • Optimal location to install enclosure during grouting operations<br>• Areas/extent to which grouting is needed<br>• Enclosure and subsurface conditions sufficient to prevent contaminated vitrified material from surfacing outside enclosure | • Important<br>• Important<br>• Critical | • Intermediate<br>• Intermediate<br>• Intermediate | • Judgment (Farnsworth, 1999)<br>• Judgment<br>• Judgment (Farnsworth, 1999) | There have been previous tests and applications of *in situ* vitrification technology (Farnsworth, 1999) from which information can be drawn concerning the ability to control such events. |
| 1D.4.4<br>Vitrify selected areas for subsurface stabilization | • Area and depth that must be vitrified to immobilize the contaminants of concern<br>• Amounts and distributions of water, other volatiles, vapor pockets, and drums in the subsurface<br>• Resources required to complete needed *in situ* vitrification in the SDA<br>• Time (and worker hours) needed to complete vitrification | • Critical<br>• Critical<br>• Important<br>• Important | • Intermediate<br>• Large<br>• Intermediate<br>• Intermediate | • ABRA, (Farnsworth, 1999)<br>• Judgment<br>• Judgment, PERA<br>• Judgment, PERA | There is reasonably complete information concerning what was buried in the SDA; however, the distributions of the contaminants of potential concern are less well known. Furthermore, the amounts and distributions of water and other volatile substances are critical to effecting satisfactory immobilization using this technique. These will be difficult to quantify prior to beginning *in situ* vitrification. |

* ABRA is the *Ancillary Basis for Risk Analysis* of the Subsurface Disposal Area (SDA) (Holdren, 2002), PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik, 2002), and RBES is the DRAFT *Risk-Based End State* Vision for the Idaho Site (DOE-ID, 2004a).

**Table I-4. Gap Analysis for Contain-in-Place Alternative, *In Situ* Vitrification Option (1D)—Continued**

| **1D.4 *IN SITU* VITRIFICATION (ISV) FOR CONTAMINANT IMMOBILIZATION—CONTINUED** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 1D.4.5<br>Manage secondary TRU wastes (WIPP) | • Quantities of TRU-contaminated wastes that must be sent to WIPP<br>• TRU-contaminated waste forms and relative fractions | • Important<br>• Important | • Large<br>• Intermediate | ABRA, (DOE-ID, 2004b) | The results of the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b) and historic waste retrievals including those from Pit 9 should provide useful information concerning the expected amount of TRU waste that must be sent to WIPP for ultimate disposal. |
| 1D.4.6<br>Manage secondary non-TRU wastes (Idaho Site) | • Quantities of non TRU-contaminated wastes that must be manage on-site<br>• Non TRU-contaminated waste forms and relative fractions | • Important<br>• Important | • Large<br>• Large | ABRA, (DOE-ID, 2004b) | The results of the Pit 4 Accelerated Retrieval Project (DOE-ID, 2004b) and historic waste retrievals including those from Pit 9 should provide useful information concerning the expected amount of non TRU waste that must be managed and disposed of on-site. |
| 1D.4.7<br>Dismantle/decon ISV equipment and enclosure | • Resources and equipment required to complete dismantling operations<br>• Time (and worker hours) needed to complete dismantling operations<br>• Level to which equipment and secondary wastes have been contaminated | • Inconsequential<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment | Much of the risk associated with this task is based upon how long the dismantling operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) must be used. |
| 1D.4.8<br>Dispose ISV equipment under cap | • Site/volume availability for contaminated equipment/material disposal<br>• Need for interim storage of contaminated equipment/material to be interred<br>• Resources and equipment required to complete internment operations<br>• Time (and worker hours) needed to complete internment operations | • Important<br>• Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | Judgment | An appropriate site must be identified and made available to receive the contaminated material and equipment from the dismantling operations, and interim storage may be required for contaminated material/equipment until the site is available. Much of the risk associated with this task is based upon how long the internment operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) will be required. |

* ABRA is the *Ancillary Basis for Risk Analysis* of the Subsurface Disposal Area (SDA) (Holdren, 2002).

