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Draft A

Focused Feasibility Study for the K Basins Interim Remedial Action

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Focused Feasibility Study for the K Basins Interim Remedial Action

November 1998

United States Department of Energy

P.O. Box 550, Richland, Washington 99352

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EXECUTIVE SUMMARY

This K Basins Focused Feasibility Study (FFS) evaluates alternatives for remediation of the K East (KE) and K West (KW) Basins, located in the 100-K Area of the Hanford Site. The basins contain spent nuclear fuel (SNF) and contaminated sludge, water, and debris. The SNF is deteriorating under the current storage conditions. In addition, there have been at least two documented leaks of contaminated water from the basins into the underlying soil and groundwater. The FFS supports implementation of a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) interim remedial action on the K Basins cleanout project and will be used to support development of a CERCLA proposed plan and record of decision for the cleanout.

The K Basins cleanout and disposition of the SNF were originally evaluated by the U. S. Department of Energy (DOE), Richland Operations Office, in the *Environmental Impact Statement for the Management of Spent Nuclear Fuel from the K Basins at the Hanford Site* (EIS) prepared pursuant to the *National Environmental Policy Act of 1972* (NEPA). The alternatives analyzed in the EIS focused on managing the SNF, with secondary discussions of the sludge, water, and debris. The alternative selected in the EIS record of decision consisted of removing the SNF from the basins; vacuum drying, conditioning, and sealing the SNF in canisters; and placing it in dry vault storage in a new facility to be built at the Hanford Site. The SNF process was modified subsequently to delete the conditioning process; this modification was reviewed in a NEPA Supplement Analysis. The selected alternative also included removal of the sludge and transfer to either a double-shell tank (DST) or transuranic (TRU) waste management facilities in the 200 Area; disposition of the basin water; removal of the debris and disposal in a low-level burial ground at the Hanford Site; and deactivation of the basins pending decommissioning. Sludge characterization data and storage criteria available at the time the EIS was prepared did not indicate that substantial sludge treatment would be required. Therefore, sludge treatment processes were not analyzed in the EIS.

The U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology subsequently determined that cleanout of the K Basins could most effectively be done

under CERCLA authority as an interim remedial action. The CERCLA action is consistent with the EIS record of decision and establishes the sludge treatment process. The scope of the K Basins CERCLA action was defined as follows:

- Removing the SNF, sludge, debris, and water from the basins
- Transferring the SNF to the drying facility
- Treating the sludge to meet waste acceptance criteria of the selected receiving facility
- Transferring the sludge to the receiving facility
- Pretreating the water and transferring it to the Effluent Treatment Facility (ETF)
- Transferring the debris to appropriate waste management facilities
- Deactivating the basins.

The scope of the CERCLA action does not include drying or interim storage of the SNF.

The purpose of this FFS is to (1) identify the requirements under CERCLA for removing the SNF, sludge, water, and debris from the basins and deactivating the basins and (2) evaluate alternatives for treating the K Basins sludge. Alternatives for removing the SNF, sludge, water, and debris from the basins and deactivating the basins are not analyzed because the associated environmental impacts were previously analyzed in the EIS.

Four alternatives were identified for the K Basin CERCLA interim remedial action. Alternative 1, No Action, would consist of leaving the SNF, sludge, water, and debris in the basins. It is included only to provide a baseline for evaluation; it is not the intent to change decisions made via the NEPA process regarding removal of the SNF, sludge, water, and debris. Alternatives 2, 3, and 4 all include the following activities, previously analyzed in the K Basins EIS:

- The SNF will be removed from the basins, packaged in multi-canister overpacks, and transferred to the Cold Vacuum Drying facility located in the 100-K Area.

- The sludge will be retrieved from various locations in the basins and transferred to waste management facilities in the 200 Area for interim storage. The specific facility or facilities will depend on the type of sludge treatment.

- The water will be pretreated to meet waste acceptance criteria of the ETF using systems installed at the basins and transferred to the ETF in the 200 Area.

- Debris that is not designated as TRU waste will be treated and packaged as appropriate and transferred to the 200 Area for disposal at the Environmental Restoration Disposal Facility. Debris that designates as TRU waste will be packaged and transferred to the Central Waste Complex in the 200 Area for management with other Hanford TRU waste.

- The basins will be deactivated by removing equipment that is not permanently fixed to the structure, decontaminating or stabilizing contaminated surfaces, de-energizing systems that are no longer required, and controlling access points.

Alternatives 2, 3, and 4 also include sludge treatment. Several treatment alternatives have been identified but only one, chemical treatment via acid dissolution, has been developed sufficiently to evaluate all of the CERCLA criteria. In particular, implementability (i.e., technical feasibility) and cost could not be fully evaluated for other alternatives. Because the cost of chemical treatment is high, a Sludge Treatment Alternatives Analysis is underway to more fully evaluate the sludge treatment alternatives. The analysis will be used in conjunction with this FFS to prepare the proposed plan for this CERCLA action. The sludge treatment alternatives are:

- Alternative 2: Chemical Treatment. The sludge would be retrieved from the basins and treated by a chemical process to meet current DST waste acceptance criteria. Treatment would include separation and leaching of ion exchange media, acid dissolution or hot water dissolution of the sludge, separation and leaching of insoluble solids, addition of neutron absorber, and caustic precipitation. The treated sludge would be a mixed TRU waste or HLW that would meet DST criteria for nuclear criticality prevention, reactivity, and flammable gas control. It would also meet EPA requirements for treatment of

polychlorinated biphenyls (PCBs). The sludge treatment facility would be located in the 100-K Area or at another Hanford Site location determined to be environmentally protective. The treated sludge would be transferred to a DST in the 200 Area for eventual processing with other Hanford tank waste at the planned vitrification facility and disposal at the national geologic repository for SNF and HLW. Sludge components with a low concentration of TRU constituents that do not designate as TRU waste after treatment (e.g., organic resin beads, sludge fractions that are primarily sand) would be solidified and disposed at the Hanford Environmental Restoration Disposal Facility.

- Alternative 3: Thermal Treatment. The sludge would be retrieved from the basins and treated by a thermal process such as vitrification or calcination to oxidize metals and remove PCBs. The treated sludge would be packaged and stored onsite in the 200 Area until it could be disposed at the national geologic repository for SNF and HLW or the Waste Isolation Pilot Plant; alternately, the treated sludge would be processed with Hanford tank waste. The sludge treatment facility would be located in the 100-K Area or at another Hanford Site location determined to be environmentally protective. Thermal treatment of the sludge is being evaluated in more detail in the Sludge Treatment Alternatives Analysis.

- Alternative 4: Physical Treatment. The sludge would be retrieved from the basins and treated by physical processes such as high-energy milling to reduce particle size and oxidize metals. A PCB treatment step involving solvent extraction or chemical oxidation could be added. The sludge would be treated sufficiently to meet acceptance criteria for either an existing DST or another tank associated with the tank waste treatment program. The treated sludge would be transferred to the selected interim storage tank in the 200 Area for eventual processing with other Hanford tank waste at the planned vitrification facility. Physical treatment of the sludge is being evaluated in more detail in the Sludge Treatment Alternatives Analysis.

The alternatives were evaluated against the nine criteria required under CERCLA: overall protectiveness; compliance with applicable or relevant and appropriate requirements (ARARs);

long-term effectiveness; reduction of toxicity, mobility, and volume; short-term effectiveness; implementability; cost; State of Washington acceptance; and community acceptance. In summary, all of the alternatives except Alternative 1 would provide overall protection of human health and the environment, comply with ARARs, and be effective in the short and long term. The greatest difference between Alternatives 2, 3, and 4 is the degree of uncertainty associated with implementability and cost. The technical feasibility of the chemical treatment process proposed for sludge in Alternative 2 is supported by laboratory tests using actual and simulated K Basins sludge. Neither thermal nor physical treatment processes have been evaluated with specific application to the K Basins sludge. Because of this, the technical feasibility and cost of these alternatives is uncertain at this time. The Sludge Treatment Alternatives Analysis initiated by DOE is evaluating the technical feasibility and cost of thermal and physical treatment.

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ACRONYMS

AEA	*Atomic Energy Act of 1954*
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BACT	best available control technologies
BARCT	best available radionuclide control technology
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CSB	Canister Storage Building
CVD	Cold Vacuum Drying
CWC	Central Waste Complex
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
FFS	focused feasibility study
FR	Federal Register
GAC	granular activated carbon
HEPA	high-efficiency particulate air
HLW	high-level waste
IWTS	Integrated Water Treatment System
KE	K East
KW	K West
LDR	land disposal restriction
LLW	low-level waste
MCO	multi-canister overpack
MEI	maximally exposed individual
NEPA	*National Environmental Policy Act of 1969*
NOC	Notice of Construction
NRC	U.S. Nuclear Regulatory Commission
OIER	organic ion exchange resins
PCB	polychlorinated biphenyl
ppb	parts per billion
ppm	parts per million
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
ROD	record of decision
SALDS	State-Approved Land Disposal Site
SDWA	*Safe Drinking Water Act*
SNF	spent nuclear fuel
TBC	to be considered

TCLP	toxicity characteristic leaching procedure
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRU	transuranic
TSCA	*Toxic Substances Control Act*
TWRS	Tank Waste Remediation System
WAC	Washington Administrative Code
WIPP	Waste Isolation Pilot Plant

1.0 INTRODUCTION

This focused feasibility study (FFS) was prepared pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), as amended by the *Superfund Amendments and Reauthorization Act of 1986*. It evaluates alternatives for interim remedial action at two spent nuclear fuel (SNF) storage basins designated as the K East (KE) and K West (KW) Basins and located in the 100 Area of the Hanford Site. The Hanford Site is a former plutonium manufacturing facility located in Washington State and operated by the U.S. Department of Energy (DOE). As a result of contamination caused by past operations, certain areas of the Site, including the 100 Area, have been placed on the National Priorities List to be addressed under CERCLA.

1.1 K BASINS CLEANOUT STRATEGY

The basins presently contain SNF and contaminated sludge, water, and debris. Past leaks from the basins have contaminated the underlying soil and groundwater. In addition, the SNF is degrading, which poses potential safety concerns.

In the early 1990's, the DOE determined that action was necessary to mitigate further releases from the basins and SNF degradation. Subsequently, the Defense Nuclear Facility Safety Board recommended that the DOE accelerate the program to place deteriorating SNF into a stable configuration for interim storage (Conway 1994) and committed the DOE to a number of specific actions to address the recommendation. The DOE used the *National Environmental Policy Act of 1969* (NEPA) process to evaluate alternatives for action. In support of this, DOE prepared the *Draft Environmental Impact Statement, Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington* (EIS) (DOE 1995) pursuant to NEPA requirements. The K Basins EIS evaluated alternatives to upgrade the basins or remove the SNF and contaminated materials from the basins. After public review of the draft EIS, DOE issued a final EIS (DOE 1996a) and record of decision (ROD) (61 *Federal Register* [FR] 10736) to document the selected alternative, which consisted of the following activities:

- Removal of the SNF from the basins, stabilization at a facility located in the 100-K Area, and interim storage in the 200 Area of the Hanford Site

- Removal of the water, pretreatment at systems installed in the basins, and transfer to the Effluent Treatment Facility (ETF) in the 200 Area for further treatment and disposal

- Removal of the sludge and transfer to either a double-shell tank (DST) or solid waste management facilities in the 200 Area. (Substantial treatment of the sludge prior to the transfer was not expected to be required based on information regarding sludge characterization and storage requirements at that time; therefore, sludge treatment was not evaluated in the EIS.)

- Removal of the debris and transfer to solid waste management facilities in the 200 Areas

- Preparation of the basins for deactivation and turnover to the decontamination and decommissioning program.

These activities are described in more detail in Section 5, and important conclusions from the K Basins EIS are presented in Appendix A.

Subsequent to preparation of the EIS and ROD, the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology), in consultation with the DOE, determined that cleanout of the K Basins could be addressed most effectively under CERCLA regulatory authority as an interim remedial action. The regulatory agencies believe that CERCLA authority will provide the greatest degree of enforceability for ensuring that hazardous substances are removed from the basins. EPA was identified as the lead regulatory agency for the action.

The decision to perform the basin cleanout under CERCLA led to the preparation of this FFS. The purpose of the K Basins CERCLA interim remedial action is to address the potential threat of a release of hazardous substances[1] posed by the KE and KW Basins. Certain activities that were covered in the K Basins EIS have thus been brought under CERCLA authority, including the removal of the SNF, sludge, water, and debris from the basins and pretreatment of the water. Other activities covered in the K Basins EIS and ROD, namely the stabilization and interim storage of the SNF, have not been brought under CERCLA authority. Stabilization and interim storage of the SNF continue to be conducted under the authority of the *Atomic Energy Act of 1954* (AEA) as analyzed via the NEPA process. **The analysis of environmental impacts associated with removing SNF, sludge, water, and debris from the K Basins and pretreating the water was presented in the K Basins EIS and is not repeated in this FFS.** However, the FFS serves as the vehicle for describing how these activities will be conducted under CERCLA authority.

Treatment of the K Basins sludge is an important element of the CERCLA action. Sludge treatment was not analyzed in the K Basins EIS; therefore, it is emphasized in this FFS. Preliminary studies conducted before the FFS was prepared led to the early selection of a chemical treatment process for the project baseline. The baseline chemical treatment process is presented as Alternative 2 in this FFS. New regulatory requirements, changes to waste acceptance criteria, and new information on treatment technologies that might result in a more cost-effective treatment process have led to preparation of a new Sludge Treatment Alternatives Analysis, which includes:

- Screening of a range of technologies for treatment

- Analysis of opportunities for more cost-effective treatment by sludge segregation during retrieval

[1] "Hazardous substances" are defined under CERCLA as a broad range of constituents including radionuclides. Under this definition, the SNF, sludge, water, and debris all contain CERCLA hazardous substances.

- Evaluation of several technologies identified as potentially viable in the screening. The evaluation includes consideration of whether the technology could meet waste acceptance criteria for storage and disposal, requirements for infrastructure, secondary waste management, and air emissions control. It also includes the relative costs of the technologies versus the costs of the baseline chemical treatment process.

Initial information on the technologies being evaluated is provided in this FFS. However, the Analysis is not complete, especially with respect to the technical feasibility and relative cost. The Sludge Treatment Alternatives Analysis will be completed by February 1999 and the results will be incorporated into the proposed plan for this CERCLA action before it is issued for public review. Thus, the proposed plan will be based on the K Basins EIS and ROD, this FFS, and the Sludge Treatment Alternatives Analysis.

1.2 PURPOSE

The purpose of this FFS is two-fold:

- Identify the requirements for conducting certain basin cleanout activities that were addressed in the K Basins EIS and ROD under CERCLA

- Evaluate alternatives for treating the K Basins sludge.

This FFS is intended to satisfy the requirements of CERCLA and its implementing regulations (Title 40, *Code of Federal Regulations* [CFR], Part 300). The FFS also includes consideration of NEPA values, for those activities that were not addressed in the EIS.

EPA, Ecology, and DOE will use this FFS and information from the Sludge Treatment Study as the basis for selecting a remedy to mitigate potential threats to human health and the environment posed by the contents of the K Basins. The preferred alternative will be presented for public review and comment in a proposed plan. A remedy will be selected by EPA in a ROD for the K Basin interim remedial action.

1.3 SCOPE

The scope of the K Basins CERCLA interim remedial action and this FFS consists of the following:

- Removing the SNF, sludge, debris, and water from the basin

- Transferring the SNF to the SNF drying facility

- Treating the sludge to meet waste acceptance criteria of the receiving facility

- Transferring the sludge to the receiving facility, including disposal at the Environmental Restoration Disposal Facility (ERDF), as appropriate
- Pretreating the water and transferring it to the ETF
- Transferring the debris to appropriate facilities, including disposal at ERDF, as appropriate
- Deactivating the basins.

The scope of the CERCLA action does not include the following:

- Stabilization, transfer to interim storage, interim storage, or final disposition of the SNF
- Interim storage or operation of final treatment or disposal facilities for the sludge, water, or debris[2]
- Final decontamination and decommissioning of the basin structures or remediation of underlying soil and groundwater[3].

The scope of the K Basins CERCLA action evaluated in this FFS versus the scope of the NEPA action evaluated in the K Basins EIS is illustrated in Figure 1-1.

1.4 INTEGRATION WITH OTHER REMEDIATION ACTIVITIES

There are several remediation activities underway or planned in the 100-K Area in addition to cleanout and deactivation of the K Basins. Those activities include remediation of the soil and groundwater, interim safe storage of the KE and KW Reactors, and deactivation and decommissioning of inactive facilities in the 100-K Area. Each of those activities has been or will be addressed in other CERCLA documents as illustrated in Figure 1-2. The contents of the K Basins must be removed and the basins deactivated before other remedial actions at or near the reactor buildings can occur. After basin cleanout and deactivation are complete, the ancillary portions of the reactor building will be decontaminated and demolished. The remaining core of the reactor, including the basins, will be stabilized for interim storage, until the reactors are eventually dispositioned (DOE 1992).

Many of the waste sites in the 100-K Area have been investigated and evaluated in other CERCLA documents (DOE-RL 1993a, DOE-RL 1995a). Those evaluations resulted in the decision that soil and structures at liquid waste disposal sites would be remediated by excavation to meet prescribed cleanup levels (EPA et al. 1995, 1997). Likewise, the groundwater under the 100-K Area has been investigated and evaluated (DOE-RL 1993b, DOE-RL 1995b) and, in 1996,

[2] Interim storage and disposal facilities that might be used have been authorized under other regulatory actions as described in Section 5.0.
[3] These other cleanup activities will be addressed as separate CERCLA remedial actions.

a CERCLA interim remedial action ROD was issued to begin pumping and treating the groundwater to reduce migration of chromium to the Columbia River (EPA et al. 1996). Actions at K Basins addressed by this FFS will be coordinated with these other cleanup activities, as necessary.

1.5 ORGANIZATION

This FFS is organized into the following sections:

- Section 2.0, Background Information, includes a site description and history, the nature and extent of contamination in the basins, and risks justifying the CERCLA action.
- Section 3.0, Remedial Action Objectives (RAOs), establishes the objectives and requirements for this action.
- Section 4.0, Screening of Process Options, summarizes various evaluations of sludge treatment, interim storage, and disposal options.
- Section 5.0, Description of Alternatives, describes alternatives for sludge treatment and management and summarizes the common elements of SNF, water, and debris management and basin deactivation.
- Section 6.0, Detailed Evaluation of Alternatives, evaluates the alternatives individually against the CERCLA criteria
- Section 7.0, Comparative Evaluation of Alternatives, compares the alternatives to one another in the context of the CERCLA criteria.

Figure 1-1. Scope of K Basins Environmental Impact Statement Versus CERCLA Interim Remedial Action.

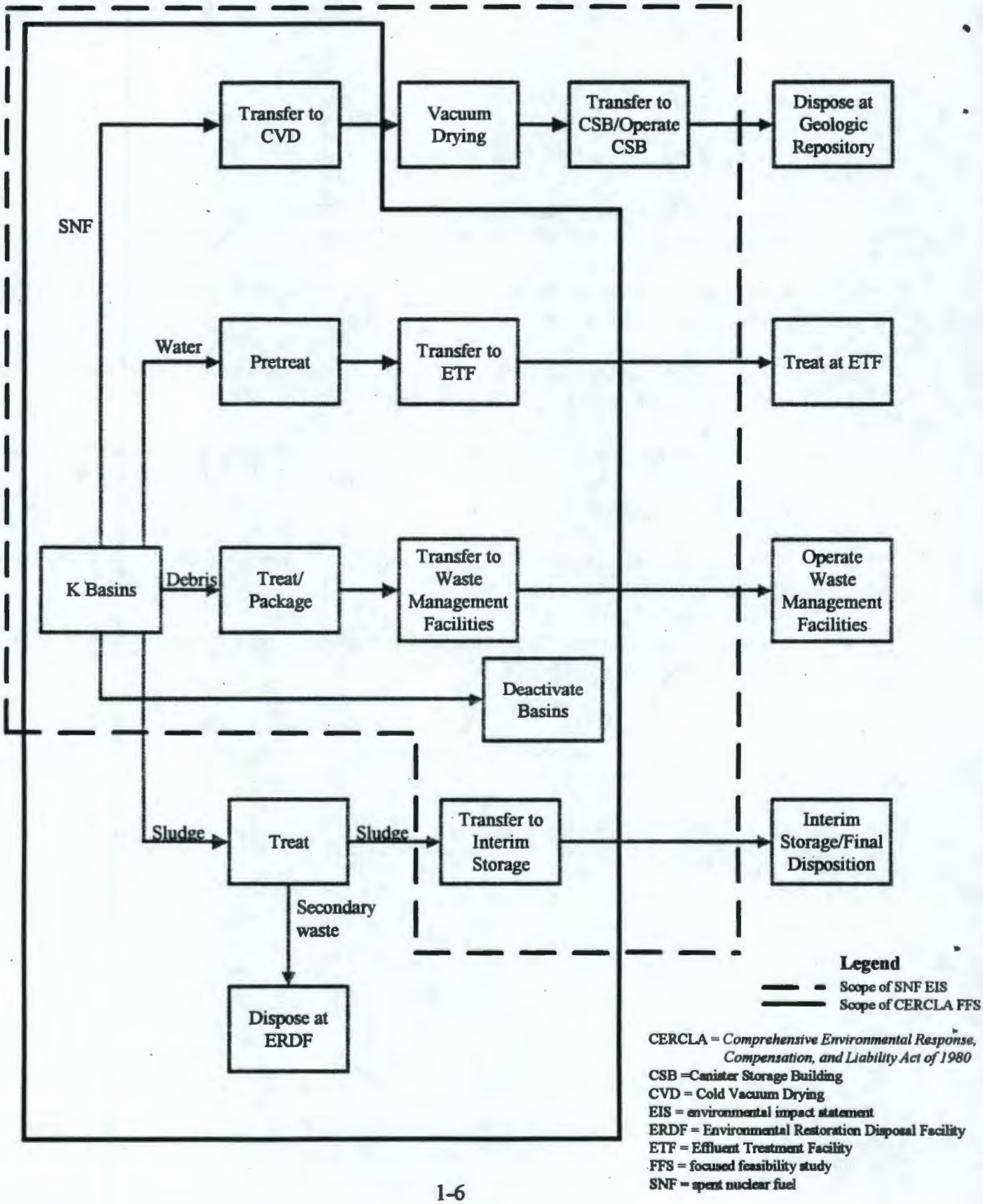
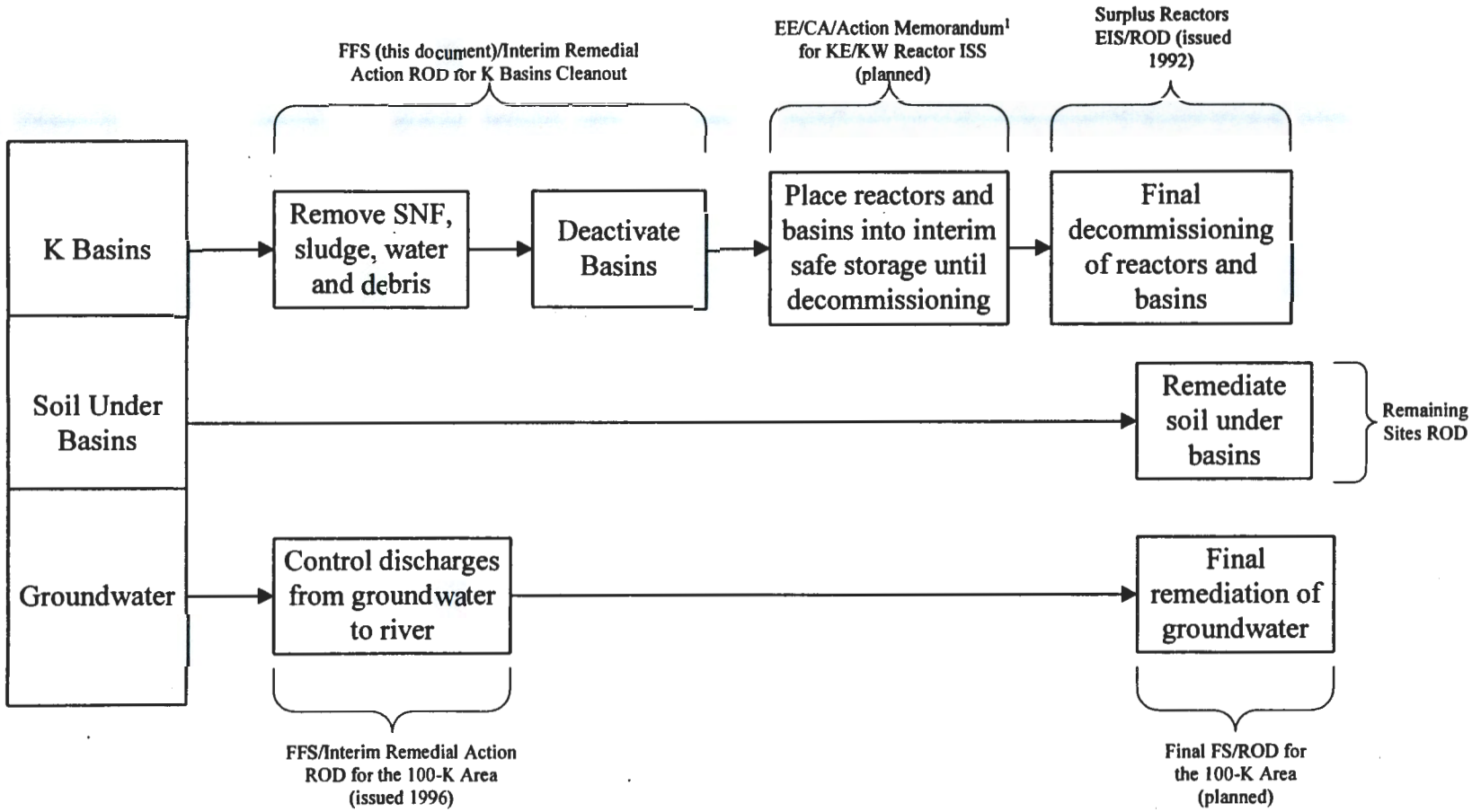


Figure 1-2. Integration of Cleanup in the 100-K Area.



CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
EE/CA = engineering evaluation/cost analysis
EIS = environmental impact statement
FFS = focused feasibility study
FS = feasibility study
ISS = interim safe storage
ROD = record of decision
SNF = spent nuclear fuel

[1] An Engineering Evaluation/Cost Analysis is the CERCLA document prepared to evaluate removal (versus remedial) action. An Action Memorandum is the decision document that authorizes a removal action.

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2.0 BACKGROUND INFORMATION

2.1 SITE DESCRIPTION

The Hanford Site occupies approximately 1,450 km^2 (560 mi^2) in the Columbia Basin of south central Washington State (Figure 2-1). The Site was selected as the nation's first large-scale nuclear materials production site in January of 1943. It is divided into several operational areas, including the 100 Area, which is located in the north-central part of the Site along the southern shore of the Columbia River. The 100 Area contains nine inactive nuclear reactors and associated support facilities and waste sites.

The 100-K Area is one of six reactor areas in the 100 Area. It consists of the KE Reactor, the KW Reactor, and associated support facilities and waste sites (Figure 2-2). The KE and KW Reactors were constructed in the early 1950s and are located about 420 m (1,400 ft) from the Columbia River (DOE 1995). Each reactor building contains an SNF storage basin that originally served as a collection, storage, and transfer facility for the fuel elements discharged from the reactor. The basins are uncovered, unlined, concrete water pools with a capacity of 4.9 million L (1.3 million gal). The SNF is stored in the basins under approximately 5 meters (16 feet) of water. The basins are located inside buildings that are ventilated to the outside. An asphaltic membrane is located beneath each pool. In 1981, after the KW Basin had been in service for about 30 years, the concrete surfaces inside that basin were reconditioned by coating them with an epoxy to keep radioactive elements from being absorbed into the concrete. The KE Basin was not similarly reconditioned. Each basin is divided into three zones: the SNF discharge area, the storage area, and the transfer area. A schematic of the K Basins is shown in Figure 2-3.

The affected environment at the 100-K Area is described in the K Basins EIS (DOE 1995, DOE 1996a). Additional detail can be found in *Hanford Site National Environmental Policy Act (NEPA) Characterization* (Nietzel et al. 1998). In summary, the region in which the Hanford Site is located is characterized as having a semiarid climate with hot summers and mild winters. Public access to the Hanford Site is currently restricted, and land use in the 100 Area consists primarily of DOE cleanup activities such as excavating contaminated waste sites, removing and treating groundwater, and decontamination and decommissioning of facilities, and spent fuel management. The Columbia River adjacent to the 100 Area is accessible to the public and is used for recreational purposes such as boating and sport fishing. The U.S. Department of the Interior has proposed establishing a National Fish and Wildlife Refuge and designating a National Wild and Scenic River along the Hanford Reach of the Columbia River (DOI 1996). Past land use in the 100 Area (prior to federal nuclear activities) includes various Native American uses, irrigated and dry-land farming, livestock grazing, and commercial activities at the old town sites. In the more recent past, members of the Yakama Indian Nation have been authorized access to the 100-K Area for the purpose of raising fish in water basins located near the river, although this activity is currently on hold. Future land use of the 100 Area has not been determined. However, land uses for the next 50 years of Federal occupation are being considered in an EIS that is currently in preparation. Land uses near the Hanford Site include dry and irrigated farming, rural and urban residential use, and commercial activities in the cities and towns. There are no ecological or cultural resources of significance within the core area around

the K Reactors that would be affected by the interim remedial action. Certain buildings in the 100-K Area have been determined to be eligible for listing on the National Register of Historic Places. However, mitigation efforts for these buildings have been completed.

2.2 SITE HISTORY

The KE and KW Reactors operated from the mid-1950s until 1971 and 1970, respectively. SNF discharged from the reactors was stored in the K Basins until it was transferred to the 200 Areas at the Hanford Site for reprocessing. Water in the basins provided both radiation shielding for workers and cooling to remove decay heat until the SNF was transferred. Most of the SNF discharged from the KE and KW Reactors was removed from the basins when the reactors were shut down. The basins subsequently have been used to store N Reactor SNF, starting in 1975 for KE and 1981 for KW. In 1992, the decision was made to deactivate the plant where the SNF was being reprocessed. This left approximately 2,100 metric tons (2,300 tons) of SNF in the K Basins with no means for reprocessing. An estimated one percent of the original mass of this SNF has corroded and become radioactive sludge. The water and debris in the basins are also radioactively contaminated.

The KE Basin leaked up to 56.8 million L (15 million gal) of contaminated water to the soil in the 1970s and another 341,000 L (90,000 gal) in early 1993 (Bergsman et al. 1995). It was suspected that the water was coming from leakage at the construction joints between the foundation of the basin and the foundation of the reactor. To mitigate the consequences of a seismic event, the construction joints in both basins were isolated from the rest of the basin by metal isolation barriers. The previously applied epoxy coating in the KW Basin provides additional protection.

Nuclear fuel is regulated under the AEA. Historically, the K Basins and their contents have been managed in accordance with the AEA with the goal of safely storing the SNF. Activities in the basins have also been subject to regulation under applicable environmental laws and regulations (e.g., regulations governing air emissions). Regulation under the AEA and applicable environmental laws and regulations will continue in the future.

2.3 NATURE AND EXTENT OF CONTAMINATION AND OTHER HAZARDS

The hazardous substances addressed by this interim remedial action are the SNF, sludge, debris, and water present in the KE and KW Basins and surface contamination removed as part of deactivation. They are described in the following subsections. This section does not address the nature and extent of contamination that might be present in underlying soils and groundwater as a result of past releases from the basins. Contamination of the soil and groundwater will be addressed in separate CERCLA documents as described in Section 1.4.

2.3.1 Spent Nuclear Fuel

Approximately 2,100 metric tons (2,300 tons) of SNF are stored in the KE and KW Basins (Praga 1998). (Some of this SNF is currently in the 300 Area for characterization purposes.) Most of the fuel is from the past operation of the N Reactor. In addition, about 160 kg (350 pounds) of SNF removed during the N Basin deactivation will eventually be taken to the K Basins. The SNF consists primarily of metallic uranium, but also includes plutonium and radioactive fission and activation products. The fuel is encased in either an aluminum or Zircaloy cladding.

The KE Basin contains about 1,150 metric tons (1,260 tons) of SNF (Praga 1998), stored underwater in 3,673 open-top canisters. This SNF has been stored for varying lengths of time ranging from 9 to 25 years. Much of the SNF stored in the KE Basin is damaged, and it has been estimated that about one percent of the original mass of the fuel has corroded because of cracks and breaks in the cladding and contributed to the radioactive sludge in that basin (DOE 1995).

The remainder of SNF, approximately 953 metric tons (1,050 tons) (Praga 1998), is stored underwater in the KW Basin in 3,817 closed canisters. Because the SNF was placed in closed containers before storage, corrosion products were retained within the canisters and the volume of sludge accumulated on the floor of the KW Basin is much smaller than in the KE Basin.

