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Summary

Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington

U.S. Department of Energy

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Cover Sheet

Responsible Agency: U.S. Department of Energy (DOE)

Cooperating Agencies: Washington State Department of Ecology (Ecology)
U.S. Environmental Protection Agency (EPA)

Title: *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (*TC & WM EIS*) (DOE/EIS-0391)

Location: Benton County, Washington

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Abstract: The Hanford Site (Hanford), located in southeastern Washington State along the Columbia River, is approximately 1,518 square kilometers (586 square miles) in size. Hanford's mission from the early 1940s to approximately 1989 included defense-related nuclear research, development, and weapons production activities. These activities created a wide variety of chemical and radioactive wastes. Hanford's mission now is focused on the cleanup of those wastes and ultimate closure of Hanford. To this end, several types of radioactive waste are being managed at Hanford: (1) high-level radioactive waste (HLW) as defined in DOE Manual 435.1-1; (2) transuranic (TRU) waste, which is waste containing alpha-particle-emitting radionuclides with atomic numbers greater than uranium (92) and half-lives greater than 20 years in concentrations greater than 100 nanocuries per gram of waste; (3) low-level radioactive waste (LLW), which is radioactive waste that is neither HLW nor TRU waste; and (4) mixed low-level radioactive waste (MLLW), which is LLW containing hazardous constituents as defined under the Resource Conservation and Recovery Act (RCRA) of 1976 (42 U.S.C 6901 et seq.). Thus, this environmental impact statement (EIS) analyzes the following three key areas:

1. **Retrieval, treatment, and disposal of waste from 149 single-shell tanks (SSTs) and 28 double-shell tanks (DSTs) and closure of the SST system.** In this *TC & WM EIS,* DOE proposes to retrieve and treat waste from 177 underground tanks and ancillary equipment and dispose of this waste in compliance with applicable regulatory requirements. At present, DOE is constructing a Waste Treatment and Immobilization Plant (WTP) in the 200-East Area of Hanford. The WTP would separate waste stored in Hanford's underground tanks into HLW and low-activity waste (LAW) fractions. HLW would be treated in the WTP and stored at Hanford until disposition decisions are made and implemented. LAW would be treated in the WTP and disposed of as LLW at Hanford as decided in DOE's Record of Decision (ROD) issued in 1997 (62 FR 8693), pursuant to the *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement* (DOE/EIS-0189, August 1996). DOE

proposes to provide additional treatment capacity for the tank LAW that can supplement the planned WTP capacity in fulfillment of DOE's obligations under the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement). DOE would dispose of immobilized LAW and Hanford's (and other DOE sites') LLW and MLLW in lined trenches on site. These trenches would be closed in accordance with applicable regulatory requirements.

2. **Final decontamination and decommissioning of the Fast Flux Test Facility (FFTF), a nuclear test reactor.** DOE proposes to determine the final end state for the aboveground, belowground, and ancillary support structures.

3. **Disposal of Hanford's waste and other DOE sites' LLW and MLLW.** DOE needs to decide where to locate onsite disposal facilities for Hanford's waste and other DOE sites' LLW and MLLW. DOE committed in the ROD (69 FR 39449) for the *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington* (DOE/EIS-0286F, January 2004) that LLW would be disposed of in lined trenches. Specifically, DOE proposes to dispose of the waste in either the existing Integrated Disposal Facility (IDF) in the 200-East Area (IDF-East) or the proposed 200-West Area IDF (IDF-West).

DOE released the *Draft TC & WM EIS* in October 2009 (74 FR 56194) for review and comment by other Federal agencies, states, American Indian tribal governments, local governments, and the public. The comment period was 185 days, from October 30, 2009, to May 3, 2010.

In accordance with Council on Environmental Quality (CEQ) regulations (40 CFR 1502.9(c)) and DOE regulations (10 CFR 1021.314(c)), DOE prepared a supplement analysis (SA) of the *Draft TC & WM EIS* (*Supplement Analysis of the "Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington"* [DOE/EIS-0391-SA-01, February 2012]). DOE prepared an SA to evaluate updated, modified, or expanded information developed subsequent to publication of the *Draft TC & WM EIS* to determine whether a supplement to the draft EIS or a new draft EIS was warranted. Fourteen topic areas were reviewed. Revisions include changes to contaminant inventories, corrections to estimates, updates to characterization data, and new information that was not available at the time of publication of the *Draft TC & WM EIS*. The modified inventories do not change the key environmental findings presented in the draft EIS. They do not present significant new circumstances or information relevant to environmental concerns and bearing on the proposed action(s) and their impacts. Changes to some of the parameters used in the alternatives analysis do not significantly affect the potential environmental impacts of the alternatives on an absolute or relative basis, whether the changes are considered individually or collectively. These are not substantial changes in the proposed action(s) that are relevant to environmental concerns. DOE concluded, based on analyses in the SA, that the updated, modified, or expanded information developed subsequent to the *Draft TC & WM EIS* does not constitute significant new circumstances or information relevant to environmental concerns and bearing on the proposed actions(s) in the *Draft TC & WM EIS* or their impacts. Therefore, DOE determined that a supplement to the *Draft TC & WM EIS* or a new *Draft TC & WM EIS* was not required.

DOE posted the *Supplement Analysis of the "Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington"* on the DOE NEPA website, http://energy.gov/nepa/office-nepa-policy-and-compliance, on February 8, 2012, and on the *TC & WM EIS* website, http://www.hanford.gov/index.cfm?page=1117&, on February 9, 2012, and the SA was provided on February 14, 2012, to the DOE public reading room at 2770 University Drive, Room 101L, Richland, Washington 99352. The SA is also provided here as Appendix X of this final EIS for convenience only.

In preparing this *Final TC & WM EIS*, DOE considered all comments received on the draft EIS and revised this final EIS, as appropriate. DOE has clarified and/or revised its Preferred Alternatives for the three program areas as presented in this *TC & WM EIS*, as follows:

Tank Closure

Eleven alternatives for potential tank closure actions are evaluated in this final EIS. These alternatives cover tank waste retrieval and treatment, as well as closure of the SSTs. DOE has identified the following Preferred Alternatives: For retrieval, DOE prefers Tank Closure alternatives that would retrieve at least 99 percent of the tank waste. All Tank Closure alternatives would do this except Alternatives 1 (No Action) and 5. For closure of the SSTs, DOE prefers landfill closure; this could include implementation of corrective/mitigation actions as described in the Summary of this EIS, Section S.5.5.1, and Chapter 2, Section 2.10.1, which may require soil removal or treatment of the vadose zone. Decisions on the extent of soil removal or treatment, if needed, will be made on a tank farm– or waste management area–basis through the RCRA closure permitting process. These landfill closure considerations would apply to Tank Closure Alternatives 2B, 3A, 3B, 3C, 5, and 6C. DOE does not prefer alternatives that include removal of the tanks as evaluated in Tank Closure Alternatives 4, 6A, and 6B. As described in the Summary of this EIS, Section S.5.5.1, and Chapter 2, Section 2.10.1, DOE believes that removal of the tank structures is technically infeasible and, due to both the depth of the contamination and the technical issues associated with removal of the tank structures, that it presents significant uncertainty in terms of worker exposure risk and waste generation volume.

DOE does not have a preferred alternative regarding supplemental treatment for LAW; DOE believes it beneficial to study further the potential cost, safety, and environmental performance of supplemental treatment technologies. Nevertheless, DOE is committed to meeting its obligations under the TPA regarding supplemental LAW treatment. When DOE is ready to identify its preferred alternative regarding supplemental treatment for LAW, this action will be subject to NEPA review as appropriate. DOE will provide a notice of its preferred alternative in the *Federal Register* at least 30 days before issuing a ROD. For the actions related to tank waste retrieval, treatment and closure, DOE prefers Tank Closure Alternative 2B, without removing technetium in the Pretreatment Facility.

Although DOE previously expressed its preference that no Hanford tank waste would be shipped to the Waste Isolation Pilot Plant (WIPP) (74 FR 67189), DOE now prefers to consider the option to retrieve, treat, and package waste that may be properly and legally designated as mixed transuranic (TRU) waste from specific tanks for disposal at WIPP, as analyzed in Tank Closure Alternatives 3A, 3B, 3C, 4, and 5. Initiating retrieval of tank waste identified as mixed TRU waste would be contingent on DOE's obtaining the applicable disposal and other necessary permits and ensuring that the WIPP Waste Acceptance Criteria and all other applicable regulatory requirements have been met. Retrieval of tank waste identified as mixed TRU waste would commence only after DOE had issued a *Federal Register* notice of its preferred alternative and a ROD.

FFTF Decommissioning

There are three FFTF Decommissioning alternatives from which the Preferred Alternative was identified: (1) No Action, (2) Entombment, and (3) Removal. DOE's Preferred Alternative for FFTF Decommissioning is Alternative 2: Entombment, which would remove all above-grade structures, including the reactor building. Below-grade structures, the reactor vessel, piping, and other components would remain in place and be filled with grout to immobilize the remaining radioactive and hazardous constituents. Waste generated from these activities would be disposed of in an IDF, and an engineered modified RCRA Subtitle C barrier would be constructed over the filled area. The remote-handled special components would be processed at Idaho National Laboratory and returned to Hanford. Bulk sodium inventories would be processed at Hanford for use in the WTP.

Waste Management

Three Waste Management alternatives were identified for the proposed actions: (1) Alternative 1: No Action, under which all onsite LLW and MLLW would be treated and disposed of in the existing lined Low-Level Radioactive Waste Burial Ground 218-W-5 trenches and no offsite waste would be accepted; (2) Alternative 2, which would continue treatment of onsite LLW and MLLW in expanded, existing facilities and dispose of onsite and previously treated, offsite LLW and MLLW in a single IDF (IDF-East); and (3) Alternative 3, which also would continue treatment of onsite LLW and MLLW in expanded, existing facilities, but would dispose of onsite and previously treated offsite LLW and MLLW in two IDFs (IDF-East and IDF-West). DOE's Preferred Alternative for waste management is Alternative 2, disposal of onsite LLW and MLLW streams in a single IDF (IDF-East). Disposal of SST closure waste that is not highly contaminated, such as rubble, soils, and ancillary equipment, in the proposed River Protection Project Disposal Facility (RPPDF) is also included under this alternative. After completion of disposal activities, IDF-East and the proposed RPPDF would be landfill-closed under an engineered modified RCRA Subtitle C barrier. The final EIS analyses show that, even when mitigation is applied to certain offsite waste streams (e.g., removal of most of the iodine-129), some environmental impacts of small quantities of iodine-129 would still occur and, therefore, limitations for that constituent should apply regardless of the alternative selected.

DOE will continue to defer the importation of offsite waste to Hanford, at least until the WTP is operational, subject to appropriate NEPA review and consistent with its previous Preferred Alternative for waste management (74 FR 67189). The limitations and exemptions defined in DOE's January 6, 2006, Settlement Agreement with the State of Washington (as amended on June 5, 2008) regarding *State of Washington v. Bodman* (Civil No. 2:03-cv-05018-AAM), signed by DOE, Ecology, the Washington State Attorney General's Office, and the U.S. Department of Justice, will remain in place.

This *Final TC & WM EIS* contains revisions and new information based in part on comments received on the *Draft TC & WM EIS*. Sidebars in the margins indicate the locations of these revisions and new information. Minor editorial changes are not marked. Volume 3 contains the comments received on the draft EIS and DOE's responses to the comments. DOE will use the analysis presented in this final EIS, as well as other information, in preparing one or more RODs. DOE will issue a ROD no sooner than 30 days after EPA publishes a Notice of Availability of this *Final TC & WM EIS* in the *Federal Register*.

Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (Final TC & WM EIS)

Washington State Department of Ecology (Ecology) Foreword

Summary

Ecology believes that the U.S. Department of Energy (DOE) and its contractor have prepared a *Final TC & WM EIS* that presents many important issues for discussion. Ecology's involvement in the production of this *TC & WM EIS* shows that this document has benefited from quality reviews and quality assurance procedures. In addition, this document benefited from public comments, and important additions were made in regard to mitigation measures and sensitivity studies.

The single best thing this document does is to clearly indicate the severity of the environmental impacts (both current and future) associated with the waste at the Hanford Site (Hanford), and, as such, DOE and its environmental impact statement (EIS) contractor should be commended for their factual representation.

The information in this document will help shed light on many key decisions that remain to be made about Hanford cleanup. To Ecology, the results of this EIS clearly indicate that some basic tenets concerning future Hanford cleanup are needed to reduce the impacts. They include the following:

- Waste from the tanks needs to be removed to the maximum extent possible. It is not the shell of the tanks or the act of landfill closing that increases the environmental impacts, it is the extent of retrieval from the tanks and the amount of vadose zone remediation.
- Glass is the only acceptable waste form for immobilized low-activity waste (ILAW) that is going to be disposed of at Hanford. This is true for the low-activity waste (LAW) treated through the existing LAW Vitrification Facility and for the LAW treated in the additional supplemental LAW treatment facility. This *TC & WM EIS* shows that all other waste forms are not protective of the groundwater and Columbia River.
- Groundwater pump-and-treat systems will have to continue to treat the groundwater beneath the Central Plateau for a long time after the tank waste has been retrieved and treated.
- A new emphasis should be placed on remediating problematic soil contamination in and beneath the tank farms and in other Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) waste sites in the Central Plateau to limit further groundwater impacts; this would include development of vadose zone remediation methods.
- Hanford's existing waste burden exceeds the capacity of the natural and engineered environment to attenuate it. Therefore, poorly performing waste forms and offsite waste should be eliminated as waste management options.
- As DOE and Ecology have indicated consistently throughout the *TC & WM EIS* development process, certain secondary waste from the Waste Treatment Plant (WTP) must be treated and immobilized to a greater extent to protect groundwater. The performance criteria for secondary waste must be improved beyond a grouted waste form.

- Hanford should embrace the use of a Central Plateau cumulative risk tool to ensure that all individual remediation decisions are protective in aggregate.

Ecology expects DOE to consider our input through this foreword, as well as through our comments made during the public comment process. Ecology worked with DOE with the intent of helping to produce a final EIS that fully informs future decision making. Ecology will continue to work with DOE as it develops the National Environmental Policy Act (NEPA) Record of Decision (ROD) and the important mitigation action plan. As defined in our cooperating agency Memorandum of Understanding (MOU), Ecology expects to be fully involved in the preparation of the ROD.

I. Introduction

Ecology has been a cooperating agency with DOE since 2002 in the production of both the *Draft* and this *Final TC & WM EIS*, as well as a coauthor in the preceding *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement* (*TWRS EIS*). DOE prepared this EIS to meet the requirements of NEPA. In addition, Ecology has reviewed this EIS to ensure important sections can be adopted to satisfy the requirements of the State Environmental Policy Act (SEPA) to support our permitting processes. The information in this EIS will help inform Ecology and others about critical future cleanup decisions impacting Hanford's closure. When Ecology makes decisions through its permitting process, Ecology will look to this *Final TC & WM EIS* and, if appropriate, adopt portions. Ecology will use the information to develop mitigating permit conditions.

Ecology provided comments regarding the *Draft TC & WM EIS* to document areas of agreement or concern with this EIS and to assist the public in their review. Public and regulator input on the *Draft TC & WM EIS* were critical for the completion of an acceptable *Final TC & WM EIS*.

In this *Final TC & WM EIS*, Ecology issued a revised foreword to comment on the EIS key findings, DOE's Preferred Alternatives, and disposition of Ecology's comments on the *Draft TC & WM EIS*. Ecology has also issued this revised foreword to discuss Ecology's position on certain issues and future needed mitigation actions.

II. Ecology's Role as a Cooperating Agency

Ecology has been a cooperating agency in the preparation of this EIS. A state agency may be a cooperating agency on a Federal EIS when the agency has jurisdiction by law over, or specialized expertise concerning, a major Federal action under evaluation in the EIS.

As a cooperating agency, Ecology did not coauthor or direct the production of this EIS. Ecology did have access to certain data and information as this document was being prepared by DOE and its contractor. Our roles and responsibilities in this process were defined in an MOU between Ecology and DOE.

DOE retained responsibility for making final decisions in the preparation of this *Final TC & WM EIS*, as well as for determining the Preferred Alternatives presented in this EIS. However, Ecology's participation as a cooperating agency enabled us to help formulate the alternatives presented in this *TC & WM EIS*.

Ecology's involvement as a cooperating agency—and the current scope of this *Final TC & WM EIS*—is grounded in a series of events.

On November 8, 2002, DOE asked Ecology to be a cooperating agency on the ―Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland, Washington," known as the ―Tank Closure EIS." On November 27, 2002, Ecology formally agreed. The March 25, 2003, MOU outlines the respective agency roles and responsibilities.

While the ―Tank Closure EIS" was being developed, another DOE EIS, the *Draft Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington (HSW EIS)*, was in the review stage. Among other matters, the *HSW EIS* examined the impacts of disposal at Hanford of certain volumes of radioactive waste and mixed radioactive and hazardous waste, including waste generated from beyond Hanford.

In March 2003, Ecology filed a lawsuit in the U.S. District Court seeking to prevent the importation and storage of certain offsite transuranic (TRU) and mixed TRU wastes that DOE had decided to send to Hanford prior to issuance of the *Final HSW EIS*. Ecology and intervening plaintiffs obtained a preliminary injunction against these shipments.

In January 2004, DOE issued the *Final HSW EIS*. Based on the *Final HSW EIS*, DOE amended a ROD that directed offsite radioactive and hazardous wastes to Hanford (within certain volume limits) for disposal and/or storage. In response, Ecology amended its lawsuit to challenge the adequacy of the *HSW EIS* analysis.

In May 2005, the U.S. District Court expanded the existing preliminary injunction to enjoin a broader class of waste and to grant Ecology a discovery period to further explore issues with the *HSW EIS*.

In January 2006, DOE and Ecology signed a Settlement Agreement, ending litigation on the *HSW EIS* and addressing concerns found in the *HSW EIS* quality assurance review during the discovery period. The Settlement Agreement called for expanding the scope of the ―Tank Closure EIS" to provide a single, integrated set of analyses of (1) tank closure impacts considered in the ―Tank Closure EIS" and (2) the disposal of all waste types considered in the *Final HSW EIS*. The Settlement Agreement also called for an integrated cumulative impacts analysis.

Under the Settlement Agreement, the ―Tank Closure EIS" was renamed this *TC & WM EIS*. Ecology's existing MOU with DOE was revised along with the Settlement Agreement so that Ecology remained a cooperating agency on the expanded *TC & WM EIS*.

The Settlement Agreement defined specific tasks to address concerns Ecology had with the *HSW EIS*. DOE has now revised information and implemented quality assurance measures used in this *TC & WM EIS* related to the solid-waste portion of the analysis. Ecology and its contractors have performed discrete quality assurance reviews of that information to help confirm that the quality assurance processes of DOE's EIS contractor have been followed.

Based on Ecology's involvement throughout the years of EIS development, we believe that positive changes have been made to address data quality shortcomings in the *HSW EIS*. These specifically relate to the following:

- The data used in analyzing impacts on groundwater
- The integration of analyses of all waste types that DOE may dispose of at Hanford
- The adequacy of the cumulative impacts analysis

Ecology reviewed the *Draft TC & WM EIS* and this *Final TC & WM EIS*. In our reviews, we confirmed that the terms of the Settlement Agreement have been addressed to our satisfaction.

III. Regulatory Relationships and SEPA

Now that this *TC & WM EIS* has been finalized, Ecology will proceed with approving regulatory actions required to complete the Hanford cleanup. These include actions under the (1) Hanford Federal Facility Agreement and Consent Order, also known as the Tri-Party Agreement (TPA), and (2) *State of Washington v. Chu* (Civil No. 2:08-cv-05085-FVS) Consent Decree, as well as actions that require state permits or modifications to existing permits, such as the Hanford Dangerous Waste Sitewide Permit. This permit regulates hazardous waste treatment, storage, and disposal activity at Hanford, including actions such as tank closure and supplemental treatment for tank waste.

Ecology must comply with SEPA when undertaking permitting actions. It is Ecology's sense that this *Final TC & WM EIS* will be suitable for adoption in whole or in part to satisfy SEPA. It is Ecology's plan to adopt in part portions of this *Final TC & WM EIS* when needed for individual permitting actions.

In addition, Ecology will have a substantial role in establishing standards and methods for the cleanup of contaminated soil and groundwater at Hanford, including areas that are regulated under hazardous waste corrective action authority and/or under CERCLA through a CERCLA ROD. Information developed in this EIS will thus be useful in other applications for the cleanup of Hanford.

IV. DOE's Responses to Ecology's Comments on the *Draft TC & WM EIS*

Ecology submitted comments on the *Draft TC & WM EIS* with a cover letter from Jane Hedges, Program Manager of Ecology's Nuclear Waste Program. These comments were discussed in detail with DOE and the EIS contractor. Many of our comments resulted in changes and additions in this *Final TC & WM EIS*. All of our comments were resolved to our satisfaction. Our comments and DOE's responses to those comments can be seen in the Comment-Response Document, Section 3.1, at Commentor No. 498.

V. Preferred Alternatives

This *Final TC & WM EIS* considers three sets of actions: tank waste treatment and tank farm closure, Fast Flux Test Facility (FFTF) decommissioning, and waste management. The Preferred Alternatives are summarized in this section. DOE's Preferred Alternative decisions with which Ecology disagrees are discussed in this section under Area of Disagreement; those Ecology generally agrees with are discussed in the subsequent section VI of this foreword.

The Preferred Alternatives for the three sets of actions can be summarized as follows:

<u>Tank Waste Treatment and Tank Farm Closure:</u>

- Retrieval of at least 99 percent of the waste from each tank.
- Landfill closure of the tank farms.
- Possible soil removal or treatment of the vadose zone.
- DOE chose to not identify a preferred alternative for supplemental treatment needed to treat that portion of LAW that the WTP, as currently designed, does not have the capacity to treat in a reasonable timeframe.

<u>FFTF Decommissioning:</u>

- All above-grade structures, including the reactor building, would be removed.
- Below-grade structures, the reactor vessel, piping, and other components would remain in place and be filled with grout to immobilize the remaining radioactive and hazardous constituents (FFTF Decommissioning Alternative 2: Entombment).
- Waste generated from these activities would be disposed of in an Integrated Disposal Facility (IDF), and an engineered modified Resource Conservation and Recovery Act (RCRA) Subtitle C barrier would be placed on top.
- Bulk sodium inventories would be processed at Hanford.

Waste Management:

- Onsite low-level radioactive waste (LLW) and mixed low-level radioactive waste (MLLW) streams would be disposed of in a single 200-East Area IDF (IDF-East) under a modified RCRA Subtitle C barrier.

- Single-shell tank (SST) closure waste that is not highly contaminated would be disposed of in the River Protection Project Disposal Facility (RPPDF) under a modified RCRA Subtitle C barrier.

- This final EIS shows that, even when mitigation is applied to offsite waste, environmental impacts would still occur. DOE is deferring the decision on the importation of offsite waste at Hanford, at least until the WTP is operational, subject to appropriate NEPA review. The limitations and exemptions defined in DOE's January 6, 2006, Settlement Agreement with the State of Washington (as amended on June 5, 2008), signed by DOE, Ecology, the Washington State Attorney General's Office, and the U.S. Department of Justice, regarding *State of Washington v. Bodman* (Civil No. 2:03-cv-05018-AAM) will remain in place.