**Table I-4. Gap Analysis for Contain-in-Place Alternative, *In Situ* Vitrification Option (1D)—Continued**

| | | | | | |
|---|---|---|---|---|---|
| **1D.5 PAD A RECONFIGURATION** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1B: For details, please refer to Table I-2 for 1B.5 Pad A Reconfiguration* | | | | | |
| **TASKS 1D.6 THROUGH 1D.9 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | |
| **1D.10 SURFACE BARRIER SELECTION, PREPARATION, AND EMPLACEMENT** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1B: For details, please refer to Table I-2 for 1B.10 Surface Barrier Selection, Preparation, and Emplacement* | | | | | |
| **1D.11 LONG-TERM STEWARDSHIP ACTIVITIES** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1A: For details, please refer to Table I-1 for 1A.11 Long-term Stewardship Activities* | | | | | |
| **TASKS 1D.12 THROUGH 1D.14 ARE NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | |

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# J. Gap Analysis Tables for Alternative 2: Retrieve/Treat/Dispose (2 Options)

## List of Tables

**Box F-2. Definitions for Gap Analysis Tables**

## How Important (a Gap)?

**Critical:** Lack of this piece of knowledge is sufficient to provide a high degree of uncertainty in the ability to assess the threat to human health (both worker and the general public), the environment (both on-site and off-site), and/or security; i.e., result in a critical or severe hazard (as defined in Box F-1).

**Important:** Possession of this knowledge is important to the ability to assess the threat to human health (both worker and the general public), the environment (both on-site and off-site), and/or security. Other information must be lacking to the ability to assess the threat to human health and the environment.

**Inconsequential:** This knowledge may have localized significance to non-safety-related activities (including routine maintenance, repair, etc.).

## Low large a Gap? (Magnitude of Gap or Level of Knowledge)

**Large:** Little is known or can be reasonably inferred concerning this piece of information (from other sources of information).

**Intermediate:** Incomplete information is available concerning this piece of information or can only be inferred from other data not necessarily directly related to the missing piece of information.

**Small:** Complete or nearly complete information is available concerning this piece of information or an adequate, well-known analogue can be established.

**Table J-1. Gap Analysis for Retrieve/Treat/Dispose Alternative, Targeted Rocky Flats TRU Waste Retrieval Option (2A)**

| | | | | | |
|---|---|---|---|---|---|
| **2A.1 SUBSURFACE DISPOSAL AREA (SDA) CHARACTERIZATION** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1A: For details, please refer to Table I-1 for 1A.1 Subsurface Disposal Area (SDA) Characterization* | | | | | |
| **2A.2 *IN SITU* THERMAL DESORPTION PRETREATMENT (ISTD)** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1B: For details, please refer to Table I-2 for 1B.2 In Situ Thermal Desorption (ISTD) Pretreatment* | | | | | |
| **2A.3 *IN SITU* GROUTING (ISG) FOR SUBSURFACE STABILIZATION AND CONTAMINANT IMMOBILIZATION** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1C: For details, please refer to Table I-3 for 1C.3 In Situ Grouting (ISG) for Subsurface Stabilization and Contaminant Immobilization* | | | | | |
| **2A.4 *IN SITU* VITRIFICATION (ISV) IS NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | |
| **2A.5 PAD A RECONFIGURATION** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1B: For details, please refer to Table I-2 for 1B.5 Pad A Reconfiguration* | | | | | |

**Table J-1. Gap Analysis for Retrieve/Treat/Dispose Alternative, Targeted Rocky Flats TRU Waste Retrieval Option (2A)—Continued**