2.3.2 Contaminated Sludge

Both the KE and KW Basins contain contaminated sludge that resides on the basin floors, in the basin pits, and in the SNF storage canisters. Sludge will also be generated when additional corrosion product is separated from the SNF as the SNF is washed prior to removing it from the basins. This sludge is referred to as wash sludge. The composition of the sludge varies depending on the location and the basin.

Sludge on the floor and in the pits of the KE Basin is potentially a mix of the following:

- SNF corrosion products (including uranium compounds, fission and activation products, and aluminum and zirconium compounds from the cladding)
- Iron and aluminum oxide from the storage racks and canisters
- Inorganic zeolite ion exchange media and organic ion exchange resin beads (OIER or Purolite) inadvertently introduced from the water treatment system
- Concrete grit from the basin walls
- Sand and dirt from outside the basins
- Biological debris.

The large quantity of fuel corrosion products in the floor and pit sludge is a result of the open tops, and in some cases open-screened bottoms, of the fuel storage canisters in the KE Basin. Sludge in the KE Basin canisters themselves consists primarily of fuel corrosion products.

There is very little sludge on the floor of the KW Basin, and what there is appears to consist primarily of dust and sediment. The floor sludge is not expected to contain significant amounts of fuel corrosion products because the canisters in the KW Basin have closed tops and bottoms, but there are still low levels of radioactivity in the floor sludge. Only one of the areas (the North Loadout Pit) in the KW Basin contains a significant amount of sludge and this is likely to consist of a mix of sand and fuel corrosion products. Because the canisters in the KW Basin are completely closed, any sludge in them is expected to derive almost exclusively from SNF and consist of fuel corrosion products.

Estimated volumes of sludge are shown in Tables 2-1 and 2-2. The total volume of sludge in the KE and KW Basins combined is estimated to be 50 m^3 (1,800 ft^3 or 13,000 gallons). While the sludge is in the basins, it is commingled with SNF and is not considered a waste by DOE. When the sludge is separated from the SNF and removed from the basins it will be designated and managed as a waste (Wagoner 1996). For purposes of differentiating SNF and debris from sludge, any material less than or equal to 0.64 cm (0.25 in) in diameter is defined as sludge (Pearce 1998). A formal determination regarding designation of the sludge as a high-level waste (HLW) has not yet been made. Some fractions of the sludge (the canister sludge and wash sludge) that derive predominantly from corrosion of the SNF might be determined to be HLW. A designation of HLW would restrict options for treatment and ultimate disposal, because the only proposed disposal location for HLW is the national geologic repository.[4].

Estimated compositions for the K Basins sludge are provided in Tables 2-1 and 2-2 and are taken from tables in Pearce (1998). These compositions are based on three sludge characterization campaigns that have been conducted for the KE Basin floor and Weasel Pit, the KE Basin canisters, and the KW Basin canisters (Pearce 1998). Where a specific sludge population was not sampled, the composition estimate was based on a similar sludge population that was sampled. For example, the sludge in the KE Tech View Pit and Dummy Pit were assumed to be similar to the sludge in the KE Weasel Pit.

Based on the characterization data, it is assumed that the KE Basin floor and pit sludge will be designated as a *Toxic Substances Control Act* (TSCA)-regulated mixed transuranic (TRU) waste[5]. The mixed waste designation is based on analyses to obtain total concentrations of heavy metals in the sludge. The sludge was not tested using the toxicity characteristic leaching procedure (TCLP) prescribed by the dangerous waste regulations in *Washington Administrative Code* Chapter 173-303 (which governs mixed waste designation) and is therefore conservative. The sludge is regulated under TSCA based on the presence of polychlorinated biphenyls (PCBs) at concentrations of greater than 50 parts per million (ppm) by weight. Seven of the sludge

[4] High-level waste is defined as (1) irradiated reactor fuel, (2) liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, in a facility for reprocessing irradiated reactor fuel, and (3) solids into which such liquid wastes have been converted (10 CFR 60.2).

[5] TRU waste is defined as waste that contains more than 100 nCi/g of alpha-emitting TRU isotopes with half-lives greater than 20 years. Transuranic refers to those isotopes with an atomic number greater than 92.

samples were screened for organic contaminants; PCBs were detected in two of the samples at concentrations above 50 ppm. The highest concentration detected was 140 ppm on a settled solids basis (Schmidt 1997). Based on the TSCA anti-dilution rule[6] and the fact that basin activities have caused the floor sludge to mix, all of the sludge from the floor and pits of the KE Basin is considered to be TSCA-regulated.

It is assumed that the sludge from the floor and pits of the KW Basin will be similar in composition to the pit sludge from the KE Basin. Therefore, it is assumed that the floor and pit sludge in the KW Basin would designate as mixed TRU waste. The KW floor and pit sludge will be managed in a manner similar to the KE floor and pit sludge unless actual samples of the KW sludge demonstrate that an alternate management is appropriate.

Based on the characterization data, it is assumed that the canister and wash sludge from the KE and KW Basins will be designated as a mixed TRU waste. Analyses for PCBs in the canister sludge in both basins showed PCB concentrations well below the 50-ppm limit that would require regulation under TSCA (Pearce 1998). The canister and wash sludge contain a higher fraction of fuel corrosion products than floor and pit sludge. Because of this, additional concerns that are important in developing treatment alternatives for the canister and wash sludge include the following:

- The sludge is highly radioactive, and the surface dose for an unshielded container of sludge is many times higher than the 200-mrem/hr limit for contact-handled waste (FDH 1998). Because of this, it is anticipated that containers of treated sludge will need to be managed as a remote-handled[7] waste unless special overpacking is provided.

- The high concentrations of fissile materials (uranium and plutonium) require careful evaluation of criticality control for all activities involving the sludge.

- Metal fines and metal hydrides in the sludge (e.g., uranium, uranium hydride, and zirconium) are potentially pyrophoric, reactive, and capable of generating flammable gas.

During sludge characterization activities, the sludge was sometimes observed to be generating bubbles, presumably of hydrogen gas. This phenomenon was evaluated to determine whether excessive accumulation of flammable gas could occur during sludge retrieval and removal

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[6]TSCA regulates materials that contain 50 ppm or greater of PCBs. TSCA's anti-dilution rule states that TSCA requirements that are based on a concentration cannot be avoided by dilution (40 CFR 761.1(b)). If a material that contains 50 ppm or greater of PCBs (and is thus regulated under TSCA) is mixed with a material that has less than 50 ppm PCBs, the entire mixture becomes regulated under TSCA. Most of the sludge analyses from the floor and in the pits of the KE Basin showed PCB concentrations of less than 50 ppm, but because the floor sludge has been disturbed and mixing of the material has occurred, it has been determined that all of the floor and pit sludge in KE Basin will be regulated under TSCA.

[7]TRU waste is classified as either contact-handled or remote-handled based on the contact dose rate at the surface of the waste container. If the contact dose rate is less than or equal to 200 millirem per hour, the waste is defined as contact-handled TRU. If the contact dose rate is greater than 200 millirem per hour, the waste and its container are defined as remote-handled TRU. Because of the higher contact dose rate, remote-handled TRU requires special handling and management.

activities. It was determined that the gas did not pose a potential for excessive flammable gas accumulation.

2.3.3 Contaminated Debris

For purposes of this FFS, debris is defined as any solid waste with a size of 0.64 cm (0.25 in.) or greater. The definition excludes SNF and sludge. It includes but is not limited to the following:

- Approximately 7,500 fuel canisters[8]
- Old basin equipment and piping, hand tools, the storage racks used to hold the SNF canisters, construction materials from the basins, and miscellaneous scrap
- Equipment used to remove SNF, sludge, water, and debris from the basins
- Components of the basin water pretreatment system (e.g., spent ion exchange modules containing resin) when they are no longer required for service
- Previously-generated ion exchange columns packaged in burial boxes and residing in the 100-K Area
- Components of the sludge treatment system when they are no longer required for service
- Miscellaneous waste generated during deactivation of the basins.

The debris could designate as uncontaminated solid waste, low-level waste (LLW), mixed waste, TRU waste, or mixed TRU waste, depending on the chemical composition of the debris itself and residual sludge attached to the debris. The K Basins annual debris report states that debris that has contact sludge (which is regulated under TSCA) in the KE Basin pool is considered a PCB article (DOE-RL 1998a). The TSCA implementing regulations have a provision whereby PCB articles containing between 50 and 500 ppm of PCBs are not regulated under TSCA once they are drained of free-flowing liquid (40 CFR 761.60[b][5][ii]). The KE basin debris will be drained of free-flowing liquid as it is removed from the basin; therefore, it will not be TSCA-regulated.

2.3.4 Contaminated Water

Each basin contains approximately 4.9 million L (1.3 million gal) of water that is used to shield and cool the SNF. The water is currently maintained in a closed-loop system and is continually recycled from the basins, circulated through existing treatment systems, then returned to the basins. This treatment is required to maintain adequate water quality (e.g., reduce cloudiness) and temperatures in the basins and also functions to reduce concentrations of soluble radionuclides.

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[8]Approximately 2,000 empty canisters that were in the basins were removed in 1998.

The primary contaminants in the water are radionuclides, including tritium at a concentration of about 3 μCi/L in the KE Basin and other soluble or partially soluble nuclides (e.g., Cs-134 and Cs-137). Based on concentrations of chemical constituents, the water is not regulated as a mixed waste. The water contains less than 0.5 parts per billion (ppb) PCBs and is therefore not regulated under TSCA, even though it has been in contact with the sludge, which is a TSCA-regulated stream in the KE Basin.

2.4 RISK EVALUATION

The contaminants of concern in the K Basins that drive the risk evaluation are primarily radionuclides. Concentrations of radionuclides in the basin water exceed drinking water standards established under the *Safe Drinking Water Act* (SDWA). For example, the maximum concentration level for tritium established under the SDWA is 20,000 pCi/L, compared to basin water concentrations of about 3,000,000 pCi/L. Concentrations of radionuclides in the K Basins sludge (Tables 2-1 and 2-2) are such that unshielded exposure to the sludge would result in a significant radiation dose. Any substantial release of water or sludge from the basins would cause further degradation of the groundwater.

Potential risks to human health and the environment associated with current conditions at the K Basins include the following:

- **Potential for releases.** Past deterioration of construction joints in the KE Basin resulted in large releases of contaminated water to the underlying soil and groundwater, and groundwater contaminant concentrations near the K Basins exceed human health protection criteria. For example, Well 199-K-30, located near the KE Reactor, showed a maximum tritium concentration of 536,000 pCi/L in 1997 as compared to the drinking water standard of 20,000 pCi/L (Dirkes and Hanf 1998). The potential for future releases has been mitigated by modification of the construction joints as described in Section 2.1, and there is currently no public use of the groundwater in the 100-K Area or public access to the K Basins. However, deficiencies at both basins continue to present a potential for future leaks.

- **Fuel degradation**. The SNF was not designed for long-term wet storage. However, some of the SNF has been stored underwater in the basins for more than 20 years. In the KE Basin, damaged fuel cladding surrounding the metallic uranium fuel elements has allowed water to corrode the fuel. The corrosion further damages the fuel, releasing radioactive material to the water and contributing to the buildup of a thick layer of sludge on the basin floor.

- **Basin Design and seismic adequacy**. As the basins continue to age there is a potential for further loss of structural integrity and further releases from the basins to the environment. The K Basins have currently exceeded their 20-year design life by more than 20 years. Because of poor historical maintenance of systems, major problems have been experienced with electrical systems and water distribution and treatment systems. Upgrades are required to ensure occupational safety. The K Basins were designed to

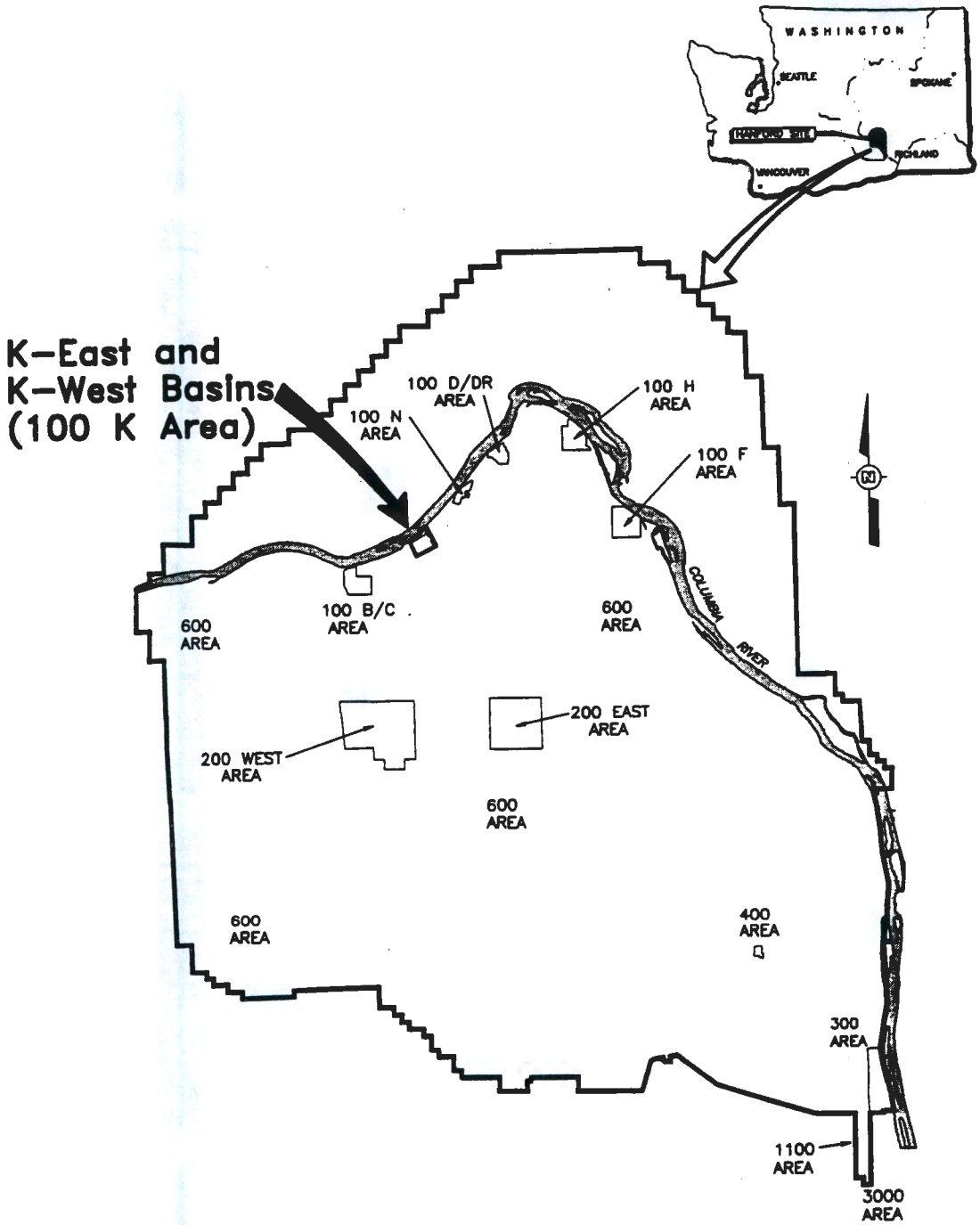
consensus codes and standards of the 1950s. Accordingly, the electrical, fire protection, and water systems and the basin structures do not conform to modern design standards and the basins do not provide confinement of radioactive materials (airborne or liquid). In addition, the basins were not designed to modern seismic criteria. Seismic isolation barriers have been installed to isolate the discharge chute area from the main basin at both the KE and KW Basins. In the event of a seismic event, the barriers will limit basin water leakage to the soil through the construction joints where it is assumed previous leakage has occurred. However, analyses indicate that other areas of the basin structure could fail during a seismic event and allow large volumes of water to leak to the soil. Failure to maintain a sufficient amount of water to cool the SNF and sludge and provide shielding for workers would allow the SNF and sludge to dry and heat, resulting in an airborne release of radionuclides.

- **Location.** The K Basins are located approximately 430 m (1,400 ft) from the Columbia River. The proximity of the basins to the river increases the likelihood that the river would become contaminated as a result of a leak from the basins and migration to the soil and groundwater.

- **Occupational exposure.** The lack of confinement for the corroding fuel in the KE Basin has resulted in higher than desired radiation exposure to workers during routine and non-routine activities. Dose reduction activities are underway at the basin. These activities are designed to improve overall occupational safety at the K Basins but are not expected to achieve current standards for occupational exposure for prolonged storage at the K Basins.

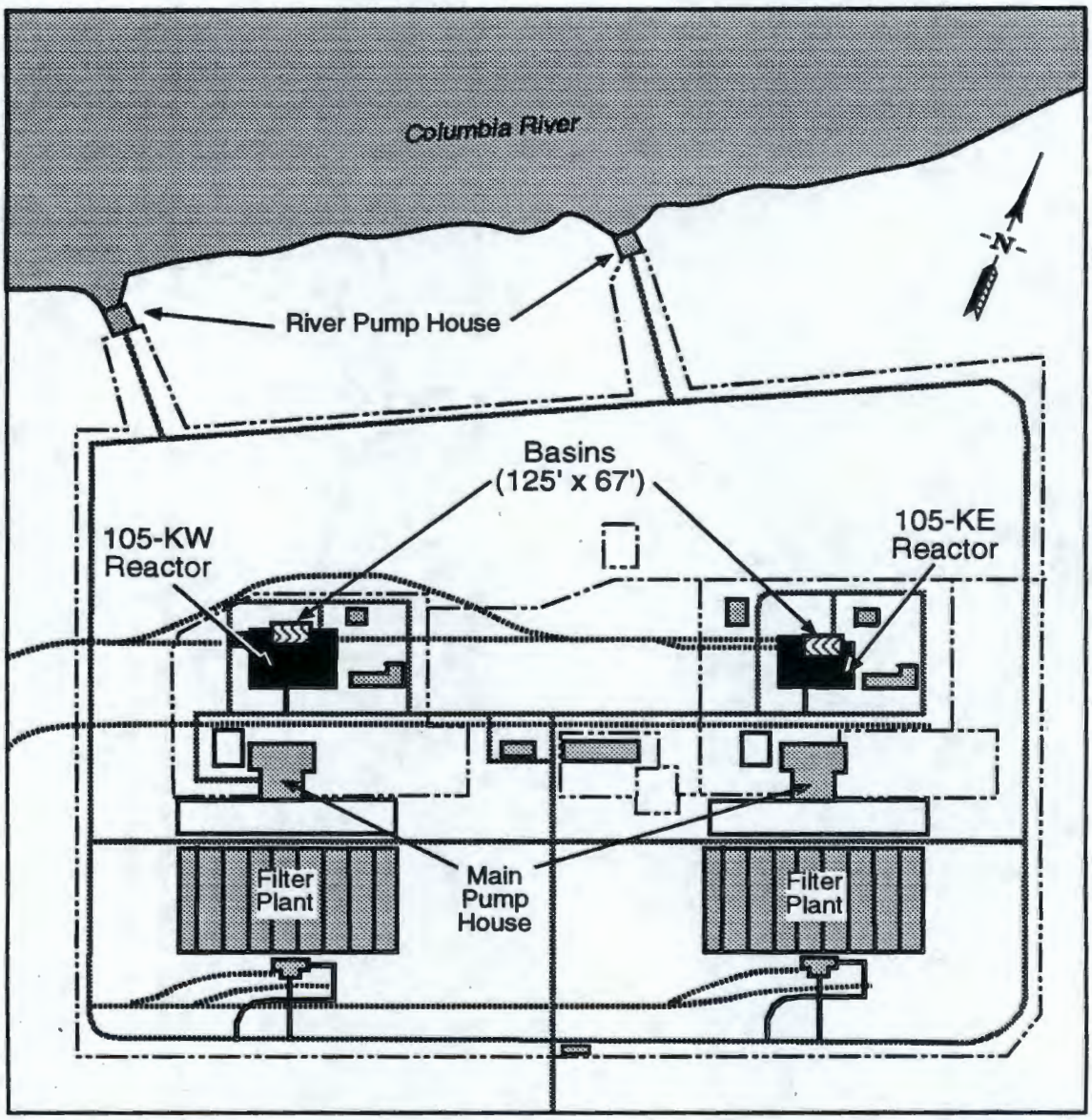
DOE believes the potential for a near-term release is small, but the K Basins are continuing to age and are already considered substandard by current codes. A major natural event (e.g., seismic event) could release most or all of the basin water and potentially some of the basin sludge to the subsurface environment, where it would be available for leaching to groundwater and transport to the Columbia River. Specific accident scenarios for continued storage of basin hazardous substances were evaluated for the no action alternative in the K Basins EIS (DOE 1995). The potential risk to the environment combined with the continued occupational risk to workers justifies the interim remedial action.

Figure 2-1. Hanford Site Overview.



G:\MAPS\101298A

Figure 2-2. 100-K Area Site Plan.



SG95100088.16

Note:

K-Basin (125' x 67')

Fenceline

Roads

Railroad Tracks

0 500 Scale in Feet

0 100 Scale in Meters

Figure 2-3. Schematic of KE and KW Basins.

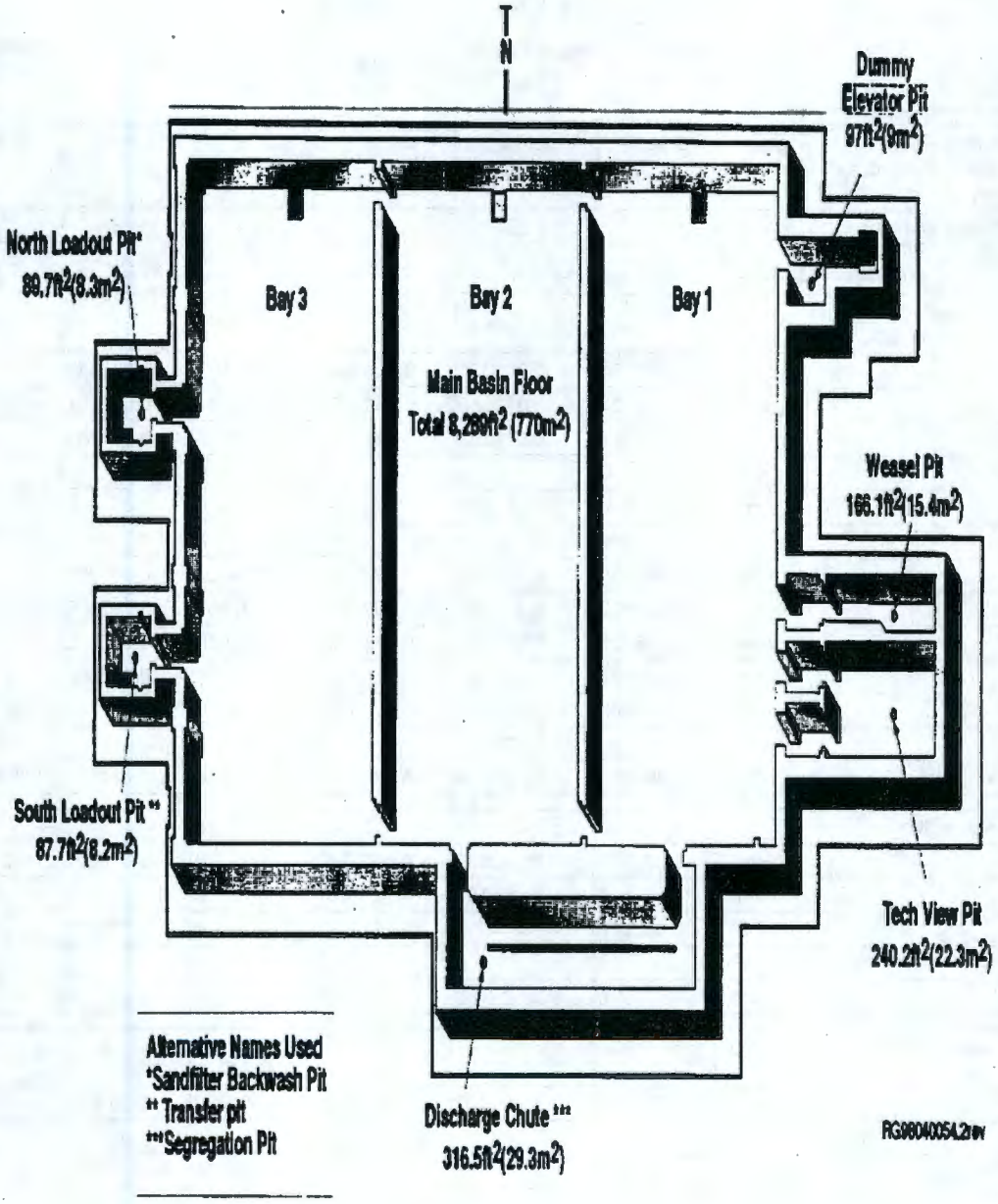


Table 2-1. Estimated Inventory for KE Basin Sludge Locations. (3 sheets) (from Pearce 1998)

		Source – K East						
	Units	Weasel Pit	Main Basin Floor	Tech View	North Loadout Pit	Dummy Elevator Pit	Canisters Full	Canisters Empty
As-settled Sludge Solid Content (g dry solids/cm3 as-settled sludge)	g/cm³	0.931	0.375	0.931	0.370	0.931	0.884	0.884
As-settled Sludge Density	g/cm³	1.56	1.32	1.56	1.27	1.56	1.62	1.62
Volume of Sludge	m³	10.10	21.50	0.40	6.30	1.40	3.00	0.40
As-settled Sludge Composition Chemical								
U	g/cm³	0.000554	0.000336	0.000554	0.000133	0.000554	0.023489	0.023489
UO_2	g/cm³	0.031127	0.018880	0.031127	0.007471	0.031127	0.239820	0.239820
U_3O_7	g/cm³	0.031741	0.019253	0.031741	0.007619	0.031741	0.244557	0.244557
UO_4 $C4H_2O$	g/cm³	0	0	0	0	0	0	0
UH_3	g/cm³	0	0	0	0	0	0.023785	0.023785
$Al(OH)_3$	g/cm³	0	0	0	0	0	0.170042	0.170042
Al_2O_3	g/cm³	0.062895	0.041372	0.062895	0.014103	0.062895	0	0
FeO(OH)	g/cm³	0.403050	0.128683	0.403050	0.037761	0.403050	0.109399	0.109399
SiO_2	g/cm³	0.235325	0.073942	0.235325	0.297060	0.235325	0.039261	0.039261
CaO	g/cm³	0.015968	0.003087	0.015968	0.003699	0.015968	0.001624	0.001624
CO_2	g/cm³	0.007600	0.004923	0.007600	0	0.007600	0.007565	0.007565
C	g/cm³	-	0.001107	-	0	-	0.002339	0.002339
Sum of Other Compounds	g/cm³	0.080532	0.026479	0.080532	0.001955	0.080532	0.010330	0.010330
Miscellaneous solids								
PCB	g/cm³	0.000225	0.000083	0.000225	0	0.000225	0.0000018	0.0000018
OIER	g/cm³	0	0.056651	0	0	0	0.010235	0.010235
Zeolite	g/cm³	0.062079	0	0.062079	0	0.062079	0	0
Zircalloy 2	g/cm³	0	0	0	0	0	0	0
Grafoil [1]	g/cm³	0	0	0	0	0	0	0
Dry solid - radionuclide content								
^{238}Pu and $^{239/240}Pu$	g/cm³	0.000076	0.000102	0.000076	0.000060	0.000076	0.001536	0.001536
^{238}Pu and $^{239/240}Pu$	µCi/g	5.37	19.88	5.37	10.05	5.37	108.70	108.70
^{241}Am	µCi/g	8.17	28.11	8.17	7.27	8.17	138.34	138.34
^{137}Cs	µCi/g	293.54	310.24	293.54	37.84	293.54	806.35	806.35
$^{89/90}Sr$	µCi/g	223.55	302.20	223.55	0	223.55	1053.40	1053.40
Uranium composition								
U	kg	559.83	722.84	22.17	83.87	77.60	1408.97	187.86
^{233}U	mass%	-	-	-	0.00000	-	0.00050	0.00050
^{234}U	mass%	0.00697	0.00587	0.00697	0.00685	0.00697	0.00836	0.00836
^{235}U	mass%	0.69730	0.57976	0.69730	0.70079	0.69730	0.66250	0.66250
^{236}U	mass%	0.07477	0.05735	0.07477	0.07586	0.07477	0.06864	0.06864

Table 2-1. Estimated Inventory for KE Basin Sludge Locations. (3 sheets) (from Pearce 1998)

		Source -- K East						
	Units	Weasel Pit	Main Basin Floor	Tech View	North Loadout Pit	Dummy Elevator Pit	Canisters Full	Canisters Empty
^{238}U	mass%	99.22096	99.35702	99.22096	99.21790	99.22096	99.26036	99.26036
	Units	Fuel Wash – Internal Sludge	Fuel Wash -- Coating	Fuel Wash - - Fuel Pieces		Totals		
As-settled Sludge Solid Content (g dry solids/cm3 as-settled sludge)	g/cm³	2.312	0.969	10.611				
As-settled Sludge Density	g/cm³	3.00	1.50	11.02				
Volume of Sludge	m³	0.518	0.061	0.149		43.83	m³	
As-settled Sludge Chemical Composition								
U	g/cm³	-		9.828354		1,558.9	Kg	
UO_2	g/cm³	1.734693	-	-		2,537.3	Kg	
U_3O_7	g/cm³	-	-	-		1,671.1	Kg	
UO_4 $C4H_2O$	g/cm³	-	0.673135	-		41.1	kg	
UH_3	g/cm³	0.172178	-	-		170.1	kg	
$Al(OH)_3$	g/cm³	0.02539	0.213762	-		604.3	kg	
Al_2O_3	g/cm³	-	-	-		1,726.8	kg	
FeO(OH)	g/cm³	0.004348	0.028622	-		8,176.8	kg	
SiO_2	g/cm³	0.348580	-	-		6,575.7	kg	
CaO	g/cm³	-	0.014884	-		286.1	kg	
CO_2	g/cm³	-	-	-		222.0	kg	
C	g/cm³	-	-	-		31.8	kg	
Sum of Other Compounds	g/cm³	0.017895	0.036809	0.056162		1,595.0	kg	
Miscellaneous solids								
PCB [2]	g/cm³					4.5	kg	
OIER	g/cm³					1,252.8	kg	
Zeolite	g/cm³					738.7	kg	
Zircalloy 2	g/cm³			0.692665		103.2	kg	
Grafoil	g/cm³					-		
	Units	Fuel Wash – Internal Sludge	Fuel Wash -- Coating	Fuel Wash - - Fuel Pieces		Totals		
Dry solid - radionuclide content								
^{238}Pu and $^{239/240}Pu$	g/cm³	0.008681	0.001794	0.033569		18.3	kg	
^{238}Pu and $^{239/240}Pu$	µCi/g	232.67	114.50	195.91				
^{241}Am	µCi/g	210.50	93.40	168.01				
^{137}Cs	µCi/g	3443.33	1,410.00	5342.20				
$^{89/90}Sr$	µCi/g	3851.61	1,767.75	4045.39				
Uranium composition								
U	kg	880.43	26.14	1464.42		5434.1	kg	
^{233}U	mass%	0.00000	0.00000	0.00000				
^{234}U	mass%	0.00726	0.00694	0.0065				

Table 2-1. Estimated Inventory for KE Basin Sludge Locations. (3 sheets) (from Pearce 1998)

		Source – K East					
	Units	Fuel Wash – Internal Sludge	Fuel Wash – Coating	Fuel Wash - - Fuel Pieces		Totals	
^{235}U	mass%	0.764	0.682	0.719			
^{236}U	mass%	0.0859	0.086	0.090			
^{238}U	mass%	99.14	99.23	99.19			

[1] Grafoil is a carbon-based material used to seal canister lids in the KW Basin.

[2] To convert PCB concentrations from g/cm^3 to ppm divide the PCB concentration (in g/cm^3) by the density (in g/cm^3) and multiply by one million.

Values shown in this table are approximate; the high precision implied by the number of significant figures was required to permit consistent preparation of design and data sheets.