Area of Disagreement:

Ecology agrees with a majority of the Preferred Alternative choices made in this *Final TC & WM EIS*, except for DOE's decision to omit a preferred supplemental treatment alternative from this *Final TC & WM EIS*. This omission leaves this EIS incomplete. This omission is not supported by (and is contrary to) the analysis in this *TC & WM EIS*, which clearly supports a second LAW vitrification alternative as the only environmentally protective option for supplemental treatment. Further, the cost comparisons in this EIS show that all the various options are cost neutral, so any assumptions about potential cost savings in choosing other treatment options are invalid.

As a cooperating agency on this *TC & WM EIS*, Ecology encourages DOE to select a preferred alternative in the ROD that includes a supplemental treatment decision. Ecology prefers an alternative that is similar to Tank Closure Alternative 2B or, at the very least, Alternative 2A. It is essential that ILAW to be disposed of above groundwater and upstream from the Columbia River be vitrified to ensure the water and future users will be protected from the tank waste constituents.

Alternative 2B is consistent with the TPA and the *State of Washington v. Chu* Consent Decree. Also, Alternative 2B does not extend the mission as far as Alternative 2A. Alternatives 2A and 2B both support the retrieval of waste from all the tanks, treatment of all that waste, and a defined end of mission.

Ecology is concerned that, by choosing vague language in this *Final TC & WM EIS* concerning supplemental treatment, DOE is bringing into question its previous commitments about when and if all of the waste will be removed from the SSTs and when and if all the tank waste will be treated. This puts into question the end of mission for tank waste treatment. Because such an undefined scenario was not analyzed in any of the alternatives in this *TC & WM EIS*, related impacts are not visible to decision makers or the public. There are several milestone dates that were critical components of the Consent Decree settlement that resolved the *State of Washington v. Chu* lawsuit. We believe DOE's failure to identify a preferred alternative in this *Final TC & WM EIS* will jeopardize compliance with these dates.

DOE has invested 10 years and $85 million, and Ecology has provided significant effort in cooperating agency review and consultation in producing this *TC & WM EIS*. Ecology expects that investment should result in a *Final TC & WM EIS* that supports making a supplemental treatment decision. We are especially concerned because the *Draft TC & WM EIS* identified no data gaps and gave no indication of DOE's intent to delay a decision on supplemental treatment. Further, no analysis in the *Preliminary Final TC & WM EIS* reviewed by Ecology identified gaps in the supplemental treatment data, nor did the analysis support a delay in making a supplemental treatment decision. No public comment received on the *Draft TC & WM EIS* encouraged DOE to delay selecting a preferred alternative.

If DOE does not select a preferred alternative for supplemental tank waste treatment, we request that it identify the following:

- The data it is using to make this decision and where is it documented in this *TC & WM EIS*.
- Any data gaps in this *TC & WM EIS* and how those gaps will be addressed in the future.
- Additional data it is analyzing to aid it in making the decision.
- The NEPA documentation DOE will use to analyze and support supplemental waste treatment selection. Will it be an additional EIS? How will DOE reconcile the timing of future NEPA documentation and TPA supplemental treatment milestones?

VI. Ecology Insights on Alternatives Considered, EIS Key Findings, and Needed Mitigation Measures

This *Final TC & WM EIS* considers 17 alternatives. Ecology's insights, technical perspectives, and legal and policy perspectives are provided below. Areas of agreement with DOE and points of concern are noted.

SST Waste Retrieval and Tank Farm Closure

Ecology believes that DOE has presented an appropriate range of alternatives for evaluating tank waste retrieval and tank closure impacts. However, based on the hazardous waste tank closure standards of the ―Dangerous Waste Regulations" (WAC 173-303-610(2)) and the TPA requirements, Ecology supports only alternatives that involve tank waste retrieval to the maximum extent possible or 99 percent, whichever is greater, from each of the 149 SSTs. An acceptable performance assessment is essential in establishing a clear understanding of the risks and benefits of this retrieval goal. This assessment will be an important part of any specific tank farm closure plan permitting actions.

The analysis in this final EIS, including the new mitigation section, shows that the two most important factors in tank farm closure are (1) maximizing tank waste retrieval and (2) vadose zone remediation of specifically identified hot spots of contamination. Specific vadose zone mitigation will be addressed in specific tank farm closure plan permitting actions.

While DOE has identified the Preferred Alternative for tank closure as including landfill closure, it is important to point out that the specific details of how a tank farm will be closed will be identified in each tank farm closure plan permit. These closure plans will be subject to public comment and agency response before landfill decisions can be implemented.

High-Level Radioactive Waste Disposal

High-level radioactive waste (HLW) associated with the tank waste includes, but may not be limited to, immobilized high-level radioactive waste (IHLW) and HLW melters (both retired and failed). It has been DOE's longstanding plan to store these wastes at Hanford and then ship them off site and dispose of them in a deep geologic repository. The idea was that the nature of the geology would isolate the waste and protect humans from exposure to these very long-lived, lethal radionuclides. The Nuclear Waste Policy Act (NWPA) indicates that these waste streams require permanent isolation. By contrast, the ILAW glass, and perhaps other waste streams, may not require deep geologic disposal due to the level of pretreatment resulting in radionuclide removal and the degree of immobilization provided for in the ILAW glass.

However, the final decision on HLW disposal has recently become an issue with significant uncertainty. This *Final TC & WM EIS* contains the following statement:

> The Secretary of Energy has determined that a Yucca Mountain repository is not a workable option for permanent disposal of spent nuclear fuel (SNF) and HLW. However, DOE remains committed to meeting its obligations to manage and ultimately dispose of these materials. The Administration has convened the Blue Ribbon Commission on America's Nuclear Future (BRC) to conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle, including all alternatives for the storage, processing, and disposal of SNF and HLW. The BRC's final recommendations will form the basis of a new solution to managing and disposing of SNF and HLW.

The State of Washington asserts that there is only one legal process in place for developing a geologic repository, which is provided by the NWPA. Under the NWPA, only Congress can take Yucca Mountain off the table. The convening of the BRC to examine alternatives to Yucca Mountain and recommend possible amendments to the NWPA cannot substitute for a process already provided by law. Legally, Yucca Mountain is still the location for the deep geologic repository.

The NWPA requires permanent isolation of these most difficult waste streams. Leaving these wastes stored at Hanford indefinitely is not a legal option or an acceptable option to the State of Washington.

Ecology is concerned about the glass standards and canister requirements for the IHLW. These standards were developed based on what was acceptable for Yucca Mountain. Now that Yucca Mountain is no longer DOE's assumed disposal location, Ecology is concerned about what standards for glass and canisters will be utilized by the WTP. Ecology insists that DOE implement the most conservative approach in these two areas to guarantee that the glass and canister configurations adopted at the WTP will be acceptable at the future deep geologic repository.

In addition, Ecology maintains that DOE should build and operate adequate interim storage capacity for the IHLW and the HLW melters in a manner that does not slow down the treatment of tank waste.

This *Final TC & WM EIS* assumes that the used (both retired and failed) HLW melters are HLW and, therefore, should be disposed of in a deep geologic repository. This EIS also assumes that the used HLW melters will stay on site before shipment to such a repository. DOE has not requested, and Ecology has not accepted, long-term interim storage of used HLW melters at Hanford.

The final disposal of these melters should be in a deep geologic repository. This EIS evaluates only storage of the HLW melters and not the disposal pathway. The disposal pathway for the used melters (both retired and failed) will require further evaluation than is presented in this *Final TC & WM EIS*. Ecology and DOE will need to reach a mutual understanding and agreement on the regulatory framework for disposal.

Pretreatment of Tank Waste

This *Final TC & WM EIS* includes numerous alternatives that pretreat tank waste to separate the high-activity components and direct them to an HLW stream. The HLW stream will be vitrified, resulting in a glass waste product that will be sent to a deep geologic repository. However, this final EIS has one alternative (not the Preferred Alternative) that provides no pretreatment for some portion of the waste in the 200-West Area.

As a legal and policy issue, Ecology does not agree with alternatives that do not require pretreatment of the tank waste. Such alternatives do not meet the intent of the NWPA to remove as many of the fission products and radionuclides as possible to concentrate them in the HLW stream. For this reason, Ecology requests that DOE rule out any alternative that does not pretreat tank waste.

TRU Tank Waste

This *Final TC & WM EIS* considers the option of treating waste from specific tanks as mixed TRU waste and sending it to the Waste Isolation Pilot Plant (WIPP). This final EIS also considers WTP processing of the waste from these specific tanks.

Ecology is concerned by DOE's current approach to the potential mixed TRU tank waste. Prior to public comment on the *Draft TC & WM EIS*, DOE issued a statement in the Federal Register (74 FR 67189) that indicated that it was no longer considering sending Hanford tank waste to WIPP:

> DOE is now expressing its preference that no Hanford tank wastes would be shipped to WIPP. These wastes would be retrieved and treated in the Waste Treatment Plant (WTP) being constructed at Hanford. The State of Washington Department of Ecology (Ecology), a cooperating agency on the EIS, has revised its Foreword to the Draft EIS in response to this modification to the preferred alternative for tank waste.

For this reason, Ecology did not comment on this approach during public comment, and no public meeting was held in New Mexico.

However, this *Final TC & WM EIS* reversed this course and is now supporting the idea of some tank waste being classified as TRU waste and being packaged for disposal at WIPP. Ecology has concerns that there may be significant public concern regarding this path forward that has not been given the opportunity to be voiced, particularly since the public meetings in New Mexico were canceled.

Ecology has legal and technical concerns with any tank waste being classified as mixed TRU waste at this time. DOE must provide peer-reviewed data and a strong, defensible, technically and legally detailed justification for the designation of any tank waste as mixed TRU waste, rather than as HLW. DOE must also complete the WIPP certification process and assure Ecology that there is a viable disposal pathway (i.e., permit approval from the State of New Mexico and the U.S. Environmental Protection Agency) before Ecology will modify the Hanford Sitewide Permit to allow tank waste to be treated as mixed TRU waste. Further, Ecology is concerned with the cost benefit viability of an approach that sends a relatively minor amount of tank waste to WIPP, given the cost it would take to secure the disposal path, and to construct and operate the drying facility for the TRU tank waste.

Supplemental Treatment

In this *Final TC & WM EIS*, DOE considers additions to the treatment processes that the WTP would use; specifically, technologies to supplement the WTP's treatment of LAW. Because the WTP as currently designed does not have the capacity to treat the entire volume of LAW in a reasonable timeframe, additional LAW treatment capacity is needed. In section V of this foreword, we describe DOE's approach to delay the decision on supplemental treatment and describe Ecology's significant concern over that approach. In this section, we provide further information on our concerns.

Ecology is stating that this EIS and ROD should make a decision on supplemental treatment; that the only viable choice is the second LAW Vitrification Facility; and that to delay the decision in this EIS will endanger future tank waste milestones and commitments.

<u>Vitrification Options:</u>

Ecology agrees that evaluation of additional LAW vitrification treatment capacity as part of the scope of this EIS was needed. An additional supplemental LAW treatment system is necessary to treat all the tank waste in a reasonable amount of time. Ecology fully supports the *Final TC & WM EIS* alternative that assumes a second LAW Vitrification Facility would provide additional waste processing. Building a second LAW Vitrification Facility has consistently been Ecology's and DOE's baseline approach.

Ecology is supportive of a second LAW Vitrification Facility as the Preferred Alternative in the ROD for the following reasons:

- LAW vitrification is a mature technology that is ready to be implemented with no further testing.
- LAW vitrification produces a well-understood waste form that is extremely protective of the environment (the bulk vitrification waste form is not as protective and the waste form performance data show that cast stone and steam reforming are the least protective forms).

Ecology's measuring stick for a successful supplemental treatment technology has always been whether it is ―as good as glass" (from the WTP).

Bulk vitrification is a type of vitrification; however, data from the last bulk vitrification experimental testing indicate waste form performance and technology implementation issues. There has been a lack of significant progress on advancing a bulk vitrification test facility for actual waste. The environmental results from the waste form performance presented in this *Final TC & WM EIS* indicate that LAW vitrification is superior to bulk vitrification. A recently published DOE report indicates that a second LAW Vitrification Facility would be preferable.

Cast Stone and Steam Reforming Options:

Ecology is not supportive of alternatives that consider supplemental treatment methods that are not vitrification. This issue was addressed during the *State of Washington v. Chu* settlement negotiations and resolved with a series of target milestones, to become enforceable after the 2015 TPA negotiations on supplemental treatment, which dictate the schedule for a ―Supplemental Treatment Vitrification Facility" (see TPA Milestones M-62-31-T01 through M-62-34-T01 and Milestone M-62-45). Specifically related to the cast stone (grout) and steam reforming alternatives, Ecology has waste form performance and technical concerns. From a technical standpoint, the waste treatment processes of steam reforming and cast stone would not provide adequate primary-waste forms for disposal of tank waste in onsite landfills. This has been the subject of a previous DOE down-select process, in which Ecology and other participants rated these treatment technologies as low in performance. This final EIS shows that the waste form performance of both cast stone and steam reforming would be inadequate. These alternatives do not merit any further review.

Specifically related to the steam reforming alternative, Ecology has technical concerns about the *Draft* and *Final TC & WM EIS* assumptions regarding contaminant partitioning and its effects on waste form performance. Additionally, recent testing (2009 to 2011) on steam reforming development has shown that the technology readiness is very low, the mass balance cannot be closed, cost savings assumptions have evaporated, and waste performance is still undetermined. In addition, there have been operational off-normal events in 2012 in an Idaho steam reforming plant that raise many operations and safety questions. DOE should not include steam reforming as part of the Preferred Alternative and no further studies are warranted.

Washington State is particularly concerned with the recent re-emergence of cast stone or grout as the favored choice for treating LAW. Because this re-emergence coincides with the vague-language change about a preferred alternative for supplemental treatment in this *TC & WM EIS*, Ecology would like to recap the important history of grouting tank waste at Hanford.

For the past two decades, the citizens of the Northwest have vigorously opposed grouting LAW. Their concerns included waste form performance and the increased waste volume (twice as much as ILAW glass) that would create increased disposal needs and associated costs.

Important information on grout and cast stone waste form performance history includes the following:

- The Hanford Waste Task Force, a stakeholder advisory group, concluded that “grout doesn’t adequately protect public, workers, and environment” and that “reduction of waste volume was an issue for grout” because grout increases final-waste-form volume significantly. (*Final Report of the Hanford Waste Task Force, Appendix F*, 1993.)

- DOE’s 1995 waste form performance assessment resulted in identification of three constituents that would ultimately violate drinking water standards if grout is used. The three constituents (nitrate, iodine-129, and technetium-99) violated drinking water standards before and after the 10,000-year analysis timeframe. (*Performance Assessment of Grouted Double Shell Tank Waste Disposal at Hanford*, 1995, WHC-SD-WM-EE-004 Rev. 1.)

- The 2003–2006 supplemental treatment down-select showed that cast stone would not be appropriate for LAW treatment because it would significantly impact the groundwater, i.e., above drinking water standards, and would not be “as good as glass.” Roy Schepens, Office of River Protection Manager, defined the term “as good as glass” in his letter to Mike Wilson, Ecology (June 12, 2003), as follows:

  > The waste form resulting from treatment must meet the same qualifications of those imposed for the expected glass form produced by the Waste Treatment Plant (WTP). We expect all waste forms produced from any supplemental technology to: (1) perform over the specified time period as well as, or better than WTP vitrified waste; (2) be equally protective of the environment as WTP glass; (3) meet LDR [land disposal restrictions] requirements for hazardous waste constituents; (4) meet or exceed all appropriate performance requirements for glass, including those identified in the WTP contract, Immobilized Low Activity Waste (ILAW) Interface Control Documents, and ILAW Performance Assessment.

- The 2009 *Draft* and 2011 *Preliminary Final TC & WM EIS* indicated that the environmental performance of the grouted waste form would not meet required standards and that grout actually performed the worst of all the supplemental treatment options considered.

- In 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a report, *Technical Evaluation Report for the Revised Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site, South Carolina*, exposing issues related to long-term performance of the resulting waste form.

Based on this history and the results of this *Final TC & WM EIS*, no further consideration of grout or cast stone is warranted.

Cost Comparisons:

We believe that credible cost comparisons have been made in a number of documents and that all current data, including that in this EIS, do not demonstrate marked cost reductions, nor have our experiences with other technologies (bulk vitrification) at Hanford demonstrated significant cost reductions. The cost information is included in the following:

- In the mid-1990s, recognizing the broad-based public concern about grout and the potential for LAW vitrification at costs that appeared similar to those for grout on a grand scale, Washington State opted for vitrification when negotiating a new set of milestones for tank waste treatment. In return, Washington agreed to DOE’s desire to delay construction of the Hanford Waste Vitrification Plant [the treatment plant prior to the WTP] for budgetary reasons and other DOE sites competing for the same resources.

- DOE's 2003 report, *Assessment of Low-Activity Waste (LAW) Treatment and Disposal Scenarios for the River Protection Project (RPP)*, did not show a favorable grout waste treatment cost estimate.

- DOE's 2007 report, *Hanford River Protection Project Low Activity Waste Treatment: A Business Case Evaluation*, examined the cost and viability of implementing cast stone, bulk vitrification, and steam reforming waste treatment. The report stated that ―cost differences between Business Cases 2 through 7 are unlikely to be the major factor in selecting a supplemental LAW technology."

  In the report, all the technologies were cost neutral when compared to each other and to ILAW glass. The report went on to comment on the added time and cost that would be required to bring the supplemental technologies up to the technology readiness level of ILAW glass.

- The 2009 *Draft* and 2011 *Preliminary Final TC & WM EIS*, which have gone through extensive DOE and external review, indicate that the costs are relatively equivalent for ILAW glass and grouted LAW approaches.

Summary of Important History of Tank Waste Treatment:

This summary provides select relevant history on issues related to Hanford tank waste treatment that should be considered before the *TC & WM EIS* decision on supplemental treatment is finalized in the ROD.

- The 1996 *TWRS EIS*, which Ecology coauthored with DOE, resulted in a ROD that committed to some important actions, including the following:

  - Treating all of the tank waste
  - Pretreating and separating the tank waste so that some of the tank HLW can be disposed of in a near-surface landfill, while the remainder is disposed of in a deep geologic repository
  - Vitrifying the pretreated LAW portion prior to near-surface disposal and vitrifying the HLW portion for deep geologic disposal
  - Removing all of the retrievable waste out of the tanks

  Because the *TWRS EIS* ROD will be superseded by the *TC & WM EIS* ROD, it is important to the State of Washington that DOE stand by its commitments to these actions.

- In 1997, NRC issued a determination that a portion of Hanford tank waste could be considered waste incidental to reprocessing and, therefore, could be disposed of in a near-surface landfill. The tank waste treatment system for 177 tanks included the following:

  - Solids leaching, complexant destruction, liquid–solids separation, and cesium ion exchange to separate tank waste into HLW and incidental waste fractions
  - Vitrification (glass) for treatment and disposal of the incidental waste fraction

  NRC stated that the determination of the proposed LAW fraction as incidental waste is a provisional agreement. If the Hanford tank waste is not managed using a program comparable to the technical basis analyzed in the reference letter, NRC must revisit the waste determination (Paperiello [1997], NRC, to J. Kinzer, DOE). Changing the methods of pretreatment, the near-surface disposal location, or the form of treatment for LAW from vitrification to something new would invalidate the incidental waste determination, and a new analysis would be necessary.

- Between 2003 and 2006, Washington State agreed to allow DOE to consider alternative supplemental treatment approaches as long as they performed —as good as glass." DOE stated that its goal was to identify alternative approaches that were faster and cheaper, but still performed just as well as glass. This effort examined many different technologies; however, in the end, no viable approaches have been identified.

- In the Consent Decree settlement that resolved *State of Washington v. Chu*, Civil No. 2:08-cv-05085-FVS, we agreed to the following:

  - A delay in the end of tank waste treatment from 2028 to no later than 2047
  - A delay in final waste removal from SSTs from 2018 to no later than 2040
  - A schedule for supplemental treatment to be online by 2022

  As outlined above, the State of Washington asserts that the milestones resulting from these negotiations dictate that supplemental treatment be some form of vitrification.

Secondary Waste from Tank Waste Treatment

This *Final TC & WM EIS* evaluates the impacts of disposing of secondary waste that would result from tank waste treatment. Ecology agrees with DOE that secondary waste from the WTP and from supplemental treatment operations will need additional mitigation before disposal. This assumption is not reflected in (and, in fact, is contradicted by) the current DOE baseline, which does not identify additional mitigation.

The new mitigation section in this final EIS outlines the requirement for treatment standards for the secondary waste. This was an important addition to this EIS. Chapter 7, Section 7.5.2.8, and Appendix M, Section M.5.7.5, discuss a number of options for improving grout performance for secondary waste. At an infiltration rate of 3.5 millimeters per year, lowering the diffusivity for grout by two orders of magnitude (i.e., from 1×10^{-10} to 1×10^{-12} square centimeters per second) would decrease the contribution of Effluent Treatment Facility–generated secondary waste by a factor of 100, thus deleting this waste from the list of dominant contributors to risk.

DOE has not determined what the secondary-waste treatment would be, but DOE and its contractor are evaluating various treatment options. These treatment options should meet at least the performance standard (1×10^{-12} square centimeters per second) identified in this final EIS. This will have to be refined and verified through the risk budget tool mitigation measures required in the IDF permit.

Tank Waste Treatment Flowsheet

In preparing this *Final TC & WM EIS*, some assumptions were made about highly technical issues, such as the tank waste treatment flowsheet, which is a representation of how much of which constituent would end up in which waste form and in what amount.

Certain constituents, such as technetium-99 and iodine-129, are significant risk drivers because they are mobile in the environment and have long half-lives. This final EIS assumes that 20 percent of the iodine-129 from the tank waste would end up in vitrified glass and 80 percent in the grouted secondary waste. The same assumption was made for bulk vitrification glass and the WTP LAW Vitrification Facility waste glass.

Based on review of the *Final TC & WM EIS* contaminant flowsheets for the WTP and bulk vitrification, Ecology has technical concerns with this approach. The design configuration for the WTP indicates that iodine-129 recycles past the melter multiple times, which leads to a higher retention in the glass and less in the secondary waste. Therefore, Ecology believes the retention rate of iodine-129 in the ILAW glass may be higher than that in the bulk vitrification glass. However, Ecology is aware that there is uncertainty in the actual glass retention results.

Through our cooperating agency interactions, DOE agreed to run a sensitivity analysis to show the information under a different approach. The sensitivity analysis in this *Final TC & WM EIS* shows that if recycling of iodine-129 is as effective as the WTP flowsheets indicate, then the WTP with a Bulk Vitrification Facility alternative would place 80 percent of iodine-129 in secondary waste (a less robust waste form). This can be compared to an alternative that includes a second LAW Vitrification Facility in addition to the WTP, which would place 30 percent of the iodine-129 in secondary waste. This 50 percent difference in capture reinforces Ecology's opinion that choosing Tank Closure Alternative 2B, which would use the WTP and a second LAW Vitrification Facility, would be most protective from a tank waste treatment perspective. This is one more reason that Ecology is supportive of Alternative 2B as the Preferred Alternative.