| **2A.6 LOCATE AND RETRIEVE TARGETED RFP BURIED TRU WASTE AND SEGREGATE INTO TRU AND NON-TRU FRACTIONS** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 2A.6.1 Identify retrieval methods | • Available, sufficient, and cost-effective retrieval alternative (pending Pit 4 work)<br>• Results of the Pit 4 Accelerated Retrieval Project | • Important<br>• Important | • Intermediate<br>• Large | • PERA, ARP, (Helm, 2003; DOE-ID, 2004d)<br>• ARP | There have been previous waste retrieval demonstrations in the SDA (Zitnik, 2002; Holdren, 2002; Thompson, 1972; McKinley, 1978; Miller, 2004). The most recent was that for Pit 9 using the Glovebox Excavator Method (GEM) where a 40 ft x 40 ft area was investigated (DOE-ID, 2004c). However, the method tested was excessively expensive to be used for the entire SDA—hence, the Pit 4 Accelerated Retrieval Project. |
| 2A.6.2 Determine extent of retrieval | • Geospatial distribution of wastes and waste forms<br>• Future legal decisions and resulting actions<br>• Future land-use decisions | • Critical<br>• Critical<br>• Important | • Large<br>• Large<br>• Intermediate | • ABRA<br>• Judgment<br>• Judgment, RBES | The extent to which buried waste must be retrieved from the SDA is controversial and may ultimately be the result of future legal decisions concerning ultimate disposition of Rocky Flats Plant waste that was buried in the SDA prior to 1970. |
| 2A.6.3 Plan/manage retrieval | • Resources and equipment needed to complete retrieval operations<br>• Time (and worker hours) needed to complete retrieval operations<br>• Retrieval method to be used<br>• Extent of retrieval needed (from 2A.6.2) | • Important<br>• Important<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | • PERA<br>• PERA<br>• PERA, ARP, (Helm, 2003; DOE-ID, 2004d)<br>• Judgment, ABRA | The primary gaps will be programmatic in nature. |
| 2A.6.4 Install retrieval equipment & enclosure | • Locations to install retrieval equipment | • Important | • Intermediate | • Judgment, ABRA | The locations for the enclosure will be based upon a number of factors including experience, historical records, etc. |
| 2A.6.5 Retrieve wastes from target areas | • Resources and equipment required to complete retrieval operations<br>• Time (and worker hours) needed to complete retrieval operations<br>• Level to which equipment and any secondary wastes are contaminated | • Important<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment, PERA, ARP, GEM | The majority of the risk associated with this task is based upon how long the retrieval operations will take and what kind of equipment must be used. The integrity of the waste containers will also play a major role. As indicated elsewhere, there have been numerous waste retrieval demonstrations in the SDA (Zitnik, 2002; Holdren, 2002; Thompson, 1972; McKinley, 1978; Miller, 2004). |

* ABRA is the *Ancillary Basis for Risk Analysis* of the Subsurface Disposal Area (SDA) (Holdren, 2002), PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik, 2002), RBES is the DRAFT *Risk-Based End State* Vision for the Idaho Site (DOE-ID, 2004a), ARP is the *Accelerated Retrieval Project* (ARP) for a designated area in Pit 4 (DOE-ID, 2004b), and GEM is the *Glovebox Excavator Method (GEM)* for waste retrieval in Pit 9 (DOE-ID, 2004c).

**Table J-1. Gap Analysis for Retrieve/Treat/Dispose Alternative, Targeted Rocky Flats TRU Waste Retrieval Option (2A)—Continued**

| **2A.6 LOCATE AND RETRIEVE TARGETED RFP BURIED TRU WASTE AND SEGREGATE INTO TRU AND NON-TRU FRACTIONS —CONTINUED** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 2A.6.6<br>Segregate retrieved wastes | • Resources and equipment required to complete waste segregating operations<br>• Time (and worker hours) needed to complete segregation operations<br>• State of the retrieved waste containers | • Important<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment, ARP, GEM | The risk associated with this task depends primarily on the duration of the handling and treatment tasks as well as the integrity of the waste containers upon removal from the SDA |
| 2A.6.7<br>Temporary waste storage | • The quantities and forms of waste that will have to be stored<br>• The types of waste that will have to be stored<br>• The lengths of time that the wastes will have to be stored<br>• Permits required for extended storage | • Important<br>• Important<br>• Important<br>• Important | • Intermediate<br>• Large<br>• Large<br>• Intermediate | Judgment, ARP, GEM | The wastes that will be retrieved from the SDA under this option are from the Rocky Flats Plant and will be treated and packaged. Thus the types of wastes that must be stored will be reasonably known; however, the storage duration will be dependent upon a number of factors including regulatory and site-specific. |
| 2A.6.8<br>Backfill retrieval areas | • Volume of borrow material required<br>• Location of borrow area and distance of borrow area to SDA<br>• Resources and equipment needed to complete backfill operations<br>• Time (and worker hours) needed to complete backfill operations | • Critical<br>• Critical<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | Judgment, PERA, ARP, GEM | The primary gaps are the location of the borrow site and the amount of borrow material that will be needed. |
| 2A.6.9<br>Dismantle/decon retrieval equipment and facilities | • Resources and equipment required to complete dismantling operations<br>• Time (and worker hours) needed to complete dismantling operations<br>• Level to which equipment and secondary wastes have been contaminated | • Important<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment, ARP, GEM | Much of the risk associated with this task is based upon how long the dismantling operation will take, to what degree the equipment has been contaminated, and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) must be used. |
| 2A.6.10<br>Dispose of equipment under cap | • Site/volume availability for contaminated equipment/material disposal<br>• Need for interim storage of contaminated equipment/material to be interred<br>• Resources and equipment required to complete internment operations<br>• Time (and worker hours) needed to complete internment operations | • Important<br>• Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | Judgment, ARP, GEM | An appropriate site must be identified and made available to receive the contaminated material and equipment from the dismantling operations, and interim storage may be required for contaminated material/equipment until the site is available. Much of the risk associated with this task is based upon how long the internment operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) will be required. |

* PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik, 2002), ARP is the *Accelerated Retrieval Project* (ARP) for a designated area in Pit 4 (DOE-ID, 2004b), and GEM is the *Glovebox Excavator Method (GEM)* for waste retrieval in Pit 9 (DOE-ID, 2004c).

**Table J-1. Gap Analysis for Retrieve/Treat/Dispose Alternative, Targeted Rocky Flats TRU Waste Retrieval Option (2A)—Continued**

| 2A.7 *EX SITU* TREATMENT (E.G., COMPACTION) | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 2A.7.1<br>Performance criteria | • Results of the Pit 4 Accelerated Retrieval Project<br>• New treatment and safety technology applicable to waste retrieval activities<br>• Stakeholder input | • Important<br>• Important<br>• Important | • Large<br>• Large<br>• Large | • (DOE-ID, 2004b)<br>• Judgment<br>• Judgment | The regulatory and site-specific requirements should be well-known prior to defining these criteria. |
| 2A.7.2<br>Development and treatability testing | • Changes that will have to be made to the study based upon intermediate results<br>• The data and other information that will be obtained from the study<br>• Waste forms & contaminant distributions | • Important<br>• Important<br>• Important | • Intermediate<br>• Large<br>• Large | Judgment, (DOE-ID,1999b; Landman, 2003) | One cannot know what will be obtained from the *ex situ* treatability studies; however, there have been previous tests and applications of this technology (both at the Idaho Site and other sites) from which relevant information can be drawn. |
| 2A.7.3<br>Construction and equipment installation | • Resources required to complete construction and installation<br>• Time (and worker hours) needed to complete construction and installation | • Important<br>• Important | • Intermediate<br>• Intermediate | PERA, (Landman, 2003) | Once the *ex situ* treatment method has been selected, there should be few gaps other than the resources and time required to install the necessary equipment. |
| 2A.7.4<br>Perform needed *ex situ* treatment | • Waste forms and contaminant distributions<br>• Relative fractions and amounts of contaminated soils, TRU wastes, and non-TRU/soil wastes to be treated | • Important<br>• Important | • Large<br>• Large | PERA, (Landman, 2003) | Information such as the integrity of the waste containers, amount of material that must be treated, and extent to which the material is contaminated will drive the risks associated with this treatment. |
| 2A.7.5<br>Dismantle/decon equipment | • Resources and equipment required to complete dismantling operations<br>• Time (and worker hours) needed to complete dismantling operations<br>• Level to which equipment and secondary wastes have been contaminated | • Important<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment | Much of the risk associated with this task is based upon how long the dismantling operation will take, the extent to which the equipment is contaminated, and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) must be used. |
| 2A.7.6<br>Dispose equipment under cap | • Site/volume availability for contaminated equipment/material disposal<br>• Need for interim storage of contaminated equipment/material to be interred<br>• Resources and equipment required to complete internment operations<br>• Time (and worker hours) needed to complete internment operations | • Important<br>• Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | Judgment | An appropriate site must be identified and made available to receive the contaminated material and equipment from the dismantling operations, and interim storage may be required for contaminated material/ equipment until the site is available. Much of the risk associated with this task is based upon how long the internment operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) will be required. |

* PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik, 2002).

**Table J-1. Gap Analysis for Retrieve/Treat/Dispose Alternative, Targeted Rocky Flats TRU Waste Retrieval Option (2A)—Continued**