PCB = polychlorinated biphenyl

OIER = organic ion exchange resins

Table 2-2. Estimated Inventory for KW Basin Sludge Locations. (2 Sheets) (From Pearce 1998)

		Source – K-West						
	Units	Weasel Pit	Main Basin Floor	Discharge Chute	Tech View	North Loadout Pit	Dummy Elevator Pit	Canisters Full
As-settled Sludge Solid Content (g dry solids/cm3 as-settled sludge)	g/cm^3	0.869	0.318	0.869	0.869	0.370	0.869	2.053
As-settled Sludge Density	g/cm^3	1.56	1.32	1.56	1.56	1.27	1.56	2.68
Volume of Sludge	m^3	0.03	0.82	0.06	0.07	3.65	0.04	1.01
As-settled Sludge Chemical Composition								
U	g/cm^3	0.000554	0.000336	0.000554	0.000554	0.000133	0.000554	0.066167
UO_2	g/cm^3	0.031127	0.018880	0.031127	0.031127	0.007471	0.031127	0.675574
U_3O_7	g/cm^3	0.031741	0.019253	0.031741	0.031741	0.007619	0.031741	0.688918
$UO_4 \cdot 4H_2O$	g/cm^3	0	0	0	0	0	0	0
UH_3	g/cm^3	0	0	0	0	0	0	0.067001
$Al(OH)_3$	g/cm^3	0	0	0	0	0	0	0.117661
Al_2O_3	g/cm^3	0.062895	0.041372	0.062895	0.062895	0.014103	0.062895	0
FeO(OH)	g/cm^3	0.403050	0.128683	0.403050	0.403050	0.037761	0.403050	0.209042
SiO_2	g/cm^3	0.235325	0.073942	0.235325	0.235325	0.297060	0.235325	0
CaO	g/cm^3	0.015968	0.003087	0.015968	0.015968	0.003699	0.015968	-
CO_2	g/cm^3	0.007600	0.004923	0.007600	0.007600	0	0.007600	0.002910
C	g/cm^3	-	0.001107	-	-	0	-	0.002934
Sum of Other Compounds	g/cm^3	0.080532	0.026479	0.080532	0.080532	0.001955	0.080532	0.161471
Miscellaneous solids								
PCB	g/cm^3	0	0	0	0	0	0	0.000015
OIER	g/cm^3	0	0	0	0	0	0	0
Zeolite	g/cm^3	0	0	0	0	0	0	0
Zircalloy 2	g/cm^3	0	0	0	0	0	0	0
Grafoil	g/cm^3	0	0	0	0	0	0	0.055248
Dry solid - radionuclide content								
^{238}Pu and $^{239/240}Pu$	g/cm^3	0.000076	0.000102	0.000076	0.000076	0.000060	0.000076	0.005648
^{238}Pu and $^{239/240}Pu$	µCi/g	5.37	19.88	5.37	5.37	10.05	5.37	175.03
^{241}Am	µCi/g	8.17	28.11	8.17	8.17	7.27	8.17	136.66
^{137}Cs	µCi/g	293.54	310.24	293.54	293.54	37.84	293.54	1898.75
$^{89/90}Sr$	µCi/g	223.55	302.20	223.55	223.55	0	223.55	3096.25
Uranium composition								
U	kg	1.66	27.57	3.33	3.88	48.59	2.22	1,329.96
^{233}U	mass%	-	-	-	-	0.00000	-	0.00000
^{234}U	mass%	0.00697	0.00587	0.00697	0.00697	0.00685	0.00697	0.00451
^{235}U	mass%	0.69730	0.57976	0.69730	0.69730	0.70079	0.69730	0.80023
^{236}U	mass%	0.07477	0.05735	0.07477	0.07477	0.07586	0.07477	0.09443
^{238}U	mass%	99.22096	99.35702	99.22096	99.21999	99.21790	99.21999	99.15356

Table 2-2. Estimated Inventory for KW Basin Sludge Locations. (2 Sheets) (From Pearce 1998)

	Units	Fuel Wash – Internal Sludge	Fuel Wash – Coating	Fuel Wash – Fuel Pieces		Totals	
As-settled Sludge **Solid Content** (g dry solids/cm3 as-settled sludge)	g/cm^3	2.310	0.970	10.612			
As-settled Sludge **Density**	g/cm^3	3.00	1.50	11.02			
Volume of Sludge	m^3	0.518	0.405	0.149		6.75	m^3
As-settled Sludge Chemical Composition							
U	g/cm^3	-	-	9.828354		1,531.8	kg
UO_2	g/cm^3	1.718239	-	-		1,618.0	kg
U_3O_7	g/cm^3	-	-	-		742.3	kg
$UO_4 \cdot 4H_2O$	g/cm^3	-	0.022194	-		9.0	kg
UH_3	g/cm^3	0.170544	-	-		155.7	kg
$Al(OH)_3$	g/cm^3	0.129080	0.544151	-		405.5	kg
Al_2O_3	g/cm^3	-	-	-		98.0	kg
FeO(OH)	g/cm^3	0.004031	0.306839	-		660.4	kg
SiO_2	g/cm^3	0.194161	0.028835	-		1,300.3	kg
CaO	g/cm^3	-	0.004574	-		21.1	kg
CO_2	g/cm^3	-	-	-		8.5	kg
C	g/cm^3	-	-	-		3.9	kg
Sum of Other Compounds	g/cm^3	0.087033	0.063777	0.056162		290.4	kg
Miscellaneous solids							
PCB	g/cm^3					0.015	kg
OIER	g/cm^3					-	
Zeolite	g/cm^3					-	
Zircalloy 2	g/cm^3			0.692665		103.2	kg
Grafoil	g/cm^3					55.5	kg
Dry solid - radionuclide content							
^{238}Pu and $^{239/240}Pu$	g/cm^3	0.006865	0.000073	0.034805		14.8	kg
^{238}Pu and $^{239/240}Pu$	µCi/g	184.00	4.62	203.12			
^{241}Am	µCi/g	148.00	4.38	165.58			
^{137}Cs	µCi/g	2210.00	57.70	6505.54			
$^{89/90}Sr$	µCi/g	2116.08	92.90	5065.27			
Uranium composition							
U	kg	872.08	5.72	1464.42		3,759.4	kg
^{233}U	mass%	0.00000	0.00000	0.00000			
^{234}U	mass%	0.00594	0.00901	0.00690			
^{235}U	mass%	0.67100	0.90860	0.78000			
^{236}U	mass%	0.08870	0.09256	0.09900			
^{238}U	mass%	99.24000	98.98856	99.11000			

Values shown in this table are approximate; the high precision implied by the number of significant figures was required to permit consistent preparation of design and data sheets.

PCB = polychlorinated biphenyl

OIER = organic ion exchange resins

3.0 REMEDIAL ACTION OBJECTIVES

RAOs are based on the nature and extent of contamination, the associated risk, and compliance with federal and State of Washington applicable or relevant and appropriate requirements (ARARs). The nature and extent of the contamination and the potential risk associated with hazardous substances at the K Basins were presented in Section 2. A discussion and comprehensive list of ARARs is provided in Appendix B. Key ARARs for the K Basin cleanout include standards related to how wastes removed from the basins must be managed (i.e., stored, treated, and disposed) or that define constraints for the sludge treatment process design (e.g., air emissions limits).

The overall purpose of this action is to control a potential source of environmental contamination by removing the SNF, debris, sludge, and water from the K Basins and transferring them to facilities that will manage them in a manner that protects human health and the environment. The scope of this action does not include final disposition of the basin structures themselves or remediation of the underlying soil or groundwater. Disposition of the basins, contaminated soil, and groundwater has been or will be addressed under other CERCLA actions as described in Section 1.4.

The RAOs are as follows:

- Reduce the potential for future releases of hazardous substances from the K Basins to the environment
  - Remove hazardous substances from near the Columbia River
  - Provide pathway for safe treatment, storage, and final disposal of the SNF, sludge, water, and debris removed from the K Basins
  - Prevent further deterioration of the SNF
- Reduce occupational radiation exposure to workers at the basins.

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4.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

CERCLA guidance identifies a range of general response actions that includes no action, institutional controls, containment, in-situ treatment, ex situ treatment, and removal. As described in Section 1.1, this interim remedial action and FFS adopt the alternative for removal of the SNF, sludge, water, and debris from the basins and management of the SNF, water, and debris selected in the K Basins EIS and ROD. Therefore, response actions for the removal activities and SNF, water, and debris management are not identified and new alternatives for these activities are not developed as part of this FFS.

However, the K Basins EIS and ROD did not evaluate alternatives for sludge treatment. Thus, this FFS focuses on the evaluation of alternatives for treating the K Basins sludge. With respect to the sludge, the only response actions that would meet the RAOs are removal and ex situ treatment. Removal is required because institutional controls would not mitigate the potential for an environmental release from the basins and the poor condition of the basins and difficulty associated with upgrades effectively precludes containment or in situ treatment. Removal without ex situ treatment would not meet the RAO of providing for safe treatment, storage, and/or disposal of the sludge.

Several studies have been conducted previously to evaluate options for treating and dispositioning the sludge. This section summarizes the results of those studies and uses them to define remedial alternatives for further analysis. Section 4.1 addresses storage of the sludge and Section 4.2 addresses final disposition. Potential storage and disposal locations are described first because they tend to define treatment needs. Section 4.3 addresses options for treatment.

4.1 SLUDGE STORAGE

The proposed *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) milestone date to begin sludge removal is July 31, 2004. It is not anticipated that there will be any facilities available at the Hanford Site that are capable of providing final disposition of the K Basins sludge by that time. Therefore, it is necessary to provide for interim storage of the sludge after it is removed from the K Basins. The preferred alternative in the final K Basins EIS (DOE 1996a) identified existing DST in the Hanford 200 Area as the interim storage location for sludge removed from the K Basins. The K Basins ROD (61 FR 10736) clarified that if it were not possible to place the sludge into the tanks, the sludge would be disposed as a solid waste or continue to be managed as SNF. DOE has determined, subsequently, that the sludge will be managed as a waste rather than as SNF when it is removed from the basins (Wagoner 1996).

A value engineering study was conducted in 1996 for the purpose of evaluating interim storage options for the K Basins sludge (ARES 1996). More than 50 interim storage options were identified. The study then narrowed the list to the six most feasible options. These options and

others identified since that time, along with key advantages and disadvantages, are listed in Table 4-1. Storage of the sludge in an existing DST was the recommended option. Based in part on that study, the current project baseline is to store the K Basins sludge in an existing DST, identified, in the project baseline as Tank 241-AW-105 (Tank 105-AW). The contents of the tank will be separated into high-level and low-activity waste streams for vitrification.

Safety issues are the overriding concern for interim storage of K Basin sludge in Tank 105-AW. These issues include nuclear criticality prevention; metal fines (potential pyrophoricity and reactivity issues); and flammable gas generation, accumulation, and sudden release (Daling et al. 1997). Additional concerns include corrosivity, retrievability, and the presence of *Resource Conservation and Recovery Act of 1976-* (RCRA) and TSCA-regulated wastes. Acceptance criteria for storing the sludge in Tank 105-AW are listed in Table 4-2. Because some of the waste in Tank 105-AW will ultimately be vitrified, the acceptance criteria for the vitrification facility are also important. Preliminary acceptance criteria for the vitrification facility are discussed in the following section.

Methods of preventing a nuclear criticality include using neutron absorbers or storing the sludge in tanks that are geometrically favorable for criticality prevention. The use of neutron absorbers was evaluated by Daling and Vail (1997) and two options for achieving criticality control were identified:

- A co-precipitated solid having the absorber bound in the crystal structure with the fissile material
- A physical mixture of absorber and sludge in which the particle size is small enough that the particles of fissile material and neutron absorber remain intermingled.

The chemical co-precipitation option could be achieved by dissolving the uranium-bearing K Basins sludge in acid, adding a neutron absorber (ferric nitrate was recommended), and reprecipitating the solution through caustic addition. The physical mixture option would involve reducing the maximum particle size of the sludge to meet a particle size limit to be set somewhere in the range of 10 to 50 microns and blending it with ferric oxide particles meeting the same maximum particle size limit.

The pyrophoricity and reactivity associated with metal fines in the sludge (specifically, uranium and zirconium) can be addressed by oxidizing or removing the metal. The acid dissolution process used to co-precipitate neutron absorber would oxidize uranium, but would not be aggressive enough to oxidize zirconium. Other processes for chemical oxidation are available, including enhanced oxidation with water under certain conditions. Thermal treatment (i.e., heating the sludge to high temperatures in air) can also be used to oxidize metals.

Flammable gas is generated both by corrosion of metal fines and by radiolysis of water in the sludge. Oxidizing the metals can reduce the production of flammable gas. Limiting the volume and density of the sludge as stored in a DST can mitigate excessive accumulation of flammable

gas in the sludge that can result in a sudden release. Drying the sludge can reduce radiolytic gas generation, although drying would not be appropriate for tank storage.

Subsequent to the ARES study, further consideration has been given to other storage options, in particular storage in a new tank or as a solid waste. A new tank for the sole purpose of storing K Basins sludge would not necessarily be cost effective. However, if evaluation of the need for additional tanks within the TWRS program indicates that additional tank capacity is required, it could be advantageous to include consideration of the K Basins sludge in the design of new tanks. For example, a new tank could be designed and constructed to be geometrically favorable for criticality prevention; otherwise, criticality prevention likely would be provided in much the same manner as in an existing DST. The primary difference between using an existing DST and a new tank would be that an existing tank would have some fissile material in it that would have to be accounted for in calculating limits for criticality prevention. A new tank could also be provided with mixing systems and ventilation systems that could mitigate flammable gas concerns and provide greater flexibility on particle size, for example, if in-tank mixing were to be provided. Another tank storage alternative that has been proposed is to store the sludge in a new or existing tank at the T Plant. The T Plant is a former reprocessing facility that currently serves as a decontamination facility for large equipment.

The K Basins sludge could also be packaged in containers and stored as a solid waste at the Hanford Central Waste Complex (CWC) in the 200 Area. The CWC is authorized to store mixed waste and has specific areas for storage of TSCA-regulated TRU waste. Key acceptance criteria at the CWC are provided in Table 4-2. Criticality control for solid waste is relatively simple (although potentially expensive) and can be achieved by a combination of geometrically favorable containers and limiting the quantity of sludge in individual containers. However, high radioactivity levels such as those associated with the K Basins sludge would present other concerns with storage as a solid. Containers with relatively large quantities of sludge would have high surface dose rates and would require remote handling. Remote-handled storage capacity at the CWC is limited. Smaller quantities of sludge could be placed into containers with substantial overpacking to achieve contact-handled dose rates, but this would generate a larger number of containers, again with the potential for capacity issues. Capacity limitations at the CWC and the potential need to expand CWC would have to be considered as part of any solid waste storage option.

4.2 SLUDGE DISPOSAL

The K Basins ROD (61 FR 10736) did not specify how sludge in interim storage would ultimately be disposed, although there was an underlying assumption that if the sludge were to be stored in a DST, it would be treated and disposed with the tank waste. In any case, disposal options for the sludge are limited mainly because of the waste designation and radioactivity. Disposal options are listed and evaluated in Table 4-3. The disposal options are essentially driven by the waste acceptance criteria associated with each disposal facility. The waste acceptance criteria for the facilities are listed in Table 4-4.

For final disposal of the K Basins sludge, the distinguishing features of disposal options are a disposal facility's ability to accept TRU waste or HLW. It has not been determined which designation will apply to the treated K Basins sludge. Neither TRU waste nor HLW can be disposed at the Hanford Site. Waste that is TRU can be disposed of at the Waste Isolation Pilot Plant (WIPP) in New Mexico and presumably at the planned national geologic repository (if WIPP disposal is not an option). The WIPP is a RCRA-permitted facility, but it is not a TSCA-permitted landfill. Although TSCA regulations allow bulk PCB remediation waste (like the sludge) to be disposed at either a TSCA-approved chemical waste landfill or a RCRA-permitted (or State of Washington equivalent) landfill (40 CFR 761.61), the WIPP waste acceptance criteria limit PCB concentrations to less than 50 ppm (DOE 1996b). The WIPP cannot accept HLW for disposal.

The national geologic repository is intended primarily for the disposal of SNF and HLW. At this time, it is anticipated that the national geologic repository will not be a RCRA-permitted facility. Mixed waste must be treated to remove hazardous waste characteristics (and delisted, if appropriate) prior to repository disposal (TRW 1996). It is further anticipated that the national geologic repository will not seek approval as a TSCA-approved landfill.

Although disposal of the sludge at Hanford Site facilities is prohibited if it is TRU waste or HLW, acceptance criteria for selected Hanford facilities are provided because they may be considered for disposal of non-TRU wastes generated during sludge treatment. For example, the ERDF is a CERCLA-authorized facility that can accept mixed LLW and certain types of PCB-contaminated waste.

4.3 SLUDGE TREATMENT

Treatment technologies and process options focus on preparing the sludge to meet acceptance criteria for the various storage/disposal options discussed in Sections 4.1 and 4.2. The treatment options address the following issues: nuclear criticality, corrosivity, flammable gas generation, pyrophoricity, particle size for retrievability, and PCBs.

Many treatment technologies and process options for the K Basins sludge have been considered in previous Hanford studies (Beary et al. 1995, Papp 1997, Ashworth and Flament 1998, Precechtel and Turnbaugh 1998) and are summarized in Table 4-5. The table also identifies treatment options that have been identified from other sources. Process options are grouped into the categories of physical, thermal, and chemical treatment technologies.

As discussed in Section 4.1, nuclear criticality prevention, metal fines, and flammable gas generation, accumulation, and sudden release are the overriding concerns for tank storage of the sludge. Processing options to address these issues include the following:

- Criticality: chemically dissolving the fissile material in the sludge and coprecipitating with a neutron absorber, or blending the sludge with a neutron absorber and reducing the particle size of the mixture to such a size (10 to 50 microns) that separation of the particles becomes physically impossible.

- Metal fines: chemical or thermal oxidation, high-energy milling (water oxidation enhanced by particle size reduction), and solidification.

- Flammable gas: oxidation of metal fines, moisture reduction, minimization of solids volume and density.

A treatment system designed to address criticality, metal fines, and flammable gas might also address the issues of corrosivity, organic resin beads, and PCBs. If it does not, additional treatment processes can be added to the system, as appropriate. Corrosivity can be addressed by chemical adjustment of the sludge. Resin beads can be addressed via physical separation, (e.g., sieving), thermal treatment to pyrolize or oxidize the resin, or stabilization (e.g., grouting). Process options that would remove PCBs from the sludge include low temperature volatilization (which could occur during acid dissolution of the sludge), solvent extraction, mechanochemical reaction (e.g., addition of calcium oxide in a high-energy mill), low temperature thermal desorption, or high temperature thermal oxidation or pyrolysis.

At least three offsite facilities capable of treating some TSCA-regulated radioactive waste are currently available or are planned to be available in the DOE complex at the time sludge is removed from the basins:

- A LLW TSCA-permitted treatment unit is planned as part of the privately-operated Allied Technology Group mixed waste treatment facility to be constructed in Richland, Washington, near the Hanford Site. The facility is expected to be operational within several years. The facility is not designed for treating high-activity TRU waste. Thus, it could not treat sludge directly. However, it may be of value for treating secondary wastes associated with sludge treatment or other basin cleanout activities.

- A TSCA-permitted facility for treating PCB-contaminated contact-handled TRU waste is proposed as part of the Advanced Mixed Waste Treatment Facility at the Idaho National Engineering Laboratory in Idaho Falls, Idaho. The facility is proposed to open in 2003.

- A LLW TSCA-permitted incinerator currently operates at the Oak Ridge National Laboratory. Again, this facility cannot accept TRU waste, but it may be a viable treatment facility for secondary wastes generated as a result of sludge treatment or other basin cleanout activities. A limitation is that the State of Tennessee currently prohibits out-of-state waste from being received at the incinerator.

Table 4-1. Screening of Options for Storage of K Basins Sludge. (2 Sheets)

Storage Option	Comments	Applicability
Existing DST (cladding removal tank or neutralized acid waste tank)	• Advantages: - Low incremental cost for interim storage/disposition if treated to TWRS acceptance criteria because it uses an existing facility - Good blending characteristics between K Basins sludge and tank waste for vitrification - No new construction required - DST retrieval/disposition pathway already identified • Issues/disadvantages: - Potential safety concerns related to criticality control, metal fines, flammable gas - Requires potentially extensive treatment to meet Tank Waste Remediation System (TWRS) acceptance criteria - Adds to overall volume of DST system.	Baseline storage option for slurry product from chemical treatment of sludge
New Tanks (critically safe or non-critically safe)	• Advantages - Does not add to volume in DST system - May reduce sludge treatment requirements (more likely for critically safe tanks than non-critically safe tanks) - May allow greater flexibility in performing sludge treatment (e.g., in-tank treatment) - Could be coordinated with vitrification project • Issues/disadvantages - Tradeoff between concentrated storage (more criticality and off-gas control issues) and dilute storage (would require additional tank space) - Retrieval/disposition pathway not identified - If not blended with other tank waste for vitrification, substantial increased cost (~$30 M) associated with production of additional glass logs - Moderate (noncritically safe) to high (critically safe) cost for new tanks	Potentially applicable for alternate storage of slurry product from treatment of sludge
Shielded Container	Container storage would require a facility at which to store the containers such as CWC, Canister Storage Building (CSB), or T Plant described below.	
Railcars	• Advantages - Does not require construction of a new facility - Does not add to volume in DST system • Issues/disadvantages - Issues related to unknown retrieval process, freeze protection, and gas generation - Potential exposure to workers during loading/offloading - Rail upgrade required - Process/location for offload to feed vitrification facility undefined - Railcar storage area unidentified - Possible weight limitations associated with load plus shielding	Eliminated from further consideration

Table 4-1. Screening of Options for Storage of K Basins Sludge. (2 Sheets)

Storage Option	Comments	Applicability
KW Basin	• Advantages - Does not add to volume in DST system - Delay in retrieving sludge may allow direct feed to vitrification facility • Issues/disadvantages: - Would not meet Tri-Party Agreement schedule - Requires significant upgrades at basin (heating and ventilation) - Requires verification that SNF mixed with sludge has been removed	Extended storage at K Basins eliminated from further consideration because delay conflicts with regulatory agreements
Central Waste Complex (CWC)	• Advantages - Does not add to volume in DST system - Uses an existing facility • Issues/disadvantages - Option to store as remote-handled waste (less volume) or over pack and store as contact-handled waste (greater volume) - Potential capacity limits at CWC - Would require treatment prior to storage for pyrophoric metals - No current plans for PCB treatment system at CWC	Potentially applicable for storage of dry solids from some sludge treatment processes
Canister Storage Building (CSB)	• Advantages - Does not add to volume in DST system - May be able to utilize existing multi-canister overpack (MCO) design as starting point for sludge container design - Uses an existing facility • Issues/disadvantages - Potential capacity limits at CSB - Potential safety concerns with use of existing MCO design for small particle storage - Storage criteria/impacts/sludge treatment requirements undefined	Potentially applicable for storage of dry solids from some sludge treatment processes
T Plant	• Advantages - Does not add to volume in DST system - Uses an existing facility • Issues/disadvantages - Storage criteria/impacts/sludge treatment requirements undefined - Extent of facility modification required unknown	Would require further evaluation; not considered further in FFS

Table 4-2. Acceptance Criteria for Selected Interim Storage Facilities.

Sludge Characteristic	Tank Waste Remediation System (TWRS) Tank 241-AW-105 (Carothers et al. 1997)	Central Waste Complex (CWC) (FDH 1998)
Corrosion	Nitrite and hydroxide concentrations as specified in Lockheed Martin Hanford Corporation (1996)	Waste compatible with container
Criticality	Maintain K_∞<0.95 (for pH > 8, particle size < 50 microns and neutron absorbers)	Fissile material limited to 177 Pu-239 FGE/55-gallon drum and Class C limits; Greater than Class C with DOE approval
Energetics	No separable organic layer; exotherms/endotherms < 1.0	No requirement specified
Flammable gas	Eliminate non-radiolytic gas generation; SpG x solids depth < 148 (solids < 379 m^3)	Radiolytic gas generation must be controlled
Heat generation	<70,000 BTU/hr (commingled with DST contents)	< 3.5 watts/m^3 or ensure integrity of container
Particle size	Less than 177 microns (for retrieval/mobilization)	No requirement specified
Pyrophoric material	Eliminate reactive materials in sludge	Radioactive pyrophorics < 1%; non-radioactive pyrophorics prohibited
RCRA-regulated metals	Waste codes acceptable	Waste codes acceptable
TSCA-regulated material	Prohibited, unless there is a formal determination that TSCA regulations do not apply	Acceptable for non-TRU waste; requires DOE approval for TRU waste because of WIPP exclusion

Table 4-3. Screening of Options for Final Disposal of K Basin Sludge.

Disposal Option	Screening Comments	Applicability
Waste Isolation Pilot Plant (WIPP)	Authorized for disposal of TRU waste. May be able to accept mixed waste in the future, but not yet approved. Prohibits waste with PCB concentrations $\geq$ 50 ppm.	Suitable for sludge designated as TRU waste. Likely requires treatment for PCBs in sludge.
National geologic repository for SNF and HLW	Hazardous or mixed waste disposal may be prohibited. No criterion established relative to PCBs. Currently identifies only borosilicate glass as a standard waste form.	Suitable for range of sludge designations. May require treatment for PCBs $\geq$ 50 ppm.
Hanford Site mixed waste trenches (Trenches 31 and 34)	Currently accepting waste for storage but not for final disposal.	Suitable for non-TRU, non-TSCA regulated mixed wastes.
Hanford Site low-level burial grounds	Authorized to accept only LLW for disposal. Mixed waste and TSCA-regulated waste prohibited.	Suitable for non-TRU, non-TSCA regulated LLW.
Hanford Site grout vaults	Anticipated use of grout vaults is for disposal of low-activity vitrified tank waste. Disposal of TRU waste prohibited.	Potentially suitable for non-TRU, non-TSCA regulated waste, but unlikely to be available.
Hanford Site Environmental Restoration Disposal Facility (ERDF)	Authorized to accept mixed LLW. Disposal of TRU waste prohibited. PCBs can be accepted.	Suitable for disposal of non-TRU, TSCA-regulated mixed wastes.

Table 4-4. Acceptance Criteria for Final Treatment and Disposal Facilities.

SLUDGE CHARACTERISTIC	Acceptance Criteria				
	High-Level Waste Envelope[a] (DOE-RL 1998b)	**National Geologic Repository (TRW 1996)**	**Waste Isolation Pilot Plant (Remote Handled TRU) (DOE 1996b)**	**Low Level Burial Grounds (FDH 1998)**	**Environmental Restoration Disposal Facility (BHI 1998)**
Particle Size	< 177 microns[b]	Particulate materials must be incorporated into encapsulating matrix	Not applicable	Not applicable	Not applicable
Pyrophoric Constituents	Prohibited[c]	No pyrophoric or reactive materials in amount that would compromise repository	Radioactive pyrophorics: <1%. Non-radioactive pyrophorics prohibited	Prohibited	Prohibited
Flammable Gas	Cannot cause[c] episodic gas generation	No combustible waste forms or explosive materials	Flammable VOCs ≤500 ppm in headspace	Must be controlled to limit pressures to 1.5 atm over 20 years	≤ 10 % organic/ carbonaceous material
Fissile Material	Pu < 0.054 g/100 grams waste oxides	Pu < 2500 grams/m^3	< 325 g total of Pu-239 FGE/cask	< 100 nCi/g and < Class C limits	<100 nCi/g and <Class C limits
Activity/Dose Rate	Specific maximum, Ci/100 grams oxides: Cs-137: 1.0E+01 U-233: 9.0E-07 U-235: 2.5E-07 Pu-238: 3.5E-04 Pu-239: 3.1E-03	Radiolytic heat generation < 1500 watts per canister	<23 Ci/L total activity ≤1000 rem/hr per canister ≤200 mrem/hr per cask	Contact handled: <200 mrem/hr, contact; <100 mrem/hr at 30 cm Remote handled: ALARA but must not exceed 100 mrem/hr	
TRU Waste	TRU constituents accepted in HLW.	Accepted if Nuclear Regulatory Commission (NRC) determines geologic disposal appropriate	Accepted (non-TRU waste specifically prohibited)	Prohibited	Prohibited
RCRA-Regulated Waste	Accepted	Prohibited	Accepted for specific waste codes	Accepted at mixed waste trenches with appropriate treatment	Accepted with appropriate treatment
TSCA/PCB-Regulated Waste	TSCA-regulated waste prohibited	No criterion defined	<50 ppm PCBs (indirect TSCA waste prohibition)	<50 ppm PCBs (indirect TSCA waste prohibition)	Solids containing PCBs accepted

[a] Vitrified HLW will be stored at CSB prior to final disposal at the national geologic repository.
[b] Not specified in Envelope D. Limit from Carothers (1997).
[c] Not specified in Envelop D. Limitation based on preliminary treatment facility design and operation.

Table 4-5. Screening of Options for Treatment of K Basin Sludge. (5 Sheets)

Technology Type	Process Option	Screening Comments	Purpose/Benefit
Solidification/ Stabilization	Macro encapsulation	Application of surface coating materials such as polymeric organics (e.g., resins and plastics) or use of a jacket of inert materials to substantially reduce surface exposure to potential leaching material.	Purpose: reduce mobility of certain contaminants in sludge or debris waste streams designated as mixed waste. Benefit: meeting land disposal restriction (LDR) treatment standards.
	Grouting	Encapsulating contaminants as fine particles within a solid grout (solidification) or chemically reacting contaminants with a stabilizing agent to reduce mobility (stabilization). Target contaminants are heavy metals, including certain radionuclides; pozzolanic and cement-based binding agents are typically appropriate for these contaminants (EPA 1993a). Effectiveness with organic contaminants varies. Limited effectiveness for PCBs; test results do not typically show significant differences between the leachability of PCBs in the untreated and treated medium (EPA 1993a).	Purpose: reduce leachability of certain contaminants in sludge or debris waste streams designated as mixed waste. Benefit: meeting LDR treatment standards.
Physical Treatment	Grinding	The use of mechanical processes to reduce particle size. Standard methods include ball mills or hammer mills and typically cannot achieve very fine particle sizes.	Purpose: reduce particle size in sludge. Benefit: meeting particle size limits for sludge storage/treatment.
	High-energy milling	A well-established process used in the ceramics, powder metallurgy and pharmaceutical industries to prepare fine particle slurries and powders and to accomplish powder/liquid reactions. Hard, wear-resistant milling media, such as alumina, zirconia, and silicon carbide, would be required for uranium particles due to hardness (Precechtel and Turnbaugh 1998). The increased surface area of the particles coupled with process heat generation would cause metals and metallic hydrides to react rapidly with slurry water to form stable hydrated oxides (Precechtel and Turnbaugh 1998).	Purpose: reduce particle size and oxidize metals and metal hydrides in sludge. Benefit: meeting sludge storage/ treatment criteria for particle size and reactivity.

Table 4-5. Screening of Options for Treatment of K Basin Sludge. (5 Sheets)

Technology Type	Process Option	Screening Comments	Purpose/Benefit
	Sieving	The use of screens of varying mesh size to segregate particles.	Purpose: separate larger particles (e.g., resin beads) from bulk sludge. Benefit: facilitate further sludge treatment.
	Phase separation	Takes advantage of differences in physical properties (e.g., density, form) to segregate two or more phases. Examples include solids-liquids separation using filtration or settling and decanting.	Purpose: remove specific components from sludge (e.g., resin beads, PCBs) or secondary waste streams (e.g., PCBs in off-gases). Benefit: facilitate further sludge treatment, meet PCB treatment standards .
Thermal Treatment	Vitrification	A proven technology, primarily for the stabilization of contaminants. Wastes or contaminated media are mixed with glass formers and heated to 1,200° C (2,000 °F) to melt and convert the mixture into glass (Federal Remediation Technologies Roundtable [FRTR] 1998). Borosilicate and soda-lime are the principal glass formers and provide the basic matrix of the vitrified product. The high temperatures volatilize or destroy organic constituents with few byproducts. Heavy metals and non-volatile radionuclides are incorporated into the glass structure which is a relatively strong, durable material that is resistant to leaching. Vitrification has been demonstrated to destroy PCBs under specific operating conditions (Davila et al. 1993). However, under some conditions, such as vitrification designs that use lower temperatures, PCBs could be volatilized rather than destroyed, necessitating PCB treatment of the off-gas.	Purpose: immobilize heavy metals and radionuclides and volatilize/destroy PCBs. Benefit: stabilize sludge to meet long-term storage criteria and potentially remove solidified sludge from TSCA regulation.

Table 4-5. Screening of Options for Treatment of K Basin Sludge. (5 Sheets)

Technology Type	Process Option	Screening Comments	Purpose/Benefit
	Thermal desorption	A proven technology for removing organic contaminants including PCBs from wastes or contaminated soils and sludges (Papp 1997). Wastes are heated to 150 to 560 °C (300 to 1,000 °F) to volatilize water and contaminants (Davila 1993). A carrier gas or vacuum system transports volatilized water and organics to a gas treatment system. Bed temperatures and residence times designed into these systems will volatilize selected contaminants but will typically not oxidize them (Davila 1993). Particulate material is removed by conventional particulate removal equipment, such as wet scrubbers or fabric filters. Contaminants are removed through condensation followed by carbon adsorption, or they are destroyed in a secondary combustion chamber or a catalytic oxidizer (FRTR 1998). Thermal desorption is being used to remove PCBs from LLW at the Sandia National Laboratory (Richardson 1996).	Purpose: volatilize PCBs and potentially oxidize some metals and metal hydrides. Benefit: remove solidified sludge from TSCA regulation and potentially reduce sludge reactivity to meet long-term storage criteria.
	Incineration (dry oxidation)	A well-established and proven technology for the destruction of organic contaminants including PCBs (Davila et al. 1993). Incineration uses high temperatures, 870 to 1,400 °C (1,400 to 2,500 °F), to volatilize and combust organic contaminants in the presence of oxygen. Destruction of PCBs requires temperatures of are 1,200 to 1,400°C. The destruction and removal efficiency for properly operated incinerators meets the 99.9999% requirement for PCBs. Off-gases and combustion residuals generally require treatment. In the case of K Basins sludge, specific off-gas concerns would be Cs, C, I, Kr, Tc and Ru (Papp 1997). Incineration would also oxidize metals and metal hydrides present in the waste matrix. However, unless particle sizes are very small, the oxide coating formed on the metal must be continuously removed (e.g., through agitation) to maintain reaction rates (Papp 1997).	Purpose: oxidize metals and metal hydrides and destroy PCBs. Benefit: reduce sludge reactivity to meet long-term storage criteria and remove incinerated sludge from TSCA regulation.
	Calcination/ Pyrolysis	Demonstrated technologies that are closely related in that they use high temperatures to effect a chemical reaction. Calcination is the heating of a solid to a temperature below its melting point to effect a thermal decomposition or phase transition other than melting. Calcination is often performed in the presence of oxygen or other oxidizing gas. Pyrolysis is the conversion of a compound into one or more other substances by heat alone and in the absence of oxygen. Operating temperatures for both are typically above 430 °C (800 °F). Calcination and pyrolysis of organic materials produces combustible gases, including carbon monoxide, hydrogen and methane, and other hydrocarbons. The off-gases are treated by combustion or condensation. Particulate removal equipment is also required. Chemical contaminants for which treatment data exist include PCBs.	Purpose: oxidize metals and metal hydrides and volatilize PCBs. Benefit: reduce sludge reactivity to meet long-term storage criteria and remove dry sludge from TSCA regulation.