One key treatment mitigation identified in this final EIS is that both WTP and supplemental treatment must include recycle of key contaminants through the melter systems to maximize the retention of these constituents into the most robust waste forms.

Waste Release

This *Final TC & WM EIS* models contaminant releases from several different types of final waste forms, including the following:

- ILAW glass
- LAW melters (retired and failed)
- Waste in bulk vitrification boxes
- Steam reformed waste
- Grouted LAW from tank waste
- Grouted secondary waste
- Waste left in waste sites
- Grouted waste in the bottom of tanks
- Waste buried directly in landfills
- Waste that has been macroencapsulate

Ecology understands the methods and formulas used for the waste form release calculations (for all waste types). After reviewing the analysis approaches and contaminant release results for the waste forms identified above, Ecology agrees with most of the approaches used. The one area where Ecology has concerns is the steam reforming waste form release rates. Based on the limited test data available, the results in this final EIS may overestimate the contaminant retention in the steam reforming waste form.

Offsite Waste

DOE is decades behind its legal schedule in retrieving tank waste from the SSTs and years behind its legal schedule in completing construction of the WTP. DOE has not even begun treating Hanford's 207 million liters (54.6 million gallons) of tank waste.

Ecology is concerned about DOE maintaining its legal schedule for contact-handled TRU waste shipments for disposal at WIPP. Additionally, it is essential that DOE proceed with planning and development of a remote-handled TRU waste facility.

Large areas of Hanford's soil and groundwater are contaminated, and many of these areas will likely remain contaminated for generations to come, even after final cleanup remedies have been instituted.

In light of the current issues associated with a deep geologic disposal facility and DOE's attempt to terminate the Yucca Mountain program, it is unclear when close to 60 percent of the nation's HLW and more than 90 percent of the nation's defense-related SNF will leave the state of Washington.

Washington State is aware that, under DOE's plans, more curies of radioactivity would leave Hanford (in the form of vitrified HLW and processed TRU waste) than would be added to Hanford through proposed offsite-waste disposal. However, based on the current lack of waste movement from Hanford, the current state of Hanford's cleanup, and the analysis in this *Final TC & WM EIS*, Washington objects to the disposal at Hanford of additional wastes that have been generated from beyond Hanford.

As the *Draft* and *Final TC & WM EIS*s show, disposal at Hanford of the proposed offsite waste would significantly increase groundwater impacts to beyond acceptable levels. Such disposal would add to the risk term at Hanford today, at a time when progress on reducing the bulk of Hanford's existing risk term has yet to be realized. DOE should take a conservative approach to ensure that the impact of proposed offsite-waste disposal, when added to other existing Hanford risks, does not result in exceeding the ―reasonable expectation" standard of DOE's own performance objectives (DOE Manual 435.1-1, Section IV.P(1)) and of other environmental standards (e.g., drinking water standards). The additional analysis in this *Final TC & WM EIS*, including the mitigation section, clearly indicates that eliminating offsite-waste disposal at Hanford is the only environmentally appropriate action.

Washington State supports a ―no offsite-waste disposal" alternative as the Preferred Alternative in this *Final TC & WM EIS*, to be adopted in a ROD. DOE should forgo offsite-waste disposal at Hanford (subject to the exceptions in the current *State of Washington v. Bodman* Settlement Agreement).

Waste Disposal Location Alternatives

Ecology agrees with DOE that a preferred alternative utilizing IDF-East appears better for long-term disposal of waste than locating the IDF in the 200-West Area (IDF-West) because of the faster rate of groundwater flow in the 200-East Area.

Climate Change

Additional qualitative discussion of the potential effects of climate change on human health, erosion, water resources, air quality, ecological resources, and environmental justice has been added to Chapter 6 of this final EIS. Additional discussion of the types of regional climate change that could be expected has also been added to Chapter 6, Section 6.5.2, Global Climate Change. Appendix V has also been expanded. In the *Draft TC & WM EIS*, Appendix V focused on the potential impacts of a rising water table from a proposed Black Rock Reservoir. Following the retraction of this proposal, the focus of Appendix V was changed to analysis of potential impacts of infiltration increases resulting from climate change under three different scenarios.

Vadose Zone Modeling

This *Final TC & WM EIS* uses the STOMP [Subsurface Transport Over Multiple Phases] modeling code for vadose zone modeling. Based on its current review, Ecology believes that the Hanford parameters used with this code are adequate for the purposes served by this EIS. Ecology notes that the *TC & WM EIS* STOMP modeling code parameters are based on a regional scale and may need to be adjusted for site-specific closure decisions or other Hanford assessments. Use of STOMP in other assessments requires careful technical review and consideration of site-specific parameters. Ecology supports the process that DOE used for the Waste Management Area C performance assessment workshops in determining appropriate site-specific parameters. These workshops included a broad level of participation with other agencies, tribal nations, and stakeholders.

Risk Assessment and Cumulative Impacts

This *Final TC & WM EIS* evaluates risk under the alternatives and in the cumulative impact analyses. The risk assessment modeling presented in this final EIS should not be interpreted as a Hanford sitewide comprehensive human health and ecological risk assessment, applied to the river corridor or other specific

Hanford areas. Specific Hanford areas will require unique site parameters that are applicable to that area's specific use.

This *Final TC & WM EIS* presents an evaluation of the cumulative environmental impacts of treatment and disposal of wastes at Hanford. The cumulative impact analyses allow DOE to consider the impacts of all cleanup actions it has taken or plans to take at Hanford.

Cumulative Risk Evaluation Tool

This *Final TC & WM EIS* indicates that Hanford's Central Plateau remediation is going to be a difficult balancing of the risks from many contamination sources. This final EIS also points out the need to make cleanup and mitigation decisions with the cumulative impacts in mind and not in isolation. It is clear from reading this EIS that contamination source remediation across the Central Plateau will have to be gauged against a tool that evaluates cumulative risks as they are determined. Another DOE document, *Status of Hanford Site Risk Assessment Integration, FY2005* (DOE/RL-2005-37), stated that the groundwater and the Columbia River are natural accumulation points for impacts from multiple sources. A comprehensive risk assessment capability is necessary to address the cumulative impacts on these resources. The proposed acceptable risk left in an individual site will have to be evaluated against such a cumulative evaluation tool prior to making final decisions. For this and other reasons, a significantly detailed mitigation action plan is required by this NEPA process. From the standpoint of SEPA, the plan will have to point to requirements in the TPA to drive the required mitigation actions and their integration. Ecology will work with DOE to incorporate new TPA requirements to accomplish the following:

- Comprehensively and transparently transfer the working files, vadose zone and groundwater modeling framework, and quality assurance and quality control requirements to the appropriate site contractor and responsible DOE agent to serve as the basis for all future modeling.
- Develop a work plan for continuing this modeling for the purpose of making overall Central Plateau risk decisions and site-specific remedial decisions.
- Identify a gap analysis to highlight areas that are currently not being addressed by a risk evaluation.
- Develop a Central Plateau cumulative risk evaluation tool.
- Develop site-specific risk assessments that are integrated with the Central Plateau cumulative risk evaluation tool.

Without these requirements and implementation of such future risk evaluation tools, future Hanford remediation has the potential to be random at best and not protective, as well as, in some places, to re-contaminate groundwater and vadose zone areas that have been remediated.

VII. Noteworthy Areas of Agreement

Ecology and DOE have discussed and reached agreement on the following significant issues and parameters for the purposes of this *Final TC & WM EIS*:

- Tank waste must be retrieved from tanks and immobilized.
- Secondary waste will need to be mitigated in waste forms that are more protective than grout to provide adequate protection.
- The best location for the IDF is in the 200-East Area.

- Waste from the tanks needs to be removed to the maximum extent possible.
- In many cases, vadose zone contamination under the tank farms will have to be mitigated to be protective of the groundwater and the Columbia River.
- Remediation of problematic soil contamination in the Central Plateau will be needed to limit further groundwater impacts; this would include development of vadose zone remediation methods.
- Eliminating or limiting offsite waste disposal at Hanford is the only legitimate approach.
- The manner in which DOE presents groundwater data and information (i.e., with graphics).
- The quality assurance requirements that DOE and Ecology identified in the *State of Washington v. Bodman* Settlement Agreement.
- The *Technical Guidance Document for Tank Closure Environmental Impact Statement Vadose Zone and Groundwater Revised Analyses* agreement, which focused on parameters shown to be important in groundwater analysis.
- The location of calculation points for contaminant concentrations in groundwater.
- The use of tank farm closure descriptions and alternatives analysis.
- The use of tank waste treatment descriptions and alternatives analysis.
- Inclusion of the US Ecology Commercial LLW Radioactive Waste Disposal Site and the cocooned reactors transported to the Central Plateau in the comprehensive cumulative impacts assessment.
- Overall modeling approaches for vadose zone and groundwater.
- The use of modeling assumptions for the double-shell tanks.
- Alternatives assumptions about how processes would treat existing wastes and generate other wastes during treatment processes, and how DOE would dispose of all of the wastes.
- The methods for evaluating and using waste inventory data.
- Release mechanisms for contaminants from various waste forms.
- An alternative in this *Final TC & WM EIS* that evaluates the impacts of treating and disposing of all tank waste and residue to meet the RCRA/Hazardous Waste Management Act HLW treatment standard of vitrification.
- The inventory assumptions used for the pre-1970 burial grounds.

Ecology's agreement on these issues and parameters is specifically for the purposes of this *Final TC & WM EIS* and is based on Ecology's current knowledge and best professional judgment.

Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (Final TC & WM EIS)

U.S. Environmental Protection Agency (EPA), Region 10 Foreword

After receiving the EPA comments on the *Draft TC & WM EIS*, the U.S. Department of Energy (DOE) wrote to the EPA, inviting the EPA to be a cooperating agency in the development of this *Final TC & WM EIS*. The two agencies signed a memorandum of understanding (MOU) in April 2011 to formalize the EPA's involvement as a cooperating agency and to define each agency's roles and responsibilities in the preparation of this final EIS. Prior to entering into the MOU, the EPA participated in two meetings organized by DOE, in April and October of 2010, to discuss the EPA's comments on the draft EIS and DOE's preliminary plans to address them.

The EPA was not involved in the development of the preliminary final EIS beyond the April and October 2010 meetings. When preliminary final EIS documents were released for review in August 2011, the limited timeframes for review necessitated our focused review on DOE's draft responses to the EPA's draft EIS comments and issues that the EPA considered important to address in this final EIS. This Foreword, therefore, reflects only a limited review of the preliminary and draft final EIS documents. Based on our limited review, the EPA has the following concerns regarding this *Final TC & WM EIS*:

Tank Closure and Waste Management

The EPA notes that the results of analyses of all Tank Closure alternatives in the preliminary and draft final EISs, including DOE's Preferred Alternative for tank closure, Tank Closure Alternative 2B, predict sustained release of contaminants to the environment, particularly to the vadose zone and to groundwater within the EIS analysis area. While we recognize the technical challenges associated with analyzing and addressing this problem, and that there are multiple sources of contaminants over time, we remain concerned about the potential impacts of sustained contaminant release to the vadose zone in the study area and migration to groundwater. We understand that the models used in this EIS to analyze impacts were developed in a process that included peer review. However, present and future users of the models should be aware of any limitations of the models, and assumptions employed in these analyses. We agree with statements in the preliminary and draft final EISs stating that, "these models are complex and rely on assumptions that are subject to a large degree of uncertainty…." At present, we collectively do not have enough information to accurately predict how various contaminants migrate through soils and groundwater, nor when peak groundwater impacts will occur. However, the best site-specific data should be incorporated into the assumptions, especially when the models are being used to inform site-specific decisions.

The EPA will continue to coordinate with DOE and the Washington State Department of Ecology (Ecology) to address contamination issues through our relevant authorities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); Resource Conservation and Recovery Act (RCRA); and Hanford Federal Facility Agreement and Consent Order, also known as the Tri-Party Agreement (TPA). The TPA currently identifies groundwater in the study area as an operable unit, which will be addressed under CERCLA.

The EPA's comments on the preliminary final EIS addressed the relationship of this EIS to permitting requirements of Ecology's authorized dangerous waste program. We appreciate the changes made to this final EIS in response. The EPA believes that this EIS can serve as a set of bounding analyses reasonably expected to reflect the environmental performance requirements that Ecology may establish through the permitting process. In this context, the EPA would support an approach to tank closure that includes landfill and clean closure components analyzed in this EIS. The EPA will continue to work closely with Ecology in support of that agency's authorized dangerous waste permitting program.

Secondary- and Offsite-Waste Disposal

This final EIS indicates that disposal of secondary and offsite waste on site at Hanford would continue to show significant impacts of the release of technetium-99 into the vadose zone and groundwater. To prevent additional contamination of the vadose zone and groundwater from such disposal, DOE will need to establish waste acceptance criteria and appropriate treatment technologies to reduce or immobilize contaminants in the wastes, primarily technetium-99 and iodine-129. For example, the steam reforming waste performance is still associated with a high degree of uncertainty, suggesting that steam reforming technology remains immature and requires more improvements. Similarly, iodine-129 is very volatile and cannot be easily converted to immobilized low-activity waste glass.

Next Steps

The EPA's role and responsibilities as a cooperating agency in the development of this final EIS are distinct from its obligations under the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act, which require the EPA to review and comment in writing on the environmental impacts of major Federal actions, including actions that are the subject of draft and final EISs under NEPA. The EPA intends to carry out this independent authority in a review of the publicly released version of this final EIS. In addition, the EPA's role as a cooperating agency is separate from, and not intended to duplicate or replace the EPA's regulatory roles, including those under RCRA, CERCLA, and the TPA. We will continue to carry out these responsibilities in coordination with other agencies as appropriate.

Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (Final TC & WM EIS)

U.S. Department of Energy (DOE) Foreword

DOE appreciates the efforts of the Washington State Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA), Region 10, which participated as cooperating agencies in the preparation of this *TC & WM EIS*. Although each had different roles as cooperating agencies, their involvement improved the quality of the National Environmental Policy Act (NEPA) process for this environmental impact statement (EIS).

Ecology began participating in the EIS development as a cooperating agency in 2002 and reconfirmed their participation in 2006 after signing the January 6, 2006, Settlement Agreement (*State of Washington v. Bodman*, Civil No. 2:03-cv-05018-AAM) (subsequently amended on June 5, 2008) ending litigation on the January 2004 *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington*. Ecology's participation as a cooperating agency was important, among other things, to ensure that this *TC & WM EIS* meets Washington State Environmental Policy Act (SEPA) requirements. As a result of the 2006 Settlement Agreement, Ecology accepted additional responsibilities under a concurrent revised Memorandum of Understanding (MOU) to conduct quality assurance reviews of the groundwater and other technical analyses. Ecology also independently ran the models used in this EIS and verified DOE's results. Ecology's role as a cooperating agency supporting SEPA requirements is different from its role under the Hanford Federal Facility Agreement and Consent Order (also known as the Tri-Party Agreement [TPA]) or its role in implementing Washington State's Hazardous Waste Program at the Hanford Site. More-detailed information on Ecology's role can be found in the cooperating agency agreements in Appendix C, Section C.1.1, of this *Final TC & WM EIS*.

DOE appreciates Ecology's support in the development of this EIS and its participation in all the scoping meetings, public hearings on the *Draft TC & WM EIS*, and stakeholder interactions, as well as its support of the EIS schedule. This EIS is needed to support NEPA and SEPA decisions related to the TPA and 2010 Consent Decree (*State of Washington v. Chu*, Civil No. 2:08-cv-05085-FVS) milestone commitments. DOE also appreciates the efforts made by Ecology to understand the inventory, input assumptions, modeling results, and uncertainty analyses and to conduct the quality assurance reviews, contribute to analysis development, assist in presentation of analyses, and participate jointly in public involvement activities. Ecology has expressed both substantial areas of agreement and some areas of disagreement with DOE's Preferred Alternative selections in its foreword to this *Final TC & WM EIS*, consistent with the opportunity afforded to them under the provisions of the *TC & WM EIS* MOU between Ecology and DOE. For its part, DOE understands the state's perspective and will continue to work with them on the path forward at the Hanford Site.

Ecology's comments on the draft EIS can be found in the Comment-Response Document (CRD) (Volume 3 of this final EIS), Section 3, commentor number 498. Ecology and DOE have identified the need for additional secondary-waste-form development (see Chapter 7, Section 7.5.2.8, and Appendix M, Section M.5.7.5). Ecology has also focused on closure of the single-shell tanks; specifically, in Waste Management Area C. More-detailed information on Ecology's permitting process in relation to the NEPA actions can be found in Section 7.1.

DOE invited EPA to be a cooperating agency in 2002 and to participate in model development in 2006 after the January 6, 2006, Settlement Agreement was signed. EPA was not able to participate as a cooperating agency until 2010. Information on EPA's role as a cooperating agency can be found in Appendix C, Section C.1.2.

EPA's comments on the draft EIS as part of their responsibility under Section 309 of the Clean Air Act and DOE's responses can be found in the CRD, Section 3, commentor number 509, of this final EIS. DOE has made changes to this final EIS as a result of EPA's specific comments. EPA's foreword to this EIS indicates a limited timeframe for review of this final EIS. DOE appreciates EPA's focus on DOE's responses to their comments on the draft EIS.

EPA expressed concern regarding the impacts of sustained releases under Tank Closure Alternative 2B. To address this concern, DOE has added information regarding Alternative 2B to Chapter 5, Section 5.1.1.3.4, showing the potential impacts when discharges from the CERCLA [Comprehensive Environmental Response, Compensation, and Liability Act] cribs and trenches (ditches) are excluded. This was done to more clearly show the impacts of the proposed actions separate from the impacts attributed to the adjacent CERCLA cribs and trenches (ditches). For example, Figure 5–87 shows the hydrogen-3 (tritium) results under Tank Closure Alternative 2B, Case 3 (Case 3 excludes cribs and trenches [ditches]), indicating that the tritium concentrations peak two to four orders of magnitude below the benchmark in this case, which highlights that the primary concentration of tritium originates from discharges to cribs and trenches (ditches). In addition, the CRD, Section 2.7, discusses impacts of alternatives based on whether a proposed action being evaluated has occurred, and how mitigation strategies and environmental compliance vary based on those factors.

EPA had comments regarding the EIS modeling that was developed as an outcome of the 2006 Settlement Agreement. DOE believes that its detailed responses to EPA's comments on this specific issue address this EPA concern. EPA also expressed concern about DOE's disclosure of uncertainty relative to future use of the model. DOE believes that discussion of uncertainty, comparison of model results to field data, and disclosure of data and model limitations are important aspects of the analysis presented in this final EIS, as required under NEPA. More-specific discussion on this point can be found in the CRD, Section 2.4. In addition, the groundwater model development process was reviewed by a Technical Review Group (TRG). The TRG was formed to evaluate conversion of the groundwater model from previous models used on site (see the Summary, Section S.1.4.1, and Chapter 1, Section 1.6.1.2). For more information, the report titled *MODFLOW Flow-Field Development: Technical Review Group Process and Results Report*, dated November 2007, can be found on the *TC & WM EIS* website at http://www.hanford.gov/index.cfm?page =1117&.

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List of Abbreviations and Acronyms

BBI	Best-Basis Inventory
BRC	Blue Ribbon Commission on America's Nuclear Future
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
CH	contact-handled
COPC	constituent of potential concern
CRD	Comment-Response Document
CWC	Central Waste Complex
CY	calendar year
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
ETF	Effluent Treatment Facility
FFTF	Fast Flux Test Facility
"FFTF Decommissioning EIS"	"Environmental Impact Statement for the Decommissioning of the Fast Flux Test Facility at the Hanford Site, Richland, Washington" (rescoped in 2006 to this *TC & WM EIS*)
FONSI	Finding of No Significant Impact
FR	*Federal Register*
GNEP PEIS	*Draft Global Nuclear Energy Partnership Programmatic Environmental Impact Statement*
GTCC	greater-than-Class C
GTCC EIS	*Draft Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste*
Hanford	Hanford Site
Hanford Comprehensive Land-Use Plan EIS	*Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*
HLW	high-level radioactive waste
HSW EIS	*Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington*
IDF	Integrated Disposal Facility
IDF-East	200-East Area Integrated Disposal Facility
IDF-West	200-West Area Integrated Disposal Facility
IHLW	immobilized high-level radioactive waste
ILAW	immobilized low-activity waste
INL	Idaho National Laboratory

List of Abbreviations and Acronyms *(continued)*

INTEC	Idaho Nuclear Technology and Engineering Center
LAW	low-activity waste
LCF	latent cancer fatality
LLBG	low-level radioactive waste burial ground
LLW	low-level radioactive waste
MCL	maximum contaminant level
MFC	Materials and Fuels Complex
MLLW	mixed low-level radioactive waste
MODFLOW	modular three-dimensional finite-difference groundwater flow model
MOU	Memorandum of Understanding
NEPA	National Environmental Policy Act
NI PEIS	*Final Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility (Nuclear Infrastructure PEIS)*
NOI	Notice of Intent
NRC	U.S. Nuclear Regulatory Commission
ORP	Office of River Protection
PM_n	particulate matter with an aerodynamic diameter less than or equal to n micrometers
PPF	Preprocessing Facility
RCB	Reactor Containment Building
RCRA	Resource Conservation and Recovery Act
RH	remote-handled
RH-SC	remote-handled special component
ROD	Record of Decision
ROI	region of influence
RPP	River Protection Project
RPPDF	River Protection Project Disposal Facility
RTP	Remote Treatment Project
SA	supplement analysis
SEIS	supplemental environmental impact statement
SEPA	State Environmental Policy Act (Washington State)
SNF	spent nuclear fuel
SPF	Sodium Processing Facility
SRF	Sodium Reaction Facility
SST	single-shell tank
SWOC	Solid Waste Operations Complex
―Tank Closure EIS”	―Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland, Washington” (rescoped in 2006 to this *TC & WM EIS*)

List of Abbreviations and Acronyms *(continued)*

TC & WM EIS	*Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*
TPA	Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement)
TRU	transuranic
TWRS EIS	*Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement*
WESF	Waste Encapsulation and Storage Facility
WIPP	Waste Isolation Pilot Plant
WM PEIS	*Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*
WRAP	Waste Receiving and Processing Facility
WRF	waste receiver facility
WTP	Waste Treatment Plant
Yucca Mountain EIS	*Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*

Measurement Units

The principal measurement units used in this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)* are SI units (the abbreviation for the *Système international d'unités*). The SI is an expanded version of the metric system that was accepted as the legal standard by the International Organization for Standardization. In this system, most units are made up of combinations of seven basic units, of which length in meters, mass in kilograms, and volume in liters are of most importance in this *TC & WM EIS*. Exceptions are radiological units that use the English system (e.g., rem, millirem).

Scientific (Exponential) Notation

Numbers that are very small or very large are often expressed in scientific, or exponential, notation as a matter of convenience. For example, the number 0.000034 may be expressed as 3.4×10^{-5} or 3.4E−05, and 65,000 may be expressed as 6.5×10^{4} or 6.5E+04. In this *TC & WM EIS*, numerical values that are less than 0.001 or greater than 9,999 are generally expressed in scientific notation, i.e., 1.0×10^{-3} and 9.9×10^{3}, respectively.

Multiples or submultiples of the basic units are also used. A partial list of prefixes that denote multiples and submultiples follows, with the equivalent multiplier values expressed in scientific notation.