| **2A.8 PACKAGE RETRIEVED (AND POTENTIALLY TREATED) WASTES** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 2A.8.1<br>Equipment installation | • No *known* gaps | • Not applicable | • Not applicable | • Judgment | No known gaps. |
| 2A.8.2<br>Package non-TRU wastes (SDA) | • Resources and equipment required to complete packaging operations<br>• Time (and worker hours) needed to complete packaging operations<br>• State of the retrieved waste containers<br>• Degree to which retrieved waste is contaminated and activity levels | • Important<br>• Important<br>• Important<br>• Important | • Intermediate<br>• Large<br>• Large<br>• Intermediate | Judgment, ARP, GEM | The duration of the handling and packaging tasks as well as the integrity of the waste containers upon removal from SDA are critical to reducing risk. |
| 2A.8.3<br>Package TRU wastes (WIPP) | • Resources and equipment required to complete packaging operations<br>• Time (and worker hours) needed to complete packaging operations<br>• State of the retrieved waste containers<br>• Degree to which retrieved waste is contaminated and activity levels | • Important<br>• Important<br>• Important<br>• Critical | • Intermediate<br>• Large<br>• Large<br>• Intermediate | Judgment, ARP, GEM | The duration of the handling and packaging tasks as well as the integrity of the waste containers upon removal from SDA are critical to reducing risk. |
| 2A.8.4<br>Handle special materials | • Presence and location of spent nuclear fuel or analogous high activity materials | • Critical | • Large | • Judgment, PERA | This handling is potentially very high risk and thus the presence and location of such material is very important. |

| **2A.9 INTERMEDIATE STORAGE OF RETRIEVED AND PACKAGED WASTES** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| 2A.9.1<br>Construct storage facilities | • Resources and equipment required to complete construction operations<br>• Time (and worker hours) needed to complete packaging operations<br>• Types (including activity) and volumes of wastes that must be stored | • Important<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment | Important knowledge gaps include required storage capacity as well as the duration that wastes must be stored. |
| 2A.9.2<br>Store wastes | • Durations that wastes must be stored<br>• Monitoring required<br>• Maintenance, repair, and replacement required | • Important<br>• Important<br>• Important | • Large<br>• Small<br>• Intermediate | Judgment | The primary knowledge gaps concern the duration that wastes must be stored and the future maintenance and repairs that will be required. |

* PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik, 2002), ARP is the *Accelerated Retrieval Project* (ARP) for a designated area in Pit 4 (DOE-ID, 2004b), and GEM is the *Glovebox Excavator Method (GEM)* for waste retrieval in Pit 9 (DOE-ID, 2004c).

**Table J-1. Gap Analysis for Retrieve/Treat/Dispose Alternative, Targeted Rocky Flats TRU Waste Retrieval Option (2A)—Continued**

| 2A.10 SURFACE BARRIER SELECTION, PREPARATION, AND EMPLACEMENT | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1B: For details, please refer to Table I-2 for 1B.10 Surface Barrier Selection, Preparation, and Emplacement* | | | | | |

| 2A.11 LONG-TERM STEWARDSHIP ACTIVITIES FOR THE SDA | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1A: For details, please refer to Table I-1 for 1A.11 Long-term Stewardship Activities* | | | | | |

| 2A.12 CONSTRUCT NEW SDA DISPOSAL CELL FOR DISPOSAL OF NON-TRU WASTES AND CONTAMINATED SOIL | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 2A.12.1<br>Performance criteria | • Types, amounts, distributions, and forms of contaminants of concern<br>• Future environmental conditions including precipitation, evapotranspiration, etc.<br>• Future land-use decisions<br>• Disposal cell site selection criteria<br>• Regulatory and other pertinent criteria including Applicable or Relevant and Appropriate Requirements (ARARs) | • Important<br>• Important<br>• Important<br>• Important<br>• Important | • Intermediate<br>• Large<br>• Intermediate<br>• Intermediate<br>• Intermediate | • Judgment<br>• Judgment<br>• Judgment, RBES<br>• Judgment<br>• Judgment, RBES | Disposal cell requirements will be based upon historic and on-going project information, relevant regulations, and other considerations such as worker health. For example, there is reasonably complete information concerning what was buried in the SDA; however, the distributions of contaminants are less well known as are the future requirements that the site must satisfy, which are a function of future land-use decisions. |
| 2A.12.2<br>Disposal cell construction | • Size of disposal cell needed<br>• Extent of contamination in area of the disposal cell | • Important<br>• Important | • Intermediate<br>• Intermediate | Judgment | The primary information gap is the size of disposal cell that will be required. |
| 2A.12.3<br>Non-TRU waste and soil disposal | • Types and amounts of wastes and soil to be disposed | • Important | • Intermediate | • Judgment | Disposal will be permanent; thus only the types and amounts of wastes and soils will be needed. |

* RBES is the DRAFT *Risk-Based End State* Vision for the Idaho Site (DOE-ID, 2004a).