Table 4-5. Screening of Options for Treatment of K Basin Sludge. (5 Sheets)

Technology Type	Process Option	Screening Comments	Purpose/Benefit
Chemical Treatment	Acid dissolution/ caustic precipitation	A proven technology for first dissolving then resolidifying the uranium found in SNF, offering opportunities to separate the SNF components (Papp 1997). In laboratory tests with K Basins sludge, two product streams are generated: the dissolved/precipitated solids (containing the bulk of the radionuclides) and solids that are insoluble in nitric acid (zirconium alloy, sand/gravel, ion exchange beads). The dissolution/precipitation process reduces particle size and oxidizes metallic uranium and uranium hydrides (Papp 1997). With the addition of an appropriate neutron absorber (e.g., iron) prior to precipitation, the process can also provide criticality control.	Purpose: oxidize metals and metal hydrides in sludge and provide criticality control. Benefit: reduce sludge reactivity and provide criticality control to meet interim storage and future treatment criteria.
	Chemical oxidation	Use of chemical agents to oxidize metals, metal hydrides, and/or PCBs. Potential oxidizers for uranium and uranium hydride include hydrogen peroxide (in nitric acid), iodine (in 2-propanol), and sodium hypoclorite (Papp 1997). The reaction rate for iodine is relatively slow, and no information is available on the ability to oxidize other reactor fuel components (Zircaloy) or on the production of off-gas products. Sodium hypochlorite produces chlorine in addition to other off-gasses. Potential oxidizers for PCBs include hydrogen peroxide, used with ultraviolet radiation or ferrous iron, Fe(II) (Fenton's reagent) (Papp 1997). If complete mineralization is achieved, the final products of oxidation are carbon dioxide, water, and salts (EPA 1993b). Carbonates, nitrates, and metal oxides can inhibit contaminant destruction efficiency (EPA 1993b).	Purpose: oxidize metals, metal hydrides, and/or PCBs in sludge. Benefit: reduce sludge reactivity to meet interim storage and future treatment criteria, potentially remove sludge from TSCA regulation.
	TRU-targeted ion exchange	A two-step process whereby the waste stream is dissolved in nitric acid and the resulting solution is processed through ion exchange resin to separate TRU from non-TRU components (Papp 1997).	Purpose: reduce TRU concentrations in secondary waste streams from sludge treatment. Benefit: allow waste stream to be disposed as a LLW rather than a TRU waste, allows consideration for disposal at the ERDF.
	Water oxidation	Oxidation of metals and metal hydrides by water. The reaction rate for uranium and uranium hydride is slow at temperatures under 100°C; a faster rate would require a pressurized reactor to effect higher temperature (Papp 1997).	Purpose: oxidize metals and metal hydrides in sludge. Benefit: reduce sludge reactivity to meet interim storage and future treatment criteria.

Table 4-5. Screening of Options for Treatment of K Basin Sludge. (5 Sheets)

Technology Type	Process Option	Screening Comments	Purpose/Benefit
	Base-catalyzed decomposition	A demonstrated process for destroying PCBs. The PCB-contaminated medium is mixed with sodium bicarbonate and heated to above 330°C (630°F) to partially decompose and volatilize PCBs (Papp 1997). The volatilized PCBs are captured and condensed. The vapor condensate is treated by reacting with sodium hydroxide at 350°C (662°F) in hydrocarbon solvent in the presence of a catalyst (Davila et al. 1993).	Purpose: oxidize PCBs in sludge. Benefit: potentially remove sludge from TSCA regulation.
DOE	Dechlorination	A demonstrated process for destroying PCBs (Davila et al. 1993). Contaminated media and an alkaline polyethylene glycol reagent are mixed and heated in a treatment vessel. The reaction causes the polyethylene glycol to replace chlorine molecules and render the PCBs nonhazardous or less toxic (Davila et al. 1993). Byproducts include glycol ether and/or a hydroxylated compound and an alkali metal salt. The process often takes numerous cycles of the process to achieve the desired results, effects partial dehalogenation, and dioxins and furans often form (Papp 1997).	Purpose: oxidize PCBs in sludge. Benefit: potentially remove sludge from TSCA regulation.
	Mechano-chemical destruction of PCBs	A variation on the base-catalyzed decomposition. This is a low temperature process (on a macro-scale) in which chemical reactions are induced by mechanically milling in the presence of suitable reactants. The milling action induces very high micro-scale temperatures (Hall et al. 1996). The destruction of PCBs (Arochlor 1254) using calcium oxide in a laboratory sized ball mill has been demonstrated (Rowlands et al. 1994; Donecker, 1997).	Purpose: oxidize PCBs in sludge while reducing particle size. Benefit: potentially remove sludge from TSCA regulation and meet interim storage and future treatment criteria for particle size.
Biological Treatment	Aerobic	A process whereby organic contaminants are destroyed or transformed to less toxic chemicals by bacteriological processes in the presence of air. Contaminated media are aerated either in situ or ex situ, often with the addition of nutrients, water, and/or heat, to facilitate bacterial action. Although proven effective for petroleum products and many volatile organic contaminants, aerobic degradation is not typically effective with PCBs.	Not applicable to contaminants or characteristics of K Basins sludge.
	Anaerobic	A process whereby organic contaminants are destroyed or transformed to less toxic chemicals by bacteriological processes in the absence of air. Nutrients, water, and/or heat may be added to facilitate bacterial action. Anaerobic treatment is not typically effective with PCBs (Davila et al. 1993).	Not applicable to contaminants or characteristics of K Basins sludge.

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5.0 DESCRIPTION OF ALTERNATIVES

This section describes the remedial alternatives determined to be suitable for the cleanout of the K Basins interim remedial action. The alternatives were developed using the remedial technologies and screening of process options presented in Section 4.0 and represent a range of technology types. The descriptions of the alternatives are based on the present understanding of the chemistry and physics of the K Basins sludge and currently available information on treatment technologies and waste management facility acceptance criteria. More definitive conceptual and detailed designs of the sludge treatment system selected in the ROD for this CERCLA action will be conducted during remedial design.

The remedial alternatives for sludge management consist of the following:

- Alternative 1: No Action
- Alternative 2: Chemical Treatment
- Alternative 3: Thermal Treatment
- Alternative 4: Physical Treatment.

These alternatives are described in Sections 5.1 through 5.4. Alternatives 2 through 4 share the common goal of treating the sludge sufficient to meet requirements for interim storage and final disposition. Key drivers in all of the treatment alternatives are assuring nuclear criticality prevention; reducing reactivity (associated with metals and metal hydrides); controlling flammable gas generation, accumulation, and sudden release; and removing or destroying PCBs, as appropriate. Other drivers (e.g., reducing particle size) are specific to the alternative.

The CERCLA action also includes managing SNF, water, and debris, and deactivation of the basins. Alternatives 2 through 4 are identical with respect to these activities. Section 5.5 describes these common elements.

5.1 ALTERNATIVE 1: NO ACTION

CERCLA regulations (40 CFR 300) require that a No Action Alternative be evaluated as a baseline for comparison with other remedial alternatives. The No Action Alternative represents a situation where there is continued storage of the SNF, sludge, debris, and water in the K Basins for up to 40 years with no modifications except for routine maintenance, monitoring, and ongoing safety upgrades. There would be no major upgrades to significantly enhance storage capabilities. The No Action alternative is included only to provide a baseline for evaluation; it is not the intent to change the decision made via the NEPA process to remove the SNF, sludge, water, and debris.

5.2 ALTERNATIVE 2: CHEMICAL TREATMENT

This alternative generally would use chemical processes to treat the sludge to make it acceptable for interim storage and final disposition. The strategy under this alternative would be to treat the sludge to separate the sludge into two fractions: a high TRU concentration[9]/low PCB concentration fraction and a low TRU concentration/high PCB concentration fraction. The goal would be to treat the high TRU concentration/low PCB concentration fraction to meet interim tank storage and vitrification facility acceptance criteria and to treat the low TRU concentration/high PCB concentration fraction to meet the ERDF waste acceptance criteria.

5.2.1 Sludge Retrieval and Removal

In general, canister, floor, and pit sludge would be collected (retrieved) and moved to staging locations (such as existing pits) within the basins for consolidation and interim storage until SNF removal is complete. Sludge would also be collected from the wash stations associated with the Fuel Removal System, from the water treatment systems, and from the debris removal systems. From the staging locations, the sludge would be removed from the basins via the Sludge Loadout System into specially-designed containers on transport trailers and transported to the sludge treatment system. It is currently anticipated that five distinct sludge streams would be removed as follows:

1) KE Basin floor and pit sludge with particle sizes less than 0.64 cm, plus fuel-washing sludge with particle sizes between 250 micron and 0.64 cm

2) KE Basin fuel-washing sludge with particle size less than 250 microns

3) KW Basin floor and pit sludge with particle size less than 0.64 cm

4) KW Basin fuel-washing sludge with particle sizes between 500 microns and 0.64 cm

5) KW Basin fuel-washing sludge with particle sizes less than 500 microns.

5.2.2 Chemical Treatment

Chemical treatment involves changing the chemical nature of a material to stabilize, transform, remove, or destroy contaminants. The SNF Project baseline assumes that the high-TRU sludge fraction will be stored in an existing DST, so preliminary evaluations of chemical treatment requirements have focused on existing DST and management under the Tank Waste Remediation System (TWRS) program. Interim storage of the K Basins sludge in a DST requires that the sludge meet a set of acceptance criteria (Table 4-2). To meet these criteria, the sludge must be treated to control criticality (by reducing particle size and adding neutron absorbers), eliminate pyrophoricity (by oxidizing or removing metal fines), and reduce particle size for retrievability. PCBs must also be removed or destroyed unless the vitrification facility is permitted to accept

[9] A goal of separating high and low TRU fractions would be to minimize the volume of waste that must be managed as TRU waste. Thus, a low TRU fraction would be one in which the final waste form (after treatment and stabilization, as appropriate) would have a TRU concentration of < 100 nCi/g.

and treat PCBs. Storage in a tank (such as a vitrification plant feed tank) other than an existing DST is also a possibility. Many of the issues related to storage in an existing DST are relevant to any interim tank storage. However, the waste acceptance criteria for a tank other than an existing DST may be more flexible depending on the design and capabilities of the other tank.

The separation of the sludge into fractions with different compositions could potentially be achieved one of two ways:

- By using chemical and/or physical methods during treatment to separate components of the sludge that have different characteristics (e.g., separating insoluble sand from acid-soluble uranium compounds).

- By keeping sludge from different locations in the basins separated during retrieval and removal activities (e.g., keeping floor sludge, which has relatively low concentrations of TRU constituents separate from canister sludge, which has relatively high concentrations of TRU constituents)

Treatability tests have focused on using the treatment process to separate the components of the sludge. Further evaluation is being done as part of the Sludge Treatment Alternatives Analysis to determine whether adequate separation of the high TRU concentration and low TRU concentration fractions in the sludge could be achieved by selective retrieval and removal from the basins. In the baseline treatment process and for purposes of developing this alternative, it is assumed that the chemical treatment process is used to achieve separation.

In this alternative, chemical treatment would be used to treat the sludge to achieve nuclear criticality prevention, eliminate pyrophoricity, minimize corrosivity, and reduce particle size for retrievability. The process would also remove PCBs from the sludge; the PCBs would end up in secondary waste streams. A simplified flowsheet illustrating the process is shown in Figure 5-1. The preliminary design flowsheet for chemical treatment includes the following operations (Westra et al. 1998):

- Sieving the sludge on a screen to remove the organic resin beads, Grafoil, and some inorganic ion exchange media followed by separation of the resin from larger sludge particles in an elutriation column

- Dissolving the sludge in nitric acid

- Physically separating residual solids (mostly zirconium, sand, dirt, and the remaining inorganic ion exchange media) from the solution

- Adding iron and/or depleted uranium as a neutron absorber

- Precipitating the solution using caustic solution

- Chemically adjusting the solution using sodium nitrite

- Leaching the organic resin beads to remove absorbed TRU constituents

- Leaching the insoluble solids to remove absorbed TRU constituents
- Combining and stabilizing the resin beads and insoluble solids in a grout matrix.

Based on engineering studies and laboratory tests of the individual steps in the chemical treatment process, the overall process would produce a sludge that would meet TWRS waste acceptance criteria as defined in Table 4-2 (Westra et al. 1998). The acid dissolution step would oxidize uranium metal and uranium hydride, reducing the pyrophoricity and reactivity associated with those constituents. The addition of neutron absorber combined with particle size reduction would provide nuclear criticality prevention. Corrosivity would be addressed by the chemical adjustment step. Based on tests of the acid dissolution step, some PCBs would volatilize during the acid dissolution, some would plate onto the treatment system equipment, and the remainder would be retained with the undissolved solids (Mong et al. 1998). The test results showed that the expected concentration of PCBs in the solids fraction of the treated sludge waste stream would be well below 2 ppm, EPA's treatment requirement for solids and sludges that are treated using alternative treatment methods (Boomer et al. 1988). The chemical treatment process would be refined during remedial design to optimize the treatment steps and achieve the most cost-effective process.

Based on the project baseline flowsheet and laboratory tests, the waste streams that would be generated from treatment would include the following:

- Treated sludge. It is anticipated that the treated sludge would be designated as a mixed TRU waste or HLW. Because the sludge would contain less than 2 ppm PCBs, it would meet TSCA treatment requirements for alternative treatment and would no longer be regulated under TSCA (Boomer et al. 1988).
- Insoluble solids/ion exchange media and resin beads. After leaching, it is anticipated that these streams would designate as either LLW or mixed LLW. Laboratory studies have shown that a large fraction of the PCBs would remain with the insoluble solids fraction, so it would be TSCA-regulated. These waste streams could be disposed of onsite at the ERDF, which can accept mixed LLW containing PCBs at TSCA-regulated concentrations. They would be combined and grouted prior to disposal.
- Contaminated off-gas. Treatment would generate an off-gas that would contain volatile and particulate radionuclides, PCBs, and other regulated contaminants (e.g., nitrogen oxides). Emissions would be controlled using technologies appropriate to the type of contaminant. PCBs in the off-gas would be absorbed using granular activated carbon (GAC).
- Granular activated carbon. The spent GAC generated from the off-gas treatment system would likely be designated as a TSCA-regulated LLW. With this designation, it would be grouted and disposed at the ERDF. There is a potential that some spent GAC would be designated as a TSCA-regulated TRU waste. In this case, it would be stored until such time as treatment facilities for TSCA-regulated TRU waste are available.

- Aqueous waste. An aqueous waste stream will be generated as a byproduct of chemical treatment. Under the project baseline, all aqueous streams generated during sludge treatment would be recycled to the treatment process. If an aqueous waste stream remains at the end of treatment, this stream would be managed with other basin water as described in Section 5.5.2.

- Miscellaneous wastes. Other potential wastes would include contaminated air filters, debris collected during initial sludge screening, contaminated equipment, personal protective equipment, etc. This debris would be managed as described in Section 5.5.3 of this FFS.

An alternative to the acid dissolution process described above is a hot water dissolution process, shown schematically in Figure 5-2. As with acid dissolution, the sludge would first be screened to remove ion exchange resin beads and Grafoil. Hot (boiling) water would be used to dissolve and oxidize the sludge materials. The product from the hot water dissolution step would be centrifuged to remove residual insoluble materials. The PCBs might be removed with the insoluble materials; alternately, a treatment step to remove PCBs might be required. The PCB treatment requirement would be less than 2 ppm PCBs in the treated sludge. Neutron absorbers would then be added to the clarified product from the centrifuge and the product would be chemically adjusted to meet TWRS acceptance criteria. The resin beads and Grafoil would likely be designated as a TRU waste. They would be stabilized (probably via grouting) and interim stored at the CWC for eventual disposal in WIPP. Insoluble materials would likely be designated as a LLW; they would be removed from the process, grouted, and disposed of at the ERDF.

As in the case with the baseline chemical process described above, treatment would generate an off-gas that would contain volatile and particulate radionuclides, PCBs, and other regulated contaminants (e.g., nitrogen oxides). Emissions would be controlled using technologies appropriate to the type of contaminant. PCBs in the off-gas would be absorbed using GAC and disposed of as described for the acid dissolution process. Under the project baseline, it is assumed that the chemical treatment system for sludge would be installed inside the Cold Vacuum Drying (CVD) facility located in the 100-K Area. The CVD facility is currently under construction and will be used to dry the SNF (Section 5.5.1). Available bays in the CVD facility would be modified to accommodate the sludge treatment system. The CVD facility has been designed to achieve a nuclear safety equivalency comparable to U.S. Nuclear Regulatory Commission (NRC)-licensed facilities. The CVD facility would be equipped with a ventilation system that would provide secondary air emissions control in addition to the ventilation system on the treatment process itself. During remedial design, the CVD facility would be further evaluated to confirm that it meets the operational and schedule requirements for the sludge treatment program. If the CVD facility is determined not to meet those requirements, or if it is determined that there is a more cost-effective treatment location, the regulatory agencies, stakeholders, and the public would be involved, as appropriate in selection of another facility.

The chemical treatment alternative is not intended to address the dangerous waste characteristics of the sludge (the existing DSTs are approved to store mixed waste and the TWRS vitrification facility would immobilize the metals in the sludge, eliminating that characteristic). However, the treatment process would have to be designed to meet dangerous waste design standards. These would include double containment and leak detection of liquid process streams, process vessels, and storage tanks.

A best available control technologies (BACT) evaluation would be performed during remedial design, as required, to identify appropriate control technologies for airborne emissions of toxics. A best available radionuclide control technologies (BARCT) evaluation would be performed, as required, to identify appropriate control technologies for airborne emissions of radionuclides. Air emissions control technologies are likely to include the use of GAC to absorb PCBs, a scrubber to remove nitrogen oxides, and high-efficiency particulate air (HEPA) filters to remove radioactive particulate matter.

5.2.3 Transfer and Disposition of Treated Sludge

The product from the chemical treatment process would be a slurry that meets TWRS waste acceptance criteria as specified in Table 4-2. With the water required to mobilize the sludge, the slurry volume transferred to the DST would be about 1,620 m^3 (430,000 gallons) for the acid dissolution option (Westra et al. 1998). A large part of this volume would be water. The treated sludge would be taken in transport packages by truck from the 100-K Area to an existing DST or another tank in Hanford's 200 Area to be off-loaded. The selected tank would have to be one that complies with the design and operating requirements specified for tank storage in the State of Washington dangerous waste regulations. The existing DSTs are operated in accordance with interim status tank storage regulations, which meet this requirement.

All transportation of the sludge would occur on the Hanford Site. A transportation safety analysis would be performed to establish the design, procedures, and controls necessary to ensure protection of workers and prevention of releases during transportation.

5.3 ALTERNATIVE 3: THERMAL TREATMENT

This alternative would use thermal methods to oxidize metals, eliminate flammability associated with the ion exchange resin, and eliminate PCBs. The goal would be to produce a solid that would either meet acceptance criteria at the WIPP or the national geologic repository or that could be used as feed to the TWRS vitrification facility. As with chemical treatment, the sludge may be separated into high TRU concentration and low TRU concentration fractions before or during treatment.

5.3.1 Sludge Retrieval and Removal

Sludge retrieval and removal would be as described in section 5.2.1

5.3.2 Thermal Treatment

Thermal treatment involves the use of elevated temperatures to stabilize, volatilize, or destroy contaminants. In the case of the K Basins sludge, thermal treatment could be used to stabilize radionuclides and metals, eliminate pyrophoricity by oxidizing metals and metal hydrides, and/or volatilize or destroy PCBs. Thermal treatment would produce a dry solid (either a solidified mass or particulate matter) that could then be packaged and placed in interim storage prior to final disposal at WIPP or the national geologic repository. If a particulate waste form is produced, it could be grouted if appropriate prior to interim storage or used as feed to the TWRS vitrification facility.

There are several thermal processes that potentially could be applied to the K Basins sludge. A general description of two candidate processes is provided below. Other potential processes include molten-salt pyrolysis and thermal desorption. Selection of one of these processes would require more detailed development to establish process flowsheets, requirements, technical feasibility, and costs for application to the K Basins sludge. The processes are being evaluated in more detail in the ongoing Sludge Treatment Alternatives Analysis.

Vitrification. Vitrification uses high temperatures to melt contaminated materials. Melters can be heated electrically or by burning a fossil fuel such as natural gas. Glass formers, stabilizers, and fluxes may be added prior to heating. The heated mass then cools to form a glass-like material. In general, vitrification immobilizes nonvolatile contaminants in the glass matrix and destroys organic materials. Applied to the K Basins sludge, vitrification would oxidize and stabilize radionuclides and metals and destroy PCBs.

As shown schematically in Figure 5-3, the sludge would be transferred to the treatment system in batches, mixed with glass formers, introduced into the melter, then heated to 1200°C or more. The PCBs typically would be destroyed in this process. Some PCBs might be volatilized and carried into the off-gas, to be treated in the off-gas treatment system.

The melter design would include specifications to provide criticality control and to meet dangerous waste requirements. The off-gas treatment system would include components to treat volatilized contaminants (including cesium and PCBs) and particulate matter. The specific components would be established during remedial design but could include condensers, GAC filters or off-gas burners for the PCBs, and HEPA filters for particulate matter. Secondary wastes generated as a result of vitrification could include spent GAC filters, contaminated HEPA filters, and contaminated water. GAC filters and HEPA filters would be disposed at the ERDF if they meet the ERDF waste acceptance criteria. If filters fail to meet the ERDF waste acceptance criteria because they designate as TRU waste, they would be taken to the CWC for interim storage until a final disposition path is identified.

Vitrification has been proven to immobilize heavy metals and radionuclides and is considered the preferred technology for radioactive waste that requires very long-term control. The vitrified product would meet land disposal restriction (LDR) requirements for treatment of heavy metals. For waste designated as dangerous waste because it fails the TCLP for heavy metals, vitrification reduces leaching such that the waste no longer designates as a dangerous waste. Vitrification

also has been used successfully to destroy PCBs in contaminated soils (Dávila et al. 1993). No vitrification testing using actual or simulated K Basins sludge has been performed, and it is likely that such testing would be required prior to implementing this alternative. The test parameters would be established during remedial design. Vitrification is defined as a physical treatment process in EPA's guidance on alternative PCB treatment (Boomer et al. 1988) so it would be subject to the alternative treatment standards of less than 2 ppm PCBs in the treated sludge to exit TSCA regulation.

Calcination. Calcination is the heating of a contaminated material to high temperatures to oxidize metals and metal hydrides and remove or destroy organic compounds. Calcination does not immobilize contaminants that remain in the product calcine. Applied to the K Basins sludge, calcination would oxidize metals and metal hydrides and volatilize or destroy PCBs. Calcination could also be used to reduce the reactivity associated with sludge and remove it from TSCA regulation.

As shown in Figure 5-4, the sludge would be transferred to the treatment system in batches, partially dried to remove the bulk of the water, then heated either in an oxygen-rich atmosphere. Calcination temperatures for treatment of the K Basins sludge would be on the order of 600°C. The PCBs in the sludge would be volatilized and carried off to the off-gas treatment system. The temperature of the process would have to be controlled to ensure that PCBs would be adequately volatilized, but fission products with relatively low boiling points, such as cesium would not be appreciably volatilized.

The calciner design would include specifications to provide criticality control and meet dangerous waste requirements. The off-gas treatment system would include components to treat volatilized contaminants (including PCBs) and particulate emissions. The specific components would be established during remedial design, but could include condensers for water vapor, GAC filters or off-gas burners for the PCBs, and HEPA filters for particulate emissions. Secondary wastes generated as a result of treatment could include spent GAC filters, contaminated HEPA filters, and contaminated water. GAC filters and HEPA filters would be disposed at the ERDF if they meet the ERDF waste acceptance criteria.

The product calcine would not meet LDR requirements for treatment of heavy metals in the waste. To address this, the product calcine would be packaged and interim stored for vitrification at the TWRS vitrification facility at a later date. An alternative would be to stabilize the calcine with grout. Grouting would involve mixing the dry particulate waste from the calcination process with grout formers to produce a solid matrix, thus stabilizing the calcine.

Calcination is a standard process for oxidizing metals and metal hydrides. Information specific to calcining as a PCB treatment process is not readily available. However, a similar process, thermal desorption, is a proven technology for PCB treatment (Dávila et al. 1993). Thermal desorption, like calcination, involves heating a waste material to several hundred degrees Centigrade, in the process volatilizing the PCBs. The PCBs are carried into the off-gas, where they can be captured for further treatment. EPA has issued several TSCA treatment permits for thermal desorption units. The permits typically specify a treatment requirement of less than 2 ppm in the treated waste, consistent with EPA guidance for alternative treatment (Boomer et al.

1988). A skid-mounted thermal desorption unit has been designed and constructed for use at Sandia National Laboratory to treat PCB-contaminated LLW (Richardson 1996).

Under either the vitrification or calcination options, the treatment process would be installed in the CVD or in another environmentally-protective facility onsite if the CVD could not meet the operational and schedule requirements for the sludge treatment program.

The final selection of a thermal treatment process option would depend on a number of factors such as costs and technical feasibility (including the ability to meet waste acceptance criteria at interim storage and disposal facilities and provide adequate air emission controls). Additional evaluation of the technical feasibility and cost of thermal treatment processes is being developed in the Sludge Treatment Alternatives Analysis.

5.3.3 Transfer and Disposition of Treated Sludge

The product of vitrification would be a solid dry mass or dry glass frit. Calcination would produce a dry particulate matter. The dry products not be amenable to tank storage. However, water could be added to the glass frit or dry particles to slurry them if desirable. The potential volume of waste produced from each process will be evaluated in the Sludge Treatment Alternatives Analysis.

Under the vitrification option, the cooled and solidified glass could be containerized, stored at the CWC or the CSB, and ultimately disposed at WIPP or the national geologic repository. There are three concerns associated with disposal WIPP:

- The sludge might be designated as a HLW, precluding WIPP disposal
- It is uncertain whether the vitrified product would meet WIPP waste acceptance criteria, such as criteria for radionuclide content
- It is likely that the vitrified product would require remote handling, and no remote-handle package has been qualified for WIPP disposal; a contact-handle package with shielding has been qualified, but the number and weight of containers produced could be constraining.

The alternative, disposal at the national geologic repository, would require that the glass form from the K Basins melter undergo a potentially extensive qualification process. As a third alternative, the K Basins vitrification process could be designed to produce a glass frit that could be placed into dry storage and eventually used as feed to the TWRS vitrification facility. This could require design modifications of the vitrification facility to accommodate this type of feed.

Under the calcination option, the particulate waste would be containerized, stored at the CWC or the CSB, and ultimately disposed at WIPP or the national geologic repository. The issues identified for WIPP disposal of vitrified K Basins sludge also apply to the calcined product. In addition, it is not known whether the particulate form or a grouted form would be technically acceptable for disposal at WIPP. If not, the calcine might need to be vitrified to make it

acceptable for disposal at WIPP or the national geologic repository. The national geologic repository would only accept a solidified form, but it is unknown whether a grouted matrix would satisfy repository requirements.

For either of the thermal treatment process options, the treated sludge would be taken in transport packages by truck from the 100-K Area to the CWC or another interim storage area to be off-loaded. All transportation of the sludge would occur on the Hanford Site. A transportation safety analysis would be performed to establish the design, procedures, and controls necessary to ensure protection of workers and prevention of releases during transportation.

5.4 ALTERNATIVE 4: PHYSICAL TREATMENT

This alternative would use physical methods to treat the sludge. Some physical treatment processes, such as high-energy milling, would be designed to reduce particle sizes in the K Basins sludge and thus facilitate tank storage of the sludge. This type of physical treatment process could be particularly appropriate if the waste acceptance criteria for existing DSTs are modified or if another tank is available that could more readily accommodate larger particle sizes in the K Basins sludge. Other physical treatment processes, such as solidification, would be designed to address solid waste storage requirements for either the sludge or secondary waste streams from sludge treatment.

5.4.1 Sludge Retrieval and Removal

Sludge retrieval and loadout would be as described in section 5.2.1.

5.4.2 Sludge Physical Treatment

Physical treatment typically consists of processes that change the physical characteristics of a waste or that separate different phases. Interim storage of the K Basins sludge, either in an existing DST or another tank, requires that the sludge be treated to meet a set of acceptance criteria. The criteria for existing DSTs are provided in Table 4-2. These criteria require that the sludge be treated to prevent criticality (by a combination of particle size reduction and the addition of neutron absorbers), eliminate pyrophoricity, and reduce particle size for retrievability. The acceptance criteria for storing the K Basins sludge in a tank other than an existing DST have not been established. If the sludge is to be vitrified via the TWRS vitrification facility, PCBs must also be removed or destroyed because the TWRS vitrification plant does not currently intend to seek a TSCA treatment permit.

One option under this alternative involves the use of a high-energy mill to reduce the particle size and concurrently effect the wet oxidation of the metals and metal hydrides (Precechtel and Turnbaugh 1998). As shown in Figure 5-5, the slurry containing the sludge would be fed to the mill where it would be milled and homogeneously blended with a neutron absorber (e.g., iron or depleted uranium oxide). An organic solvent could also be used to extract PCBs from the solids. From the mill, the slurry would be filtered by a 325-mesh screen (44 micron mesh size). Over-size sludge particles would be returned to the mill. From the screen, the milled slurry

would enter a solvent removal stage where the organic solvent containing PCBs would be separated from the slurry. An alternative to the solvent extraction of the PCBs is mechanochemical dechlorination. Calcium oxide or other suitable reagent would be added to the mill. The mechanical action activates a chemical reaction between the calcium oxide and PCBs that dechlorinates the PCBs (Rowlands et al. 1994).

Off-gas from the milling operation would be minimal, but some off-gas would be generated that would contain a small quantity of PCBs and solvent volatilized in the milling step. A GAC absorber would be used to collect the PCBs and solvent. Spent PCB-laden solvent would be treated at an offsite TSCA-permitted treatment facility designed to accept TSCA-regulated radioactive waste. If such a facility were not available at the time the solvent was generated, the solvent would be stored at the Hanford Site until such time as a treatment facility becomes available. Spent GAC would be grouted and disposed at the ERDF.

Another physical treatment option would be to directly grout and solidify the sludge. As shown in Figure 5-6, the grouting option would involve mixing the sludge with grout formers, pouring the mix into disposal containers and allowing the grout to set inside the containers. The grouted sludge would be interim stored at the CWC and disposed of at the WIPP. A PCB extraction step may be required for disposal in WIPP. This option would only be available if the sludge were designated as a TRU waste and not a HLW.

As with the chemical and thermal treatment alternatives, it is anticipated that physical treatment would take place in the 100-K Area, most likely in the CVD or another environmentally-protective facility onsite if the CVD cannot meet operational and schedule requirements for the sludge treatment program. The treatment system would be designed to meet dangerous waste design standards, and a BACT/BARCT demonstration (both toxics and radionuclides, as appropriate) would be conducted during remedial design to identify the specific technologies that would be used to control air emissions. Air emissions control technologies are likely to include the use of GAC to absorb PCBs and HEPA filters to remove radioactive particulate matter. The final selection of a physical treatment process option would depend on a number of factors such as costs and technical feasibility (including the ability to meet waste acceptance criteria at interim storage and disposal facilities and provide adequate air emission controls). Additional evaluation of the technical feasibility and cost of physical treatment processes are being performed in the Sludge Treatment Alternatives Analysis.

5.4.3 Transfer and Disposition of Treated Sludge

It is anticipated that the product from a high-energy milling option would be a slurry that meets TWRS waste acceptance criteria as specified in Table 4-2 or other approved tank storage criteria. The volume of slurry could potentially be less than under chemical treatment because of fewer chemical additions. However, an increase in volume over the initial 50 m^3 of settled solids would still be expected because of the water required to achieve pumpability. The slurry would be managed within the TWRS system as described in Section 5.2.3.