Prefix	Symbol	Multiplier	
atto	a	0.000 000 000 000 000 001	1×10^{-18}
femto	f	0.000 000 000 000 001	1×10^{-15}
pico	p	0.000 000 000 001	1×10^{-12}
nano	n	0.000 000 001	1×10^{-9}
micro	μ	0.000 001	1×10^{-6}
milli	m	0.001	1×10^{-3}
centi	c	0.01	1×10^{-2}
deci	d	0.1	1×10^{-1}
deca	da	10	1×10^{1}
hecto	h	100	1×10^{2}
kilo	k	1,000	1×10^{3}
mega	M	1,000,000	1×10^{6}
giga	G	1,000,000,000	1×10^{9}
tera	T	1,000,000,000,000	1×10^{12}
peta	P	1,000,000,000,000,000	1×10^{15}
exa	E	1,000,000,000,000,000,000	1×10^{18}

The following symbols are occasionally used in conjunction with numerical expressions:

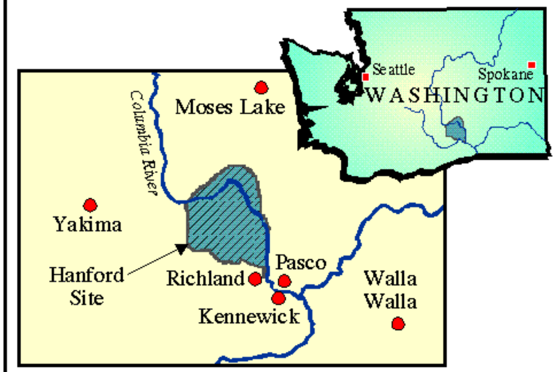
$<$ less than
$\leq$ less than or equal to
$>$ greater than
$\geq$ greater than or equal to

Conversions

English to Metric			Metric to English		
Multiply	**by**	**To get**	**Multiply**	**by**	**To get**
Area			**Area**		
square inches	6.4516	square centimeters	square centimeters	0.155	square inches
square feet	0.092903	square meters	square meters	10.7639	square feet
square yards	0.8361	square meters	square meters	1.196	square yards
acres	0.40469	hectares	hectares	2.471	acres
square miles	2.58999	square kilometers	square kilometers	0.3861	square miles
Length			**Length**		
inches	2.54	centimeters	centimeters	0.3937	inches
feet	30.48	centimeters	centimeters	0.0328	feet
feet	0.3048	meters	meters	3.281	feet
yards	0.9144	meters	meters	1.0936	yards
miles	1.60934	kilometers	kilometers	0.6214	miles
Temperature			**Temperature**		
degrees Fahrenheit	Subtract 32, then multiply by 0.55556	degrees Celsius	degrees Celsius	Multiply by 1.8, then add 32	degrees Fahrenheit
Volume			**Volume**		
fluid ounces	29.574	milliliters	milliliters	0.0338	fluid ounces
gallons	3.7854	liters	liters	0.26417	gallons
cubic feet	0.028317	cubic meters	cubic meters	35.315	cubic feet
cubic yards	0.76455	cubic meters	cubic meters	1.308	cubic yards
Weight			**Weight**		
ounces	28.3495	grams	grams	0.03527	ounces
pounds	0.4536	kilograms	kilograms	2.2046	pounds
short tons	0.90718	metric tons	metric tons	1.1023	short tons

Note: The use of the SI system of units as the principal system of measurement in this *TC & WM EIS*, combined with the use of significant figures or rounding when presenting numerical data, may cause some conversions to appear to be incorrect throughout this environmental impact statement (EIS). This is generally more common when the original value was in English units and was subsequently converted to the SI system for presentation in this EIS. The rounding error may be more noticeable when the corresponding measurement units in the English and SI systems are not relatively comparable in magnitude (e.g., feet and meters). For example, for the values in ―2.9-million-liter (758,000-gallon) capacity," the original value of 758,000 gallons is converted to 2,869,000 liters (rounded to 2.9 million liters). However, converting 2.9 million liters to gallons yields 766,000 gallons, which is different from the original value. In another example, for the values in ―22 by 29 meters (72 by 94 feet)," the original value of 94 feet is converted to 28.6 meters (rounded to 29 meters). Converting 29 meters to feet yields 95 feet, which is slightly different from the original value of 94 feet. In this *TC & WM EIS*, the original value in English units is preserved, whereas, in many instances, the SI unit is actually the converted number.

SUMMARY



S.1 INTRODUCTION

The U.S. Department of Energy (DOE) prepared this *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)*, which revises and updates previous analyses, to evaluate the potential environmental impacts of three sets of proposed actions at the Hanford Site (Hanford):

- **Tank Closure.** Tank closure includes management of the waste inventory of about 207 million liters (54.6 million gallons) of mixed radioactive and chemically hazardous waste, currently stored in underground storage tanks. The analysis considers tank waste storage, retrieval, treatment, and disposal, as well as the impacts of different scenarios for final closure of the single-shell tank (SST) system.

- **Fast Flux Test Facility (FFTF) Decommissioning.** Proposed activities to decommission FFTF, a nuclear test reactor at Hanford, include management of decommissioning-generated waste, such as remote-handled special components (RH-SCs), and the disposition of Hanford's inventory of radioactively contaminated bulk sodium from FFTF and other onsite facilities.

- **Waste Management.** Ongoing solid-waste management operations at Hanford, as well as the proposed disposal of low-level radioactive waste (LLW) and mixed low-level radioactive waste (MLLW) from Hanford and a limited volume of LLW and MLLW from other DOE sites in one or two Integrated Disposal Facilities (IDFs) at Hanford.

> **What is the Purpose of an Environmental Impact Statement (EIS)?**
>
> The primary purpose of an EIS is to serve as an action-forcing device to ensure that the policies and goals defined in the National Environmental Policy Act are infused into the ongoing programs and actions of the Federal Government. An EIS provides a full and fair discussion of potential significant environmental impacts and informs decision-makers and the public of the reasonable alternatives that would avoid or minimize adverse impacts or enhance the quality of the human environment. An EIS is used by Federal officials in conjunction with other relevant information to plan actions and make decisions (40 CFR 1502.1).

This *TC & WM EIS* describes the potential environmental impacts and cost consequences of the proposed actions and reasonable alternatives for the major activities cited above. It was prepared in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321 et seq.); DOE implementing procedures for NEPA (10 CFR 1021 and DOE Order 451.1B); and Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 CFR 1500–1508). Further, this environmental impact statement (EIS) implements the January 6, 2006, Settlement Agreement with the State of Washington (as amended on June 5, 2008), signed by DOE, the Washington State Department of Ecology (Ecology), the Washington State Attorney General's Office, and the U.S. Department of Justice. That agreement settles NEPA claims made in the case *State of Washington v. Bodman* (Civil No. 2:03-cv-05018-AAM), which addressed the *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington (HSW EIS)* (DOE 2004). Ecology is participating in this NEPA activity as a cooperating agency; as such, it is responsible for reviewing the content of this *TC & WM EIS* under authority of Washington's State Environmental Policy Act (SEPA) (RCW 43.21C) to ensure it satisfies the State of Washington's requirements and supports its proposed action to issue permits under its hazardous waste program.

Information provided in this EIS will be considered, along with other pertinent information, in the decision process for DOE's proposed actions. Since publication of the *Draft TC & WM EIS*, the U.S. Environmental Protection Agency (EPA) began participation in this NEPA activity as a cooperating agency in May 2010 (DOE and EPA 2011). The Memorandum of Understanding (MOU) between DOE and EPA identified the focus of EPA's review, i.e., DOE's responses to its comments.

S.1.1 History of the Hanford Site

Hanford occupies approximately 1,518 square kilometers (586 square miles) in southeastern Washington State along the Columbia River. From the 1940s to 1989, Hanford's mission encompassed defense-related nuclear research, development, and weapons production activities. This included operation of a plutonium production complex with nine nuclear reactors and associated facilities.

To produce plutonium, uranium metal (fuel rods) was irradiated in reactors near the Columbia River. The irradiated uranium metal (spent nuclear fuel [SNF]) was cooled and treated through chemical separation in reprocessing plants in the central part of Hanford. At the reprocessing plants, the SNF was dissolved in acid and the plutonium was separated from the remaining uranium and byproducts for use in nuclear weapons production.

Hanford's SNF reprocessing generated several hundred thousand metric tons of chemical and radioactive waste. Included were high-level radioactive waste (HLW), transuranic (TRU) waste, LLW, MLLW, and hazardous waste. The waste management process initially involved neutralizing the acidic waste with sodium hydroxide and sodium carbonate and storing the resulting caustic waste in large underground tanks until a long-term disposal solution could be found. To store the waste, 149 SSTs were built from 1943 through early 1964 in the 200 Areas of Hanford.

Waste Types Analyzed in This Environmental Impact Statement

Hazardous waste: A category of waste regulated under the Resource Conservation and Recovery Act (RCRA) (42 U.S.C. 6901 et seq.). To be considered hazardous, a waste must (1) be a solid waste under RCRA; (2) exhibit at least one of the four characteristics described in the U.S. Environmental Protection Agency's (EPA's) applicable regulations (40 CFR 261.20–24) (ignitability, corrosivity, reactivity, or toxicity); or (3) be specifically listed by EPA (40 CFR 261.31–33). Hazardous waste may also include solid waste designated as dangerous or extremely hazardous waste by the State of Washington (WAC 173-303-070 through 173-303-100).

High-level radioactive waste (HLW): Highly radioactive waste material resulting from reprocessing of spent nuclear fuel (SNF), including liquid waste produced directly from reprocessing; any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and other highly radioactive material that is determined, consistent with existing law, to require permanent isolation (DOE Manual 435.1-1).

Low-activity waste (LAW): Waste that remains after as much radioactivity as technically and economically practical has been separated from HLW that, when solidified, may be disposed of as low-level radioactive waste (LLW) in a near-surface facility. In its final form, such solid LAW would not exceed Class C radioisotope limits (10 CFR 61.55) and would meet performance objectives comparable to those in the applicable U.S. Nuclear Regulatory Commission (NRC) regulations (10 CFR 61, Subpart C). At the Hanford Site, this is mixed waste.

Low-level radioactive waste (LLW): Radioactive waste that is not HLW, SNF, transuranic (TRU) waste, byproduct material as defined in the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.), or naturally occurring radioactive material.

Mixed waste: Waste that contains source, special nuclear, or byproduct material that is subject to the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 et seq.), as well as a hazardous component subject to RCRA.

Transuranic (TRU) waste: Radioactive waste products containing more than 100 nanocuries (3,700 becquerels) of alpha-emitting TRU isotopes per gram of waste with half-lives greater than 20 years, except (1) HLW; (2) waste that does not need the degree of isolation required by the EPA disposal regulations (40 CFR 191), as determined by the Secretary of Energy with the concurrence of the EPA Administrator; or (3) waste that NRC has approved for disposal on a case-by-case basis in accordance with its regulations (10 CFR 61).

During the 1950s, uranium was extracted from some of the waste stored in SSTs, a process that introduced new chemicals into the tanks. Beginning in the 1960s, some waste was retrieved from SSTs and transferred into the B Plant at Hanford, where cesium and strontium were extracted, placed in capsules, and stored in a separate facility. This process removed approximately 40 percent of the fission product inventory from the tank waste. The remaining waste was returned to the tanks.

What are single-shell tanks?

Single-shell tanks are single-wall, underground storage tanks of varying size with carbon steel sides and bottom surrounded by reinforced-concrete shells.

What are double-shell tanks?

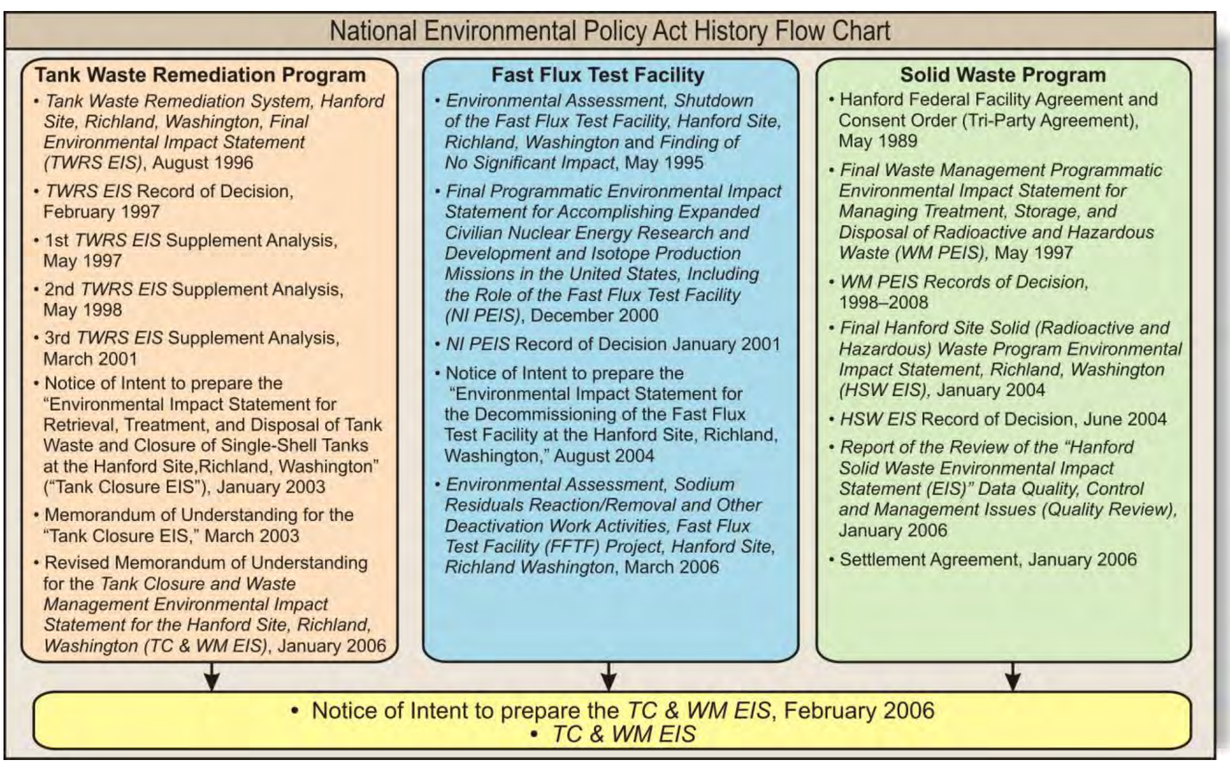
Double-shell tanks are carbon steel tanks built with external, carbon steel–lined, reinforced-concrete tanks, providing improved leak detection and waste containment.

In the mid-1950s, leaks were suspected or detected in some SSTs. To address concerns about SST designs, Hanford adopted a new double-shell tank (DST) design that would allow for detection of leaks and effective corrective actions before the waste could reach the surrounding soil. Between 1968 and 1986, a total of 28 DSTs were constructed and filled with liquids pumped from SSTs, which were subsequently interim-stabilized to minimize the potential for future leaks. The interim stabilization program was completed in 2009. Newly generated waste is also stored in the DSTs.

Presently, DOE is processing Hanford's contact-handled (CH) TRU waste (which does not require special protective shielding) for shipment to the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, an action consistent with previous Records of Decision (RODs) (63 FR 3629, 65 FR 10061) addressing treatment and disposal of TRU waste (DOE 1997a, 1997b). DOE is also disposing of Hanford's LLW and MLLW on site and has designated Hanford as a regional disposal site for LLW and MLLW from other DOE sites.

S.1.2 NEPA and Program Activities Leading Up to This *TC & WM EIS*

The history of this *TC & WM EIS* is complex; behind each of the proposed activities lies a series of related NEPA documentation. The following flowchart provides a chronology of key, relevant documents that contributed to the development of this EIS. The subsequent sections briefly summarize the history of each of the three sets of proposed actions and present a timeline of events for each set.



S.1.2.1 Tank Waste Remediation Program

The following timeline provides a brief history of the tank waste remediation program and DOE's decisions regarding its status.

1991–1998: The Tank Waste Remediation System, a DOE organization, manages all aspects of Hanford's tank farms.

1996: DOE and Ecology coauthor the *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement (TWRS EIS)* (DOE and Ecology 1996), consistent with the requirements of NEPA (10 CFR 1021) and SEPA (RCW 43.21C). The EIS evaluates the range of reasonable alternatives for managing and disposing of radioactive, hazardous, and mixed wastes stored in the Hanford tanks.

> Following issuance of the *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement* Record of Decision, the U.S. Department of Energy has made progress in a number of areas identified as issues/concerns in the National Research Council's report. For example, past leaks and spills are being characterized and contaminant fate and transport uncertainties are being addressed through Resource Conservation and Recovery Act facility investigations, and new data have been incorporated into the conceptual models used to evaluate environmental impacts in this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*. Additionally, significant advances have been made in the design, testing, construction, and estimates of costs associated with vitrification of tank waste in the Waste Treatment Plant. Supplemental treatment technologies are also being considered in this environmental impact statement.

After issuing the *Final TWRS EIS*, DOE receives comments on the *Draft TWRS EIS* in the form of a report from the National Research Council (1996) entitled *The Hanford Tanks: Environmental Impacts and Policy Choices* (National Research Council 1996) and addresses those comments in the *Final TWRS EIS* ROD. Notable comments are that (1) significant uncertainties limit DOE's ability to select a final disposal alternative for all tank waste and (2) DOE should consider remediation alternatives involving both ex situ (removal and treatment of waste) and in situ (in-place treatment and/or isolation disposal to provide flexibility in the event that specific technologies do not perform as anticipated or new technologies emerge. The council also recommends that DOE consider a phased decision strategy incorporating multiple alternatives to allow the program to move forward.

***February 1997*:** DOE publishes the *TWRS EIS* ROD (62 FR 8693), announcing its decision to implement the Preferred Alternative (Phased Implementation). The *TWRS EIS* ROD defers the matter of tank closure pending development of further information and commits to future NEPA evaluations of the tank waste remediation program to determine whether previous decisions should be changed. The ROD also incorporates proposed plans for the design, construction, and operation of waste treatment facilities; tank farm operation and maintenance; and transferral of waste from the tanks to treatment facilities.

> **What is the Phased Implementation Alternative?**
>
> The Preferred Alternative stipulated in the *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement* involves a two-phase approach to tank waste treatment: an initial demonstration phase lasting approximately 10 years and a second phase in which large, production-level waste treatment plants would treat the remainder of the tank waste by 2028. Tank waste would be separated into high-level radioactive waste and low-activity waste (LAW) streams and vitrified. The LAW would be disposed of on site in a vitrified form at the Hanford Site.

May 1997: DOE publishes the first of three *TWRS EIS* supplement analyses (SAs) (DOE 1997c), consistent with its commitment to conduct periodic evaluations under NEPA. Upon examining the potential environmental impacts of tank farm infrastructure upgrades (e.g., instrumentation and control, tank ventilation, waste transfer), DOE concludes that the potential impacts would be minor in comparison with, and are enveloped by, the impacts previously assessed under the Phased Implementation Alternative.

1998: Congress creates the Office of River Protection (ORP) as required by the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 (P.L. 105-261). ORP's manager is responsible for all aspects of Hanford's tank farm operations, including oversight of the River Protection Project (RPP).

May 1998: DOE issues the second *TWRS EIS* SA (DOE 1998) addressing the impacts of emergent information on the design and construction of a new waste treatment plant under the privatization approach. DOE concludes that the information developed since preparation of the *TWRS EIS* only minimally affects the previously estimated impacts and that the *TWRS EIS* impacts discussion sufficiently covers the changes in environmental impacts.

March 2001: DOE issues the third *TWRS EIS* SA (DOE 2001), considering information developed since approval of the *TWRS EIS* ROD relative to plans for treating Hanford tank waste. DOE concludes that no further NEPA review is needed prior to starting construction of Phase I treatment facilities, and that proposed changes to Phase II facilities to meet the goal of SST retrieval by 2018 will be included within the scope of a future NEPA analysis.

What is the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement)?

It is an agreement signed in 1989 by the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology that identifies milestones for key environmental restoration and waste management actions. One such milestone, M-45-00, established a 99 percent retrieval rate as a goal of tank closure activities at the Hanford Site.

2002: DOE begins retrieval activities on SST C-106, consistent with Milestone M-45-00 of the Hanford Federal Facility Agreement and Consent Order, also known as the Tri-Party Agreement (TPA) (Ecology, EPA, and DOE 1989).

January 2003: DOE publishes a Notice of Intent (NOI) (68 FR 1052) in the *Federal Register* to prepare the ―Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland, Washington" (―Tank Closure EIS") (DOE/EIS-0356), which includes closure of the 149 SSTs and an analysis of newly available information on supplemental treatment of a portion of the low-activity waste (LAW) from all 177 tanks (i.e., all SSTs and the 28 DSTs).

March 2003: DOE and Ecology sign an MOU, effective March 25, 2003, that identifies Ecology as a cooperating agency in the preparation of the ―Tank Closure EIS" and assists both agencies in meeting their respective responsibilities under NEPA and SEPA (RCW 43.21C).

January 2006: DOE and Ecology revise the original MOU for the ―Tank Closure EIS." The revision, signed January 6, 2006 (DOE and Ecology 2006), is consistent with the Settlement Agreement (see Section S.1.2.3 for a description of this agreement) and provides for Ecology's continuing participation as a cooperating agency in preparing this *TC & WM EIS*.

February 2006: DOE issues an NOI for the preparation of this *TC & WM EIS* (71 FR 5655).

Since issuance of the *TWRS EIS* ROD and subsequent SAs, DOE has proceeded with plans to design, construct, and operate facilities that would separate waste into HLW and LAW streams, vitrify the HLW stream, and immobilize the LAW stream. These facilities, now under construction in the 200-East Area of Hanford, are collectively referred to as the ―Waste Treatment Plant" (WTP). The WTP is the cornerstone of DOE's treatment capability for tank waste. It will separate waste stored in Hanford's underground tanks into HLW and LAW fractions. HLW will be vitrified in the WTP and stored at

Hanford until disposition decisions are made and implemented. Immobilized low-activity waste (ILAW) will also be produced at the WTP.

Design of, and preliminary performance projections for, the WTP supports DOE's proposal to extend operations beyond the 10-year period (Phase I) originally planned in the *TWRS EIS* ROD. DOE also plans to enhance WTP throughput rather than deploy a second, larger-scale treatment facility in 2012, as identified in the *TWRS EIS* ROD (Phase II). DOE has determined that the original plan for a Phase II WTP would be prohibitively expensive, and it was believed that an enhanced WTP would implement the *TWRS EIS* ROD. Accordingly, DOE changed the mission of the WTP from demonstration plant to single, full-scale production facility.

Another change since issuance of the third SA concerns the design of the WTP Pretreatment Facility. The original design of that facility provided for the removal of technetium-99 from the HLW stream. However, in light of reviews of technetium-99 in ILAW glass, DOE and Ecology agreed to delete technetium-99 removal from the WTP permit (Hedges 2008). Thus, the design of the Pretreatment Facility, currently under construction, includes no provision for technetium-99 removal. For analysis purposes, however, this *TC & WM EIS* assumes that, with appropriate design and construction modifications, a technetium-99 removal capability could be added if required.