**Table J-1. Gap Analysis for Retrieve/Treat/Dispose Alternative, Targeted Rocky Flats TRU Waste Retrieval Option (2A)—Continued**

| **2A.13 LONG-TERM STEWARDSHIP ACTIVITIES FOR THE NEW SDA DISPOSAL CELL** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| *No change from Alternative 1A: For details, please refer to Table I-1 for 1A.11 Long-term Stewardship Activities* | | | | | |
| **2A.14 OFF-SITE SHIPMENT AND DISPOSAL AT WIPP** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 2A.14.1<br>Plan and manage shipments | • Amount of waste retrieved that must be transported to and disposed of in WIPP<br>• Amounts of remote- and contact-handled wastes retrieved from SDA<br>• Packaging waste acceptance criteria | • Important<br>• Important<br>• Important | • Large<br>• Large<br>• Small | • Judgment, ABRA<br>• Judgment, ABRA<br>• Judgment, (DOE, 2005) | Characteristics such as permissible activity levels and packaging have been defined by regulation (DOE, 2005). |
| 2A.14.2<br>Load waste packages onto carrier | • Type(s) of carrier that will be used<br>• Availability of carrier for transportation to WIPP | • Important<br>• Important | • Small<br>• Large | Judgment, WIPP CH DSA | Carriers already exist for these types of wastes; however, the availability of the carriers is not known. |
| 2A.14.3<br>Load carrier onto conveyance | • Resources and equipment required to complete loading operations<br>• Time (and worker hours) needed to complete loading operations | • Important<br>• Important | • Small<br>• Small | Judgment, WIPP CH DSA | There is abundant experience of how to perform these activities. |
| 2A.14.4<br>Transport via road or rail | • Transportation method selected<br>• Route selected for waste transportation | • Important<br>• Important | • Small<br>• Small | Judgment, WIPP CH DSA | It is possible that either road or rail transportation may be used to transport wastes to WIPP. |
| 2A.14.5<br>Off-load waste at WIPP | • Resources and equipment required to complete loading operations<br>• Time (and worker hours) needed to complete loading operations | • Important<br>• Important | • Small<br>• Small | Judgment, WIPP CH DSA | There is abundant experience of how to perform these activities. |
| 2A.14.6<br>TRU Waste at WIPP | • No *additional* knowledge gaps** | • Not applicable | • Not applicable | • Judgment | Not applicable. |

* ABRA is the *Ancillary Basis for Risk Analysis* of the Subsurface Disposal Area (SDA) (Holdren, 2002) and "WIPP CH DSA" refers to the Documented Safety Analysis for Contact-Handled TRU wastes at the Waste Isolation Pilot Plant (DOE, 2004).
** There are no gaps that have been identified apart from those considered in the WIPP process.

**Table J-2. Gap Analysis for Retrieve/Treat/Dispose Alternative, Full Rocky Flats Plant Retrieval Option (2B)**

| | | | | | |
|---|---|---|---|---|---|
| **2B.1 SUBSURFACE DISPOSAL AREA (SDA) CHARACTERIZATION** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1A: For details, please refer to Table I-1 for 1A.1 Subsurface Disposal Area (SDA) Characterization* | | | | | |
| **2B.2 *IN SITU* THERMAL DESORPTION PRETREATMENT (ISTD)** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1B: For details, please refer to Table I-2 for 1B.2 In Situ Thermal Desorption (ISTD) Pretreatment* | | | | | |
| **2B.3 *IN SITU* GROUTING (ISG) FOR SUBSURFACE STABILIZATION AND CONTAMINANT IMMOBILIZATION** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1C: For details, please refer to Table I-3 for 1C.3 In Situ Grouting (ISG) for Subsurface Stabilization and Contaminant Immobilization* | | | | | |
| **2B.4 *IN SITU* VITRIFICATION (ISV) IS NOT APPLICABLE AS INDICATED IN TABLE B-1** | | | | | |
| **2B.5 PAD A RECONFIGURATION** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1B: For details, please refer to Table I-2 for 1B.5 Pad A Reconfiguration* | | | | | |