5.5 COMMON ELEMENTS

5.5.1 Spent Nuclear Fuel Management

SNF will be removed from the K Basins, subjected to cold vacuum drying at the CVD facility, and transferred to the CSB for interim storage. Alternatives for managing the SNF currently

stored in the K Basins were evaluated in the K Basins EIS (DOE 1995, DOE 1996a) and included the following:

- No action
- Enhanced K Basin storage
- New wet storage
- Drying/passivation with dry storage
- Calcination with dry storage
- Onsite processing
- Foreign processing.

The preferred alternative identified in the EIS and selected in the ROD (61 FR 10736) was removal of the SNF from the basins, drying/passivation, and dry storage. The passivation process consisted of hot conditioning. Subsequent to issuing the ROD, the method for drying the SNF was modified to cold vacuum drying. Environmental impacts of the modification were evaluated in a NEPA Supplement Analysis that determined that the environmental impacts of deleting the passivation process were bounded by the original EIS and that no further NEPA review was required (DOE 1998).

The K Basins EIS analyzed the environmental impacts of the SNF removal, drying, and interim storage and that analysis is not repeated here. Rather, this section describes those activities associated with the SNF that are part of the CERCLA action: removal and transfer to the CVD facility. Drying at the CVD facility and interim storage at the CSB are not part of the CERCLA action, but the CVD facility is briefly described here to demonstrate that SNF will be managed appropriately. The cold vacuum drying process and interim storage continue to be authorized under the original EIS and ROD and the Supplement Analysis. The specific activities conducted under the authority of the CERCLA action are as follows:

- The SNF will be agitated to loosen and remove sludge and corrosion product; the sludge and corrosion product will remain in the basin to be consolidated with other sludge.

- The SNF will be placed into fuel baskets, and the fuel baskets will be placed inside multi-canister overpacks (MCOs).

- The MCOs will be closed and transferred to the CVD for drying. The CVD has been constructed in the 100-K Area near the K Basins.

- Liquid drained from the MCOs at the CVD and during further processing will be returned to the K Basins for recycling, or transferred to an authorized onsite water treatment facility.

The SNF retrieval, washing, and packaging activities at the basins could potentially generate emissions such as airborne particulate. These activities will be conducted under water to control the generation of airborne particulate. Air emissions approvals will be obtained from the appropriate regulatory agencies prior to the start of SNF retrieval.

The CVD is an appropriate facility to receive the SNF. The CVD is being designed and constructed to achieve nuclear safety equivalence comparable to NRC-licensed facilities. The use of standards consistent with NRC requirements provides a high level of safety and environmental protection. All necessary regulatory approvals, such as air emissions approvals, will be obtained for the CVD prior to receipt of the SNF.

5.5.2 Water Management

The K Basins together contain about 9.8 million L (2.6 million gal) of contaminated water. The contaminated water removed from the K Basins will be pretreated at the basins, transferred to the ETF in the 200 East Area for further treatment, then disposed at the State-Approved Land Disposal Site (SALDS) in the 200 West Area. The K Basins EIS analyzed the environmental impacts of the water pretreatment process, treatment at ETF, and disposal at SALDS and that analysis is not repeated here. Rather, this section describes those activities associated with the K Basins water that are part of the CERCLA action: removal, pretreatment, and transfer to the 200 Area. Treatment at ETF and disposal at the SALDS are not part of the CERCLA action but are described here to demonstrate that these facilities are appropriate for receiving the water generated by the CERCLA action.

New and upgraded systems are being added to the existing water treatment system at the K Basins to create an Integrated Water Treatment System (IWTS) for each of the basins. The IWTS will provide the necessary collection of contaminated basin water, treatment of the water, and return of treated water to all basin processes that require water, such as canister decapping, fuel retrieval, debris cleaning, and sludge retrieval. During SNF retrieval, some water will be removed with the SNF and trapped inside the MCOs. When the water is drained from the MCOs during later processing, it may be recycled to the basins and managed with the bulk of the contaminated water. This recycle will help maintain necessary water levels in the basins and reduce the volumes of wastewater generated. Alternately, the water may be transferred directly to an authorized onsite treatment facility. Clean water will be added to the basins to maintain the water at the level necessary to cool and provide radiation shielding in the basins during removal activities.

The water that is removed will be treated via the IWTS at each basin. The IWTS as planned consists of a pre-filter to remove particulate matter and an ion exchange module to remove remaining radioactive contaminants except tritium. Tritium cannot be effectively separated from water. The basin water will be sampled to determine if it contains PCBs. If PCBs are detected at concentrations greater than 0.5 ppb, additional filtration will be added to the IWTS to ensure that

PCB concentrations in the water leaving the system are equal to or less than 0.5 ppb. If an aqueous stream that is separated from a TSCA-regulated waste stream has PCB concentrations less than 0.5 ppb, the aqueous stream is not regulated under TSCA (40 CFR 761.79).

Operation of the IWTS and any other water treatment systems associated with the CERCLA action will generate secondary wastes such as ion exchange modules and cartridge filters. Any carbon filters added to provide PCB treatment would be managed as a TSCA-regulated waste upon removal. All other components of the IWTS, such as ion exchange modules, will be managed as debris as described in Section 5.5.3, e.g., drained of free-flowing liquid and managed as LLW, mixed waste, TRU waste, or mixed TRU waste, as appropriate.

The IWTS will meet or be modified, as appropriate, to meet the ETF waste acceptance criteria. The pretreated water will be pumped into tanker trucks for transport to the 200 East Area. In the 200 East Area, the K Basins water will be off-loaded at the ETF and either processed there or routed to the Liquid Effluent Receiving Facility for storage and equalization. The ETF is an existing water treatment system that treats a variety of liquid wastes generated at the Hanford Site. The facility meets all applicable requirements associated with air emissions, wastewater treatment and discharge, and management of mixed waste. The ETF treatment system includes filtration to remove particulate matter, an ultraviolet/oxidation system to destroy organic constituents and a reverse osmosis and ion exchange unit that removes inorganic and radionuclide constituents, except tritium. There is currently no economically viable treatment for tritium. Treated effluent from the ETF is piped to the SALDS in the 200 West Area where it is discharged to the soil column. The discharge is performed in accordance with a State of Washington water discharge permit (Ecology 1995). The ETF also operates in accordance with dangerous waste interim status requirements, the requirements of the ETF air approval (DOH 1995), and the requirements of the final delisting (40 CFR 261, Appendix IX, Table 2-2). The water discharge permit and other documents will be modified as necessary before K Basins water is received. Contaminants and by-products removed during the treatment process at the ETF are concentrated and dried into a powder. The powder generated from treating water generated under the K Basins interim remedial action may be disposed at the ERDF if it meets the ERDF waste acceptance criteria and if the powder is associated exclusively with the treatment of K Basins water or other water generated from CERCLA activities. Otherwise, the powder will be disposed at another authorized facility.

5.5.3 Debris Management

All of the SNF management alternatives in the K Basins EIS (except no action) considered management of debris generated as part of the basin cleanout to be part of the alternative. As described in Section 2, debris is defined as any solid waste resulting from the CERCLA remedial action, excluding sludge and wastewater. Debris includes items located both above and below the water in the basins, wastes generated from operation of the water and sludge treatment systems, and wastes generated during basin deactivation. Debris will be removed from the basins throughout the course of the K Basins cleanout and during deactivation of the basins. The scope of this FFS only includes removing the debris from the basins or treatment facilities, assigning the appropriate waste designation, and transferring the debris to an approved waste management facility appropriate for the designation.

The K Basins EIS assumed that the debris would be designated as LLW and would be disposed of at Hanford Site LLW disposal facilities. Under CERCLA, the disposal facility for debris designated as LLW will be the ERDF. Based on further evaluation, debris might also designate as solid waste, low-level mixed waste, TRU waste, or TRU mixed waste, depending on contaminant concentrations associated with the specific items. All debris will be drained of free-flowing liquid as it is removed from the basins and will not subsequently be regulated under TSCA[10]. Debris for which no reuse, recycle, or decontamination option is identified will be assigned an appropriate waste designation (e.g., solid, radioactive, dangerous, mixed). Debris management will depend on the waste designation:

- **Low-level waste.** It is anticipated that most of the debris will designate as radioactive LLW and be disposed at the ERDF. The ERDF is authorized to accept debris that is designated as LLW and also non-liquid TSCA-regulated PCBs (BHI 1998). The ERDF is a near-surface landfill located in the 200 West Area, designed for permanent disposal of wastes generated from Hanford Site remediation activities. The ERDF was authorized via a CERCLA ROD (EPA et al. 1995) and can accept any remediation waste that is addressed in a CERCLA decision document and that meets the ERDF waste acceptance criteria. The ERDF meets minimum technological requirements for dangerous waste landfills including standards for a double liner, a leachate collection and removal system, leak detection, and final cover. Current and anticipated future public access controls at the 200 Area limit inadvertent intrusion.

  Before disposal at the ERDF, LLW from the K Basins might be treated (e.g., by crushing, sizing, sorting, etc.) to minimize volumes for disposal. For example, when the fuel canisters are emptied, they will be removed and transported to the privately-owned Allied Technology Group treatment facility, to be constructed in Richland, for crushing. The crushed canisters will be returned to the Hanford Site for disposal at ERDF.

- **Mixed waste.** Some of the debris might designate as mixed (radioactive and dangerous) waste. Mixed waste will be disposed at either the ERDF (described above) or the radioactive mixed waste trenches (Trenches 31/34) located in the 200 West Area of the Hanford Site. Both the ERDF and Trenches 31/34 meet the 10 CFR 61 standards for disposal of LLW and State of Washington dangerous waste landfill design standards. The ERDF can accept mixed waste that is TSCA-regulated. Trenches 31/34 are not approved as chemical landfills under TSCA, however, TSCA allows bulk PCB waste to be disposed at RCRA-permitted (or State of Washington equivalent) facilities. Trenches 31/34 are near surface trenches engineered for permanent disposal of mixed wastes generated from Hanford Site activities and operated under dangerous waste interim status. They meet minimum technological requirements for dangerous waste landfills including standards for a double liner, a leachate collection and removal system, leak detection, and final cover. The trenches are currently able to store containerized waste but have not begun receiving waste for disposal. Mixed waste from the K Basins that might

[10] Because some on the debris might have contacted TSCA-regulated sludge, it constitutes a PCB Article. In accordance with regulations at 40 CFR 761.60(b)(5)(ii), PCB Articles that are drained of free-flowing liquid are no longer regulated under TSCA.

eventually be disposed there will be temporarily stored in the trenches or at the CWC in the 200 West Area. The CWC consists of a set of buildings designed to store a variety of wastes including TRU, radioactive, and mixed wastes. The buildings are designed and operated in accordance with dangerous waste storage provisions.

Before disposal at either Trenches 31/34 or ERDF, mixed waste debris from the K Basins will be treated as necessary to meet the LDR requirements (e.g., by macro encapsulation of lead items) or to minimize volumes for disposal.

- **TRU Waste, Mixed TRU Waste.** A small fraction of the debris might designate as either contact-handled or remote-handled TRU waste, or TRU mixed waste (waste that designates as both dangerous waste and TRU waste). This might happen if sludge or fuel particles are trapped inside debris. Debris with entrained sludge or fuel particles will be placed into a basket at the K Basins, agitated to dislodge the sludge and particles, and washed with water. Any debris that is still TRU-designated after this washing will be stored temporarily at the CWC until it can be packaged and certified at Hanford's Waste Receiving and Packaging facility for eventual disposal at WIPP. Under all of the alternatives, neither SNF nor TRU waste would be disposed at the Hanford Site. The WIPP meets 40 CFR 191 requirements for TRU waste disposal and is a RCRA-permitted disposal facility. It is not authorized as a chemical landfill under TSCA. However, TSCA allows bulk PCB waste to be disposed at RCRA-permitted facilities. The WIPP waste acceptance criteria restrict PCB concentrations to less than 50 ppm.

- **Solid Waste.** Debris that is not contaminated will be managed as solid waste. To the extent practicable, such debris will be recycled. Debris that designates as solid waste and that cannot be recycled will be disposed at an authorized municipal landfill or construction debris landfill as appropriate.

5.5.4 Basin Deactivation

Once the SNF, sludge, water, and debris such as canisters are removed from the K Basins, the basins will be deactivated. Deactivation will remove additional hazardous materials and place the basins into a condition such that they can be maintained safely with minimal surveillance and maintenance until such time as interim safe storage activities are implemented. Deactivation could include the following activities:

- Equipment that is not an integral part of the basin structures will be drained, removed, decontaminated as appropriate, packaged, and disposed of as debris (see Section 5.5.3). Such equipment could include components of the SNF retrieval system and washing station, the IWTS, and the sludge retrieval system.

- Sludge treatment system equipment and the structure in which it is installed will be removed, decontaminated as appropriate, packaged, and disposed as debris.

- The basin structure will be decontaminated to the extent required to meet criteria for transition to the Environmental Restoration program.

- Support systems such as electrical, heating, ventilation, and air conditioning, water supply, and monitoring that are not required for future environmental compliance or personnel safety will be de-energized.

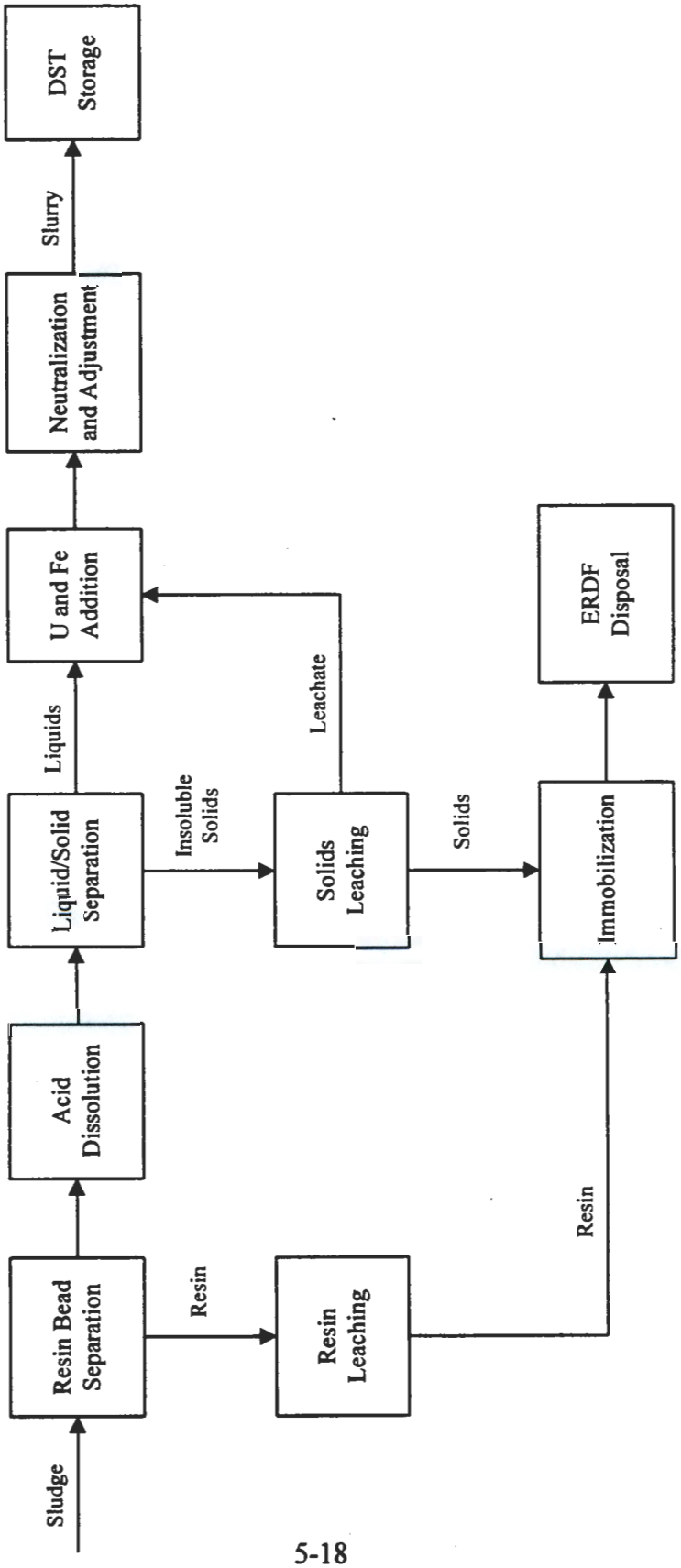
- Structural repairs will be made as necessary for future surveillance and maintenance needs.

- Building penetrations will be sealed to prevent entry of animals, and personnel access controls will be installed.

Deactivation is several years in the future and activities needed to complete deactivation have not been fully defined. There will be an amendment to the CERCLA remedial design report and remedial action work plan (prepared following the ROD) to more fully describe the activities when deactivation planning is complete.

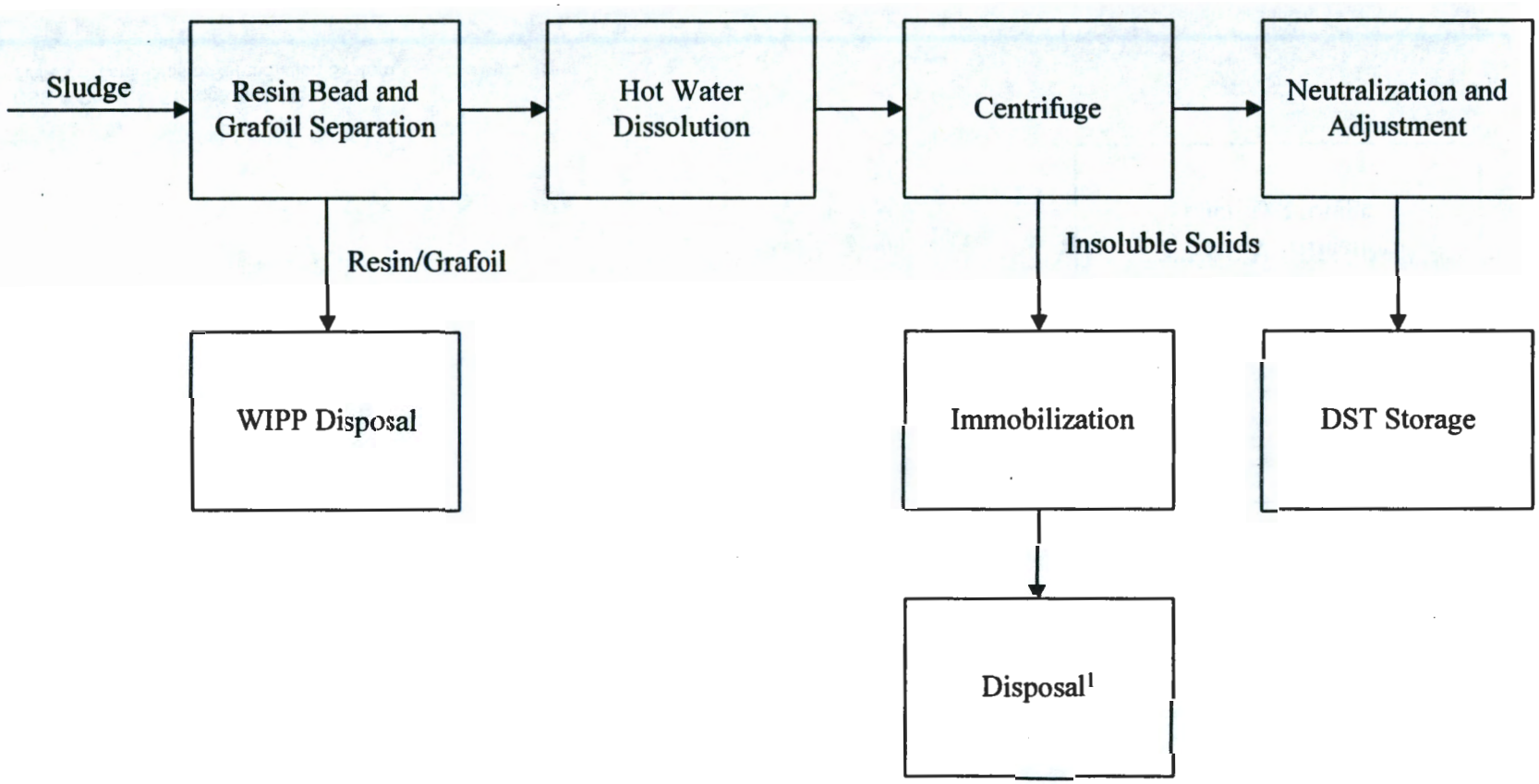
It is expected that the basins will still be radiologically contaminated at the end of deactivation, but activity levels cannot be estimated at this time. The contamination will be stabilized as part of deactivation to prevent releases to the environment. After deactivation, air and groundwater monitoring and existing controls that prevent public access will be continued until such time as final remedial action is completed.

Figure 5-1. Process Flowsheet for Alternative 2: Chemical Treatment.



DST = double-shell tank
ERDF = Environmental Restoration Disposal Facility
Fe = iron
U = uranium

Figure 5-2. Process Flowsheet for Hot Water Dissolution Process.



DST = double shell tank
ERDF = Environmental Restoration Disposal Facility
LLW = low-level waste
WIPP = Waste Isolation Pilot Plant

[1]The disposal location will depend on the waste designation. If designated as a LLW or mixed LLW, the location will be ERDF.

Figure 5-3. Draft Flowsheet for Vitrification Process.

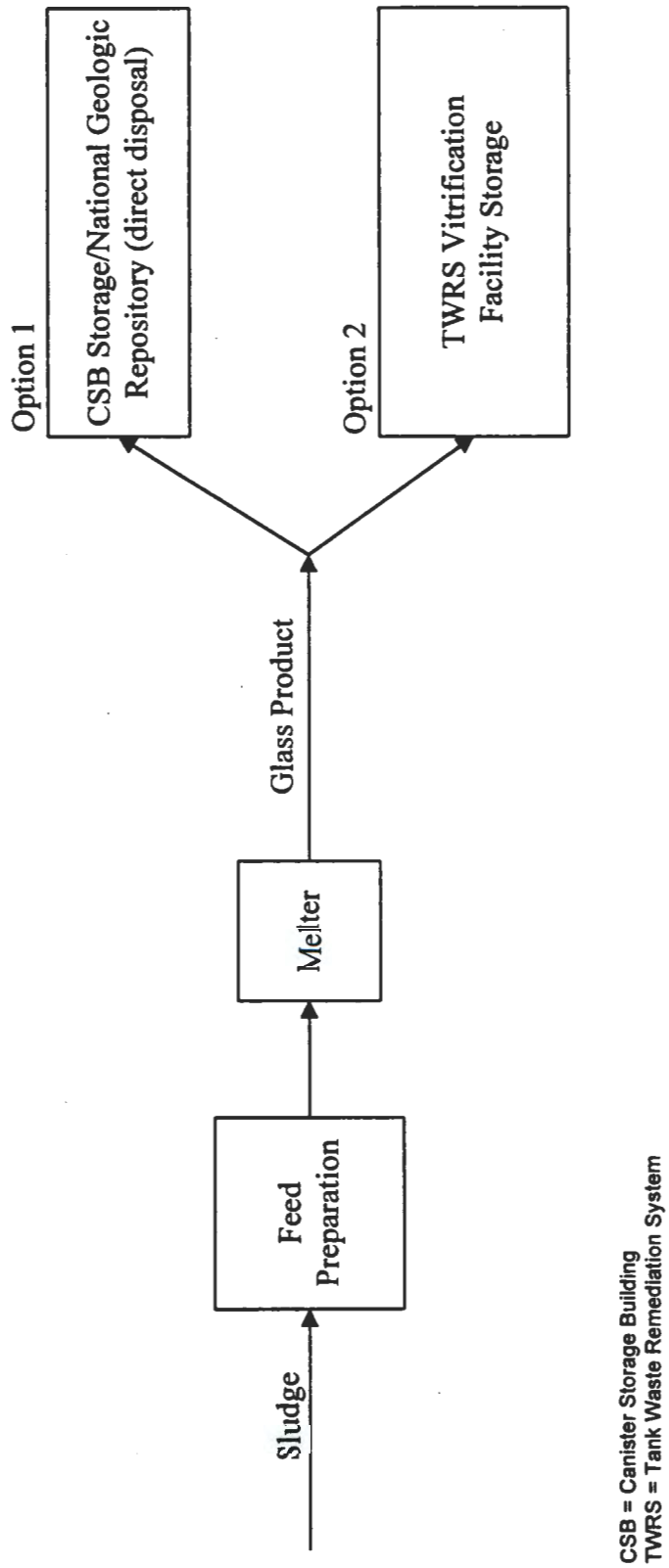
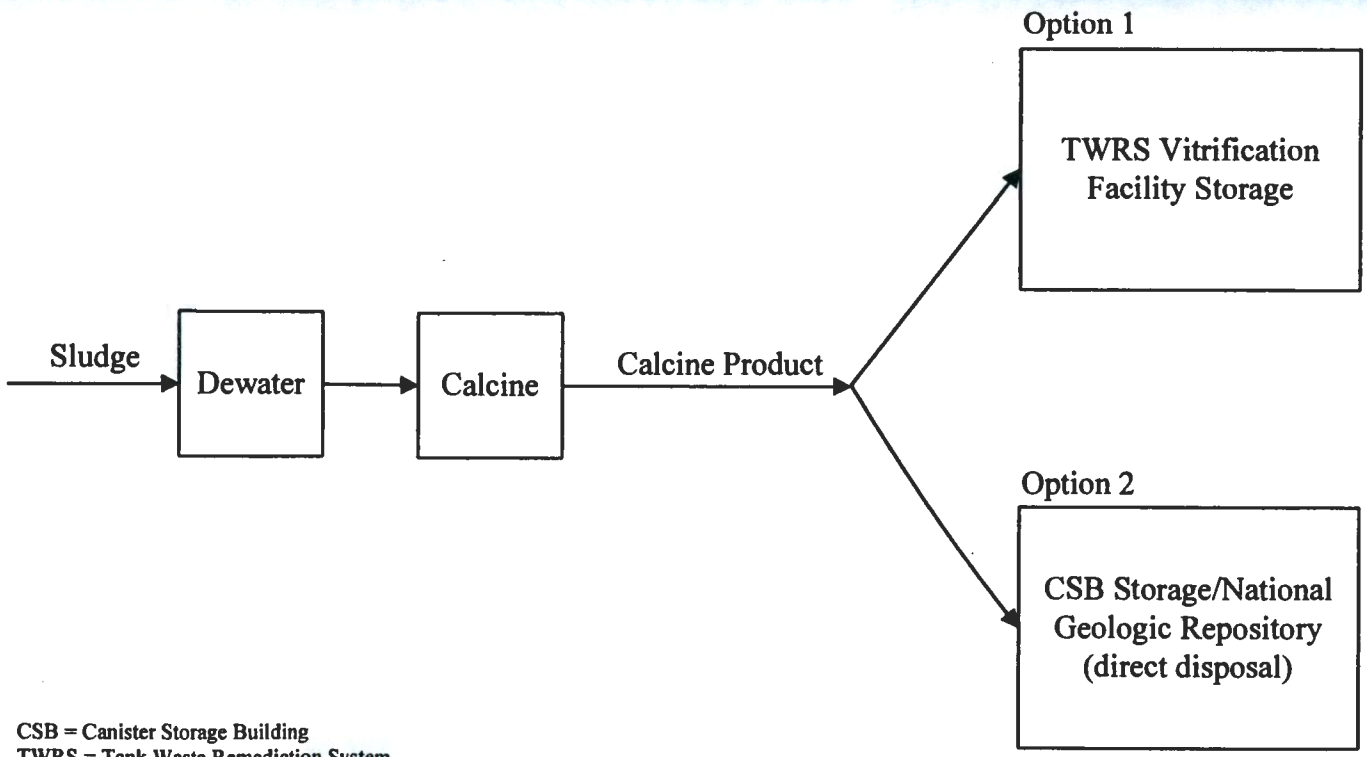
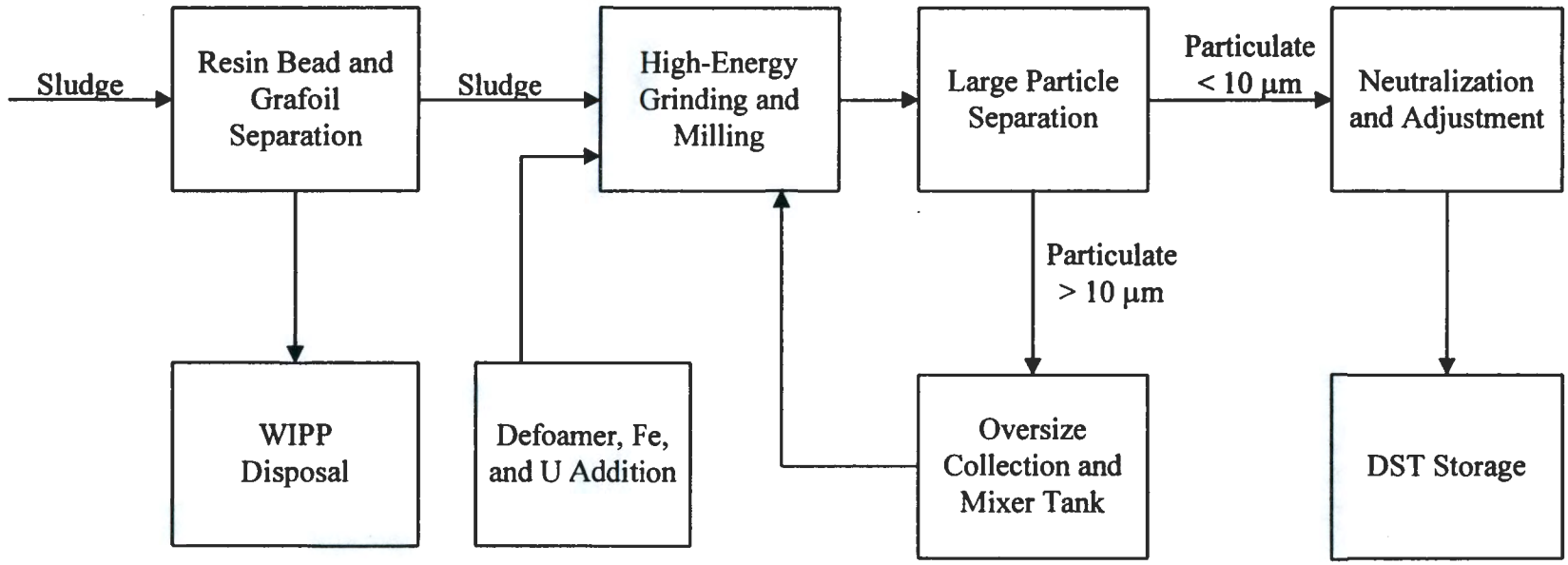


Figure 5-4. Flowsheet for Calcine Operation.



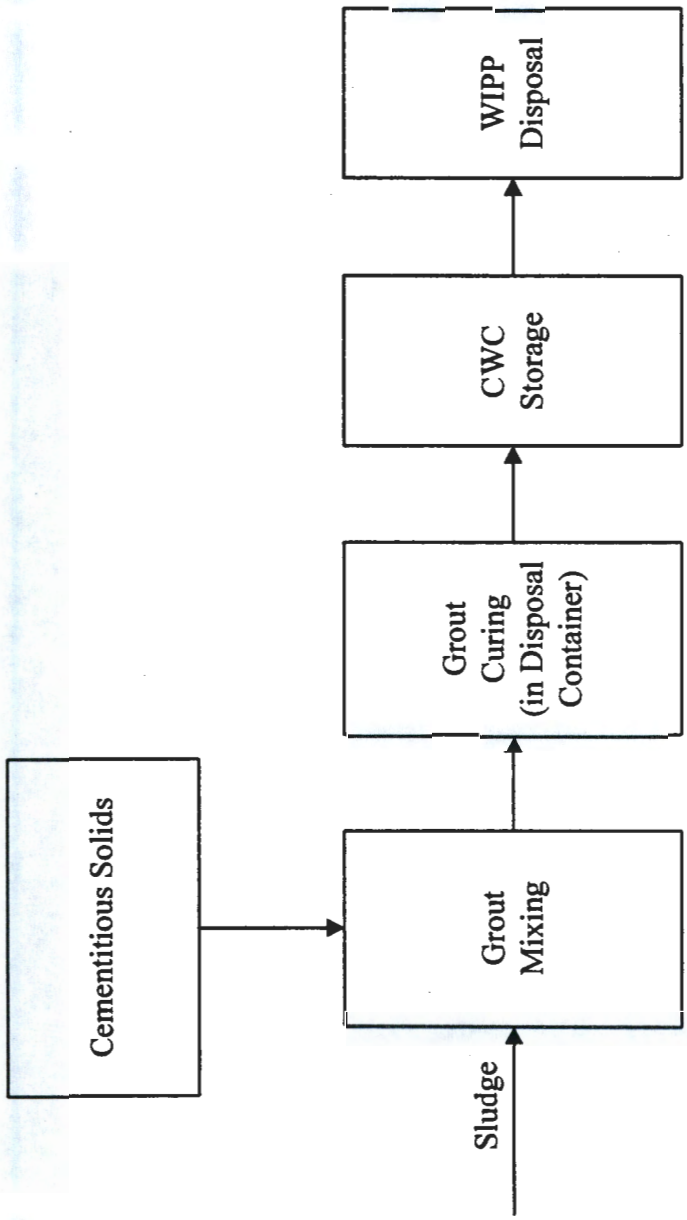
CSB = Canister Storage Building
TWRS = Tank Waste Remediation System

Figure 5-5. Process Flowsheet for Grinding-Milling Process.