Issues facing DOE include uncertainties associated with the magnitude of waste retrieval required. Consistent with TPA Milestone M-45-00, DOE began waste retrieval from SSTs in 2002 with tank C-106. Since completion of waste retrieval from that tank, retrieval from six other tanks has been completed. TPA Milestone M-45-00 specifies that closure will follow retrieval of as much tank waste as technically possible, the goal being 99 percent. By means of the TPA's Appendix H, ―Single Shell Tank Waste Retrieval Criteria Procedure," DOE can request an exception to this criterion if it deems it not achievable. This EIS provides information necessary for informed decisions regarding the impacts of meeting or not meeting the 99 percent retrieval goal.

S.1.2.2 Fast Flux Test Facility

The following timeline provides a brief history of FFTF operations and DOE decisions regarding its status.

The **Fast Flux Test Facility** is a U.S. Department of Energy–owned, formerly operating, 400-megawatt (thermal) liquid-metal (sodium)-cooled research and test reactor in the 400 Area of the Hanford Site.

1978: FFTF construction is completed.

1980: Initial operations begin.

April 1982–April 1992: FFTF operates as a national research facility testing advanced nuclear fuels, materials, and components; nuclear power plant operations and maintenance protocols; and reactor safety designs. It also produces various medical and industrial isotopes, as well as hydrogen-3 (tritium) for the U.S. Fusion Research Program, and conducts cooperative international research work.

December 1993: DOE orders FFTF to be shut down due to a lack of economically viable missions.

1994: Ecology, EPA, and DOE negotiate, under TPA authority, a set of transition-phase milestones and targets for FFTF deactivation and shutdown (the first step toward FFTF decommissioning) (Ecology, EPA, and DOE 1995).

May 1995: An evaluation of impacts of FFTF deactivation in the *Environmental Assessment, Shutdown of the Fast Flux Test Facility, Hanford Site, Richland, Washington* results in a Finding of No Significant Impact (DOE 1995a).

1994–1997: Fuel is removed from the reactor vessel for storage in aboveground dry storage casks, and some nonessential FFTF operating systems are deactivated.

January 1997: The Secretary of Energy orders FFTF to be maintained in a standby condition while DOE evaluates its future role in tritium production. Consequently, FFTF transition work is limited to activities that would not inhibit a reactor restart.

1998: The TPA agencies revise the work schedules under the TPA M-81-00 series milestones (Ecology, EPA, and DOE 1999), which cover FFTF deactivation. The agencies' ―Tentative Agreement" is issued for public comment and, as a result of the comments received, the TPA M-81-00 series milestones and target dates are temporarily suspended until the Secretary issues a final decision regarding the restart of FFTF.

December 1998: The Secretary announces that FFTF will not play a role in tritium production and that any other future FFTF mission decisions will be made by spring 1999.

May 1999: DOE initiates a two-phase process for finalizing a path forward for FFTF that includes development and review of a program-scoping plan.

December 2000: DOE issues the *Final Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility (Nuclear Infrastructure PEIS [NI PEIS])* (DOE 2000a) to document analyses of an expansion of domestic civilian nuclear energy research and development and isotope production using existing and new resources. In the *NI PEIS*, DOE evaluates the use of FFTF as an alternative irradiation services facility to accomplish these missions.

January 2001: In the *NI PEIS* ROD (66 FR 7877), DOE rules out the use of FFTF for isotope production and research missions and reaffirms its decision to permanently deactivate the facility.

April 2001: DOE suspends the decision made in the *NI PEIS* ROD to resume permanent FFTF deactivation while additional reviews of that decision are conducted.

December 2001: DOE decides to proceed with FFTF deactivation, including dry cask storage of irradiated fuel, dry storage of nonirradiated and sodium-bonded fuel, sodium draining and storage, and deactivation of the auxiliary plant systems.

2002: The TPA M-81-00 milestones are re-established and are revised to reflect the new due dates for FFTF deactivation activities (Ecology, EPA, and DOE 2002).

Late 2002: FFTF deactivation activities are temporarily suspended due to legal challenges by Benton County, Washington State, alleging that the 1995 environmental assessment is inadequate and that a full NEPA EIS on the complete decommissioning process should have been completed before any deactivation occurred.

February 28, 2003: The U.S. District Court of Eastern Washington rules in favor of DOE's decision to address only FFTF deactivation in the 1995 environmental assessment. Benton County subsequently appeals the U.S. District Court's ruling to the U.S. Ninth Circuit Court of Appeals, but files a motion to dismiss the appeal on May 6, 2003.

August 2004: DOE issues an NOI for the preparation of the ―Environmental Impact Statement for the Decommissioning of the Fast Flux Test Facility at the Hanford Site, Richland, Washington" (―FFTF Decommissioning EIS") (69 FR 50176).

February 2006: DOE issues an NOI for the preparation of this *TC & WM EIS* (71 FR 5655).

March 2006: DOE issues the *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington* (DOE 2006a) addressing continuation of ongoing FFTF deactivation work that was not extensively discussed in the *Environmental Assessment, Shutdown of the Fast Flux Test Facility, Hanford Site, Richland, Washington* (DOE 1995a). The FFTF decommissioning end state is addressed in this *TC & WM EIS*.

In previous NEPA reviews and associated RODs, DOE evaluated transportation, storage, treatment, use, and disposal of FFTF fuel at various DOE sites (DOE 1995a, 1995b, 1997d, 1999a, 2000b). Ongoing activities associated with management of the FFTF fuel are not evaluated in this EIS.

S.1.2.3 Hanford Solid Waste Program

The following timeline provides a brief history of Hanford's program to manage its waste inventories.

1986–May 1989: Ecology and EPA work with DOE to examine how to bring Hanford into compliance with the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The regulators and DOE agree to develop one compliance agreement that sets milestones for cleaning up past-disposal sites under CERCLA and bringing operating facilities into compliance with RCRA. Negotiations conclude in late 1988, and the TPA is completed in that same year and signed in 1989 (Ecology, EPA, and DOE 1989).

May 1997: DOE issues the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste (WM PEIS)* (DOE 1997a), a DOE complex–wide study examining the environmental impacts of managing more than 2 million cubic meters (2.7 million cubic yards) of radioactive waste from past, present, and future DOE activities. As stated in the *WM PEIS*, DOE would conduct further NEPA reviews regarding the specific location of new facilities at selected sites, as appropriate.

1998–2008: DOE issues *WM PEIS* RODs for management of LLW, MLLW, HLW, TRU waste, and hazardous waste. Analyses of alternatives in this *TC & WM EIS* are consistent with, and tier from, DOE complex–wide policies and practices that were described in the various *WM PEIS* RODs for each waste type. For example, Hanford is designated as a regional disposal site for LLW and MLLW from other DOE sites and is disposing of Hanford's LLW and MLLW on site.

March 2003: Ecology initiates litigation on issues related to importation, treatment, and disposal of radioactive and hazardous wastes generated off site as a result of nuclear defense and research activities. The court enjoins shipment of offsite TRU waste to Hanford for processing and storage pending shipment to WIPP.

January 2004: DOE issues the *Final HSW EIS* (DOE 2004) addressing ongoing solid-waste management operations.

June 2004: DOE issues the *HSW EIS* ROD (69 FR 39449) announcing DOE's decision to dispose of Hanford LLW and MLLW and a limited volume of offsite LLW and MLLW in a new IDF in the 200-East Area (IDF-East) of Hanford.

2004: Ecology amends its 2003 complaint, challenging the adequacy of the *HSW EIS* analysis of offsite-waste importation.

May 2005: The court grants a limited discovery period and continues its injunction against shipping offsite waste to Hanford.

July 2005: While preparing responses to Ecology's discovery requests, DOE contractor Battelle Memorial Institute, which assisted in preparing the *HSW EIS*, advises DOE of several differences between the groundwater analyses in the *HSW EIS* and its underlying data. DOE notifies the court and the State of Washington.

September 2005: DOE convenes a team of experts in quality assurance, groundwater analysis, transportation, and human health and safety impacts analysis to conduct a quality assurance review of the *HSW EIS*.

January 2006: DOE's team completes its *Report of the Review of the ―Hanford Solid Waste Environmental Impact Statement (EIS)" Data Quality, Control and Management Issues* (DOE 2006b).

January 6, 2006: DOE, Ecology, the Washington State Attorney General's Office, and the U.S. Department of Justice sign a Settlement Agreement ending the NEPA litigation (*State of Washington v. Bodman* [Civil No. 2:03-cv-05018-AAM]) and resolving Ecology's concerns, as well as addressing other concerns raised in the *Report of the Review of the ―Hanford Solid Waste Environmental Impact Statement (EIS)" Data Quality, Control and Management Issues* (DOE 2006b). The agreement also calls for expanding the ―Tank Closure EIS" to provide a single, integrated set of analyses that includes all waste types (LLW, MLLW, and TRU waste) analyzed in the *HSW EIS*.

Under the agreement, pending issuance of a ROD for this *Final TC & WM EIS*, the *HSW EIS* remains in effect to support ongoing waste management activities at Hanford (including transportation of TRU waste to WIPP) in accordance with applicable regulatory requirements. The agreement also stipulates that, when this *TC & WM EIS* has been completed, it will supersede the *HSW EIS*. Until that time, DOE will not rely on *HSW EIS* groundwater analysis for decisionmaking and will not import offsite waste to Hanford, apart from certain limited exemptions specified in the agreement.

February 2006: DOE issues an NOI for the preparation of this *TC & WM EIS* (71 FR 5655).

April 2006: Two cells of IDF-East are constructed. DOE decides to continue sending Hanford's MLLW off site for treatment and to modify Hanford's T Plant for processing remote-handled (RH) TRU waste and MLLW.

October 2010: The U.S. District Court approves two judicial Consent Decrees, one for DOE and the State of Washington and one for the State of Oregon. The Consent Decrees are the product of several years of negotiations by the parties and are part of the settlement of a lawsuit that Ecology filed against DOE (*State of Washington v. Chu*, Civil No. 2:08-cv-05085-FVS, October 25, 2010) that was later joined by the State of Oregon.

These Consent Decrees are part of a settlement imposing a new, enforceable, and achievable schedule for cleaning up waste from Hanford's underground tanks and for notification requirements. The settlement also includes new and revised Hanford tank farm milestones in the TPA.

S.1.3 Purpose and Need for Agency Action

DOE needs to take action to accomplish the following objectives:

- Safely retrieve and treat radioactive, hazardous, and mixed tank waste; close the SST system; and store and/or dispose of the waste generated from these activities at Hanford. Further, DOE needs to treat the waste and close the SST system in a manner that complies with Federal and applicable

Washington State laws and DOE directives to protect human health and the environment. Long-term actions are required to permanently reduce the risk to human health and the environment posed by waste in the 149 SSTs and 28 DSTs.

- Decommission FFTF and its support facilities at Hanford, manage waste associated with decommissioning the facilities, and manage disposition of the radioactively contaminated bulk sodium inventory at Hanford. These actions are necessary to facilitate cleanup at Hanford consistent with decisions reached by DOE as a result of previous NEPA reviews (DOE 1995a, 2000a; 66 FR 7877) and to comply with Federal, state, and local laws and regulations.

- Expand or upgrade existing waste storage, treatment, and disposal capacity at Hanford to support ongoing and planned waste management activities for on- and offsite waste. Some tank waste, LLW, and MLLW at Hanford, including waste resulting from FFTF decommissioning and waste from other DOE sites that do not have appropriate facilities, must be disposed of to facilitate cleanup of Hanford and other DOE sites.

S.1.3.1 Decisions to Be Made

In support of the proposed actions to retrieve, treat, and dispose of tank waste; decommission FFTF; and expand waste disposal capacity at Hanford to provide for disposal of on- and offsite waste, this *TC & WM EIS* supports several decisions that DOE has to make related to the ORP mission. These potential decisions are outlined below.

- **Storage of Tank Waste.** All *TC & WM EIS* alternatives require tank farm waste storage; however, each alternative considers a different length of time. This *TC & WM EIS* evaluates the construction and operation of waste transfer infrastructure, including waste receiver facilities (WRFs), which are below-grade storage and minimal waste-conditioning facilities; waste transfer line upgrades; and additional or replacement DSTs. This EIS also evaluates various waste storage facilities to manage the treated tank waste and the waste associated with closure activities. This includes construction and operation of additional immobilized high-level radioactive waste (IHLW) storage vaults, melter pads, TRU waste storage facilities, and ILAW storage facilities. This EIS also provides environmental impact information to assist in making informed decisions regarding continued storage of tank waste and storage to support treatment and disposal activities.

- **Retrieval of Tank Waste.** This EIS evaluates various retrieval benchmarks. The four waste retrieval benchmarks (0, 90, 99, and 99.9 percent) address various requirements or retrieval activities. The No Action Alternative evaluates a 0 percent retrieval benchmark, as required by NEPA; 90 percent retrieval represents a programmatic risk analysis for the tank farms as defined by Appendix H of the TPA, ―Single Shell Tank Waste Retrieval Criteria Procedure"; 99 percent retrieval is the goal established by TPA Milestone M-45-00; and 99.9 percent retrieval reflects multiple deployments of retrieval technologies to support clean closure requirements.

- **Treatment of Tank Waste.** Additional waste treatment capability can be achieved by building new treatment facilities that are either part of or separate from the WTP. DOE could also complete treatment sometime after 2028 without supplemental treatment by extending the current WTP operating period until all the waste is treated. The two primary choices that would comply with DOE's commitments are to treat all the waste in an expanded WTP or to provide supplemental treatment in conjunction with, but separate from, the WTP. DOE has conducted preliminary tests on three supplemental treatment technologies to determine whether one or more could be used to provide the additional capability needed to complete waste treatment. The decision on whether to treat all the waste in the WTP (as is or expanded) or to supplement WTP capacity by adding new treatment capability depends on demonstration of the feasibility of supplemental treatment technologies.

- **Disposal of Treated Tank Waste.** This *TC & WM EIS* addresses on- and offsite disposal, depending on the waste type. Onsite disposal includes disposal of treated tank waste and waste generated from closure activities that meet onsite disposal criteria. The decision to be made involves the onsite location of disposal facilities, specifically, one or two IDFs, which would manage treated tank waste, and the proposed River Protection Project Disposal Facility (RPPDF), which would manage closure activity waste. This EIS provides the environmental impact information needed for informed decisions on tank waste that could be classified as TRU waste for disposal. Offsite disposal of tank waste determined to be TRU waste would occur at WIPP.

- **Closure of the SST System.** This *TC & WM EIS* addresses closure of the SST system under all Tank Closure alternatives except Tank Closure Alternatives 1 and 2A (see Section S.2 for a description of the alternatives analyzed in this *TC & WM EIS*). Although DOE is committed to retrieving at least 99 percent of the waste, consistent with the TPA, the range of potential impacts in the cases considered includes those of residual waste left in the tanks at different retrieval benchmarks (0, 90, 99, and 99.9 percent). Different closure scenarios are also evaluated: clean closure, selective clean closure/landfill closure, and landfill closure with or without contaminated soil removal. In addition, two structurally different landfill barriers—an engineered modified RCRA Subtitle C barrier and a Hanford barrier—are evaluated to determine the effectiveness of the natural and engineered defense-in-depth barriers in minimizing any transport of waste over the long timeframes of interest.

- **Disposal of Hanford Waste and Offsite DOE LLW and MLLW.** The decision to be made concerns the onsite location of disposal facilities for Hanford's waste and other DOE sites' LLW and MLLW. DOE committed in the *HSW EIS* ROD to disposing of LLW in lined trenches. Thus, the decision is whether to dispose of waste at IDF-East or at a new IDF located in the 200-West Area (IDF-West).

- **Final Decommissioning of FFTF.** This decision would determine the end state for FFTF's aboveground, belowground, and ancillary support structures.

This *TC & WM EIS* is the next step in the process to close the tank farm waste management system, decommission FFTF, and expand waste management and disposal capacity at Hanford. The information provided in this EIS was used to identify Preferred Alternatives and will be used to support (along with other data sources) future decisions regarding waste treatment and tank closure, FFTF decommissioning, and waste management and disposal capacity expansion. Public participation will continue throughout this process. Decisions based on the data presented in this EIS will be documented in a ROD or a series of RODs no sooner than 30 days after publication in the *Federal Register* of EPA's Notice of Availability of this *Final TC & WM EIS*. All project work resulting from the ROD that pertains to waste storage, treatment, or disposal facilities must undergo a permitting process with Ecology. Permit conditions will specify requirements for the safe handling and storage of the waste forms and will ensure that any process air or liquid discharges are within regulatory limits. This permitting process presents an additional opportunity for public input.

What is a Record of Decision (ROD)?

The final step in the National Environmental Policy Act process is issuing a ROD, or possibly a series of RODs, which records a Federal agency's decision concerning a proposed action for which the agency has prepared the environmental impact statement. Decisions stated in a ROD sometimes may be broad. Such decisions enable subsequent, more-detailed activities to move forward through implementing documents. Examples of implementing documents at the Hanford Site include Tri-Party Agreement milestones, closure plans, permit applications, contracts, and funding requests.

S.1.3.2 Decisions Not to Be Made

DOE will not make decisions on the following as part of this NEPA process:

- **DST Closure.** A closure configuration for the original 28 DSTs was evaluated in this EIS for engineering reasons related to the closure barrier placement. However, a decision on closure of the DSTs is not part of the proposed actions because the DSTs are active components needed to complete waste treatment. Closure of the DSTs would have to be addressed at a later date subject to appropriate NEPA review.

- **WTP Closure.** The WTP is currently under construction in the 200-East Area of Hanford. As such, construction (and subsequent operations and deactivation) of the WTP from 2006 onward was analyzed under each Tank Closure alternative to establish a common reference point for use in comparing alternatives. However, closure of the WTP is not part of the proposed actions because it is needed to complete waste treatment. Closure of the WTP would have to be addressed at a later date subject to appropriate NEPA review.

- **Groundwater Remediation.** Remediation of contaminated groundwater operable units is not part of the proposed actions for this EIS. Groundwater contamination in the non-tank-farm areas of the 200 Areas is being addressed under CERCLA (42 U.S.C. 9601 et seq.), which will also satisfy substantive RCRA and Hazardous Waste Management Act corrective action requirements. NEPA values are integrated into the CERCLA analyses. However, contamination in the vadose zone resulting from tank farm past leaks is currently being evaluated under the RCRA facility investigation and corrective measures study process. Therefore, the vadose zone in the tank farms is part of an RCRA unit and is not included in the CERCLA groundwater operable unit. As a result, the vadose zone as impacted by the tank farms is part of the scope of this *TC & WM EIS*.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as Superfund)

A Federal law enacted in 1980 that provides the legal authority for emergency response and cleanup of hazardous substances released into the environment and for the cleanup of inactive waste sites. CERCLA's reauthorization in 1986 established the Federal Government's responsibility to investigate and remediate releases of hazardous substances, including radioactive contaminants, from its agencies' facilities.

- **CERCLA Past-Practice Units.** There are six sets of cribs and trenches (ditches) that are contiguous to the SSTs and would fall under the barriers placed over the SSTs during closure. They are evaluated in this EIS as part of a connected action because they would be influenced by barrier placement. However, closure of these CERCLA past-practice units is not part of the proposed actions for this EIS. Closure of these units would be addressed at a later date subject to appropriate NEPA review.

- **Deactivation of FFTF.** DOE does not intend to make any further decisions regarding deactivation of FFTF as a result of this EIS. Based on previous NEPA reviews

Resource Conservation and Recovery Act (RCRA)

This law, enacted in 1976, gives the U.S. Environmental Protection Agency (EPA) the authority to control hazardous waste from "cradle to grave" (i.e., from the point of generation to the point of ultimate disposal), including its generation, minimization, treatment, storage, transportation, and disposal. RCRA's applicability to the hazardous component of mixed waste (waste containing both radioactive and hazardous components) at U.S. Department of Energy (DOE) facilities was not recognized by DOE until 1987. In 1986, the Washington State Department of Ecology was authorized by EPA to administer its own hazardous waste program, "Dangerous Waste Regulations," in lieu of the Federal RCRA program.

(DOE 1995a, 2000a, 2006b), DOE decided to shut down and deactivate FFTF. Deactivation of FFTF as evaluated in those reviews consists of the following:

- Removing fuel from FFTF and storing it in either the 400 Area or the 200 Areas
- Draining metallic sodium from the reactor cooling systems and support facilities and storing it in the 400 Area
- Removing and disposing of some radioactive and chemically hazardous materials
- Deactivating each plant system as it becomes no longer required for safe operation
- Placing the remaining plant systems in a radiologically and industrially safe condition for long-term surveillance and maintenance
- Removing and packaging the four RH-SCs for storage in the 400 Area

- **Disposition of the Cesium and Strontium Capsules.** Treatment of the cesium and strontium capsules, which are currently stored at the Waste Encapsulation and Storage Facility (WESF), is evaluated in this EIS based on the existing TPA milestone; however, the decision on final disposition of the cesium and strontium capsules will be determined at a later date subject to appropriate NEPA review.

- **HLW Transportation and Disposition.** The scope of this *TC & WM EIS* does not include making a decision on the ultimate disposition of HLW and any transportation related to such disposition. DOE‘s basic decision to treat the Hanford tank waste, as expressed in the *TWRS EIS*, has not changed. This would still result in generation of IHLW and ILAW. The Secretary of Energy has determined that a Yucca Mountain repository is not a workable option for permanent disposal of SNF and HLW. However, DOE remains committed to meeting its obligations to manage and ultimately dispose of these materials. The Administration has convened the Blue Ribbon Commission on America‘s Nuclear Future (BRC) to conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle, including all alternatives for the storage, processing, and disposal of SNF and HLW. The BRC‘s final recommendations will form the basis of a new solution to managing and disposing of SNF and HLW.

- **Disposition of Navy Reactor Compartments.** The disposition of Navy reactor compartments in the 200 Area low-level radioactive waste burial grounds (LLBGs) at Hanford is not within the scope of this EIS and is included under the cumulative impacts analysis. These activities are addressed in previous NEPA documentation.

S.1.4 Public Participation

Scoping is a process by which the public, regulators, and other interested parties provide comments directly to a Federal agency on the scope of an EIS. This process is initiated by publication of an NOI in the *Federal Register*. The NOI to prepare this *TC & WM EIS* (71 FR 5655) was published on February 2, 2006, and initiated a 30-day scoping period that ended March 6, 2006. The NOI identified a set of preliminary alternatives available for public comment. A later notice (71 FR 8569) extended the scoping period to April 10, 2006. In the NOI, DOE requested comment on the proposed scope for the new *TC & WM EIS*. Public comments were submitted in a number of ways, including standard mail, electronic mail, fax, voicemail, and oral and written comments presented at formal public meetings. As stated in the NOI for this *TC & WM EIS*, DOE also considered earlier comments submitted in response to the 2003 NOI for the ―Tank Closure EIS” (68 FR 1052) and the 2004 NOI for the ―FFTF Decommissioning EIS” (69 FR 50176). Section S.1.4.1 discusses the *TC & WM EIS* scoping process and the comments received. Sections S.1.4.2 and S.1.4.3 similarly discuss the ―Tank Closure EIS” and ―FFTF Decommissioning EIS” scoping processes and comments, respectively. Information collected from the NEPA scoping process was used to modify the scope of this *TC & WM EIS*, as appropriate. Changes made since publication of the draft EIS are discussed in Section S.1.5.