**Table J-2. Gap Analysis for Retrieve/Treat/Dispose Alternative, Full Rocky Flats Plant Retrieval Option (2B)—Continued**

| **2B.6 LOCATE AND RETRIEVE *ROCKY FLATS PLANT* BURIED TRU WASTE AND SEGREGATE INTO TRU AND NON-TRU FRACTIONS** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 2B.6.1<br>Identify retrieval methods | • Available, sufficient, and cost-effective retrieval alternative (pending Pit 4 work)<br>• Results of the Pit 4 Accelerated Retrieval Project | • Important<br>• Important | • Intermediate<br>• Large | • PERA, ARP, (Helm, 2003; DOE-ID, 2004d)<br>• ARP | There have been numerous waste retrieval demonstrations in the SDA (Zitnik, 2002; Holdren, 2002; Thompson, 1972; McKinley, 1978; Miller, 2004). The most recent was that for Pit 9 using the Glovebox Excavator Method (GEM) where a 40 ft x 40 ft area was investigated (DOE-ID, 2004c). However, the method tested was excessively expensive to be used for the entire SDA—hence, the Pit 4 Accelerated Retrieval Project. |
| 2B.6.2<br>Determine extent of retrieval | • Geospatial distribution of wastes and waste forms<br>• Future legal decisions and resulting actions<br>• Future land-use decision | • Critical<br>• Critical<br>• Important | • Large<br>• Large<br>• Intermediate | • ABRA<br>• Judgment<br>• Judgment, RBES | The extent to which buried waste must be retrieved from the SDA may be based on future legal decisions concerning the ultimate disposition of Rocky Flats Plant waste that was buried in the SDA prior to 1970. |
| 2B.6.3<br>Plan/manage retrieval | • Resources and equipment needed to complete retrieval operations<br>• Time (and worker hours) needed to complete retrieval operations<br>• Retrieval method to be used<br>• Extent of retrieval needed | • Important<br>• Important<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | • PERA<br>• PERA<br>• PERA, ARP, (Helm, 2003; DOE-ID, 2004d)<br>• Judgment, ABRA | The primary gaps will be programmatic in nature. |
| 2B.6.4<br>Install retrieval equipment & enclosure | • Locations to install retrieval equipment | • Important | • Intermediate | • Judgment, ABRA | The locations for the enclosure will be based upon a number of factors including experience, historical records, etc. |
| 2B.6.5<br>Retrieve buried RFP TRU wastes | • Resources and equipment required to complete retrieval operations<br>• Time (and worker hours) needed to complete retrieval operations<br>• Level to which equipment and any secondary wastes are contaminated | • Important<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment, PERA, ARP, GEM | The majority of the risk associated with this task is based upon how long the retrieval operations will take and what kind of equipment must be used. The integrity of the waste containers will also play a major role. As indicated elsewhere, there have been numerous waste retrieval demonstrations in the SDA (Zitnik, 2002; Holdren, 2002; Thompson, 1972; McKinley, 1978; Miller, 2004). |

* ABRA is the *Ancillary Basis for Risk Analysis* of the Subsurface Disposal Area (SDA) (Holdren, 2002), PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik, 2002), RBES is the DRAFT *Risk-Based End State* Vision for the Idaho Site (DOE-ID, 2004a), ARP is the *Accelerated Retrieval Project* (ARP) for a designated area in Pit 4 (DOE-ID, 2004b), and GEM is the *Glovebox Excavator Method (GEM)* for waste retrieval in Pit 9 (DOE-ID, 2004c).

**Table J-2. Gap Analysis for Retrieve/Treat/Dispose Alternative, Full Rocky Flats Plant Retrieval Option (2B)—Continued**