DST = double-shell tank
Fe = iron
U = uranium
WIPP = Waste Isolation Pilot Plant

Figure 5-6. Flowsheet for Grouting Process.



CWC = Central Waste Complex
WIPP = Waste Isolation Pilot Plant

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6.0 DETAILED ANALYSIS OF ALTERNATIVES

CERCLA requires that remedial action alternatives be evaluated against nine specific criteria. These criteria serve as the basis for conducting detailed and comparative analyses and for the subsequent selection of appropriate remedial actions. The nine CERCLA evaluation criteria are:

1. Overall protection of human health and the environment
2. Compliance with 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 of Washington acceptance
9. Community acceptance.

The first two criteria, overall protection of human health and the environment and compliance with ARARs, are threshold criteria. Alternatives that do not protect human health and the environment or do not comply with ARARs (or justify a waiver) do not meet statutory requirements and are eliminated from further consideration in this FFS. The next five criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost) are balancing criteria upon which the remedy selection is based. State of Washington acceptance will be further evaluated following the State of Washington's review of this FFS. Community acceptance will be further evaluated after public review of the proposed plan.

The detailed analysis in Sections 6.2 through 6.5 evaluates each alternative against these criteria. A qualitative assessment of the criteria is made based on engineering judgement when quantitative information is not available. The detailed analysis addresses the entire scope of the CERCLA action, but greater emphasis is placed on evaluating sludge treatment because environmental impacts associated with the SNF, water, and debris were previously analyzed in the K Basins EIS.

In addition to the nine CERCLA criteria, NEPA values have been incorporated into this document. Assessment of these values is important to the integration of NEPA into CERCLA documents, as called for by both the DOE Secretarial Policy on NEPA (O'Leary 1994) and DOE Order 451.1A (DOE 1997). Appendix A evaluates the alternatives against NEPA values.

6.1 DESCRIPTION OF CERCLA CRITERIA

6.1.1 Overall Protection of Human Health and the Environment

This criterion determines whether adequate protection of human health and the environment, including preservation of natural systems and biological diversity, is achieved through implementation of the remedial alternative. Protection includes reduction of risk to acceptable levels (either by reduction of concentrations or the elimination of potential routes for exposure) and minimization of exposure threats introduced by actions during remediation. Environmental protection includes avoiding or minimizing impacts to natural, cultural, and historical resources. Additionally, this criterion evaluates the potential for human health risks, the extent of those risks, and whether there will be a net environmental benefit as a result of implementing the remedial alternative.

This first criterion is a threshold requirement and the primary objective of the remedial action program. As indicated in EPA guidance, there is overlap between this criterion and the criteria for compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness (Boomer et al. 1988).

6.1.2 Compliance with ARARs

This criterion addresses whether a remedial alternative attains the federal and State of Washington ARARs and to-be-considered (TBC) materials listed in Appendix B or whether a waiver is justified. When an ARAR is not met, the basis for justifying a waiver must be presented.

6.1.3 Long-Term Effectiveness and Permanence

This criterion addresses the results of a remedial action in terms of risks that remain at the site after RAOs are met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. The following components of the criterion are considered for each alternative:

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

- Adequacy and reliability of controls. This factor assesses the adequacy and suitability of controls used to manage treatment residuals or untreated wastes that remain at the site. It also assesses the long-term reliability of management controls for providing continued protection from residuals, and it includes an assessment of the potential need for replacement of the technical components associated with an alternative.

Residual risk to natural and cultural resources after conclusion of remedial activities also is evaluated. Current environmental conditions are assessed against the alternative's long-term and permanent solutions. The assessment considerations are based on whether lasting environmental losses would be incurred for the sake of short-term cleanup gains, including whether environmental restoration and/or mitigation options would be precluded if a remedial alternative were to be implemented.

6.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This criterion addresses the degree to which a remedial alternative uses treatment to reduce the toxicity, mobility, or volume of hazardous substances. The evaluation focuses on the following factors for each of the alternatives:

- The treatment processes used and the materials treated
- Whether there is recycling, reuse, or waste minimization in the treatment process
- The type and quantity of treatment residuals that remain following treatment, and whether any special treatment actions will be needed
- Whether the alternative satisfies the statutory preference for treatment as a principal element.

6.1.5 Short-Term Effectiveness

This criterion evaluates the potential effects on human health and the environment during the construction and implementation phases of a remedial action. This criterion also considers the time required to achieve protection. The following factors are considered for each alternative:

- Health and safety of remediation workers and the public and reliability of protective measures taken
- Physical, biological, and cultural impacts that may result from the construction and implementation of the remedial action, and whether the impacts can be controlled or mitigated
- The amount of time for the RAOs to be met.

Short-term human health impacts are closely related to the duration of exposure to hazardous wastes and risks associated with removal of wastes. Typically, the greater the exposure time, the greater the risk. As low as reasonably achievable (ALARA) guidelines will be practiced during implementation of the remedial action to minimize worker risks.

6.1.6 Implementability

This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of the required services and materials. The following factors are considered for each alternative:

- Technical feasibility, such as the likelihood of technical difficulties in constructing and operating the alternative, the likelihood of delays due to technical problems, and uncertainties related to technologies
- Administrative feasibility, such as the ability to coordinate activities with other offices and agencies and the potential for regulatory constraints to develop
- Availability of services and materials, such as the availability of adequate treatment, storage capacity, and disposal services and the availability of necessary equipment, specialists, and provisions.

6.1.7 Cost

This criterion considers the cost of implementing a remedial alternative, including capital costs, operation and maintenance, and monitoring costs.

The K Basins cleanout is an unusual CERCLA action in two ways relative to cost. First, some of the project activities were initiated before CERCLA authority was imposed, so costs associated with those activities are "pre-CERCLA." Second, many facilities needed to support the CERCLA action (e.g., the CVD) are not themselves covered under CERCLA authority. To the extent possible, the cost criterion is presented so as to differentiate costs strictly attributable to CERCLA activities from those outside of CERCLA.

The cost estimates for the purposes of this FFS are presented as future-worth dollars and prepared from information that was available at the time the FFS was prepared. The actual cost of the project will depend on additional information gained during the remedial design phase, the final scope and design of the selected remedial action, the schedule of implementation, the competitive market conditions, and other variables.

6.1.8 State of Washington Acceptance

This criterion evaluates the technical and administrative issues and concerns that the State of Washington may have regarding a remedial alternative. The regulatory acceptance process involves a review and concurrence by the State of Washington. A preliminary evaluation of this criterion is provided here based on interactions with the State to date. This criterion will be addressed further after State of Washington review of this FFS.

6.1.9 Community Acceptance

This criterion evaluates the issues and concerns the public may have regarding a remedial alternative. A preliminary evaluation of this criterion is provided here based on input from the public to date. This criterion will be addressed further following public review of the Proposed Plan.

6.2 ALTERNATIVE 1: NO ACTION

6.2.1 Overall Protection of Human Health and the Environment

The No Action Alternative would fail to provide overall protection of human health and the environment and would not meet the objectives of the remedial action. It would not mitigate further deterioration of the SNF, preclude future releases of hazardous substances to soil beneath the K Basins, or treat basin contents to make them acceptable at interim storage/disposal facilities. This alternative would require continuing surveillance and maintenance of the basins, with increased maintenance as the basins age, and this would result in increased radiation exposure to workers.

6.2.2 Compliance With ARARs

ARARs are identified in Appendix B. ARARs would not be invoked because no action would be taken.

6.2.3 Long-Term Effectiveness and Permanence

The No Action Alternative would not be effective in the long term. Rather, risk would increase in the long term because SNF, sludge, debris, and water would remain in the basins where they could present a threat to the environment. The likelihood of a release to the environment would increase with time due to the increasing difficulty of maintaining the integrity of the basins. The No Action alternative would not be permanent in that action would ultimately be required, either in the form of major upgrades to maintain the integrity of the basins or cleanout of the basins.

6.2.4 Reduction in Toxicity, Mobility, and Volume Through Treatment

There would be no reduction of toxicity, mobility, or volume by implementing the No Action Alternative.

6.2.5 Short-Term Effectiveness

The No Action Alternative would require no movement or treatment of the hazardous substances in the basins; therefore, the potential for releases and worker exposure would not increase over current operations. In 1993, routine surveillance and maintenance operations at the K Basins resulted in a collective dose to the offsite population within 80 km (50 MI) of 0.0051 person-rem; a comparable dose would be expected for each year that the No Action Alternative

continues (DOE 1995). The No Action Alternative would also fail to reduce occupational exposure and risks to workers. Although exposure and risks to workers can be mitigated via engineering and administrative controls, risks cannot be eliminated.

6.2.6 Implementability

The No Action Alternative would fail to comply with decisions made via the K Basins EIS and ROD and milestones proposed under the Tri-Party Agreement, and thus would not be administratively feasible. It might be technically feasible in the near term, but would ultimately require major upgrades to the basins that could be difficult and costly to implement.

6.2.7 Cost

The cost for the No Action Alternative would be approximately $20 M for each year that the SNF, sludge, debris, and water remain in the K Basins. This does not include costs that would be incurred if the basins are upgraded for continued storage and costs to eventually cleanout and deactivate the basins.

6.2.8 State of Washington Acceptance

During Tri-Party Agreement negotiations relative to the K Basins cleanout, the State of Washington indicated a clear preference that the contents of the K Basins should be removed and placed in more protective facilities. The No Action Alternative would be unacceptable to the State of Washington.

6.2.9 Community Acceptance

Via comments provided on the K Basins EIS, the public has indicated a clear preference that the contents of the K Basins should be removed and placed in more protective facilities. The No Action Alternative would be unacceptable to the public.

6.3 ALTERNATIVE 2: CHEMICAL TREATMENT

6.3.1 Overall Protection of Human Health and the Environment

Alternative 2 would achieve overall protection of human health and the environment. Essentially all hazardous substances that are not fixed to the structures of the K Basins would be removed, thereby reducing the potential for further releases from the basins. SNF would be vacuum, dried and place in sealed containers in dry storage to prevent further degradation. Sludge, water, and debris would be treated, as appropriate, to meet TWRS, ETF, and ERDF waste acceptance criteria. The removal and treatment processes would result in a temporary small increase in worker exposure and a potential increase in public exposure, but in the long-term occupational and public exposure and potential adverse environmental impacts would be reduced.

6.3.2 Compliance With ARARs

ARARs are identified in Appendix B. Alternative 2 would be designed to comply with all ARARs and TBC materials.

The water pretreatment system would be required to treat basin water to meet ETF waste acceptance criteria, including radionuclide limits. The PCB concentration in the water exiting the IWTS would be less than 0.5 ppb and thus the water would not be TSCA-regulated per 40 CFR 761.79. The ETF would be an appropriate receiving facility for the water because it is designed and operated in compliance with dangerous waste requirements, the radioactive air emissions approval (DOH 1995), and the discharge limits and monitoring requirements listed in the State of Washington-issued water discharge permit (Ecology 1995). Ecology has previously determined that the ETF provides all known and reasonable treatment for evaporator process condensate. Prior to implementing this alternative, Ecology would be requested to make a similar determination for the K Basins water.

Debris would be designated in accordance with solid, dangerous, and radioactive waste requirements and stored or disposed at facilities designed and operated to accept the assigned waste designation. Because the maximum PCB concentration in the KE Basin sludge is well below 500 ppm, it is assumed that the debris contains less than 500 ppm PCBs. The debris would be drained of free-flowing liquid upon removal from the basin and, as a PCB Article, would no longer be regulated under TSCA. Debris that designates as a mixed waste would be treated to meet LDR prior to disposal.

The chemical treatment system would be required treat the sludge sufficiently to meet the TWRS waste acceptance criteria for criticality control, pyrophoric materials, corrosion, flammable gas, and particle size. The TWRS criterion excluding TSCA-regulated PCB waste would be met by achieving a PCB concentration in the treated sludge of less than 2 ppm, the PCB treatment standard for alternative PCB treatment (Boomer et al. 1988). Meeting the 2 ppm standard would mean the sludge is no longer TSCA regulated. Once this is demonstrated, the treated sludge would only re-enter TSCA regulation if, at a later time, it becomes contaminated at PCB concentrations greater than 50 ppm. An existing DST would be an appropriate interim storage facility for the treated sludge because the DSTs have been determined by Ecology to satisfy dangerous waste storage requirements. Any other tank(s) used to store the treated sludge would be required to comply with the dangerous waste requirements. Vitrification of the sludge and disposal at the national geologic repository would meet radioactive waste management requirements for TRU waste or HLW and would be expected to stabilize the sludge such that the waste no longer designates as dangerous waste. Air emissions generated during consolidation and retrieval of the sludge would be controlled by keeping the sludge wet and conducting above-water sludge transfers in double-contained piping. BACT and BARCT analyses would be performed during remedial design to identify controls for off-gas from the sludge treatment system. It is anticipated that radioactive particulate air emissions generated during sludge treatment would be controlled by HEPA filters, which have generally been demonstrated to meet BARCT. Controls for nitrous oxide (a regulated air pollutant) and chemical off-gases (toxic air pollutants) would be determined via the BACT analysis. As appropriate, approvals for radioactive and nonradioactive air emissions would be obtained prior to operation via submittal

of Notices of Construction (NOCs). PCB emissions would be controlled using GAC, a standard technology that would be required to meet the PCB emissions requirement of 10 micrograms per cubic meter (Boomer et al. 1988). The sludge treatment system would be designed to meet dangerous waste management unit standards.

6.3.3 Long-Term Effectiveness and Permanence

Alternative 2 would be very effective in the long term. Removing the SNF, sludge, water, and debris from the basins and deactivating the basins would be a permanent means of significantly reducing the risk of further releases from the basins to the environment. The great majority of the radioactive and chemical contaminants would be removed from the basins and taken to more environmentally protective facilities several miles from the Columbia River. Removing the water from the basins would eliminate the major potential driving force for carrying contaminants to groundwater. Treatment of the sludge and pretreatment of the water would permanently reduce the risk associated with those streams. Deactivation of the basins would ensure that any remaining contamination is stabilized. Existing controls on public access to the 100-K Area will remain in place following the interim remedial action, until final remedial action is completed.

The SNF, treated sludge, pretreated water, and debris would be residuals from the CERCLA action that present a potential risk remaining at the end of the action. This risk would be minimized and controlled by transferring them to existing or planned facilities that provide a high degree of reliability with respect to protection of human health and the environment. For example, the facilities to dry and store the SNF are being designed to standards comparable to NRC facilities. Storage in an existing DST or other double-contained tank followed by vitrification and final disposal at the national geologic repository is recognized as one of the most effective means of managing highly-radioactive sludges such as the K Basins sludge. Geologic disposal of such wastes minimizes the reliance on long-term active controls. The ERDF would be a reliable means of disposing of debris and secondary wastes from sludge treatment that is not designated as TRU waste because the ERDF is engineered to meet stringent landfill standards.

6.3.4 Reduction in Toxicity, Mobility, and Volume Through Treatment

Alternative 2 would significantly reduce the toxicity and mobility of hazardous substances via treatment. The pretreatment process for basin water would significantly reduce activity levels in the water. The contaminants removed from the water would be concentrated onto filters and ion exchange modules where they would be less mobile and would present a smaller waste volume to manage. Treating the water at ETF would further reduce contaminant concentrations.

The chemical treatment process would reduce the risk associated with the sludge by providing criticality control and reducing the pyrophoricity/reactivity associated with metal fines. It would also reduce the toxicity of the sludge by removing PCBs. The maximum PCB concentration would be reduced from over 100 ppm to less than 2 ppm. Chemical treatment would increase the volume of the treated sludge by as much as 30 times over the volume of sludge as settled in the basins, in part because of the need to add chemicals and neutron absorber during treatment but also because of the addition of water to facilitate pumping the slurry (Westra et al. 1998). Final

treatment via the TWRS vitrification facility, which is beyond the scope of the CERCLA action, would significantly reduce the mobility of contaminants in the sludge. Final volumes of glass produced from vitrifying the treated sludge would depend on whether the chemical treatment process is based on acid dissolution or hot water dissolution and how the sludge is managed prior to and during vitrification, particularly whether it is blended with other DST waste prior to vitrification. Hot water dissolution would require less chemical addition to the sludge and would have less of an impact on volumes. Blending the treated sludge with an appropriate tank waste such as the contents of Tank 105-AW can minimize the amount of glass produced (Truax and Gerber 1996). The amount of glass produced from chemically-treated sludge will be evaluated further as part of the Sludge Treatment Alternatives Analysis. Grouting secondary wastes from the chemical treatment process would also reduce the mobility of contaminants prior to disposal. The volume of the waste would be increased somewhat by grouting because of the addition of grout formers. The grouted waste would be disposed at the ERDF, a facility designed to minimize infiltration and thus further reduce contaminant mobility.

6.3.5 Short-Term Effectiveness

Risk to public and the environment. Activities conducted as part of Alternative 2 would create a potential for the airborne release of contaminants. The release of radioactive contaminants to the environment could result in a dose to the offsite public. The offsite dose associated with removing the SNF, sludge, water, and debris from the basins, drying the SNF, and transferring the SNF, sludge, water, and debris to facilities in the 200 Area was evaluated as part of the K Basins EIS. The dose to the maximally exposed individual (MEI) for these activities was estimated to be less than 0.1 mrem/year (less than 1% of the EPA and State of Washington standard of 10 mrem/year for radioactive air emissions) and the collective dose to the offsite population was estimated at 0.59 person-rem over 2 years (DOE 1995).

The analysis presented in the EIS did not consider the impacts associated with airborne releases from a sludge treatment system. The acid dissolution process considered in Alternative 2 would create the potential for airborne releases of nitrous oxide, PCBs, and radioactive particulate matter during treatment of the sludge. Hot water dissolution would likely generate PCB and radioactive particulate air emissions, but not nitrous oxides. A conservative estimate of the potential abated dose from radioactive air emissions was made using the following assumptions:

- All of the sludge would be treated within one year
- Treatment takes place in the 100-K Area
- The potential release fraction for the sludge is 1.00E-03 (this fraction is the default fraction for particulate material specified for preparation of an NOC for radioactive air emissions under Washington Administrative Code [WAC]246-247)
- The off-gas treatment system would include at least one bank of HEPA filters with a removal efficiency rating of 99.95%.

These assumptions, the total sludge radionuclide inventory presented in Tables 2-1 and 2-2, and the CAP 88[11] air emissions model were used to calculate offsite dose. The dose to the MEI for sludge treatment was estimated to be less than 0.02 mrem/year (less than 1% of the EPA and State of Washington standard of 10 mrem/year for radioactive air emissions). Emissions estimates will be refined during remedial design and NOCs with the refined estimates will be submitted to EPA and the State of Washington for approval prior to operation. BACT and BARCT would be used to minimize airborne releases. The treatment would take place inside the CVD or another onsite enclosed facility that would provide additional control in the event that contaminants are released from the treatment system.

Risk to workers. Risks to workers include exposure to radionuclides and the potential for accidents associated with an industrial process. The treatment system would be designed to allow for remote operations and minimal maintenance to the extent practicable. Engineering and administrative controls would be used to maintain worker exposure ALARA. Workplace and individual monitoring would be performed as appropriate. Industrial safety measures would be addressed in the health and safety plan.

Environmental impacts. Releases of airborne contaminants have the potential to affect the environment. These releases would be controlled through appropriate engineering controls, particularly of the off-gas treatment system. Monitoring would be provided as necessary. It is not anticipated that sludge treatment would require disturbance of any previously undisturbed land.

Schedule. The schedule for Alternative 2 would be as follows:

- Begin SNF removal from basins: November 30,2000
- Complete SNF removal from basins: December 31, 2003
- Begin sludge removal from basins: July 31, 2004
- Complete sludge removal from basins: August 31, 2005
- Complete water removal from basins: October 31, 2006
- Complete removal of SNF, sludge, debris, and water from the basins: July 31, 2007.

These dates are consistent with the dates in the proposed modification to the Tri-Party Agreement (Milestone M-34-00).

6.3.6 Implementability

Based on available information, Alternative 2 could be readily implemented. This alternative would be administratively feasible because it would be consistent with proposed Tri-Party Agreement milestones and commitments made by DOE to the regulators, oversight agencies, stakeholders, and public. The removal of SNF, sludge, water, and debris has been evaluated extensively and processes to accomplish removal have been identified. The facilities required to manage the SNF after it is removed from the basins are under construction. The systems needed

[11] The CAP-88-PC software package allows users to perform full-featured dose and risk assessments in a personal computer environment for the purpose of demonstrating compliance with 40 CFR 61.03 (a).

to pretreat the water have been designed. The ETF is expected to be able to accommodate treatment of the basin water, and the ERDF is expected to be able to accommodate disposal of secondary wastes and debris that meet ERDF waste acceptance criteria.The chemical technologies proposed are expected to be technically feasible based on the fact that acid dissolution and precipitation of uranium-bearing material has been used extensively in the fuel manufacturing and reprocessing industries and at Hanford. The specific unit operations proposed for the K Basins sludge have been developed and tested in the laboratory using actual or simulated sludge (Westra et al. 1998). The off-gas emission controls identified are based on standard technologies used in the nuclear industry.

Three issues have been identified related to the technical feasibility of chemically treating the sludge. The first is whether the TWRS system would have sufficient capacity for the slurried treated sludge. The estimated volume of slurry produced from chemical treatment has been included in past waste volume projections for the TWRS system (Alderman 1997). However, recent changes in other Hanford programs (e.g., delay in vitrification) have placed an additional burden on tank space. Therefore, it is possible that all waste generators would be requested to review waste volumes and minimize where possible. From this standpoint, hot water dissolution could be preferable over acid dissolution because it requires less chemical addition and would likely produce a lower volume of treated sludge.

A second issue relates to the PCBs in the waste. The TWRS system currently is not authorized to store or treat TSCA-regulated waste. Alternative 2 includes treating the sludge such that it contains less than 2 ppm PCBs after treatment. EPA would need to determine that the treated sludge would not be TSCA regulated if it meets these levels, and that TSCA regulation would not be triggered unless the treated sludge is later contaminated with PCBs at a concentration of 50 ppm or greater.

The final issue relates to whether a chemical treatment system sized to accommodate all of the sludge could fit within the CVD given operational and schedule constraints. An evaluation would be completed during remedial design to confirm that processing can be done inside the CVD facility. If not, an alternate location such as an annex to the K Basins or another environmentally-protective facility onsite would be selected. The selection of location would not be expected to affect the overall feasibility of this option, although it might affect cost.

6.3.7 Cost

Costs for the SNF project assuming implementation of Alternative 2 are provided in Table 6-1. The costs were developed on a future-worth basis. In addition to showing costs associated with the CERCLA action, costs for the overall SNF project are provided because of the substantial regulator, stakeholder, and public interest in the total SNF project costs. The total estimated cost for the CERCLA action under Alternative 2 would be $723 million. Of this total, $46 million would be the cost of sludge treatment (design, construction, and operation) and sludge transportation under Alternative 2 assuming acid dissolution. The relative cost for the hot water dissolution process will be evaluated as part of the Sludge Treatment Alternatives Analysis. The cost to deactivate the sludge treatment system is included in the overall deactivation cost. The total estimated cost for the SNF project would be $1.6 billion.

Costs associated with interim storage and final disposition of the pretreated water and treated sludge are outside of the scope of the CERCLA action and the SNF project. The cost to treat water at the ETF is $0.25 per gallon. Assuming 9.8 million L (2.6 million gal) of basin water, the total cost to treat the water at ETF would be approximately $650,000. There would be minimal incremental cost to store the treated sludge in an existing DST because the additional tank volume would not require any change in current operations of the tank. In addition, it was previously estimated that vitrification of the K Basins sludge would result in little to no increase in TWRS tank waste treatment costs because the sludge would have favorable blending characteristics with respect to the contents of Tank 105-AW, resulting in no additional glass production (Truax and Gerber 1996). However, the evaluation did not consider the impact of chemicals added as part of the treatment process prior to sending the sludge to the tank. The vitrification cost impacts, including costs associated with the additional chemicals, will be reviewed during the Sludge Treatment Alternatives Analysis for both the acid dissolution and the hot water dissolution processes.

6.3.8 State of Washington Acceptance

Alternative 2 would satisfy the State of Washington's preference that the contents of the K Basins be removed and placed in more protective facilities. State of Washington acceptance of the sludge treatment process will be evaluated following State of Washington review of this FFS.

6.3.9 Community Acceptance

Alternative 2 would satisfy the public's preference that the contents of the K Basins be removed and placed in more protective facilities. Community acceptance of the sludge treatment will be evaluated following public review of the proposed plan.

6.4 ALTERNATIVE 3: THERMAL TREATMENT

6.4.1 Overall Protection of Human Health and the Environment

Alternative 3 would provide overall protection of human health and the environment. Essentially all hazardous substances that are not fixed to the structures of the K Basins would be removed and transferred to facilities that are more protective, thereby reducing the potential for further releases from the basins. The SNF would be vacuum dried and placed in sealed containers in dry storage to prevent further degradation. Sludge, water, and debris would be treated, as appropriate, to meet waste acceptance criteria of the receiving facilities. The removal and treatment processes would result in a temporary small increase in worker exposure and a potential increase in public exposure, but in the long-term occupational and public exposure and potential adverse environmental impacts would be reduced.

6.4.2 Compliance With ARARs

Alternative 3 would be designed to comply with all ARARs and TBC materials. As in Alternative 2, the water pretreatment system would be sufficient to meet ETF waste acceptance criteria and TSCA requirements, and debris would be designated in accordance with solid, dangerous, and radioactive waste requirements and disposed at facilities approved to accept the assigned waste designation.

The sludge treatment system would be required to meet the regulatory requirements and waste acceptance criteria for interim storage at the CWC or CSB and final disposition either directly to WIPP or the national geologic repository or to the national geologic repository via processing at the TWRS vitrification facility. All disposition pathways require an EPA determination that the alternative PCB treatment standards of Boomer et al. (1988) are applicable to treatment via vitrification or calcination. This would include a determination that the treated sludge is no longer TSCA regulated if it meets the treatment standard of less than 2 ppm PCBs in the treated sludge. Once this treatment level is demonstrated, the treated sludge would only re-enter TSCA regulation if, at a later time, it becomes contaminated at PCB concentrations greater than 50 ppm. Thermal treatment (in combination with grouting or vitrification, if treatment consists of calcination) would stabilize metals in the sludge so that the treated sludge no longer exhibits dangerous waste characteristics and treatment would meet the dangerous waste LDRs. The sludge treatment system would be designed to meet dangerous waste management unit standards, including double containment of tank systems and leak detection. The off-gas treatment system would be designed based on BACT/BARCT analyses, as appropriate, and would comply with air emissions standards for radionuclides, toxics, and PCBs. Either the CWC or CSB would be an appropriate interim storage facility for the treated sludge because they are both designed to meet requirements for storage of mixed radioactive waste.

6.4.3 Long-Term Effectiveness and Permanence

Alternative 3 would be very effective in the long term. The evaluation of this criterion would be the same as for Alternative 2 except with respect to sludge.

Treated sludge would be a residual from the CERCLA action that presents a potential risk remaining at the end of the action. This risk would be minimized and controlled by transferring the treated sludge to the CWC or CSB for interim storage. The risk would be somewhat greater for a calcined product than a vitrified product because the dry particles formed by calcination would be more likely to present an airborne hazard in the event of a release. Final disposal at WIPP or the national geologic repository (with possible processing at the TWRS vitrification facility) would be an effective means of managing the K Basins sludge. Geologic disposal of such highly radioactive waste minimizes the reliance on long-term active controls.

6.4.4 Reduction in Toxicity, Mobility, and Volume Through Treatment

Alternative 3 would significantly reduce the toxicity and mobility of hazardous substances via treatment. The pretreatment process for basin water would significantly reduce activity levels in the water. The contaminants removed from the water would be concentrated onto filters and ion

exchange modules where they would be less mobile and would present a smaller waste volume to manage. Treating the water at ETF would further reduce contaminant concentrations.

The thermal treatment process would reduce the risk associated with the sludge by reducing the pyrophoricity/reactivity associated with metal fines. It would also reduce the toxicity of the sludge by removing or destroying PCBs. The maximum PCB concentration would be reduced from over 100 ppm to less than 2 ppm. The impact of thermal treatment on sludge volumes depends on the specific process option. Vitrification or pyrolysis could increase the final waste volume somewhat because of the addition of glass formers or salts. Volume would also increase if neutron absorbers must be added to meet storage or disposition requirements. Calcination would reduce the volume somewhat, but this effect could be balanced by an increase in volume if the resulting particulate matter is grouted. Treatment via vitrification or molten salt pyrolysis would significantly reduce the mobility of contaminants in the sludge. Calcination would not reduce mobility unless coupled with grouting or vitrification of the calcined particles. Grouting would not be as effective as vitrification in reducing mobility.

Grouting secondary wastes from the thermal treatment process would also reduce the mobility of contaminants prior to disposal. The grouted waste would be disposed at the ERDF, a facility designed to minimize infiltration and thus further reduce contaminant mobility.

6.4.5 Short-Term Effectiveness

Risk to public and the environment. Alternative 3 would create a potential for airborne releases of radioactive contaminants associated with removing SNF, sludge, debris, and water from the basins and transporting them to other Hanford facilities. These activities are the same for Alternatives 2, 3, and 4. Therefore, dose to the MEI associated with these activities would be less than 0.1 mrem/year and the collective dose to the offsite population would be 0.59 person-rem over 2 years (DOE 1995).

In addition,, Alternative 3 would create the potential for airborne releases of PCBs, volatile radionuclides, and radioactive particulate matter resulting from thermal treatment of the sludge. Appropriate control technologies would be used to minimize airborne releases. The treatment would take place inside the CVD or another onsite facility that would provide additional control in the event that contaminants are released from the treatment system.

Risk to workers. Risks to workers include exposure to radionuclides and the potential for accidents associated with a high-temperature process. The treatment system would be designed to allow for remote operations and minimal maintenance to the extent practicable. Engineering and administrative controls would be used to maintain worker exposure ALARA. Workplace and individual monitoring would be performed as appropriate. Industrial safety measures would be addressed in the health and safety plan.

Environmental impacts. Releases of airborne contaminants have the potential to affect the environment. These releases would be controlled through appropriate engineering, particularly of the off-gas treatment system. Monitoring would be provided as necessary. It is not anticipated that sludge treatment would require disturbance of any previously undisturbed land.

Schedule. The schedule for Alternative 3 would be expected to be the same as for Alternative 2.

6.4.6 Implementability

Alternative 3 would be expected to be administratively feasible for the same reasons as Alternative 2. However, there are several uncertainties associated with the technical feasibility of Alternative 3. The removal of SNF, sludge, water, and debris has been evaluated extensively and processes to accomplish removal have been identified. However, although thermal treatment is a well-established technology for many purposes, there has been minimal evaluation of thermal treatment processes with respect to the K Basins sludge.

Thermal treatment has been used extensively to treat PCB-contaminated material. While incineration is the traditional method, vitrification, pyrolysis, and thermal desorption have all been proven or demonstrated to remove or destroy PCBs under certain operating conditions (Davila et al. 1993). Vitrification has been used to destroy PCBs at several CERCLA sites and thermal desorption has been used at many others. Similarly, thermal treatment has been used extensively to stabilize radioactive wastes. Vitrification has had the widest application and is the selected treatment process for Hanford tank waste. Calcination is being used at the Idaho National Engineering Laboratory. Issues of concern with respect to vitrifying the K Basins sludge include volatilization of cesium and other radionuclides and qualification of the glass form. Volatile radionuclides can be controlled through appropriate design of off-gas systems. Qualification of the waste form could be an expensive and time-consuming process; this could be avoided if the treatment process could produce a glass frit to feed to the TWRS vitrification facility. However, the initial contract specification for the TWRS vitrification facility does not identify solid feeds and the costs and impacts of this would have to be evaluated. One alternative would be to resuspend the treated solids in water to be introduced into the TWRS system.

Another issue affecting feasibility is the designation of the sludge. It has not been determined whether the treated sludge would be designated as a TRU waste or HLW. It the latter, options for disposing of the treated sludge to WIPP would be eliminated. It is also uncertain whether thermally treated sludge would meet WIPP waste acceptance criteria and whether cost-effective packaging could be developed.

The uncertainty regarding whether a treatment system sized to accommodate all of the sludge could fit within the CVD is also applicable to thermal treatment. An evaluation would be required to confirm that processing could be done inside CVD. If not, an alternate location such as an annex to the K Basins or another environmentally-protective facility onsite would be selected during remedial design. This would not be expected to affect the overall feasibility of this option.