Ongoing dialogue with the public continued as the *Draft TC & WM EIS* underwent public review and comment (see Figure S–1). A 140-day comment period began when EPA published a Notice of Availability in the *Federal Register*. This comment period was later extended by DOE for an additional 45 days. Public hearings were held during this comment period.

S.1.4.1 Public Meetings and Issues Identified During the *TC & WM EIS* Scoping Process

DOE and Ecology, a cooperating agency, conducted four public meetings on the proposed scope of this *TC & WM EIS* at the following locations and dates:

Seattle, Washington	March 21, 2006
Portland, Oregon	March 22, 2006
Hood River, Oregon	March 23, 2006
Tri-Cities, Washington	March 28, 2006

Both oral and written comments were received by DOE during the *TC & WM EIS* scoping period. DOE received comments from approximately 150 commentors, considered all the comments received, and made changes to the *TC & WM EIS* scope as appropriate. The issues presented below reflect the key concerns expressed during the scoping period.

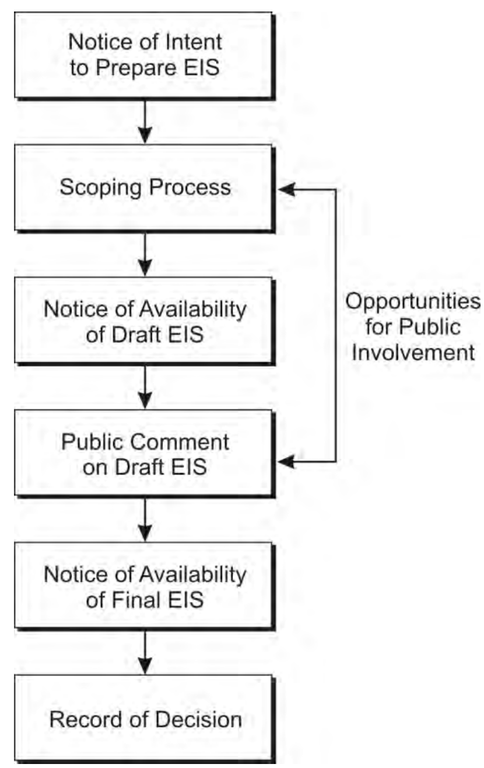


Figure S–1. National Environmental Policy Act (NEPA) Process

Issue: *DOE must do everything possible to avoid and/or mitigate contamination of the Columbia River and regional groundwater supplies due to the proposed actions.*

Response: This *TC & WM EIS* incorporates several mitigation measures into the proposed alternatives, including engineered barriers, contaminated soil removal, and waste treatment. This *TC & WM EIS* also explores other potential mitigation measures that could be pursued based on specific concerns.

Issue: *Complete Hanford waste cleanup activities as soon as possible, including removing both the waste and the tanks, as well as the waste currently buried in existing disposal facilities.*

Response: Retrieval of waste from the SSTs has been completed for seven tanks to date and is ongoing. The WTP is currently under construction to treat the tank waste. Removal of waste buried in existing disposal facilities is considered either as part of the alternatives or in the cumulative impacts section analyzed in this *TC & WM EIS*, depending on the waste stream.

Issue: *DOE should not consider an alternative for retrieving less than 99 percent of the tank waste, consistent with the TPA.*

Response: One *TC & WM EIS* alternative addresses a retrieval goal of 90 percent, less than the TPA Milestone M-45-00 minimum goal of 99 percent. Retrieval to 90 percent represents a range depicting the potential programmatic risk analysis process for the tank farms as defined by Appendix H of the TPA, ―Single Shell Tank Waste Retrieval Criteria Procedure." This alternative evaluates the potential impacts that could occur from implementing that process. To date, Ecology and DOE have initiated the Appendix H process for one tank, 241-C-106.

Issue: *DOE needs more-extensive, detailed data to complete this EIS; characterization data for all waste types is particularly lacking.*

Response: Both DOE and Ecology believe there is sufficient characterization information to support this *TC & WM EIS*. The goal of NEPA is to complete an impact analysis to support decisions that an agency needs to make related to a proposed Federal or state (in the case of Washington's SEPA) action early enough in the process to be useful. Additional information may be necessary before a final permit decision can be issued. This *TC & WM EIS* contains additional analyses and describes uncertainties in the analysis of potential impacts.

Issue: *Preserve FFTF for potential future uses such as medical isotope production.*

Response: DOE is not considering FFTF for medical isotope production at this time. DOE has previously weighed FFTF's potential use in other applications (DOE 2000a). There are currently no proposed uses. Irrespective of any proposed use, DOE needs to determine an appropriate end state for FFTF.

Issue: *Don't import waste from elsewhere to Hanford.*

Response: DOE is currently evaluating the potential for disposal of 62,000 cubic meters (81,000 cubic yards) of LLW and 20,000 cubic meters (26,000 cubic yards) of MLLW from other DOE sites at Hanford. This volume was determined to be a reasonable starting point and followed the 2006 Settlement Agreement and its associated MOU between DOE and Ecology, and was reflected in the NOI (71 FR 5655).

Issue: *DOE should ensure that independent experts provide objective oversight, analysis, and review throughout this EIS preparation process.*

Response: Throughout the EIS preparation process, DOE has coordinated and consulted, as appropriate, with the U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, Advisory Council on Historic Preservation, American Indian tribes, and local agencies on matters within their technical expertise. In addition, a technical review group was formed to evaluate the conversion of the groundwater model from the previous models used on site to MODFLOW [modular three-dimensional finite-difference groundwater flow model].

Issue: *DOE should address health risks to Hanford workers and the public from the proposed actions.*

Response: This *TC & WM EIS* addresses human health risks to workers and the public from actions proposed under the alternatives.

S.1.4.2 Public Meetings and Issues Identified During the “Tank Closure EIS” Scoping Process

The NOI to prepare the “Tank Closure EIS” (68 FR 1052) initiated a 60-day scoping period that ended March 10, 2003. DOE conducted four public meetings on the proposed “Tank Closure EIS” scope. Meetings were held at the following locations and dates:

Richland, Washington	February 5, 2003
Hood River, Oregon	February 18, 2003
Portland, Oregon	February 19, 2003
Seattle, Washington	February 20, 2003

DOE considered all oral and written comments received during the “Tank Closure EIS” scoping period. The comments summarized below represent those that affected a major component of the scope of an alternative.

Issue: *The alternatives are too complicated to understand and the titles need clarification.*

Response: Alternative titles and descriptions were clarified and, where possible, alternative descriptions were simplified. However, the multitude and combinations of retrieval/treatment/disposal/closure options make this an inherently complex assessment. For this reason, DOE prepared a Reader's Guide to help readers navigate the document.

Issue: *The proposed No Action Alternative is not an accurate portrayal of what is typically considered “no action.”*

Response: In CEQ's “Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations” (46 FR 18026), two types of No Action Alternatives are described. In one case, work is stopped and impacts are evaluated. In the second case, ongoing activities are evaluated as a “no change” and continuation of the present course of action.

In this EIS, DOE has chosen to show both types of no action. Under Tank Closure Alternative 1, the work would be stopped and impacts would be evaluated. Under Tank Closure Alternative 2A, DOE would evaluate waste retrieval from the tanks and treatment through the WTP, in accordance with the *TWRS EIS* ROD with modifications.

Issue: *No alternative is provided to address tank closure with the current all-vitrification waste treatment plans.*

Response: Tank Closure Alternative 2A retained implementation of the 1997 *TWRS EIS* ROD to address the current vitrification capacity of the existing WTP, which is currently under construction (i.e., Existing WTP Vitrification; No Closure). Tank Closure Alternative 2B was developed to address an expanded LAW vitrification capacity for the existing WTP, which would provide vitrification of all tank waste, and to add landfill closure of the SST system (i.e., Implement the *Tank Waste Remediation System EIS* ROD with Modifications – Expanded WTP Vitrification; Landfill Closure).

Issue: *DOE is proposing to minimize use of the WTP for tank waste treatment.*

Response: DOE is committed to completing construction of the WTP and operating the facility to vitrify all tank HLW and a portion of the LAW. Supplemental treatment technologies for LAW are part of the scope of this *TC & WM EIS*.

Issue: *DOE should stay the course on vitrifying all tank waste.*

Response: See the previous response. With respect to the portion of the LAW that may not be treated in the WTP, DOE is evaluating supplemental treatment (supplemental to the WTP) for that waste. This *TC & WM EIS* evaluates whether completing treatment of this waste with supplemental technologies faster could result in decreased impacts on the public and environment.

Issue: *None of the action alternatives address the possibility that separation of waste into HLW and LAW constituents may not be allowed under DOE directives.*

Response: Tank Closure Alternative 6A was created to address a scenario where separation of the tank waste into HLW and LAW components is not performed. Alternatives 6B and 6C were created to implement the current vitrification facility, supplemented with additional vitrification capacity. Under all three subalternatives, treated waste would be managed as HLW.

Issue: *Technetium-99, with its very long half-life, would impact the groundwater and Columbia River if allowed to remain in the ILAW disposed of at Hanford.*

Response: This *TC & WM EIS* evaluates the impacts on the groundwater and Columbia River resources of various waste treatment and disposal scenarios related to technetium-99. Projected impacts will be considered in making the decisions discussed in Section S.1.3.1 of this document.

Issue: *Nuclear waste residuals would be abandoned inside the tanks and would impact the environment in the future.*

Response: NEPA requires consideration of all reasonable alternatives in EISs, as well as ―no action," which serves as a baseline for comparison among alternatives. The No Action Alternative may not always be a reasonable alternative. To satisfy this requirement, DOE is evaluating the impacts of a range of waste retrieval benchmarks. The benchmarks considered are 0 (No Action Alternative), 90, 99, and 99.9 percent retrieval of the tank waste volume.

Issue: *Not enough information is available on supplemental treatment technology performance to make any decisions.*

Response: DOE is in the process of collecting available information on supplemental treatment technologies and is also funding additional studies where information gaps exist. Consistent with CEQ regulations, early evaluation is encouraged in an agency‗s planning process, when all information may not be available.

Issue: *Grout, or any similar waste form, does not have acceptable long-term performance.*

Response: DOE chose cast stone as a candidate nonthermal treatment technology to represent a lower-performing waste form for this assessment. WTP vitrification, bulk vitrification, and steam reforming were selected to represent a range of thermal waste form performance. The impacts of this treatment technology performance range will be considered in the decisions discussed in Section S.1.3.1.

Issue: *Tank Closure alternatives are either landfill for all or total removal of all—no graded approach is considered.*

Response: Tank Closure Alternative 4 was revised to include a selective clean closure of the BX tank farm (200-East Area) and SX tank farm (200-West Area) as representative tank farms and landfill closure of the remaining tank farms. The range of closure alternatives represents landfill closure, selective clean closure, and clean closure.

Issue: *This process is being rushed. There is no driver for addressing closure at this time.*

Response: DOE needs to begin specific planning actions to treat the tank waste and to close the SST system. These actions are necessary to protect human health and the environment and to comply with several enforceable milestones in the TPA, specifically Milestone M-45-00, which requires complete closure of the SST system by September 30, 2024, and Milestone M-62-00, which requires completion of vitrification treatment of tank HLW and LAW by December 1, 2028.

S.1.4.3 Public Meetings and Issues Identified During the ―FFTF Decommissioning EIS" Scoping Process

The NOI to prepare the ―FFTF Decommissioning EIS" (69 FR 50176) initiated a 56-day scoping period that ended October 8, 2004. The NOI announced the schedule for the public scoping process and summarized the alternatives to be considered in the ―FFTF Decommissioning EIS." Two scoping meetings were held at the following locations and dates:

Richland, Washington	September 22, 2004
Idaho Falls, Idaho	September 30, 2004

The following is a brief summary of the oral and written comments received by DOE during the ―FFTF Decommissioning EIS" scoping period. DOE considered all comments received and made changes to the *TC & WM EIS* alternatives as appropriate.

Issue: *This EIS should evaluate each of the proposed alternatives, including suboptions, in a way that is complete and detailed. In particular, the alternatives discussion should include a full evaluation of how each alternative would be implemented from beginning to end. The evaluation should include a full analysis of all impacts, including all impacts associated with transportation, handling, storage, and treatment of radioactive and hazardous materials; a detailed explanation of the workforce requirements; and a complete description of the ultimate disposal of all waste, including residuals. The information should be presented in a comparative format that will allow stakeholders to evaluate each alternative relative to the others.*

Response: This *TC & WM EIS* provides a full evaluation of each alternative. It includes impacts associated with transportation, handling, storage, and treatment of radioactive and hazardous materials; details on the workforce requirements; and a complete description of the ultimate disposition of waste, including residuals. These impacts are discussed in this EIS. A comparison of the alternatives is provided in this EIS for short- and long-term impacts.

Issue: *DOE should evaluate the environmental impacts of building a new facility at Hanford equivalent to the existing Sodium Processing Facility (SPF) at the Materials and Fuels Complex (MFC) (formerly Argonne National Laboratory-West) at Idaho National Laboratory (INL) (formerly Idaho National Engineering and Environmental Laboratory). In particular, the cost savings and reduced risks caused by eliminating the need for transportation to INL should be evaluated.*

Response: This *TC & WM EIS* provides options for the processing of bulk sodium at both Hanford (Hanford Option) and INL (Idaho Option). The Hanford Option would involve construction and operation of a new facility and eliminate the need for transportation to INL's MFC.

Issue: *DOE should evaluate the environmental impacts of construction and operation of a new facility at Hanford equivalent to the Remote Treatment Project (RTP) at INL.*

Response: This *TC & WM EIS* provides options for treating RH-SCs at both Hanford and INL. The Hanford Option would involve construction and operation of a new facility and eliminate the need for transportation to INL.

Issue: *The EIS should include a greenfield alternative that evaluates removal of all contaminated structures and equipment from the 400 Area. Cleanup should not result in a new waste site in the Hanford 400 Area that would require maintenance and monitoring for the foreseeable future.*

Response: FFTF Decommissioning Alternative 3: Removal is an alternative that evaluates (1) removal of all contaminated equipment while leaving small amounts of radioactivity in underground structures and (2) implementation of appropriate postclosure care, which may lead to unrestricted use of the site.

Issue: *The No Action Alternative is clearly dangerous and should not be included as a reasonable alternative.*

Response: NEPA requires consideration of all reasonable alternatives in EISs, as well as ―no action," which serves as a baseline for comparison among alternatives. The No Action Alternative may not always be a reasonable alternative. To satisfy this requirement, under the No Action Alternative, DOE is evaluating the impacts of completing only those actions consistent with previous DOE NEPA decisions. Final decommissioning would not occur. The site would be maintained under administrative control for 100 years following the ROD.

Issue: *The EIS should evaluate all impacts of transportation associated with the radioactive sodium (in liquid and solid form), reactor components, and sodium-bonded SNF that would be shipped to the MFC for treatment, including estimates of the volumes and characteristics of all radioactive and hazardous materials and waste that would be produced at the MFC as a result of treatment of the incoming materials and waste.*

Response: This *TC & WM EIS* evaluates the transportation impacts associated with the bulk sodium being considered for shipment to the MFC for processing and the RH-SCs being considered for shipment to the Idaho Nuclear Technology and Engineering Center

(INTEC) for treatment. In previous NEPA reviews, DOE evaluated transportation and storage of FFTF fuel at either Hanford or INL (DOE 1995a, 1995b, 1997d); transportation and treatment of FFTF sodium-bonded fuel at INL‘s MFC (DOE 1995a, 2000b); storage and possible disposal or commercial use of surplus plutonium (including a small quantity of nonirradiated FFTF fuel [DOE 1999a]); and transportation and disposal of SNF and HLW at a geologic repository (DOE 2002, 2008a). Ongoing activities associated with management of the FFTF fuel are not evaluated in this *TC & WM EIS*.

Issue: *The EIS should consider alternatives that are economically sound and efficient.*

Response: This *TC & WM EIS* summarizes and compares the relative costs of the alternatives.

Issue: *The EIS should consider the effects of decommissioning activities on adjacent Hanford facilities and their programs. The Laser Interferometer Gravitational-Wave Observatory research facility is in close proximity to FFTF and is highly sensitive to vibration.*

Response: This *TC & WM EIS* provides an analysis of the impacts on other Hanford activities, including the Laser Interferometer Gravitational-Wave Observatory.

Issue: *DOE is not complying with the spirit or the letter of the NEPA regulations in preparing the* ―FFTF Decommissioning EIS.” *The distinction between deactivation and decommissioning, as well as irreversible versus reversible actions, is unclear.*

Response: Section S.1.2.2 provides a discussion of deactivation of FFTF, including the court decision in the Benton County case against DOE. This EIS also provides a discussion on the deactivation activities addressed by the *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington* (DOE 2006a) and those proposed decommissioning activities under the scope of this *TC & WM EIS*.

Issue: *The EIS should demonstrate that DOE intends to comply with Federal and state regulations and international (proliferation) and tribal agreements. Waste transportation and emergency-response training agreements are not fully addressed.*

Response: This *TC & WM EIS* discusses the Federal and state regulations that may be applicable to the proposed actions and consultations with tribes.

Issue: *FFTF should be preserved for various future missions. The decision to shut down FFTF is politically driven; political pressure may yet be able to reverse the process. FFTF should not be decommissioned.*

Response: Based on previous NEPA reviews (DOE 1995a, 2000a, 2006b), DOE decided to shut down and deactivate FFTF. DOE does not intend to make any further decisions regarding deactivation of FFTF.

S.1.4.4 Public Hearings and Comments on the *Draft TC & WM EIS*

DOE released the *Draft TC & WM EIS* in October 2009 (74 FR 56194) for review and comment by other Federal agencies, states, American Indian tribal governments, local governments, and the public. DOE distributed copies to those organizations and government officials who were known to have an interest in the EIS, as well as to those organizations and individuals who requested a copy. Copies were also made available on the Internet and in regional DOE public document reading rooms and public libraries near Hanford and INL.

Initially, the formal public comment period was 140 days, from October 30, 2009, through March 19, 2010. DOE extended the comment period in March 2010 (75 FR 13268) for an additional 45 days. In total, the comment period was 185 days (longer than the required minimum of 45 days), from October 30, 2009, to May 3, 2010. As announced in the DOE Notice of Availability of the *Draft TC & WM EIS* (74 FR 56194), public hearings were one mechanism to encourage public comments on the draft EIS and to provide members of the public with information about the NEPA process and the proposed actions. Public hearings were held in locations near Hanford and INL on the following dates:

- Richland, Washington January 26, 2010
- Boise, Idaho February 2, 2010
- Hood River, Oregon February 9, 2010
- Portland, Oregon February 10, 2010
- La Grande, Oregon February 22, 2010
- Spokane, Washington February 23, 2010
- Eugene, Oregon March 1, 2010
- Seattle, Washington March 8, 2010

In addition to receiving comments during the public hearing process, the public was invited to submit comments on the *Draft TC & WM EIS* to DOE via (1) the *Draft TC & WM EIS* email address, (2) the U.S. mail, (3) a toll-free fax line, and (4) a toll-free telephone line (voicemail). DOE received 510 non-campaign comment document submissions. In addition, DOE received comment documents from two campaigns:[1] Campaign A included 4,256 comment documents, and Campaign B included 54 comment documents. In total, generated from all campaign and non-campaign comment documents, DOE received approximately 3,000 individual comments requiring response. DOE considered all comments to determine whether corrections, clarifications, or other revisions were required before publishing this final EIS. All comments were considered equally, whether written, spoken, faxed, mailed, or submitted electronically.

Several topics identified in the public comments on the *Draft TC & WM EIS* are of broad interest or concern, as follows:

- Transport and disposal of offsite waste
- Age/accuracy of data
- Remediation/cleanup at Hanford
- Vadose zone and groundwater modeling
- Cleanup actions for existing subsurface contamination
- The Oregon proposal
- Regulatory compliance
- Climate change
- Secondary-waste-form performance
- HLW disposition (Yucca Mountain issue)
- Mitigation
- Exclusion of greater-than-Class C (GTCC) waste in cumulative impacts analysis

These topics of interest, including DOE's responses to these topics, are summarized below and are also presented in Section 2 of the Comment-Response Document (CRD), Volume 3 of this *Final TC & WM EIS*.

[1] Campaigns are multiple submissions of an equivalent comment document.

S.1.4.4.1 Transport and Disposal of Offsite Waste

Topic: *Many commentors expressed concern and/or opposition to transporting LLW and MLLW from other DOE sites to Hanford for disposal. Some commentors stated that Hanford should be cleaned up before any waste is imported from off site, while others suggested that the* WM PEIS *(DOE 1997a) ROD be rescinded based on the results of the* TC & WM EIS *analysis. Some commentors reminded DOE that the citizens of Washington State voted recently to deny the shipping of more nuclear waste to the state and expressed the opinion that the vote should be respected. These concerns regarding the import of offsite waste to Hanford generally were based on the draft EIS analysis that indicated the receipt of offsite waste would contribute radiological risk drivers (iodine-129 and technetium-99, among others) to groundwater impacts on the site, where exceedances of regulatory benchmarks are already predicted.*

Also, several commentors expressed concern that there could be a terrorist attack on a waste shipment while it was being transported to Hanford. Other commentors stated the risks were too great because of factors such as the weather, road conditions, or drivers in other vehicles causing an accident that could lead to a release of radioactive waste to the environment. Some commentors stated that over 800 latent cancer fatalities (LCFs) would result from DOE transportation activities. Many commentors oppose the use of roads near their communities to transport these wastes, with many of these commentors focusing on the transportation corridors of Interstates 5 and 205.

Discussion: The transport of offsite waste to Hanford for disposal has been addressed in NEPA documentation previous to this *TC & WM EIS*. DOE issued a ROD in 2000 (65 FR 10061; February 25, 2000) for the *WM PEIS* (DOE 1997a) choosing Hanford and the Nevada National Security Site (formerly the Nevada Test Site) as the regional locations for the disposal of LLW and MLLW from across the DOE complex. In the *WM PEIS*, DOE indicated that additional site-specific analyses would be prepared to implement these programmatic decisions. This *TC & WM EIS* is that site-specific analysis of the potential environmental impacts associated with a number of proposed actions, including disposal of LLW and MLLW potentially shipped to Hanford from offsite DOE locations. This *Final TC & WM EIS* will be used to support DOE‘s future NEPA decisionmaking with respect to offsite waste when the WTP becomes operational.

Although not part of the proposed scope of this *TC & WM EIS*, the *WM PEIS* also analyzed shipment of other waste types between DOE sites, as well as disposal. In addition to potentially receiving other sites‘ LLW and MLLW, in accordance with the *WM PEIS* ROD, Hanford ships nuclear waste to other DOE sites for disposal, such as TRU waste to WIPP in New Mexico.

The *HSW EIS* (DOE 2004) analyzed offsite waste for disposal at Hanford, and DOE issued a ROD in 2004. However, a lawsuit was filed against DOE, which was later settled through a Settlement Agreement. As part of the Settlement Agreement, DOE committed to reanalyze offsite waste, with some exceptions, for disposal at Hanford. As stated in Appendix D of this *TC & WM EIS*, in accordance with DOE‘s January 6, 2006, Settlement Agreement with the State of Washington (as amended on June 5, 2008) regarding *State of Washington v. Bodman* (Civil No. 2:03-cv-05018-AAM), signed by DOE, Ecology, the Washington State Attorney General‘s Office, and the U.S. Department of Justice, this *TC & WM EIS* evaluated the transportation of LLW and MLLW from other DOE sites to Hanford for disposal.