| **2B.6 LOCATE AND RETRIEVE *ROCKY FLATS PLANT* BURIED TRU WASTE AND SEGREGATE INTO TRU AND NON-TRU FRACTIONS —CONTINUED** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources*** | **Comment** |
| 2B.6.6<br>Segregate retrieved wastes | • Resources and equipment required to complete waste segregating operations<br>• Time (and worker hours) needed to complete segregation operations<br>• State of the retrieved waste containers | • Important<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment, ARP, GEM | The risk associated with this task depends primarily on the duration of the handling and treatment tasks as well as the integrity of the waste containers upon removal from the SDA |
| 2B.6.7<br>Temporary waste storage | • The quantities and forms of waste that will have to be stored<br>• The types of waste that will have to be stored<br>• The lengths of time that the wastes will have to be stored<br>• Permits required for extended storage | • Important<br>• Important<br>• Important<br>• Important | • Intermediate<br>• Large<br>• Large<br>• Intermediate | Judgment, ARP, GEM | The wastes that will be retrieved from the SDA under this option are from the Rocky Flats Plant and will be treated and packaged. Thus the types of wastes that must be stored will be reasonably known; however, the storage duration will be dependent upon a number of factors including regulatory and site-specific. |
| 2B.6.8<br>Backfill retrieval areas | • Volume of borrow material required<br>• Location of borrow area and distance of borrow area to SDA<br>• Resources and equipment needed to complete backfill operations<br>• Time (and worker hours) needed to complete backfill operations | • Critical<br>• Critical<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | Judgment, PERA, ARP, GEM | The primary gaps are the location of the borrow site and the amount of borrow material that will be needed. |
| 2B.6.9<br>Dismantle/decon retrieval equipment and facilities | • Resources and equipment required to complete dismantling operations<br>• Time (and worker hours) needed to complete dismantling operations<br>• Level to which equipment and secondary wastes have been contaminated | • Important<br>• Important<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate | Judgment, ARP, GEM | Much of the risk associated with this task is based upon how long the dismantling operation will take, to what degree the equipment has been contaminated, and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) must be used. |
| 2B.6.10<br>Dispose of equipment under cap | • Site/volume availability for contaminated equipment/material disposal<br>• Need for interim storage of contaminated equipment/material to be interred<br>• Resources and equipment required to complete internment operations<br>• Time (and worker hours) needed to complete internment operations | • Important<br>• Important<br>• Inconsequential<br>• Important | • Intermediate<br>• Intermediate<br>• Intermediate<br>• Intermediate | Judgment, ARP, GEM | An appropriate site must be identified and made available to receive the contaminated material and equipment from the dismantling operations, and interim storage may be required for contaminated material/equipment until the site is available. Much of the risk associated with this task is based upon how long the internment operation will take and what kind of equipment (e.g., cutting torches, heavy equipment, etc.) will be required. |

* PERA is the *Preliminary Evaluation of Remedial Alternatives* for the SDA (Zitnik, 2002), ARP is the *Accelerated Retrieval Project* (ARP) for a designated area in Pit 4 (DOE-ID, 2004b), and GEM is the *Glovebox Excavator Method (GEM)* for waste retrieval in Pit 9 (DOE-ID, 2004c).

**Table J-2. Gap Analysis for Retrieve/Treat/Dispose Alternative, Full Rocky Flats Plant Retrieval Option (2B)—Continued**

| **2B.7 *EX SITU* TREATMENT (E.G., COMPACTION)** | | | | | |
|---|---|---|---|---|---|
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 2A: For details, please refer to Table J-1 for 2A.7 Ex Situ Treatment (e.g., Compaction)* | | | | | |
| **2B.8 PACKAGE RETRIEVED (AND POTENTIALLY TREATED) WASTES** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 2A: For details, please refer to Table J-1 for 2A.8 Package Retrieved (and Potentially Treated) Wastes* | | | | | |
| **2B.9 INTERMEDIATE STORAGE OF RETRIEVED AND PACKAGED WASTES** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 2A: For details, please refer to Table J-1 for 2A.9 Intermediate Storage of Retrieved and Packaged Wastes* | | | | | |
| **2B.10 SURFACE BARRIER SELECTION, PREPARATION, AND EMPLACEMENT** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1B: For details, please refer to Table I-2 for 1B.10 Surface Barrier Selection, Preparation, and Emplacement* | | | | | |
| **2B.11 LONG-TERM STEWARDSHIP ACTIVITIES FOR THE SDA** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 1A: For details, please refer to Table I-1 for 1A.11 Long-term Stewardship Activities* | | | | | |
| **2B.12 CONSTRUCT NEW SDA DISPOSAL CELL FOR DISPOSAL OF NON-TRU WASTES AND CONTAMINATED SOIL** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 2A: For details, please refer to Table J-1 for 2A.12 Construct New SDA Disposal Cell for Disposal of Non-TRU Wastes and Contaminated Soil* | | | | | |
| **2B.13 LONG-TERM STEWARDSHIP ACTIVITIES FOR THE NEW SDA DISPOSAL CELL** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change significant from Alternative 1A: For details, please refer to Table I-1 for 1A.11 Long-term Stewardship Activities* | | | | | |
| **2B.14 OFF-SITE SHIPMENT AND DISPOSAL AT WIPP** | | | | | |
| **Task** | **What information is missing?** | **How important?** | **How large a gap?** | **Sources** | **Comment** |
| *No change from Alternative 2A: For details, please refer to Table J-1 for 2A.14 Off-site Shipment and Disposal at WIPP* | | | | | |