There is also uncertainty regarding the location to store the dry, treated sludge. Current capacity to store remote-handled TRU waste onsite is limited, but the packaging required to make containers contact handled would increase container size or numbers. An alternate storage location would be the CSB that will provide interim storage for SNF, but this would require

further evaluation. New storage for the dry solids could be constructed but this also would require evaluation.

Finally, there is some uncertainty as to whether the WIPP would accept the treated sludge in any case because of capacity limitations. If not, the final disposal location is limited to the national geologic repository. There is also uncertainty as to whether the repository would accept a grouted waste or saltcake-based waste, which could limit thermal treatment options to vitrification.

6.4.7 Cost

The processes to remove SNF, sludge, water, and debris from the K Basins, manage the SNF, water, and debris, and deactivate the basins are identical for Alternatives 2, 3, and 4. Therefore, the costs for these activities, shown in Table 6-1 for Alternative 2, are the same for Alternative 3. Downstream costs to treat the basin water at ETF are also the same as in Alternative 2.

The cost that varies among the alternatives is the cost for sludge treatment and for interim storage and final disposition of the treated sludge. The relative costs for treatment via thermal methods will be estimated in the Sludge Treatment Alternatives Analysis.

6.4.8 State of Washington Acceptance

Alternative 3 would satisfy the State of Washington's preference that the contents of the K Basins be removed and placed in more protective facilities. State of Washington acceptance of the sludge treatment process will be evaluated following State of Washington review of this FFS.

6.4.9 Community Acceptance

Alternative 3 would satisfy the public's preference that the contents of the K Basins be removed and placed in more protective facilities. Community acceptance of the sludge treatment will be evaluated following public review of the Proposed Plan.

6.5 ALTERNATIVE 4: PHYSICAL TREATMENT

6.5.1 Overall Protection of Human Health and the Environment

Alternative 4 would achieve overall protection of human health and the environment. Essentially all hazardous substances that are not fixed to the structures of the K Basins would be removed and transferred to facilities that are more protective, thereby reducing the potential for further releases from the basins. The SNF would be vacuum dried and placed in sealed containers in dry storage to prevent further degradation. Sludge, water, and debris would be treated, as appropriate, to meet waste acceptance criteria of the receiving facilities. The removal and treatment processes would result in a temporary small increase in worker exposure and a potential increase in public exposure, but in the long-term occupational and public exposure and potential adverse environmental impacts would be reduced.

6.5.2 Compliance With ARARs

Alternative 4 would be designed to comply with all ARARs and TBC materials. As in Alternative 2, the water pretreatment system would be sufficient to meet ETF waste acceptance criteria and TSCA requirements, and debris would be designated in accordance with solid, dangerous, and radioactive waste requirements and disposed at facilities approved to accept the assigned waste designation.

The sludge treatment system would be designed to meet the regulatory requirements and waste acceptance criteria of the identified receiving facility (an existing DST or another tank in the 200 Area). The TWRS criterion excluding TSCA-regulated PCB waste would be met by achieving a PCB concentration in the treated sludge of less than 2 ppm, the PCB treatment standard for alternative PCB treatment (Boomer et al. 1988). Meeting the 2-ppm standard would mean the sludge is no longer TSCA regulated. Once this is demonstrated, the treated sludge would only re-enter TSCA regulation if, at a later time, it becomes contaminated at PCB concentrations greater than 50 ppm. The sludge treatment system would be designed to meet dangerous waste management unit standards. The off-gas treatment system would comply with air emissions standards for radionuclides, hazardous air pollutants, and PCBs. Any offsite transportation of radioactive PCB-contaminated solvent would be performed in compliance with U.S. Department of Transportation and NRC requirements.

6.5.3 Long-Term Effectiveness and Permanence

Alternative 4 would be very effective in the long term. The evaluation of this criterion would be the same as for Alternative 2 except with respect to sludge.

Treated sludge would be a residual from the CERCLA action that presents a potential risk remaining at the end of the action. This risk would be minimized and controlled by transferring the treated sludge to an existing DST or other double-contained tank for storage. The long-term effectiveness of subsequent management in the TWRS system would be the same as in Alternative 2.

6.5.4 Reduction in Toxicity, Mobility, and Volume Through Treatment

Physical treatment would be much the same as chemical treatment with respect to reduction of toxicity and mobility. The treatment process would reduce the risk associated with the sludge by providing criticality control and reducing the pyrophoricity/reactivity associated with metal fines. It would also reduce the toxicity of the sludge by removing PCBs. There might be a greater opportunity for destruction (versus removal and disposal) of the PCBs under this alternative, depending on the method of treating the PCBs. The maximum PCB concentration would be reduced from over 100 ppm to less than 2 ppm. Physical treatment would likely increase the sludge volume somewhat because of the need to add neutron absorber and chemically adjust the solution, but the increase would not be as great as for chemical treatment by acid dissolution because large quantities of acid and caustic would not be added. Final treatment via the TWRS vitrification facility would significantly reduce the mobility of contaminants in the sludge. Final

volumes of vitrified sludge would depend on how the sludge is managed prior to and during vitrification, particularly whether it is blended with other DST waste prior to vitrification.

Grouting secondary wastes from the physical treatment process would also reduce the mobility of contaminants prior to disposal. The grouted waste would be disposed at the ERDF, a facility designed to minimize infiltration and thus further reduce contaminant mobility.

6.5.5 Short-Term Effectiveness

Risk to public and the environment. Alternative 4 would create a potential for airborne releases of radioactive contaminants while removing SNF, sludge, debris, and water from the basins and transporting them to other Hanford facilities. These activities are the same for Alternatives 2, 3, and 4. Therefore, dose to the MEI associated with these activities would be less than 0.1 mrem/year and the collective dose to the offsite population would be 0.59 person-rem over 2 years (DOE 1995).

In addition, Alternative 4 would create the potential for airborne releases of particulate matter during size reduction, but significant volatilization of PCBs or radionuclides would not be anticipated. Appropriate control technologies would be used to minimize airborne releases. The treatment would take place inside the CVD or another onsite enclosed facility that would provide additional control in the event that contaminants are released from the treatment system.

Risk to workers. Risks to workers include exposure to radionuclides and the potential for accidents associated with an industrial process. The treatment system would be designed to allow for remote operations and minimal maintenance to the extent practicable. Engineering and administrative controls would be used to maintain worker exposure ALARA. Workplace and individual monitoring would be performed as appropriate. Industrial safety measures would be addressed in the health and safety plan.

Environmental impacts. Releases of airborne contaminants have the potential to affect the environment. These releases would be controlled through appropriate engineering, particularly of the off-gas treatment system. Monitoring would be provided as necessary. It is not anticipated that sludge treatment would require disturbance of any previously undisturbed land.

Schedule. The schedule for Alternative 4 would be expected to be the same as for Alternative 2.

6.5.6 Implementability

Alternative 4 would be expected to be administratively feasible for the same reasons as Alternative 2. However, there are several uncertainties associated with the technical feasibility of Alternative 4. The removal of SNF, sludge, water, and debris has been evaluated extensively and processes to accomplish removal have been identified. However, although various physical treatment processes are used in industry, there has been minimal evaluation of these processes with respect to the K Basin sludge. There is also uncertainty regarding potential alternate interim storage locations, the flexibility of waste acceptance criteria, and the impacts of changing those criteria.

Physical treatment via high-energy milling has the potential to be a relatively simple approach to preparing the sludge for interim storage and TWRS vitrification, but no detailed evaluations have been performed to demonstrate that physical treatment could achieve the objectives of assuring criticality safety, oxidizing metals and hydrides, and removing or destroying PCBs. High-energy milling is used successfully in the pharmaceutical industry to achieve very small particle sizes. However, uranium metal is very hard, and a grinding test is recommended by the vendor to develop an appropriate design for application to the K Basins sludge. Although there is some evidence that the milling process will also oxidize metal fines, the test would need to include an evaluation of this effect. The design would also need to accommodate introduction of neutron absorbers. PCBs might need to be removed from the sludge as part of the treatment process. Solvent extraction would be a more common method, but would introduce risks and costs associated with a solvent system. Calcium oxide oxidation might be an alternative, but it has not been widely demonstrated and the technical feasibility would have to be evaluated.

In addition, the three issues identified for Alternative 2 would also be issues under Alternative 4 as follows:

- Although DST tank space would still be an issue, the volume of treated sludge from a high-energy milling process would be less than for Alternative 2.

- The issue of TSCA regulation of the treated sludge would be the same as for Alternative 2. EPA would need to determine that 2 ppm is an appropriate standard to exit TSCA regulation and that TSCA would not be triggered unless the sludge later became contaminated at PCB concentrations of 50 ppm or greater.

- The treatment location would be confirmed during remedial design.

There is also uncertainty regarding the interim storage location for the treated sludge. One possibility is storage in a tank constructed as part of the feed system for the TWRS vitrification facility, but information on the availability and waste acceptance criteria of such a tank is not yet available. Use of an existing DST would require a criticality safety analysis to establish whether particle size reduction and mixing with neutron absorbers would achieve criticality control without the co-precipitation achieved by chemical treatment.

6.5.7 Cost

The processes to remove SNF, sludge, water, and debris from the K Basins, manage the SNF, water, and debris, and deactivate the basins are identical for Alternatives 2, 3, and 4. Therefore, the costs for these activities, shown in Table 6-1 for Alternative 2, are the same for Alternative 4. Downstream costs to treat the basin water at ETF are also the same as in Alternative 2.

The cost that varies among the alternatives is the cost for sludge treatment and for interim storage and final disposition of the treated sludge. The relative costs for treatment via physical methods will be estimated in the Sludge Treatment Alternatives Analysis.

6.5.8 State of Washington Acceptance

Alternative 4 would satisfy the State of Washington's preference that the contents of the K Basins be removed and placed in more protective facilities. State of Washington acceptance of the sludge treatment process will be evaluated following State of Washington review of this FFS.

6.5.9 Community Acceptance

Alternative 4 would satisfy the public's preference that the contents of the K Basins be removed and placed in more protective facilities. Community acceptance of the sludge treatment will be evaluated following public review of the proposed plan.

Table 6-1. Costs for Alternative 2[a].

Category	CERCLA Cost[b] ($M)	Non-CERCLA Cost ($M)	Total ($M)
Project Management and Integration[c]	215.6	141.3	356.8
Basin Maintenance and Operation[d]	156.1	168.0	324.1
Basin Facility Projects	8.9	38.7	47.6
SNF Retrieval (Design/Modification/Construction)	10.8	41.8	52.6
SNF Cask Transportation System and MCO Acquisition	65.1	43.4	108.6
SNF Retrieval (Operations)	165.2	31.1	196.3
Cold Vacuum Drying Facility (Design/Modification/Construction)[e]		77.7	77.7
Cold Vacuum Drying (Operations)		44.7	44.7
CSB Facility (Design/Modification/Construction)		155.1	155.1
CSB Facility (Operations)		51.4	51.4
Sludge Retrieval/Removal (Design/Modification/Construction)	12.6	7.1	19.7
Sludge Retrieval/Removal (Operations)	6.3	0	6.3
Sludge Treatment (Design/Modification/Construction)	36.6	5.7	42.3
Sludge Transport/Offloading (Design/Modification/Construction)	4.6	0.3	4.9
Sludge Treatment/Transport (Operations)	3.7	0	3.7
Water Treatment (Design/Modification/Construction)	13.5	25.4	38.9
Debris Removal (Design/Modification/Construction)	11.8	5.1	16.9
Debris Removal (Operations)	12.1	1.6	13.7
Site-Wide Spent Fuel Activities[g]		24.9	24.9
Total[h]	**722.9**	**863.3**	**1,586.2**

a. From proposed SNF Project Baseline as of October 9, 1998, rounded to the nearest $100,000.
b. Excludes costs incurred before CERCLA authority is implemented (assumed to be October 1, 1999) and costs outside the scope of the CERCLA interim remedial action.
c. Includes Project Fee.
d. Includes maintenance and operation both before and after fuel removal.
e. Includes costs expended on evaluation of hot conditioning system.
f. Not in scope of CERCLA action.
g. Includes 327 fuel transfer, N Basin fuel movement, 200 Area interim storage area design/construction, design/move fuel to 200 ISA, and operation/maintenance of the 200 ISA.
h. The SNF project has transferred $133.5 million transition budget into the SNF project scope for deactivation. These deactivation costs are not reflected in the table. The total cost including deactivation is $1,719.7 million.

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7.0 COMPARATIVE EVALUATION OF ALTERNATIVES

7.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternatives 2, 3, and 4 would all provide overall protection of human health and the environment by removing hazardous substances from the K Basins and transferring them to facilities that are more protective, thereby reducing the potential for further degradation of the SNF and future releases from the basins. In contrast, the no action alternative would fail to protect human health and the environment.

7.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Alternatives 2, 3, and 4 would all meet ARARs. In all cases, the sludge treatment process would require an EPA determination that the treatment qualifies as an alternative PCB treatment under TSCA subject to the treatment requirements for alternative treatment specified in Boomer (1988). Alternative 1 would not invoke ARARs because no action would be taken. Applicable requirements would continue to be required if Alternative 1 were selected as the preferred alternative.

7.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternatives 2, 3, and 4 provide a significantly higher degree of long-term effectiveness than Alternative 1. The contaminants associated with the SNF, sludge, water, and debris would be removed from the K Basins and placed at more environmentally protective facilities. The basin water would be removed, thus eliminating the primary driving force for contaminant migration. After deactivation, the basins would be left in a condition where they would present minimal threat to the environment. Final remediation of the basins will be undertaken as part of a later CERCLA action.

None of the alternatives provide for immediate disposal of the sludge, but in all cases the treated sludge would be transferred to facilities that are designed to provide safe interim storage and minimize the potential of an environmental release. Alternative 3 might be somewhat more effective than Alternatives 2 and 4 relative to interim storage if vitrification is used. Storing the treated sludge as a vitrified product rather than a slurry would reduce the risk of releases to the environment. In contrast, Alternative 3 might be less effective than Alternatives 2 and 4 relative to interim storage if calcination is used without additional grouting, because the calcine product would be a particulate that could become airborne in the event of a release.

7.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME

Alternative 1 would involve no treatment. Therefore, Alternatives 2, 3, and 4 would be substantially better than Alternative 1 in reducing the toxicity and mobility of hazardous substances removed from the K Basins. Because water management is the same under Alternatives 2, 3, and 4, the alternatives would be equally effective in reducing the toxicity associated with contaminated water. The alternatives would vary somewhat with respect to sludge treatment. All of the alternatives would oxidize metals and metal hydrides, reducing the risk associated with reactive metals. Alternative 3 could reduce the toxicity of PCBs to the greatest extent if vitrification is used, because vitrification would tend to destroy PCBs rather than simply separate them from the sludge. In addition, only vitrification (Alternative 3) or grouting (Alternative 4) would reduce the mobility of heavy metals and radionuclides as part of the CERCLA action. Heavy metals and radionuclides eventually would be immobilized under all of the alternatives, but in the cases of chemical treatment (Alternative 2), calcination (Alternative 3), and grinding-milling (Alternative 4, immobilization would be accomplished outside the scope of the CERCLA action. All of the treatment alternatives have the potential to increase (rather than reduce) waste volumes. This effect is likely to be greatest with the acid dissolution process in Alternative 2, where substantial quantities of chemicals would be added to the sludge.

7.5 SHORT-TERM EFFECTIVENESS

Risk to public and the environment. All of the treatment alternatives have the potential to affect the public through airborne releases during removal and treatment activities, but none of the alternatives are expected to pose unacceptable risks. The potential for airborne releases could be somewhat greater for Alternatives 2 and 3 than for Alternative 4 because they involve higher temperature treatment systems.

Risk to workers. None of the alternatives would be expected to pose unacceptable short-term risks to site workers. The risks associated with Alternatives 2 and 3 might be somewhat greater than for Alternative 4 because they involve use of large quantities of hazardous chemicals (Alternative 2) and very high temperatures (Alternative 3), respectively.

Environmental impact. None of the alternatives would be expected to result in short-term impacts to the environment.

Schedule. Based on current information, the schedules for Alternatives 2, 3, and 4 are identical.

7.6 IMPLEMENTABILITY

Alternative 1 is not administratively feasible because it fails to comply with the K Basins EIS and ROD, proposed Tri-Party Agreement milestones, and commitments made to the regulators, oversight agencies, stakeholders, and public.

Alternatives 2, 3, and 4 all appear to be administratively feasible. They would also be technically feasible with respect to management of SNF, water, and debris. However, the technical feasibility of sludge treatment can only be evaluated with some degree of certainty for the acid dissolution process proposed in Alternative 2 at this time. Based on general information and K Basins-specific engineering and laboratory studies, the technical feasibility of acid dissolution as proposed in Alternative 2 has been well demonstrated. Acid dissolution would be expected to meet interim storage and final disposal criteria established by the TWRS program, although interim storage would require careful planning to accommodate the anticipated volume of slurry. Studies specific to hot water dissolution, thermal treatment, and physical treatment of the sludge such as whether such treatment could adequately meet interim storage and final disposal criteria have not been performed. However, thermal treatment processes (Alternative 3) has been demonstrated for waste similar to the K Basins sludge and therefore are considered to be more technically feasible than Alternative 4. If the thermal treatment of the sludge is determined to be technically feasible with respect to subsequent management of the treated sludge and secondary wastes, Alternative 3 could ultimately be more favorable than Alternatives 2 and 4 because it could reduce waste volume impacts related to storing of the treated sludge in a DST.

The Sludge Treatment Alternatives Analysis will be used to more fully evaluate the criterion of Implementability for hot water dissolution, thermal treatment, and physical treatment.

7.7 COST

The estimated cost for Alternative 2 was shown in Table 6-1. The only costs for Alternatives 3 and 4 that would differ from the table would be costs for sludge treatment. The relative costs for sludge treatment via chemical, thermal, and physical methods will be assessed in the Sludge Treatment Alternatives Analysis. In addition, costs outside the scope of the CERCLA action associated with interim storage and final disposition of the treated K Basins sludge are likely to vary among alternatives. These relative costs will also be evaluated in the Sludge Treatment Alternatives Analysis.

7.8 STATE OF WASHINGTON ACCEPTANCE

All of the alternatives would satisfy the State of Washington's preference that the contents of the K Basins be removed and placed in more protective facilities. State of Washington acceptance of the sludge treatment process will be evaluated after State of Washington review of this FFS and the Sludge Treatment Alternatives Analysis.

7.9 COMMUNITY ACCEPTANCE

All of the alternatives would satisfy the public's preference that the contents of the K Basins be removed and placed in more protective facilities. Community acceptance of the sludge treatment process will be evaluated after public review of the proposed plan.

7.10 SUMMARY

In summary, all of the alternatives except Alternative 1 would provide overall protection of human health and the environment, comply with ARARs, and be effective in the short and long term. The greatest difference between Alternatives 2, 3, and 4 is the uncertainty associated with technical feasibility and cost. The technical feasibility of the acid dissolution process proposed for sludge in Alternative 2 is supported by engineering studies and laboratory tests using actual and simulated K Basins sludge. Treatment via hot water dissolution, thermal processes, and physical processes have not been evaluated with specific application to the K Basins sludge. Because of this, the technical feasibility and cost of these alternatives is uncertain at this time. The Sludge Treatment Alternatives Analysis initiated by DOE will further evaluate the technical feasibility and relative costs of hot water dissolution, thermal treatment, and physical treatment.

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APPENDIX A

NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 VALUES ANALYSIS

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A1.0 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 VALUES EVALUATION

The *National Environmental Policy Act of 1969* (NEPA) process is intended to help federal agencies make decisions that are based on understanding environmental consequences and take actions that protect, restore, and enhance the environment. Secretarial policy and U.S. Department of Energy (DOE) Order 451.1 require that *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) documents incorporate NEPA values such as analysis of cumulative, offsite, ecological, and socioeconomic impacts, to the extent practicable in lieu of preparing separate NEPA documentation for CERCLA activities.

A1.1 DESCRIPTION OF NEPA VALUES

Several of the CERCLA evaluation criteria involve consideration of environmental resources, but the emphasis is frequently directed at the potential effects of chemical contaminants on living organisms. The NEPA regulations (40 CFR 1502.16) specify evaluation of the environmental consequences of proposed alternatives. These include potential effects on transportation resources, air quality, cultural and historical resources, noise, visual and aesthetic effects, environmental justice, and the socioeconomic aspects of implementation. The NEPA process also involves consideration of several issues such as cumulative impacts (direct and indirect), mitigation of adversely impacted resources, and the irreversible and irretrievable commitment of resources. The NEPA-related resources and values that have been considered in the alternative evaluations include the following:

- Transportation impacts. This value considers impacts on local traffic (i.e., traffic at the Hanford Site) and traffic in the surrounding region resulting from the interim remedial action.

- Air quality. This value considers potential air quality concerns associated with emissions generated during the interim remedial action.

- Natural, cultural, and historical resources. This value considers impacts on wildlife, wildlife habitat, archeological sites or artifacts, or historically-significant properties in the 100-K Area resulting from the interim remedial action.

- Noise, visual and aesthetic effects. This values considers increases in noise levels or impaired visual or aesthetic values in the 100-K Area during or following the interim remedial action.

- Socioeconomic impacts. This value considers impacts pertaining to employment, income, other services (e.g., water and power utilities), and how the implementation of the interim remedial action affects the availability of services and materials

- Environmental justice. Environmental justice, as mandated by Executive Order 12898 (Clinton 1994), refers to fair treatment of all races, cultures, and income levels with respect to laws, policies, and government actions. This value considers whether interim

remedial action taken at the K Basins would have inappropriately or disproportionately high and adverse human health or environmental effects to minority or low-income populations.

- Cumulative impacts (direct and indirect). Implementing interim remedial action at the K Basins may have cumulative impacts on human health or the environment when considered together with other activities in the 100 Area, at the Hanford Site, or in the region. This value considers those cumulative impacts.

- Mitigation. If adverse impacts cannot be avoided, remedial action planning should minimize them to the extent practicable. This value identified required mitigation activities.

- Irreversible and irretrievable commitment of resources. This value evaluates the use of nonrenewable resources for the K Basins remedial action and the effects that resource consumption would have on future generations. When a resource (e.g., energy, minerals, water, or wetland) is used or destroyed and cannot be replaced within a reasonable amount of time, its use is considered irreversible. An example would be consumables such as fuel and chemicals that might be used in treatment systems. Because irreversible commitments cannot always be avoided, the evaluation examines the nature and amount of resources that would be irreversibly committed.

A1.2 SPENT NUCLEAR FUEL ENVIRONMENTAL IMPACT STATEMENT

The K Basins environmental impact statement (EIS) (DOE 1996a) and record of decision (ROD) (61 FR 10736) evaluated the environmental impacts associated with the management of spent nuclear fuel (SNF) stored in the K Basins. It also addressed, in less detail, management of the sludge, water, and debris in the basins. The preferred alternative selected in the ROD was to remove the SNF, sludge, water, and debris from the basins and transport them to facilities in the 200 Area. The preferred alternative included a process for conditioning the SNF prior to interim storage.

Alternatives related to SNF that were evaluated in the SNF EIS included no action; enhanced K Basin storage; new wet storage; drying/passivation (conditioning) with dry storage; calcination with dry storage; onsite processing; and foreign processing. The analysis of these alternatives considered such aspects as potential accidents; socioeconomics; cultural, geologic, air, water, and ecological resources; transportation; health and safety; and site services. The preferred alternative for handling the SNF has evolved as additional information has been acquired on the SNF and potential conditioning options. A Supplement Analysis was prepared in which it was determined that proposed modifications to the SNF conditioning process were bounded by the analysis in the original EIS and no further NEPA review was required (DOE 1998).

For all of the alternatives analyzed in the K Basins EIS, management of the sludge, basin water, and debris were included as part of the analysis. Water treatment options consisted of (1) the no action alternative and (2) pretreatment at the basins using existing filtering and ion exchange treatment methods with transportation to the 200 Area Effluent Treatment Facility (ETF) for

final disposal. The alternatives for handling the debris were 1) no action and 2) standard removal techniques, decontamination and volume reduction where possible, and disposal at appropriate burial grounds. The scope of these proposed actions for basin water and debris has not changed substantially from the EIS with the clarification that only the Environmental Restoration Disposal Facility will be used for disposal of debris that designates as LLW or mixed waste. The water and debris management are not re-evaluated in this focused feasibility study (FFS). However, the sludge treatment requirements were not fully defined at the time the K Basins EIS was prepared. Consequently, alternatives for handling sludge are the focus of this FFS. This integrated NEPA values analysis for sludge treatment builds on the previous K Basins EIS analysis for the SNF alternatives, since the actions for sludge removal and handling are similar in effects to those for SNF, but on a smaller scale.

Overall, the K Basins ROD determined that environmental impacts under normal operating conditions were neither very large nor varied greatly among alternatives (61 Federal Register [FR] 10736). Although the no action alternative would have fewer environmental impacts in the near term, over the long term, the preferred alternative would protect public health and the environment because it would remove the SNF from aging facilities and place it into a safer configuration.

Health impacts to the public from the action were estimated by considering the effects on the maximally exposed individual (MEI). The MEI is a hypothetical member of the public who lives at a location and has a lifestyle such that it is unlikely that other members of the public could receive a higher radiation dose. This individual's diet, home, and other factors are chosen to maximize the combined doses from all reasonable pathways of exposure to radionuclides from project activities. In reality, this combination of maximized parameters is unlikely to apply to any one individual. However, the dose to the MEI is useful for establishing an upper bound on potential exposure to any member of the public. Expected average impacts to the surrounding general public are also evaluated, and are provided as the regional collective dose to all people (approximately 380,000) living within a radius of 80 km (50 miles) from the project site.

None of the alternatives evaluated in the EIS resulted in a dose to the MEI that exceeded 0.01 mrem/year (DOE 1996a). For comparison, the *Hanford Site Environmental Report* (Dirkes and Hanf 1998) reported that the potential radiological doses from Hanford Site operations to the hypothetical offsite MEI during calendar year 1997 was 0.01 mrem. The national average dose from background sources is 300 mrem/year and the current DOE radiation limit for an individual member of the public is 100 mrem/year (Dirkes and Hanf 1998).

The potential collective consequences of removing SNF, sludge, debris, and water from the K Basins and staging the SNF in the 200 Area were estimated at 0.59 person-rem to the population living within 80 km (50 miles) (DOE 1996a). For comparison, the potential collective dose to the local population from Hanford operations was 0.2 person-rem in 1997 (Dirkes and Hanf 1998). The total dose received in a year by this same population from natural background radiation was about 110,000 person-rem (DOE 1996a).

Several accident scenarios and potential impacts from those scenarios were evaluated in the SNF EIS. The EIS postulated a design basis accident in which a fire results in airborne releases of a fraction of the SNF inventory. The EIS assumed that about 10 canisters of SNF were in the

CVD at the time and assigned release fractions to the volatile, semi-volatile, and nonvolatile radionuclides.

The K Basins EIS concluded that offsite impacts from activities addressed in the EIS would be comparable to impacts from overall Hanford Site operations.

Because of ongoing vegetation control programs, the area within the reactor building fenceline of the 100-K Area is virtually devoid of vegetation, and consequently the use by wildlife is minor. The large amount of ground disturbance during initial facility construction has eliminated any near-surface, tangible, cultural or archeological resources that might have been present within the 100-K Area before the site was built. Because the resources at the 100-K Area have already been severely affected, the alternatives analyzed in the K Basins EIS were not expected to have any significant cumulative effects on the environmental, cultural, or historic resources in the area. Subsequent to preparation of the EIS, certain facilities in the 100-K Area were identified as eligible for listing on the National Register of Historic Places. Mitigation efforts for these facilities have been completed, so impacts on historical resources are not anticipated.

A1.3 NEPA VALUES RELATED TO SLUDGE TREATMENT

As concluded in the K Basins EIS, the no-action alternative would have fewer impacts in the short term. There would be no change to air quality, no direct impact on cultural or ecological resources, and labor needs would continue at current levels. However, over the long term, the no-action alternative would present an increased threat to the environment because continued storage of the hazardous substances the K Basins presents a threat of a release to the environment. Further, without treatment to meet interim storage facility acceptance criteria, sludge would remain in the K Basins.

A1.3.1 Transportation Impacts

The primary transportation impact would be associated with transportation of the sludge, first as a slurry to the treatment system then as a slurry (Alternatives 2 and 4) or a solid (Alternative 3) to the interim storage location. All sludge transport would take place on the Hanford Site. A slurry transport system has been designed to mitigate the potential for a release during transport. If Alternative 4 were to be selected, a solids transport system would be similarly designed. A transportation safety analysis would be performed prior to any sludge transport activities. The analysis would identify the need for specific precautions (e.g., road closures) to be taken. Increases in the work-force traffic related to sludge treatment would be expected to be minor.

A1.3.2 Air Quality

Sludge treatment would result in potential near-term impacts to air quality, but these impacts could be mitigated through appropriate engineering controls. The primary impacts would be associated with routine air emissions and non-routine releases that could result in airborne contamination. Local and regional air quality are not expected to be significantly affected by routine air emissions because off-gas treatment systems would be employed as appropriate to control potential emissions. In particular, off-gas treatment would address radioactive

particulate, volatile radionuclides, hazardous air pollutants, and PCBs. Chemical and thermal treatment (Alternatives 2 and 3, respectively) may have a greater potential to produce routine air emissions than physical treatment, but control methodologies are readily available. The potential dose to the MEI from sludge treatment as proposed under Alternative 2 was estimated at less than 0.02 mrem/year.

Potential impacts associated with non-routine releases postulated for the sludge treatment system are expected to be bounded by the accidents described in the K Basins EIS for SNF conditioning, because the radioactive sludge is only an estimated one percent of the original mass of the SNF. Only a small fraction of the sludge inventory would be treated at one time. For this FFS, a similar accident is postulated whereby an event occurs during sludge treatment that results in airborne releases of a fraction of the sludge inventory in the CVD. All sludge treatment would occur within an environmentally-protective facility either in the 100-K Area (such as the CVD) or in the 200 Area. A very conservative assumption is that a maximum 10 percent of the total volume of sludge (i.e., 5 m^3 on a settled solids basis) is present at the sludge treatment system at any one time. If the same release fractions for volatile, semi-volatile, and nonvolatile radionuclides are applied to the sludge as were used for the SNF, the release estimates for individual radionuclides would be lower for a sludge accident by at least an order of magnitude. Therefore, the SNF fire scenario in the conditioning facility bounds a fire scenario involving sludge treatment at CVD.

A1.3.3 Natural, Cultural, and Historical Resources

Natural and cultural resources within the main portion of the 100-K Area are minimal. However, certain facilities within that area have been identified as eligible for listing on the National Register of Historic Places. Mitigation work on these facilities has been completed. A treatment system would likely be located inside existing facilities, thus no impacts to cultural and ecological resources from new construction would be expected. If a new facility were required, it would likely be constructed in a previously disturbed area, such as within the main portion of the 100-K Area.

The proposed sludge treatment would take place within one-quarter mile of the Columbia River, which has been nominated for Wild and Scenic status. The National Park Service would be consulted during design of the treatment facility as required by Public Law 100-605 (as amended by Public Law 104-333) to ensure that the treatment system selected would not adversely affect the attributes of the river or adjacent shoreline.

A1.3.4 Noise, Visual, and Aesthetic Effects

Sludge treatment operations could increase noise levels or impair visual and aesthetic values during treatment. However, treatment would only occur for one year, and would likely occur inside a facility that is already constructed in the 100-K Area.

A1.3.5 Socioeconomic Impacts

The treatment alternatives would require more labor in the short term than the no action alternative but would reduce the long-term need for maintenance. The labor force required to

construct and operate a treatment system would be drawn from current Hanford Site contractors and the local labor force. No significant socioeconomic impacts would be expected.

A1.3.6 Environmental Justice

Because offsite impacts would be expected to be minimal and the sludge would be treated and removed from the 100-K Area, it is not expected that treatment would disproportionately affect any group.

A1.3.7 Cumulative Impacts

Cumulative impacts of sludge treatment are considered together with impacts from past and foreseeable future actions at and near the Hanford Site. Authorized current and future activities in the 100 Areas include the removal and drying of SNF from the K Basins; soil and groundwater remediation; interim safe storage of reactors; and surveillance, maintenance, decontamination, and decommissioning of facilities. Other Hanford Site activities include storage and vitrification of tank wastes, deactivation and decontamination of reprocessing facilities, and operation of the Washington Public Power Supply System commercial reactor. A privately-owned radioactive and mixed waste treatment facility is planned adjacent to the southern boundary of the Hanford Site and is in the process of obtaining permits and approvals. Other activities that are being considered at or near the Hanford Site but which are not currently authorized include the construction and operation of an aluminum smelter in the 400 Area.

Two areas of concern with respect to cumulative impacts are air quality and waste management. Air quality limits at the Hanford Site boundary are not expected to be approached as a result of current or future activities that are currently authorized. The air quality analysis presented for Alternative 2 indicates that implementation of this alternative would not result in these limits being exceeded, even in conjunction with other Site activities. Estimates would be expected to be on the same order for Alternatives 3 and 4.