A number of commentors questioned the validity of the volume of offsite waste or questioned DOE‘s apparent reliance on the *HSW EIS* analysis. The volume of this offsite waste was established in the ―Record of Decision for the Solid Waste Program, Hanford Site, Richland, WA: Storage and Treatment of Low-Level Waste and Mixed Low-Level Waste; Disposal of Low-Level Waste and Mixed Low-Level Waste, and Storage, Processing, and Certification of Transuranic Waste for Shipment to the Waste Isolation Pilot Plant" (69 FR 39449). The volumes are limited to 62,000 cubic meters (81,100 cubic yards) of LLW and 20,000 cubic meters (26,200 cubic yards) of MLLW. This volume was determined to be a reasonable starting point and followed the 2006 Settlement Agreement and its associated MOU between DOE and Ecology, and was reflected in the 2006 NOI (71 FR 5655). The Preferred Alternative for waste management in the *Draft* and this *Final TC & WM EIS* also included limitations on, and exemptions for, offsite waste importation at Hanford, at least until the WTP is operational.

Regardless of the limitation on offsite waste importation at Hanford (at least until the WTP is operational), DOE recognizes in this *TC & WM EIS* the potential negative impacts on Hanford groundwater that the offsite waste poses. The *TC & WM EIS* analysis shows that receipt of offsite waste streams that contain specific amounts of certain isotopes, specifically iodine-129 and technetium-99, which are radiological risk drivers, could cause an adverse impact on the environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of offsite waste streams at Hanford. For example, DOE evaluated the effect of applying waste acceptance criteria to offsite waste by removing a highly radioactive waste stream (e.g., high inventories of iodine-129 and technetium-99) from the inventory of offsite waste analyzed for disposal at Hanford in this final EIS. Another mitigation measure could be to treat the waste so the final waste form is more protective once it is disposed of. This and other mitigation measures are discussed in Chapter 7, Table 7–1 and Sections 7.1.6, 7.5.2.2, and 7.5.3, of this final EIS.

Other individuals indicated this EIS should not evaluate offsite waste because of the Cleanup Priority Act. In November 2004, Washington State voters passed Initiative 297, known as the Cleanup Priority Act. This act would have restricted the importation of offsite waste to Hanford, among other things. The U.S. Department of Justice challenged the initiative, arguing it violated the U.S. Constitution. The Federal District Court agreed and ruled the initiative ―invalid in its entirety.” The State of Washington appealed the ruling, but the Ninth Circuit Court of Appeals affirmed the lower court, declaring the initiative was preempted by the Atomic Energy Act of 1954.

A number of comments regarding offsite waste also included concerns related to the possibility of a terrorist attack and the potential impacts resulting from such an event. DOE considered the threat of terrorist attack and has taken steps to reduce any vulnerability to this threat. DOE considers, evaluates, and plans for potential terrorist attacks during transportation and storage of radioactive materials. The details of DOE‘s plans for terrorist countermeasures and the security of its facilities and transports are classified. DOE evaluates acts of sabotage or terrorism related to the transport of radioactive materials and waste in this *TC & WM EIS*, Appendix H, Section H.6.6. In considering the potential consequences of an act of sabotage or terrorism in this EIS, DOE has determined that the analyses of sabotage events described in the *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (Yucca Mountain EIS)* (DOE 2002) and its supplemental environmental impact statement (SEIS) (DOE 2008a) are bounding (i.e., the consequences of such an action involving transportation of waste to Hanford would be less than the corresponding consequences in the *Yucca Mountain EIS* and its SEIS) for this *TC & WM EIS* for the potential impacts of transporting LLW and MLLW to Hanford.

DOE understands that there is always a risk of an accident when transporting radioactive waste. DOE is constantly working to ensure that the risk of a traffic accident is minimized and has issued guidance for the safe transport of radioactive materials and wastes. As specified in DOE Manual 460.2-1A, *Radioactive Material Transportation Practices Manual for Use with DOE O 460.2A*, carriers of LLW and MLLW are expected to exercise due caution and care in dispatching shipments. According to the manual, the carrier will determine the acceptability of weather and road conditions, whether a shipment should be held before departure, and when actions should be taken while en route. The manual emphasizes that shipments should not be dispatched if severe weather or bad road conditions make travel hazardous. Current weather conditions, the weather forecast, and road conditions would be considered before dispatching a shipment. Conditions at the point of origin and along the entire route would be considered.

DOE uses DOE Order 151.1C, *Comprehensive Emergency Management System*, as a basis to establish a comprehensive emergency management program that provides detailed, hazard-specific planning and preparedness measures to minimize the health impacts of accidents involving loss of control over radioactive material or toxic chemicals, as discussed in this *TC & WM EIS,* Chapter 3, Section 3.2.10.5, Emergency Preparedness. DOE contractors are responsible for maintaining emergency plans and response procedures for all facilities, operations, and activities under their jurisdiction and for implementing those plans and procedures during emergencies. The Transportation Emergency Preparedness Program was established by DOE to ensure its operating contractors and state, tribal, and local emergency responders are prepared to respond promptly, efficiently, and effectively to accidents involving DOE shipments of radioactive material. These measures would help DOE minimize and mitigate impacts on the environment.

A number of commentors indicated they believed shipping offsite waste to Hanford for disposal would result in 800 LCFs. This value for transportation risk does not exist in this *TC & WM EIS*. DOE believes that the value of approximately 800 LCFs, cited in the public comments, is from the results provided in the *Draft Global Nuclear Energy Partnership Programmatic Environmental Impact Statement (GNEP PEIS)* (DOE 2008b) regarding transportation of SNF and HLW, which did not include Hanford's HLW. This value represents the maximum impacts associated with 50 years of transportation activities supporting the operations of all existing U.S. commercial light-water reactors if they all were replaced with high-temperature, gas-cooled reactors. The *GNEP PEIS* was canceled by DOE on June 29, 2009 (74 FR 31017), because DOE is no longer pursuing domestic commercial reprocessing. As shown in Section S.5.3, Table S–7, and Chapter 2, Section 2.8.3.10, it is unlikely that the estimated total public radiation exposures from transporting LLW and MLLW to Hanford for disposal would result in any additional LCFs.

This *TC & WM EIS* analyzes the transport of radioactive waste from specific origination sites to specific destinations. Appendix H, Figure H–4, Waste Management Alternatives – Analyzed Truck and Rail Routes, shows the routes that were analyzed in this EIS. It is possible that, due to changes in route characteristics, weather conditions, and highway construction, routes between Hanford and other sites could vary; however, this change is not expected to alter the comparative risk results presented for the alternatives. DOE recognizes the concerns of Portland area residents regarding the transport of radioactive waste to Hanford; however, analysis shows that the risks would be small. Further, DOE does not expect any shipments to use Interstate 5 or 205 because waste shipments would originate east and southeast of Hanford. None of the offsite radioactive waste streams analyzed in this *TC & WM EIS* that would originate on the West Coast would use Interstate 5 or 205.

S.1.4.4.2 Age/Accuracy of Data

Topic: *Some commentors noted that some of the inventory data included in this EIS came from 2002–2003 and, therefore, are outdated (e.g., tank farm and offsite waste volume projections). Other commentors questioned how the use of newer data/methodology would affect analytical results and requested that a qualitative discussion be added to this* Final TC & WM EIS *on how newer data/methodology results may differ from those presented in this final EIS. Some commentors recommended that more-recent data be used in this final EIS to enhance accuracy.*

Discussion: To address a number of comments, DOE reevaluated the data used in the draft EIS; determined whether newer data were available and appropriate to use; and incorporated the latest relevant data and information, wherever available, applicable, and referenceable, in this final EIS. Some of the data changes are discussed in Section 3.0 in more detail in the supplement analysis of the *Draft TC & WM EIS* (DOE 2012). These include radioactive and nonradioactive inventories used in the cumulative impacts analysis (Section 3.1) and changes to the alternatives analyses (Section 3.2). Examples include inventories for unplanned releases and offsite waste. In both cases, DOE updated the projected waste inventories. To address uncertainties and lack of data in some areas, conservative assumptions were made that overestimate the impacts.

To address a specific comment on the draft EIS that questioned DOE‘s use of the 2002 Best-Basis Inventory (BBI) for tank waste inventory data, the 2002 BBI estimates were reviewed in 2005 by Ecology and several DOE offices, i.e., ORP; Richland Operations Office; Office of Health, Safety, and Security; Office of Environmental Management; and Office of the General Counsel. The conclusion then, which is supported by a review in 2011 of the 8-year span of BBI data and of the uncertainty, was that the 2002 BBI is appropriate for the analyses in this *TC & WM EIS*. This conclusion is supported in Section 4.0, Assumptions, in the *Technical Guidance Document for Tank Closure Environmental Impact Statement Vadose Zone and Groundwater Revised Analyses* (DOE 2005), dated March 25, 2005, which was approved by DOE and Ecology. In summary, DOE and Ecology concluded that the 2002 BBI inventory values for both technetium-99 and iodine-129, two risk-driving radionuclides, are at the higher end of the range of numbers, based on the inherent uncertainty in the way the BBI is formulated. This use of some conservatism by using the higher numbers for two risk drivers is still considered appropriate for this EIS analysis. Appendix D, Section D.1.1.4, of this *TC & WM EIS* discusses the continued use of, and uncertainties associated with, the 2002 BBI, and Section D.1.1.5 provides a comparison of the 2002 BBI with the latest available update to the BBI, dated October 2010, and discusses the differences between the two BBI estimates. Also, the Ecology foreword to this EIS includes a discussion on technetium-99 and iodine-129 inventories and partitioning of these constituents among IHLW, ILAW, and secondary waste.

To address the specific comment that inventory estimates in the *Draft TC & WM EIS* for tank waste in the soil are not complete, DOE undertook a detailed review of the past leaks released to the soil evaluated in the draft EIS and determined that the inventory of 14 unplanned releases needed to be revised. This change in inventory is relatively minor, but the inventory estimates and the groundwater analysis were revised in this *Final TC & WM EIS*. However, as noted by commentors and discussed in Appendix D, Section D.1.4, of this EIS, this does not change the uncertainty regarding the volume of tank waste leaked.

With regard to the comment that the EIS estimates of tank residuals may have resulted in a disproportionate amount of radioactivity in the residues at the bottom of the tanks, DOE currently does not have a technical basis for making more-specific assumptions about the expected compositions of the waste “heels” that would remain in the tanks after retrieval. Retrieval has been completed for only a small number of SSTs, and there is uncertainty as to how those tanks will compare with the range across all 149 SSTs. However, the tank closure process, which includes examination of the tanks and residual waste, requires preparation of performance assessments and a closure plan. These required documents will, prior to physical closure actions, provide the information and analysis necessary for DOE and the regulators to make specific decisions on what levels of residual tank waste are acceptable in terms of short- and long-term risks.

DOE received comments about offsite waste volumes and the uncertainty related to the characteristics of potential waste streams that could be transported to Hanford for disposal. The volumes and characteristics cannot be specifically identified because the waste has yet to be generated. However, as stated in both the *Draft* and this *Final TC & WM EIS*, Appendix D, Section D.3.6, DOE prepared the report *Analysis of Offsite-Generated Waste Projections, “Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site”* in 2006 using the best-available waste volume projections (consistent with CEQ requirements [40 CFR 1502.22] for addressing incomplete or unavailable information) while focusing on ongoing DOE operations and post-2010 cleanup activities that may generate wastes requiring or utilizing DOE regional disposal facilities. Expert judgment was then applied to these waste projections and waste characteristics data to develop a waste forecast for use in this *TC & WM EIS* based on similar waste streams that had been generated previously. DOE acknowledges that uncertainty remains in the waste projections, where most waste volume estimates were derived from, but conservative assumptions were employed to support EIS analyses.

Other data-related clarifications added in this final EIS include an explanation of the —206 baseline start date.” A start date of 2006 was assumed in this EIS to establish the durations of, and relationships between, the alternatives, thus allowing a comparison of short-term impacts between them. However, this start date and subsequent dates do not necessarily reflect current milestones/commitments and have no relationship to the EIS long-term analysis. Further discussion on this subject can be found in Section S.1.3.2.

S.1.4.4.3 Remediation/Cleanup at Hanford

Topic: *Many commentors supported a full cleanup of groundwater contamination at Hanford. Some commentors felt strongly that existing waste at Hanford should be cleaned up before more waste (i.e., offsite waste) is brought to the site for disposal.*

Discussion: In general, the scope of this *TC & WM EIS* does not include (nor will the potential NEPA ROD) groundwater remediation activity as part of the proposed actions evaluated. Hanford groundwater remediation activities, as required under RCRA, CERCLA, and/or the TPA, are in various stages of assessment, risk-based end-state development, corrective action, and/or active remediation. Site groundwater contamination in the non-tank-farm areas of the 200 Areas is being addressed under CERCLA remedial action. However, actions to address tank farm past leaks and associated contamination in the vadose zone are being evaluated under the RCRA Facility Investigation/Corrective Measures Study process. As such, the vadose zone contamination associated with tank farm past leaks is included as part of the tank farm RCRA operable unit rather than a CERCLA operable unit and is assessed in this *TC & WM EIS*.

Although some contamination has reached the groundwater, efforts are ongoing at Hanford to prevent existing plumes from reaching the river. Groundwater pump-and-treat systems are currently in place or under construction (for cleanup of contaminants such as carbon tetrachloride). Temporary caps are being placed on the tank farms as part of RCRA corrective action. The EIS impacts analysis shows that, if additional steps like those indicated above are not taken, plumes would continue to migrate over time to the river.

DOE received comments on the potential impacts of future remediation activities that are in various stages of planning (which, given the inherent uncertainty, were not included in the cumulative impacts analysis). In response, DOE performed a sensitivity analysis in this final EIS to evaluate the potential impacts if certain remediation activities were conducted in the future at some of the more prominent waste sites on the Central Plateau and along the river corridor. The goal of the sensitivity analysis is to help DOE, EPA, and Ecology prioritize cleanup efforts in the future. This analysis is provided in Appendix U, Section U.1.3, and is discussed further in Chapter 7, Section 7.5.

See Section S.1.4.4.1 for a discussion on the transport and disposal of offsite waste.

S.1.4.4.4 Vadose Zone and Groundwater Modeling

Topic: *A number of commentors expressed concern about the levels of detail and complexity in the vadose zone and groundwater modeling. The concern was typically expressed as an assertion that the modeling was not acceptable because a particular process, parameter, or feature was not modeled at a more detailed, mechanistic level.*

Discussion: DOE acknowledges that the vadose zone and groundwater model constructs are abstractions (and approximations) of real-world features. The primary purpose of this *TC & WM EIS* is to support the decisionmaking process as required by NEPA. DOE used vadose zone and groundwater models that are appropriate for the scope of this *TC & WM EIS* and allow DOE to evaluate and disclose the potential impacts of the courses of action under the alternatives against each other and against relevant standards.

DOE acknowledges that the potential long-term impacts evaluated during the 10,000-year period of analysis provided by the vadose zone and groundwater modeling constructs used in this EIS are not exact estimates of what will occur in the future due to assumptions and uncertainties. However, that does not mean that the analysis is not useful, as discussed in Chapter 5, Sections 5.1.1, 5.2.1, 5.3.1, and 5.4.1, of this EIS. NEPA requires DOE to fully disclose the estimates of long-term impacts and their uncertainties to inform the decisionmaking process. EPA indicated in its foreword that, because DOE disclosed model limitations and uncertainties, there is not enough information to accurately predict future migration of groundwater contaminants. DOE disagrees that limits and uncertainty diminish the model usefulness as part of the decisionmaking process, now or in the future. DOE believes that, in addition to the groundwater model results themselves, comparison of the results with actual field data and discussion of the uncertainty in the results are important aspects of the evaluation of the alternatives. Accordingly, Appendix U of this *Final TC & WM EIS* has been expanded to include a more complete comparison of model results with field data, and additional sensitivity analyses have been added to further clarify whether changes in assumptions would affect comparison of the alternatives. Both of these discussions were added to this *Final TC & WM EIS* in response to EPA comments on the draft EIS. DOE also believes, as indicated in this *TC & WM EIS*, that the uncertainties in the groundwater modeling are largely a function of data availability and scenario uncertainty, rather than of the models or software used for the long-term groundwater impact analyses.

Throughout the development of the vadose zone and groundwater models, choices were made regarding the level of abstraction and complexity in the components of the models. In all cases, the choices were made subject to the primary goal of comparing the long-term potential impacts of the alternatives without bias and in the context of other sources at Hanford. These choices were systematically discussed and reviewed by the *TC & WM EIS* Technical Review Group, the Hanford Local Users‘ Group, and Ecology. EPA was invited, but chose to not participate. A summary of this interactive process is included in the November 2007 document, *MODFLOW Flow-Field Development: Technical Review Group Process and Results Report*, available on the ORP website at http://www.hanford.gov/orp. Ecology‘s views on the acceptability of the vadose zone and groundwater modeling in the context of this NEPA analysis can be found in its foreword to this *TC & WM EIS*. Finally, in response to public comment, DOE has provided additional explanatory material to Appendices L, —Groundwater Flow Field Development”; M, —Release to Vadose Zone”; N, —Vadose Zone Flow and Transport”; and O, —Groundwater Transport Analysis,” in this final EIS to more clearly describe the modeling choices, uncertainty, and relationship to the decisionmaking process.

S.1.4.4.5 Cleanup Actions for Existing Subsurface Contamination

Topic: *Several commentors expressed concern that existing contamination at Hanford will migrate to the Columbia River, negatively affecting offsite populations living downriver, as well as wildlife living in and around the river. Further, commentors expressed concern that no cleanup actions were being undertaken to reduce impacts associated with existing subsurface contamination.*

Discussion: As discussed in Chapter 5 of this *TC & WM EIS*, DOE acknowledges that —benchmark standards” could be exceeded in groundwater at the Core Zone Boundary and/or at the Columbia River nearshore at various dates. The term —benchmark standards” used in this *TC & WM EIS* represents dose or concentration levels that correspond to established human health effects. For groundwater, the benchmark is the maximum contaminant level (MCL), provided that an MCL is available. Ecology may impose additional mitigation measures through future permitting processes or corrective actions under the scope of the TPA. In response to comments received on the *Draft TC & WM EIS* concerning potential long-term impacts on groundwater resources, several sensitivity analyses in the draft EIS were combined and integrated into this final EIS to clarify or enhance mitigation discussions. The additional analyses evaluate the potential impacts if certain remediation activities were conducted in the future at some of the more prominent waste sites on the Central Plateau and along the river corridor. Furthermore, sensitivity analyses that evaluate improvements in IDF performance (e.g., infiltration rates) and in secondary- and supplemental-waste-form performance (e.g., release rates) were performed and are included in this EIS. The discussion found in Chapter 7, Section 7.5, Long-Term Mitigation Strategies, was added to summarize these results. The results of these analyses will aid DOE in formulating an appropriate mitigation action plan subsequent to this EIS and its associated ROD and in prioritizing future Hanford remedial actions that would be protective of human health and the environment and would reduce long-term impacts on groundwater. Further discussion regarding mitigation topics is provided in Section S.1.4.4.11. As referenced in Chapter 7, Section 7.5.2.8, DOE has drafted a roadmap that implements a strategy for the development of better-performing secondary-waste forms.

Regarding further migration of existing contamination into the Columbia River, the estimated human health impacts on offsite populations living downriver are small. In fact, under all alternatives analyzed, the estimated annual dose to offsite populations is less than 1 percent of the natural background radiation dose. For this dose analysis, members of the offsite population are assumed to have the activity pattern of residential farmers, using the surface water to meet the entirety of annual drinking water requirements and to irrigate a garden that provides approximately 25 percent of annual crop and animal product requirements. The offsite population is also assumed to consume fish harvested from the river. For more information addressing long-term impacts and estimates of human health impacts on a population using Columbia River water downstream of Hanford, see Appendix Q of this EIS.

S.1.4.4.6 The Oregon Proposal

Topic: *On January 4 and March 18, 2010, the Oregon State Department of Energy submitted comments on the* Draft TC & WM EIS *that included a proposal (which they referred to as the ―Oregon proposal") to combine various tank closure elements to form a new Tank Closure alternative and suggested that this proposed new alternative be analyzed in this* TC & WM EIS.

Discussion: DOE has reviewed Oregon's proposal for a new Tank Closure alternative and has determined that the proposal is technically infeasible as defined. Accordingly, the Oregon proposal cannot be considered a reasonable alternative and was not analyzed in detail in this *TC & WM EIS*, as described in Section S.4.1.6. In its entirety, the Oregon proposal fails to account for the required tradeoffs inherent in the design, capacity, and implementation schedule associated with its storage, retrieval, treatment, disposal, and closure elements. DOE reached this conclusion based upon a number of factors. The WTP, which is currently designed and more than 62 percent constructed, has inadequate waste treatment throughput capacity to support completing the processing of the tank waste through LAW treatment by the year 2040, as suggested in the Oregon proposal. Technical and resource shortcomings for meeting the required waste throughput in 18 years of operation include inadequate tank waste storage, retrieval, and pretreatment capacity. The Oregon proposal also assumes the implementation of iron phosphate (i.e., phosphate glass) and fractional crystallization treatment technologies. However, both of these technologies have been assessed by DOE repeatedly over the last decade, with the conclusion remaining that they are not mature enough for implementation and therefore do not merit further analysis in this EIS. Additional discussions on these two treatment technologies are included in Appendix E, Section E.1.3.3.3. Further, the Oregon proposal assumes that DOE is making a decision on the closure of the cribs and trenches (ditches) through this EIS; however, their closure is not within the scope of the EIS proposed actions, as described in Section S.1.3.2.

Several elements of the Oregon proposal were included in the alternatives analyses, sensitivity analyses, and/or potential mitigation measures. These include additional tank waste storage capacity, dry storage of the cesium and strontium capsules, onsite interim storage of all IHLW canisters, and selective clean closure of a number of SST farms, as well as clean closure of all the SST farms. Clean closure of the cribs and trenches (ditches) is analyzed in the cumulative impacts analysis sections of this EIS.

S.1.4.4.7 Regulatory Compliance

Topic: *Several commentors expressed concern that none of the proposed alternatives comply with Federal and state laws or are protective of human health and the environment. Specifically, statements were made that the CEQ regulations for implementing NEPA require that an EIS —rigorously explore and objectively evaluate all reasonable alternatives.” Among other things, this means that reasonable alternatives should meet the purpose and need for agency action. One of the purposes and needs for DOE action is —to treat the waste and close the single-shell tank…system in a manner that complies with Federal and applicable Washington State laws and USDOE directives to protect human health and the environment.”*

Discussion: The alternatives presented in this *TC & WM EIS* were developed under NEPA (42 U.S.C. 4321 et seq.) to address the essential components of DOE‘s three sets of proposed actions (tank closure, FFTF decommissioning, and waste management) and to provide an understanding of the differences between the potential environmental impacts of the range of reasonable alternatives. Consistent with CEQ guidance (46 FR 18026), this EIS analyzes the range of reasonable alternatives that covers the full spectrum of potential combinations. The alternatives considered by DOE in this EIS are —reasonable” in the sense that they are practical or feasible from a technical and economic standpoint and meet the agency‘s purposes and needs. Potential conflicts with laws and regulations do not necessarily cause an alternative to be unreasonable, but such conflicts must be considered, and additional mitigation commitments may be required if it is selected for implementation.