Waste management impacts associated with sludge treatment center on the availability of DST storage. DST space is constrained, and it would be both a schedule and cost impact to Hanford programs to provide new DSTs. Alternative 2 would be likely to have the greatest impact on DST space. The anticipated volume of treated sludge under Alternative 2 would be as high as 1,620 m^3 (over 400,000 gal). This volume has been included in tank space planning. However, changes to other Site programs could affect the ability of the DST system to receive space, which could affect the treatment alternatives.

A1.3.8 Irreversible and Irretrievable Commitment of Resources

Alternative 2 would consume chemicals, and all of the treatment alternatives would require energy resources. However, these needs would not be expected to be a significant commitment of resources.

APPENDIX B

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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B1.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Applicable or relevant and appropriate requirements (ARARs) are standards, requirements, criteria, or limitations promulgated under federal or State of Washington environmental laws that must be met or waived for actions conducted under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). A requirement may be "applicable" or "relevant and appropriate," but not both. Only the substantive (versus administrative) provisions of ARARs must be met for those actions conducted entirely onsite (CERCLA Sec. 121(d)(2)). "Onsite" is defined under CERCLA as the area of contamination and working areas in close proximity to the area of contamination. Such onsite actions are exempted from obtaining federal, State of Washington, and local permits (CERCLA Sec. 121(e)(1)). To-be-considered (TBC) materials are federal and State of Washington advisories and non-promulgated guidance that may be referenced to the extent necessary for the response action to be adequately protective. Remedial actions at Hanford are also subject to the requirements of DOE orders and policies, as applicable; however, because these orders are not issued by the environmental regulatory agencies, they are not identified as TBC materials.

As part of the ongoing environmental compliance program at Hanford and project requirements for the spent nuclear fuel (SNF) project, a Standards/Requirements Identification Document (S/RIDs) process was applied to the SNF project and a S/RIDs was completed (PHMC 1998). The purpose of the S/RIDs process is to identify requirements relevant to the project and clearly connect the requirements to implementing procedures. The S/RIDs process encompasses promulgated laws and regulations as well as DOE policies, orders, and guidance. The S/RIDs will be coordinated with the ARARs identified here, as appropriate.

ARARs are typically grouped into one of three categories: chemical specific, location specific, and action specific. Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies that result in establishment of numerical values. These values establish the acceptable amount or concentration of a hazardous substance that can remain in or be discharged to the environment. Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities because they occur in special or sensitive locations or environments. Action-specific ARARs are those that place either technology-based or activity-based requirements on remedial action.

Under CERCLA, the no-action alternative invokes no ARARs. Potential ARARs for Alternatives 2, 3, and 4 include standards for radioactive and dangerous waste management, polychlorinated biphenyl (PCB) management, effluent discharge, air emissions control, and radiation protection. Because the scope of the interim remedial action does not include remediation of subsurface structures or soil or groundwater contamination, environmental media cleanup standards have not been identified as ARARs. Waste acceptance criteria at various storage, treatment, and disposal facilities may be considered TBC materials. Waste acceptance criteria were presented in Chapter 4.

Key provisions of the various ARARs are described in the following sections. Table B-1 provides a listing of the federal ARARs and TBC materials and Table B-2 provides a listing of the State of Washington ARARs and TBC materials.

B1.1 RADIOACTIVE WASTE MANAGEMENT STANDARDS

The *Atomic Energy Act* (AEA) (42 U.S.C. 2011 et seq.) authorizes the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the U.S. Nuclear Regulatory Commission (NRC) to set standards and restrictions governing SNF and radioactive waste. Key implementing regulations pertinent to designating and managing SNF and radioactive waste generated by the K Basins interim remedial action include:

- 10 *Code of Federal Regulations* (CFR) 20: establishes NRC requirements for protection against radiation hazards that may result from occupational exposure or discharges to the air and water. One requirement is that the total effective dose equivalent to individual members of the public must not exceed 0.1 rem/year. This regulation is not legally applicable to DOE facilities but is relevant and appropriate for radioactive releases to the air and water.

- 10 CFR 61: establishes NRC requirements for land disposal of radioactive waste (excluding high-level and transuranic [TRU] waste). Subpart C of this regulation contains performance objectives. The objectives specify that LLW disposal sites must provide protection of the general population from releases of radioactivity, protection of individuals from inadvertent intrusion, and stability of the disposal site after closure. This regulation is not legally applicable to DOE facilities but is relevant and appropriate for the disposal of low-level waste (LLW) and mixed waste (such as debris or sludge treatment residuals) generated by the interim remedial action.

- 40 CFR 191: establishes EPA requirements for management of SNF, high-level waste, and TRU waste. This regulation is applicable to DOE facilities. Subpart B addresses disposal of SNF and high-level and TRU waste and contains disposal requirements including the expectation that containment will be provided for 10,000 years. It is an ARAR for SNF and TRU waste (such as sludge, and potentially, debris) generated by the interim remedial action.

B1.2 DANGEROUS WASTE MANAGEMENT STANDARDS

The Resource Conservation and Recovery Act of 1976 (RCRA) governs the identification, storage, treatment, and disposal of hazardous waste and the hazardous component of mixed waste. Authority to implement portions of RCRA has been delegated to the State of Washington; the State of Washington implements RCRA via the *Hazardous Waste Management Act* and *Washington Administrative Code* (WAC) Chapter 173-303. Under the State of

Washington authority, the term dangerous waste is used instead of hazardous waste, and the definition of dangerous waste encompasses a larger universe of wastes. When a waste is both a dangerous waste and a radioactive waste, it is designated as a mixed waste.

It is anticipated that the sludge will be regulated as a mixed waste due to concentrations of heavy metals. Some debris might also designate as mixed waste. Basin water is not expected to designate as mixed waste.

Facilities to treat, store, and dispose of the sludge must meet substantive dangerous waste management requirements that include the following:

- Tank-based sludge treatment and storage systems must be double contained, provided with appropriate leak detection capabilities, and cathodically protected.
- Tanks must be inspected daily and subjected to periodic integrity testing. New tanks must undergo a structural integrity assessment.
- Containers must be in good condition, compatible with the waste, closed except when adding/removing waste, handled in a manner that will not cause a release, and provided with at least 30 inches of aisle space.
- Container storage areas must provide containment sufficient to hold spills and leaks and prevent run-on.
- Storage container areas inspected weekly.

Mixed waste is subject to land disposal restrictions (LDR) that depend on the waste designation and waste type (e.g., certain types of debris like concrete have separate requirements). In general, wastes must be treated to either specific contaminant levels or by specific technologies prior to disposal. If basin sludge or basin debris designates as a mixed waste, it will most likely designate because of heavy metals. Wastes that are designated as characteristic wastes due to the presence of heavy metals are subject to Phase IV of the LDR which requires treating the waste to meet universal treatment standards for both the characteristic constituent and underlying constituents.

B1.3 PCB MANAGEMENT STANDARDS

The *Toxic Substances Control Act* (TSCA) and its implementing regulation (40 CFR 761) govern the storage, treatment, and disposal of materials and wastes containing greater than 50 ppm of PCBs. The 1998 amendments to 40 CFR 761 (the "Megarule") added specific provisions relative to PCB bulk waste, PCB remediation waste, and decontamination. Key substantive provisions of TSCA relative to identifying TSCA-regulated materials include the following:

- Material containing ≥ 50 ppm of PCBs is regulated under TSCA. Floor and pit sludge in the KE Basin is regulated under TSCA due to PCBs at concentrations greater than 50 ppm.

- TSCA prohibits deliberate or incidental dilution as a means of avoiding regulation (the "anti-dilution provision"). If the original source contained ≥ 50 ppm of PCBs, all materials that are mixed with that source and all wastes derived from that source are TSCA regulated, regardless of PCB concentration, unless treated by specific methods or to specific standards.

- For multiphase wastes (e.g., sludge), the phases (e.g., solids and liquids) must be separated before analysis for PCBs. Solid phases must be analyzed on a dry weight basis.

Key substantive provisions of TSCA relative to storage include the following:

- PCB containers and storage areas must be marked with a PCB warning label.

- Facilities used to store PCBs must prevent rain water from reaching the stored PCBs; must have secondary containment equal to two times the volume of the largest PCB article or Container or hold 25 percent of the total PCB volume (whichever is greater); must have no penetrations that would allow liquids to flow out of the secondary containment; and must not be located in a 100-year flood plain.

- Large storage containers (e.g., tanks) for liquid PCBs must be designed and operated in accordance with standards in 29 CFR 1910.106, "Flammable and Combustible Liquids." However, the K Basins sludge meets the definition of a Class IIIB liquid (flashpoint above 200°F [93.6°C]), and Class IIIB liquids are not subject to the requirements of the section.

- For storage in large containers (e.g., tanks), a Spill Prevention, Control, and Countermeasure Plan must be prepared for the facility in accordance with 40 CFR 112. Existing facility emergency plans or contingency plans can be used to satisfy this requirement.

- Bulk PCB remediation waste may be stored onsite in a way that prevents uncaptured releases in the event of spills and controls migration from precipitation and volatilization.

Key substantive provisions of TSCA relative to treating and disposing PCB waste include the following:

- PCB liquids and PCB items (but not PCB remediation waste or bulk product waste) must be treated via incineration (with a destruction removal efficiency [DRE] of 99.9999%), a high-energy boiler, or an alternate treatment method approved by EPA.

- Bulk PCB remediation waste with a PCB concentration ≥ 50 ppm that is not treated to TSCA standards must be disposed in a permitted hazardous waste landfill or an approved PCB disposal facility (40 CFR 761.61(a)(5)(i)(B)(2)(iii)). EPA may approve risk-based cleanup levels on a case-by-case basis (40 CFR 761.61(c)).

- For multiphase wastes in which the phases are not separated for disposal, disposal must comply with the requirements for the phase with the highest concentration. If the phases are separated for PCB remediation waste or decontamination waste, each phase may be disposed of or decontaminated based on the concentration of PCBs in that phase.

- Liquid PCB remediation waste must be disposed as TSCA-regulated material or decontaminated. The decontamination standard for water is ≤ 0.5 ppb (40 CFR 761.79(b)(1)(iii)).

- PCB articles containing between 50 and 500 ppm of PCBs are not regulated under TSCA once drained of free-flowing liquid; if greater than 500 ppm, they must be disposed in a chemical waste landfill or incinerated (40 CFR 761.60(5)).

For thermal destruction technologies, EPA considers equivalent performance to be a DRE for PCBs equivalent to 99.9999% (Boomer, et al. 1988) as determined by PCB concentrations in the off-gas. For non-thermal technologies, EPA considers equivalent performance to be removal or destruction of the PCBs such that PCBs cannot be quantified in the residual waste or in releases to the air, water, or land (Boomer, et al. 1988). This is defined by EPA as follows:

- Solid matrices or organic liquids must contain less than 2 ppm PCBs per resolvable gas chromatograph peak

- Aqueous streams must contain less than or equal to 3 ppm PCBs (this is superceded by the revised TSCA regulation that requires treatment to 0.5 ppb in for aqueous streams)

- Air emissions must contain less than 10 μg/cubic meter of PCBs.

A stream that does not meet these standards is still regulated under TSCA. EPA considers chemical treatment, physical treatment (specifically including vitrification), and biological treatment in this category (Boomer, et al. 1988). In addition, "thermal" treatment systems that act by causing physical separation of the PCBs (such as thermal desorption) have been permitted under the alternative treatment standards with a requirement that the treated product contain less than 2 ppm PCBs.

B1.4 EFFLUENT DISCHARGE STANDARDS

The federal *Clean Water Act of 1988* (CWA) and the State of Washington *Water Pollution Control Act* regulate discharges to waters of the United States and waters of the State of Washington, respectively. The State of Washington law is implemented via WAC

Chapter 173-216 and controls direct and indirect discharges to waters of the State of Washington, including effluent discharges to the soil column. This control consists of setting concentration limits for soil column discharges, establishing requirements for monitoring, and requiring application of all known, available, and reasonable methods of treatment.

B1.5 AIR EMISSION STANDARDS

The federal *Clean Air Act* (CAA) and the *Washington Clean Air Act* regulate both radioactive and non-radioactive airborne emissions. EPA administers the federal radioactive emissions requirements and the Washington State Department of Health (DOH) administers the State of Washington radioactive emissions requirements. Implementing regulations found in 40 CFR 61, Subpart H, and WAC Chapter 246-247 limit radionuclide airborne emissions from all combined operations at the Hanford Site to 10 mrem/year effective dose equivalent to the hypothetical offsite maximally exposed individual. WAC 246-247 Chapter requires verification of compliance, typically through either continuous or periodic confirmatory air sampling depending on the potential unabated dose, and application of best available radionuclide control technology (BARCT). EPA and DOH determine whether the federal and State of Washington requirements have been met through review and approval of Notices of Construction (NOC) submitted by the party proposing a new or modified activity.

Ecology administers the non-radioactive airborne emissions requirements. Implementing regulations, found in WAC Chapter 173-400, establish emission limits for visibility, particulate matter, fugitive odor, and hazardous air pollutants. The regulations establish standards for the control and/or prevention of the emission of non-radioactive air contaminants, including the application of best available control technologies (BACT) for new sources of regulated and toxic air emissions. Ecology also uses an NOC process to determine whether requirements have been met.

Both radioactive and nonradioactive air emissions NOCs have already been submitted to the regulatory agencies for activities conducted at the K Basins in preparation for the cleanout or for which substantial planning had been performed prior to the implementation of CERCLA. These NOCs and conditions in the agency approvals will be binding on the K Basin interim remedial action. Under agreements between EPA and DOH, and EPA and Ecology, DOE will continue to submit NOCs for activities at the K Basins, even after CERCLA is implemented. Activities for which NOCs addressing the scope of the CERCLA action have been submitted and approvals received are as follows:

- Fuel removal, water treatment, and cask loadout at KE Basin
- Fuel removal, water treatment, and cask loadout at KW Basin
- Chiller bay modifications at KE Basin (approval of the original NOC has expired and the NOC will be resubmitted)

- Demolition for multi-canister overpack (MCO)/cask at KE Basin
- Demolition for MCO/cask at KW Basin
- Corridor 7 modifications at KE/KW Basins
- Hydrolasing of piping at KE Basin
- Fuel hanger removal at KE/KW Basins
- Vestibule modifications at KE/KW Basins
- Sludge pumping of SW Loadout Pit at KW Basin
- Shipments of SNF from the 327 Building
- Air sparging in KW Basin
- KE and KW drain valve mitigation

The approvals specify emissions controls and monitoring requirements for each activity based on the potential unabated offsite dose. Activities for which NOCs will be submitted in the future include KE and KW Basins sludge loadout and operation of the sludge treatment system.

B1.6 WASTE TRANSPORTATION STANDARDS

The U.S. Department of Transportation (DOT) Requirements for Hazardous Materials (49 CFR Parts 100 to 179) establish standards for packaging and shipping hazardous materials on public highways. The DOT standards, including all administrative requirements, would be strictly applicable to the offsite transport of any SNF, sludge, water, and debris. The performance requirements in these standards are relevant and appropriate for transportation on the Hanford Site.

The DOT performance requirements include specifications on the type of transport container and appropriate marking and labeling.

B1.7 RADIATION PROTECTION STANDARDS

Under the authority of the AEA, DOE's Occupational Radiation Protection Rule (10 CFR 835) establishes radiation protection standards, limits, and program requirements for protecting workers and visitors from ionizing radiation resulting from the conduct of DOE activities. It also requires that measures be taken to maintain radiation exposure as low as reasonably achievable. This regulation is applicable to any actions taken with respect to the K Basins and the radioactive materials therein.

Table B-1. Identification of Potential Federal ARARs and TBCs for the K Basins Interim Remedial Action. (5 sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
CHEMICAL-SPECIFIC			
Comprehensive Response, Compensation, and Liability Act of 1980 (CERCLA), 42 USC 9601, et seq.			
Designation, Reportable Quantities, and Notification, 40 CFR 302	Applicable	Defines the universe of hazardous substances subject to CERCLA authority. Specifies reportable quantities for these substances. Sets forth the notification requirements for releases of these substances.	Hazardous substances are present in the K Basins.
Resource Conservation and Recovery Act of 1976 (RCRA), 42 USC 6901, et seq.			
Land Disposal Restrictions, 40 CFR 268	Applicable	Specifies numerical standards to which some restricted wastes must be treated prior to land disposal.	Dangerous wastes subject to the land disposal restrictions will be generated as part of the K Basins remedial action.
Radiation Protection of the Public and the Environment, 10 CFR 834 (proposed at 58 FR 16268)	To be considered	Would promulgate standards presently found in DOE Order 5400.5 by setting radiation standards for protection of the public in the vicinity of DOE facilities. Identifies derived concentration guidelines (DCGs) as reference values for estimating potential dose and determining compliance. Annual effective dose equivalent is set at 100 mrem. Where residual radioactive materials remain, requires evaluation impacts beyond the 1,000-year time period identified in the existing DOE Order.	The K Basins remedial action might result in releases to the environment.
Toxic Substances Control Act (TSCA), 15 USC 2601 et seq.			
Regulation of PCBs, 40 CFR 761	Applicable	Specifies numerical standards under which certain materials and wastes are regulated under TSCA. In general, materials with PCB concentrations $\geq$ 50 ppm are regulated under TSCA. Specifies treatment and decontamination numerical standards to exit TSCA regulation.	PCBs have been detected above regulated levels in KE Basin sludge.
LOCATION-SPECIFIC			
National Historic Preservation Act of 1966, 16 USC 470	Applicable	Requires that historically significant properties be protected. Requires that agencies undertaking projects must evaluate impacts to properties listed on or eligible for inclusion on the National Register of Historic Places. An eligibility determination provides a site the same level of protection as a site listed on the National Register of Historic Places. The regulations implementing the act require that the lead agency for a project identify, evaluate, and determine the effects of the project on any cultural resource sites that may be within the area impacted by the project and resolve negative impacts.	Certain properties in the 100-K Area may be eligible for listing on the National Register.

Table B-1. Identification of Potential Federal ARARs and TBCs for the K Basins Interim Remedial Action. (5 sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Archeological and Historic Preservation Act, 16 USC 469a	Potentially applicable	Requires that actions conducted at the site must not cause the loss of any archeological and historic data. This act mandates preservation of the data and does not require protection of the actual facility. Where a site is determined to be eligible for the National Register and mitigation is unavailable, artifacts and data will be recovered and preserved prior to commencement of the action.	Archeological and historic sites in the 100 Area are not expected to be impacted by the K Basins remedial action. Cultural resource surveys will be conducted prior to field activities to confirm this.
Endangered Species Act of 1973, 16 USC 1531, et seq.	Potentially applicable	This act prohibits federal agencies from jeopardizing threatened or endangered species or adversely modifying habitats essential to their survival. If waste site remediation is within sensitive habitat or buffer zones surrounding threatened or endangered species, mitigation measures must be taken to protect this resource.	No threatened or endangered species or sensitive habitats are expected to be impacted by the K Basins remedial action. Ecological resource surveys will be conducted prior to field activities to confirm this
Hanford Reach Applicable Study Act, Public Law 100-605, as amended	Applicable	Provides for a comprehensive Columbia River conservation study. New federal and non federal projects and activities are required, to the extent practicable, to minimize direct and adverse affects on the values for which the river is under study and to use existing structures.	The K Basins CERCLA action will take place near the Columbia River. The National Park Service will be consulted to minimize and provide mitigation for any direct and adverse effects on the river.
ACTION-SPECIFIC			
Atomic Energy Act of 1954, as amended, 42 USC 2011, et seq.			
Nuclear Regulatory Standards for Protection Against Radiation, 10 CFR 20	Relevant and appropriate	Establishes standards for protecting the public against radiation arising from the use of regulated materials at NRC-licensed facilities. Specifies that exposure from releases to levels cannot exceed 0.1 rem/yr total effective dose equivalent or 2 mrem/hr from external exposure in unrestricted areas.	This standard is not applicable because the Hanford Site is not NRC licensed. However, the regulation is relevant and appropriate because remedial actions will involve radioactive material.
Licensing Requirements for Land Disposal of Radioactive Waste 10 CFR 61	Relevant and appropriate	Establishes the performance requirements and technical design standards for facilities intended for land disposal of radioactive waste. Generally prohibits near-surface disposal of greater-than-Class-C waste.	This standard is not applicable to Hanford Site disposal facilities because they are not NRC licensed. However, the regulation is relevant and appropriate because K Basin radioactive waste will likely be disposed at Hanford facilities. It is applicable for any K Basins radioactive wastes that will be disposed offsite at NRC-licensed facilities.
Environmental Radiation Protection Standards for Nuclear Power Operations, 40 CFR 190	Relevant and appropriate	Specifies the levels below which normal operations of the uranium fuel cycle are determined to be environmentally acceptable. The standard sets dose equivalents from the facility that are not to exceed 25 mrem/yr to whole body, 75 mrem/yr to thyroid, or 25 mrem/yr to any other organ.	These standards are not applicable because the K Basins action does not involve operation of a uranium fuel cycle. However, the standards are relevant and appropriate because they address acceptable dose to the public resulting from radioactive operations.

Table B-1. Identification of Potential Federal ARARs and TBCs for the K Basins Interim Remedial Action. (5 sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste, 40 CFR 191	Applicable	Establishes standards for management and disposal of spent nuclear fuel, high-level waste, and transuranic wastes at facilities operated by the DOE.	The requirements are applicable because SNF will be managed and transuranic wastes will be generated during the K Basins remedial action.
Resource Conservation and Recovery Act, as amended, 42 USC 6901			
Generator Standards, 40 CFR 262	Not applicable	Establishes requirements for facilities that generate hazardous waste.	Authority to implement this element of RCRA has been delegated to the State of Washington (see Table B-2).
Standards Applicable to Transporters of Hazardous Waste, 40 CFR 263	Not applicable	Establishes standards applicable to transporters of hazardous wastes.	Authority to implement this element of RCRA has been delegated to the State of Washington (see Table B-2).
Standards for Owners and Operators of TSD Units, 40 CFR 264 and 265	Not applicable	Sets standards for owners and operators of hazardous waste treatment, storage, and disposal facilities.	Authority to implement this element of RCRA has been delegated to the State of Washington (see Table B-2).
Land Disposal Restrictions, 40 CFR 268	Applicable	These requirements prohibit the placement of restricted hazardous wastes in land-based units such as landfills, surface impoundments, and waste piles until treated to standards considered protective for disposal. Specific treatment standards are included in the requirements.	Waste subject to the land disposal restrictions is likely to be generated during the K Basin remedial action.
Toxic Substances Control Act (TSCA), 15 USC 2601 et seq.			
Regulation of PCBs, 40 CFR 761	Applicable	Specifies storage, treatment, and disposal requirements for materials and waste containing PCBs at regulated levels. The "Megarule" amendments to the regulation provide specific requirements for management of PCB remediation waste and decontamination.	Waste that is regulated under TSCA will be generated during the K Basin remedial action.
Clean Air Act of 1977, as amended 42 USC 7401, et seq.			
National Ambient Air Quality Standards, 40 CFR 50	Potentially applicable	Establishes release limits for airborne releases of specific criteria pollutants.	Criteria pollutants may be generated as a result of remedial action at the K Basins.
Ambient Air Quality Monitoring, 40 CFR 58	Potentially applicable	Presents the criteria and requirements for ambient air quality monitoring and reporting for operators of new sources of air pollutants.	If a sludge treatment system is required as part of the K Basins remedial action, it may meet the regulatory definition of a new source.
Standards of Performance for New Stationary Sources, 40 CFR 60	Potentially applicable	Provides standards for new stationary sources or modifications of existing sources.	If a sludge treatment system is required as part of the K Basins remedial action, it could meet the regulatory definition of a new stationary source.

Table B-1. Identification of Potential Federal ARARs and TBCs for the K Basins Interim Remedial Action. (5 sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
National Emission Standard for Hazardous Air Pollutants (NESHAP), 40 CFR 61	Applicable	Provides general requirements and listings for emissions at a regulated facility. Establishes emission standards for hazardous air pollutants including radionuclides. Subpart H sets emission limits from the entire facility to ambient air that are not to cause any member of the public to receive an effective dose equivalent of 10 mrem/yr. The definition of facility includes all buildings, structures, and operations at one contiguous site.	Hazardous air pollutants, including radionuclides, are likely to be generated as a result of remedial action at the K Basins.
National Emission Standards for Asbestos, Standard for Demolition and Renovation, 40 CFR 61.145 – 150	Potentially applicable	Defines regulated asbestos-containing materials and establishes removal requirements based on quantity present and handling requirements. Also specifies handling and disposal requirements for regulated sources having the potential to emit asbestos.	Asbestos may be removed as part of deactivation activities under the K Basins remedial action.
Atomic Energy Act of 1954, as amended, 42 USC 2011, et seq.			
Licensing Requirements for the Land Disposal of Radioactive Waste, 10 CFR 61	Relevant and appropriate	Requires that radioactive waste disposal systems be designed to limit the annual dose equivalent beyond the facility boundary below 25 mrem to the whole body, 75 mrem to the thyroid, or 25 mrem to any other organ are relevant and appropriate to remedial actions that include land disposal or release radioactive effluent. Inadvertent intruder requirements for land disposal units are also contained in this regulation	Radioactive waste generated by the K Basins remedial action must be disposed in a facility that meets these requirements.
Packaging and Transportation of Radioactive Material, 10 CFR 71	Relevant and appropriate	Establishes requirements for packaging, preparation for shipment, and transportation of licensed radioactive material.	The regulations are only applicable for NRC-licensed plants and facilities where material is transported outside the confines of the plant. The Hanford Site is not a NRC-licensed plant; however, potentially radioactive waste will be generated by the k Basins remedial action. Subparts of this regulation are relevant and appropriate for packaging, testing, and preparation of packages containing radioactive material.
Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Wastes, 40 CFR 191	Applicable	Establishes requirements for disposal of SNF, high-level waste, and TRU waste. Precludes near-surface disposal of these materials. Requires that radionuclide release to the environment for a period of 10,000 years after disposal shall have a likelihood of less than one chance in ten of exceeding specified levels.	SNF and TRU waste will be generated by the K Basins remedial action and must be disposed at a facility that meets these requirements.
Department of Energy Occupational Radiation Protection, 40 CFR 835	Applicable	Sets occupational dose limits for adults. Total effective dose equivalent is equal to 5 rem/yr	Workers will be exposed to radiation as a result of the K Basins remedial action.

Table B-1. Identification of Potential Federal ARARs and TBCs for the K Basins Interim Remedial Action. (5 sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Hazardous Materials Transportation Act, 49 USC 1801, et seq.			
Hazardous Materials Regulation, 49 CFR 171	Potentially applicable	Establishes standards for classifying, packaging, marking, and labeling hazardous materials that will be transported on public roadways.	Hazardous materials may be transported off the Hanford Site in connection with the K Basins remedial action.
Hazardous Materials Tables, Hazardous Materials Communications Requirements, and Emergency Response Information Requirements, 49 CFR 172	Potentially applicable	Includes tables used to identify requirements for labeling, packaging, and transportation based on categories of waste types. Small quantities of radioactive wastes are not subject to the requirements of the standard if activity levels are below limits established in paragraph 173.421, 173.422, or 173.424. Specific performance requirements are established for packages used for shipping and transport of hazardous materials.	Hazardous materials may be transported off the Hanford Site in connection with the K Basins remedial action.

Table B-2. Identification of Potential State of Washington ARARs and TBCs for the K Basins Interim Remedial Action. (3 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
CHEMICAL-SPECIFIC			
Hazardous Waste Management Act, Ch. 70.105 RCW			
Designation of Waste, WAC 173-303-070 through 110	Applicable	Establishes the numerical criteria and methodology to determine if solid waste requires management as dangerous waste.	Dangerous waste will likely be generated as a result of the K Basins remedial action.
State of Washington Radiation Protection Requirements, Ch. 70.98 RCW			
Radiation Protection Standards, WAC 246-221	Relevant and appropriate	Establishes annual average concentration limits for radioactive releases in gaseous and liquid effluent released to unrestricted areas for licensed facilities. Sets occupational dose limits and dose limits for members of the public.	This regulation is not applicable because the Hanford Site is not a licensed facility. However, it is relevant and appropriate to releases from the K Basins remedial action.
Washington Clean Air Act, Ch. 70.94 RCW and Ch. 43.21A RCW			
Ambient Air Quality Standards and Emission Limits for Radionuclides, WAC 173-480	Applicable	Requires that the most stringent federal or State of Washington ambient air quality standard for radionuclides are enforced. WAC 173-480 defines the standard as a maximum accumulated dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to any critical organ. However, the standard of 10 mrem/yr under 40 CFR 61 Subpart H is more stringent.	The K Basins remedial action will result in radionuclide air emissions.
Radiation Protection - Air Emissions, WAC 246-247	Applicable	Establishes limits for airborne radionuclide emissions. Ambient air emissions are not to exceed amounts that result in an effective dose equivalent of 10 mrem/yr to any member of the public.	The K Basins remedial action is likely to produce radioactive air emissions.
LOCATION-SPECIFIC			
Department of Game Procedures, WAC 232-012	Potentially applicable	Defines the requirements that the Department of Game must take to protect endangered or threatened wildlife.	No threatened or endangered species or sensitive habitats are expected to be impacted by the K Basins remedial action. Ecological resource surveys will be conducted prior to field activities to confirm this.

Table B-2. Identification of Potential State of Washington ARARs and TBCs for the K Basins Interim Remedial Action. (3 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
National Area Preserves, RCW 79.70			
Washington Natural Heritage Program	To be considered	Program serves as an advisory council to the Washington State Department of Natural Resources, Fish and Wildlife, the Parks and Recreation Commission, and other State of Washington agencies managing State of Washington-owned land or natural resources. Develops a list of State of Washington endangered, threatened, and sensitive plants developed by the program, along with program-recommended levels of protection to assist resource managers. Designations provided to plants are advisory and do not specify a regulatory level of protection.	No threatened or endangered plant species or sensitive habitats are expected to be impacted by the K Basins remedial action. Ecological resource surveys will be conducted prior to field activities to confirm this.
ACTION-SPECIFIC			
Hazardous Waste Management Act, 70.105 RCW			
Land Disposal Restrictions, WAC 173-303-140	Applicable	Identifies dangerous wastes that are restricted from land disposal, describes requirements for State of Washington-only restricted wastes, and defines the circumstances under which a prohibited waste may be disposed.	The K Basins remedial action is likely to generate dangerous or mixed waste that will require disposal.
Requirements for Generators of Dangerous Waste, WAC 173-303-170 through 230	Applicable	Defines generator requirements including safe management of dangerous wastes, personnel training, and emergency preparedness.	The K Basins remedial action is likely to generate dangerous or mixed waste.
General Requirements for Dangerous Waste Management Facilities, WAC 173-303-280 through 395	Applicable	General requirements include siting standards, emergency preparedness, security, inspections, contingency planning, waste analysis, and management of containers.	The K Basins remedial action is likely to require management of dangerous or mixed waste, including potentially treatment of sludge that designates as mixed waste.
Treatment, Storage, and Disposal Facility Requirements, WAC 173-303-600 through 695	Applicable	Specifies design and operating requirements for units that will store, treat, or dispose of dangerous waste. Specific unit requirements are included for containers and tanks.	The K Basins remedial action is likely to generate dangerous or mixed waste that will require storage, treatment, and disposal.

Table B-2. Identification of Potential State of Washington ARARs and TBCs for the K Basins Interim Remedial Action. (3 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Water Pollution Control/Water Resources Act, Ch. 90.48 RCW/Ch. 90.54 RCW			
State of Washington Waste Discharge Program, WAC 173-216	Potentially applicable	Establishes requirements for discharges to the groundwater or surface waters of the State of Washington. Specific discharges prohibited under the program are identified.	The K Basins remedial action will likely require treatment and disposal of contaminated basin water. Disposal will be subject to the 216 requirements.
Washington Clean Air Act, Ch. 70.94 RCW and Ch. 43.21A RCW			
General Regulations for Air Pollution, WAC 173-400	Applicable	Requires that all sources of air contaminants meet emission standards for visible, particulate, fugitive, odors, and hazardous air emissions. Requires that all emission units use reasonably available control technology and perform source testing and monitoring.	The K Basins remedial action is likely to result in the emission of hazardous air pollutants.
Controls for New Sources of Air Pollution, WAC 173-460	Potentially applicable	Requires that new sources of air emissions provide emission estimates for toxic air contaminants listed in the regulation. Requires that emissions be quantified and used in risk modeling to evaluate ambient impacts and establish acceptable source impact levels. Establishes requirements to use best available control technology, quantify toxic emissions, and demonstration that human health is protected.	The K Basins remedial action, particularly some sludge treatment options, may result in the emission of toxic air contaminants.
Ambient Air Quality Standards and Emission Limits for Radionuclides, WAC 173-480	Applicable	Requires emission controls for new and modified emission units to use best available radionuclide control technology.	The K Basins remedial action will result in radionuclide air emissions.
Radiation Protection - Air Emissions, WAC 246-247	Applicable	Requires confirmatory air sampling for radioactive emissions.	The K Basins remedial action is likely to produce radioactive air emissions.

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