This *TC & WM EIS* addresses the potential laws and requirements that would apply, depending on the alternative. Issues concerning the ability to meet legal standards or requirements are also discussed, along with the potential mitigation measures that may be needed and are feasible for implementation by DOE. Additional mitigation measures could be required to obtain future permits issued by the State of Washington, or they may be addressed under the scope of the TPA as part of future remedial actions that are subject to CERCLA. In the ROD for this EIS, DOE will identify and discuss the factors considered in reaching its decisions, such as economic, technical, and national policy considerations, along with mitigation and monitoring measures that DOE will implement.

The scope of this *TC & WM EIS* includes decisions on storage, retrieval, treatment, and disposal of tank waste and on closure of the SST system. This closure includes the tank system and the vadose zone impacted by the tank farms (i.e., past leaks). However, as discussed in Section S.1.3.2, DOE will not make decisions on groundwater remediation, including the remediation of groundwater contamination resulting from non-tank-farm areas within the 200 Areas, because that is being addressed under CERCLA (42 U.S.C. 9601 et seq.)

As EISs are to be completed early in the planning process for proposed actions, mitigation approaches to potential issues evaluated in an EIS can vary, based on whether the potential impacts have occurred. As a result, the approach to regulatory compliance depends on the portion of the proposed action being evaluated. For example, some activities analyzed in this EIS have not yet occurred. Secondary waste associated with the WTP has not been generated yet. Although this EIS highlights potential compliance issues with secondary waste, the purpose of mitigation measures is to identify those activities necessary to prevent the potential secondary-waste issues evaluated in this *Final TC & WM EIS* from occurring or to minimize their impacts.

A similar situation exists related to receipt of offsite waste. This *Final TC & WM EIS* identifies potential issues with receipt of offsite waste containing iodine-129 and some amounts of technetium-99. One mitigation measure to address this type of issue would be to apply waste acceptance criteria, which would eliminate or restrict receipt of certain waste streams for disposal at Hanford. Another option could be to generate a better waste form.

Addressing regulatory compliance issues associated with closure of the SSTs is a little different. There are potential compliance issues presently identified with the tanks, as well as with the associated CERCLA cribs and trenches (ditches) adjacent to them. In this case, this EIS is evaluating options for addressing and mitigating an existing situation that has already occurred due to 60 years of activities associated with the Hanford mission. The *TC & WM EIS* analysis indicates that, over the long term, removal of the waste from the SSTs and closure of the tanks would have long-term benefits over not closing the SSTs.

Following completion of the mitigation action plan and before implementing closure actions, DOE will develop a tank farm system closure plan that will be implemented for each of the waste management areas. The first waste management area to be addressed is Waste Management Area C. The TPA has milestones for the completion of a soil investigation for Waste Management Area C (Milestone M-45-61), submittal of a closure plan (Milestone M-45-82), and completion of Waste Management Area C closure (Milestone M-45-83). DOE will complete the soil investigation to determine the nature and extent of the contamination. To inform the decision process for closure, DOE will complete a Waste Management Area C performance assessment and risk assessment. Following completion of the tank waste retrievals and data collection activities for residuals in the pipelines, ancillary equipment, and soil, the performance assessment will be revised to reflect all data. This revised performance assessment and closure plan will be presented for public review and comment, and the Waste Management Area C closure plan will be modified and incorporated into the Hanford sitewide permit. The same process will apply for all tank farm waste management areas.

S.1.4.4.8 Climate Change

Topic: *Several commentors stated that the effects of climate change on various resources at Hanford and the possible effects on environmental impacts of the Tank Closure, FFTF Decommissioning, and Waste Management alternatives were not adequately considered in this EIS.*

Discussion: Regarding commentors' concerns, DOE has reviewed and revised, as necessary, its analyses on the effects of climate change on various resources at Hanford and the possible effects on environmental impacts of the *TC & WM EIS* alternatives. As described in Chapter 6, Section 6.3.4, DOE has reviewed climate studies that forecast general trends in Hanford regional climate change. However, there are no reliable methodologies for projections of specific future climate changes in the Hanford region, and thus such changes have not been quantified in this EIS. To account for this uncertainty, Appendix O, Section O.6.2, describes the effects of enhanced infiltration such as that which may occur during a wetter climate. In the *Draft TC & WM EIS*, Appendix V focused on the potential impacts of a rising water table from a proposed Black Rock Reservoir. Following the retraction of the Black Rock Reservoir proposal, the focus of Appendix V in this final EIS was changed to analysis of potential impacts of infiltration increases resulting from climate change under three different scenarios. Appendix V includes sensitivity analyses of potential impacts at Hanford that could result from climate changes that may increase model boundary recharge parameters and the rise of the groundwater table. Additional qualitative discussion of the potential effects of climate change on human health, erosion, water resources, air quality, ecological resources, and environmental justice has been added to Chapter 6 of this final EIS. Additional discussion of the types of regional climate change that could be expected has also been added to Chapter 6, Section 6.5.2, Global Climate Change. The potential impacts of the alternatives on climate change are addressed in Chapter 6, Section 6.5.2, and Appendix G, Section G.5, of this *TC & WM EIS*.

S.1.4.4.9 Secondary-Waste-Form Performance

Topic: *Numerous commentors were concerned that the disposal of secondary waste derived from treatment of tank waste would cause unacceptable adverse impacts on the groundwater. These commentors supported the mitigation of these potential adverse impacts.*

Discussion: DOE acknowledges the concerns regarding secondary-waste-form performance and its potential importance to impacts on groundwater quality. The *TC & WM EIS* analysis confirms the *TWRS EIS* (DOE and Ecology 1996) ROD (62 FR 8693) to retrieve waste from the SSTs and treat the waste. Accordingly, there are risks and uncertainties associated with the treatment and disposal of secondary waste produced by the WTP, as well as by the supplemental treatment technologies and, in particular, with the impacts this waste may have at an IDF. As discussed in Chapter 7, Section 7.1.6, this is a particular area of focus for DOE, especially with regard to partitioning and capture of iodine-129, a conservative tracer, in secondary-waste forms. —Conservative tracer" means that iodine-129 moves at the same rate as the groundwater and that its relatively high mobility results in minimal attenuation at the Core Zone Boundary and the Columbia River nearshore. Additional sensitivity analyses have been performed and are included in this final EIS. The additional analyses evaluate the potential impacts of increasing the partitioning of contaminants in primary-waste forms, as well as improving secondary- and supplemental-waste-form performance. The discussion found in Section 7.1 was expanded to summarize these results. The results of these analyses will aid DOE in formulating appropriate performance requirements for secondary- and supplemental-waste forms.

As referenced in Chapter 7, Section 7.5.2.8, DOE has drafted a roadmap that implements a strategy for the development of better-performing secondary-waste forms. DOE, along with EPA, Ecology, the Oregon State Department of Energy, the U.S. Nuclear Regulatory Commission (NRC), technical experts from the DOE national laboratories, academia, and private consultants, participated in a Hanford Site Secondary Waste Roadmap Workshop on July 21–23, 2008, to develop the roadmap. This workshop, discussed in Section 7.5.2.8 and Appendix E, Section E.1.2.4.5.6, included discussions to identify the risks and uncertainties associated with treatment and disposal of secondary waste generated during HLW and LAW treatment and disposal and to develop a roadmap for addressing these associated risks and uncertainties. These activities are still ongoing. To provide additional insight, DOE performed a sensitivity analysis in this final EIS to evaluate the potential impacts if certain remediation activities were conducted in the future at some of the more prominent waste sites (including those containing technetium-99) on the Central Plateau and along the river corridor. The goal of the sensitivity analysis is to help DOE, EPA, and Ecology prioritize cleanup efforts in the future. This analysis is provided in Appendix M of this EIS and is discussed further in Section 7.5.

The secondary-waste roadmap workshop focused on the waste streams that are expected to contain the largest fractions of iodine-129 and technetium-99, which the draft EIS IDF risk assessment analyses showed may have the largest contribution to the estimated IDF disposal groundwater impacts. For example, the roadmapping effort evaluated sending the scrubber/offgas treatment liquids with technetium-99 to the Effluent Treatment Facility (ETF) for treatment and solidification, followed by disposal in an IDF, and sending the silver mordenite and carbon beds with the captured iodine-129 to be packaged and sent to an IDF.

The workshop culminated in development of the following programmatic/regulatory and technical needs elements (PNNL 2009):

- Select and deploy Hanford tank waste supplemental treatment technology.
- Provide treatment capability for secondary-waste streams resulting from tank waste treatment.
- Develop consensus on secondary-waste-form acceptance.

- Define secondary-waste composition ranges and uncertainties.
- Identify and develop waste forms for secondary-waste immobilization and disposal.
- Develop test methods to characterize secondary-waste-form performance.

Section 7.5 of Chapter 7 was added and Appendix M of this final EIS was expanded to provide more-detailed discussion, sensitivity analysis, and potential mitigation strategies for the treatment and disposal of the secondary waste than that originally presented in the draft EIS.

S.1.4.4.10 High-Level Radioactive Waste Disposition (Yucca Mountain Issue)

Topic: *Many commentors expressed concern that currently there is no viable disposal pathway for Hanford's HLW. Some were opposed to storing HLW at Hanford because of its proximity to the Columbia River, while others supported storage until a permanent disposal site is found. One commentor stated that, because the Nuclear Waste Policy Act requires permanent isolation of HLW and SNF, leaving these wastes stored at Hanford indefinitely is not a legal option or an acceptable option to the State of Washington. Many commentors supported the completion of a geologic repository for HLW disposal, and some questioned the decision to terminate the Yucca Mountain program.*

Discussion: The Secretary of Energy has determined that a Yucca Mountain repository is not a workable option for permanent disposal of SNF and HLW. However, DOE remains committed to meeting its obligations to manage and ultimately dispose of these materials. The Administration has convened the BRC to conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle, including all alternatives for the storage, processing, and disposal of SNF and HLW. The BRC's final recommendations will form the basis of a new solution to managing and disposing of SNF and HLW (BRC 2012).

Because it is now unclear when IHLW shipments off site will begin, DOE reexamined storage needs for IHLW canisters under each Tank Closure alternative. The EIS analysis shows that vitrified HLW can be safely stored at Hanford for up to 145 years until disposition decisions are made and implemented.

S.1.4.4.11 Mitigation

Topic: *Numerous comments were made regarding the mitigation of potential impacts of the proposed actions identified in this EIS. Some commentors stated that mitigation was either missing from, or not adequately addressed in, the draft EIS. One commentor stated that, under both NEPA and CEQ regulations implementing NEPA, mitigation actions are required. The commentor expressed the opinion that the mitigation discussion in Chapter 7, Section 7.1, of the draft EIS, for the most part, proposes ways to lessen the impacts of the proposed actions and does not constitute actual mitigation of the impacts. Moreover, DOE does not commit to these actions. Another commentor suggested that each alternative presented in the* Draft TC & WM EIS *be amended to identify mitigation to protect the environment (specifically, soil and groundwater) and uncounted future generations.*

Discussion: DOE disagrees that mitigation measures have been inadequately analyzed in this *TC & WM EIS*. The NEPA evaluation process is conducted early in agency planning, when details of the proposed project may not yet be well enough defined for specific mitigation measures to be developed. Chapter 7, Section 7.1, of the draft EIS discusses mitigation measures that could be used to avoid or reduce potential impacts on all resource areas. Some of the mitigation measures discussed would apply across all alternatives due to the similar nature of many of the activities analyzed in this EIS (e.g., facility construction). Therefore, for the purpose of limiting redundancy, the discussion of these measures is not duplicated for each alternative in this EIS. However, the resource subsections of Section 7.1 do acknowledge specific alternatives where only certain mitigation measures would apply or where additional mitigation consideration may be warranted. The discussion presented in this EIS identified potential mitigation measures that could be applied; specific mitigation measures would be selected based on the course of action chosen by DOE as identified in the ROD. Following completion of this *Final TC & WM EIS* and its associated ROD, DOE would be required, in accordance with DOE implementing procedures for NEPA (10 CFR 1021.331), to prepare a mitigation action plan that explains mitigation commitments expressed in the ROD. This mitigation action plan will be prepared before DOE would implement any *TC & WM EIS* alternative actions that are the subject of a mitigation commitment expressed in the ROD. Copies of any mitigation action plan developed by DOE will be made available for inspection in appropriate DOE public reading room(s), will be posted on the DOE NEPA website, and will also be available upon request.

In response to comments received on the *Draft TC & WM EIS* concerning the potential long-term impacts on groundwater resources, additional sensitivity analyses were performed and are included in this final EIS. The additional analyses evaluate the potential impacts if certain remediation activities were conducted in the future at some of the more prominent waste sites on the Central Plateau and along the river corridor. Furthermore, sensitivity analyses that evaluate improvements in IDF performance (e.g., infiltration rates) and in secondary- and supplemental-waste-form performance (e.g., release rates) were performed and are included in this final EIS. The discussion found in Chapter 7, Section 7.5, was added to summarize these results. The results of these analyses will aid DOE in formulating an appropriate mitigation action plan subsequent to this EIS and its associated ROD and in prioritizing future Hanford remedial actions that would be protective of human health and the environment and would reduce long-term impacts on groundwater.

S.1.4.4.12 Exclusion of Greater-Than-Class C Waste in Cumulative Impacts Analysis

Topic: *Several commentors questioned the exclusion of GTCC waste impacts analysis in the* Draft TC & WM EIS. *One commentor stated that DOE is in violation of NEPA requirements for simultaneous disclosure of all actions by separating the* TC & WM EIS *from an EIS being drafted by DOE concerning GTCC waste.*

Discussion: DOE has prepared the *Draft Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste (GTCC EIS)*, DOE/EIS-0375-D (DOE 2011), which addresses the transportation and disposal of LLW generated by activities licensed by NRC or an agreement state that contains radionuclides in concentrations exceeding Class C limits (10 CFR 61). The *Draft GTCC EIS* also addresses DOE LLW and non-defense-generated TRU waste, which have characteristics similar to GTCC LLW and for which there may be no path for disposal. The *Draft GTCC EIS* was published in February 2011 after the *Draft TC & WM EIS* had already been issued in October 2009; however, information from the *Draft GTCC EIS* was incorporated into the *Final TC & WM EIS* cumulative impacts analysis. Even though the *Draft GTCC EIS* was not available prior to issuance of the *Draft TC & WM EIS*, DOE did identify the *GTCC EIS* in the draft EIS in Chapter 1, Section 1.8, Related NEPA Reviews, based on a Notice of Intent to prepare the *GTCC EIS* in the *Federal Register* (72 FR 40135).

Hanford is being considered as a candidate location for a new GTCC waste disposal facility in the *GTCC EIS*, although DOE did not identify a preferred alternative for the location in the *Draft GTCC EIS.* Such a facility is not expected to be operational until after 2019. Further, DOE announced on December 18, 2009, a modification of the *TC & WM EIS* Preferred Alternatives in the *Federal Register* (74 FR 67189). In the announcement, DOE modified its Preferred Alternative for waste management in this *Final TC & WM EIS* by stating that DOE would not ship GTCC LLW to Hanford, at least until the WTP was operational. This moratorium on shipment of offsite waste, including GTCC LLW, to Hanford would allow time to better understand waste form performance and potential impacts on groundwater before allowing the receipt of offsite waste at Hanford.

S.1.5 Changes Since the *Draft TC & WM EIS* Publication

S.1.5.1 Revisions to Preferred Alternative Discussion

In the *Draft TC & WM EIS*, DOE narrowed its range of Preferred Alternatives for treatment of the tank waste to Alternatives 2A, 2B, 3A, 3B, 3C, 4 and 5. Alternatives 3A, 3B, 3C, 4, and 5 include options for treating the waste from specific tanks as mixed TRU waste (approximately 11.4 million liters [3 million gallons]), which would be prepared as necessary and shipped to WIPP for disposal. Based on further consideration, DOE subsequently concluded in December 2009 that its preference is to manage the waste from these tanks by treating it through the WTP, currently under construction, as either HLW or LAW, as would be the case with the other waste to be treated under each alternative, and to not ship it to WIPP for disposal (74 FR 67189).

As stated in the Preferred Alternatives in Section S.6.1 of this *Final TC & WM EIS*, DOE now prefers to consider the option to retrieve, treat, and package waste that may be properly and legally designated as mixed TRU waste from specific tanks for disposal at WIPP, as analyzed in Tank Closure Alternatives 3, 4, and 5. Initiating retrieval of tank waste identified as mixed TRU waste would be contingent on DOE‘s obtaining the applicable disposal and other necessary permits and ensuring that the WIPP Waste Acceptance Criteria and all other applicable regulatory requirements have been met. Retrieval of tank waste identified as mixed TRU waste would commence only after DOE had issued a *Federal Register* notice of its preferred alternative and a ROD.

DOE also announced in December 2009 its preference to not send LLW and MLLW from other DOE sites to Hanford for disposal (with some limited specific exceptions), at least until the WTP is operational. Offsite waste would be addressed after the WTP is operational, subject to appropriate NEPA review. Similar to its preference regarding the importation of LLW and MLLW, DOE further announced that it prefers to not import GTCC LLW to Hanford, at least until the WTP is operational (74 FR 67189). This remains DOE‘s preference as discussed in Section S.6.1 of this final EIS.

S.1.5.2 Supplement Analysis of the *Draft TC & WM EIS*

In accordance with CEQ regulations (40 CFR 1502.9(c)) and DOE regulations (10 CFR 1021.314(c)), DOE prepared an SA (DOE 2012) to evaluate updated, modified, or expanded information developed subsequent to the publication of the *Draft TC & WM EIS* to determine whether a supplement to the draft EIS or a new draft EIS is warranted.

Revisions include changes to contaminant inventories, corrections to estimates, updates to characterization data, and new information that was not available at the time of publication of the *Draft TC & WM EIS*. When reanalyzed, the modified inventories do not change the key environmental findings presented in the draft EIS. That is, they do not present significant new circumstances or information relevant to environmental concerns and bearing on the proposed action(s) and their impacts. Similarly, changes to some of the parameters used in the alternatives analysis (e.g., increases in the inhalation rate used for calculation, changes to barrier locations for human health risk reporting, changes in assumptions used for analytical purposes) do not significantly affect the potential environmental impacts of the alternatives on an absolute or relative basis, whether the changes are considered individually or collectively. These are not substantial changes in the proposed action(s) that are relevant to environmental concerns.

DOE concluded, based on analyses in the SA, that the updated, modified, or expanded information developed subsequent to the publication of the *Draft TC & WM EIS* does not constitute significant new circumstances or information relevant to environmental concerns and bearing on the proposed action(s) in the *Draft TC & WM EIS* or their impacts. Further, DOE has not made substantial changes in the proposed action(s) that are relevant to environmental concerns. Therefore, in accordance with CEQ regulations

(40 CFR 1502.9(c)) and DOE regulations (10 CFR 1021.314(c)), DOE determined that a supplemental or new *Draft TC & WM EIS* was not required.

S.1.5.3 Changes Made to the *Draft TC & WM EIS*

In response to public comments received on the *Draft TC & WM EIS* and to provide additional references or corrections to source documents (for example, *Cumulative Impact Analysis, Inventory Development* [SAIC 2011]), inventory databases were revised, sensitivity analyses were added, and updated information was included in this *Final TC & WM EIS*. The following paragraphs summarize the noteworthy changes made to this *Final TC & WM EIS*.

> **Revisions to the Draft Environmental Impact Statement (EIS)**
>
> Sidebars in this final EIS identify revisions made to the draft EIS in response to comments, revised information, or updates. Sidebars are not used to identify editorial changes.

Changes to Methods of Analysis, Alternatives, or Impact Analyses

Offsite Waste Inventory and Waste Acceptance Criteria – The *Draft TC & WM EIS* analysis showed that receipt of offsite waste streams containing specific amounts of certain risk-driving radionuclides, e.g., iodine-129 and technetium-99, could cause an exceedance of the benchmark concentrations for these radionuclides. As discussed in the draft EIS, one means of mitigating this impact would be for DOE to limit or restrict receipt of offsite waste containing iodine-129 or technetium-99 at Hanford (e.g., through waste acceptance criteria). In response to public comments on the draft EIS, DOE eliminated one waste stream with relatively high concentrations of technetium-99 and iodine-129 from the offsite waste inventory estimates in a reanalysis. The removal of this waste stream resulted in a significant reduction in the technetium-99 and iodine-129 offsite waste inventories.

> **Benchmark**
>
> ―Benchmark” refers to a dose or concentration known or accepted to be associated with a specific level of effect. Thus, Federal drinking water standards (40 CFR 141 and 143) are used as benchmarks against which potential contamination can be compared. Drinking water standards for Washington State are found in *Washington Administrative Code* 246-290. Benchmark standards used in this environmental impact statement represent dose or concentration levels that correspond to known or established human health effects. For groundwater, the benchmark is the maximum contaminant level (MCL) if an MCL is available. For constituents with no available MCL, additional sources for benchmark standards include Washington State guidance and relevant regulatory standards, e.g., Clean Water Act, Safe Drinking Water Act. For example, the benchmark for iodine-129 is 1 picocurie per liter; for technetium-99, it is 900 picocuries per liter. These benchmark standards for groundwater impacts analysis were agreed upon by both the U.S. Department of Energy and the Washington State Department of Ecology as the basis for comparing the alternatives and representing potential groundwater impacts.

The Oregon Proposal – The Oregon State Department of Energy, in its *Draft TC & WM EIS* comments to DOE, suggested that the elements contained within the range of alternatives analyzed in the draft EIS be combined in a new alternative that would provide a ―preferable long-term approach for successfully immobilizing Hanford‘s tank waste, closing the tank farms, and protecting the public and the environment." Chapter 2 of this *Final TC & WM EIS* has been revised to include a discussion of this proposal and how DOE has addressed the range of reasonable alternatives for tank waste storage, retrieval, and treatment and remediation of the existing tank farms in the alternatives outlined in the *Draft TC & WM EIS*.

Unplanned-Releases Inventory – To address the specific comment that some waste site inventories may not have been included, DOE reviewed tank farm waste inventories in the draft EIS and determined that the inventory for a number of unplanned releases was inadvertently omitted. This inventory is relatively minor, but the inventory estimates and the groundwater analysis were revised to include these additional sources. DOE also revised the inventories estimated for historical leaks to reflect recently updated field investigation reports.

Vadose Zone and Groundwater Parameters and Methodology Clarifications – DOE has provided additional discussion in this final EIS wherever appropriate to more clearly describe modeling methodologies, as well as the process of choosing parameters and the parameters themselves, based on public comment.

Potential Future Cleanup Actions – In response to comments received on the *Draft TC & WM EIS* concerning potential long-term impacts on groundwater resources, several sensitivity analyses in the draft EIS were combined and integrated into this final EIS to clarify or enhance the mitigation discussions. One of these analyses evaluates the potential impacts if certain remediation activities are conducted at some of the more prominent waste sites on the Central Plateau and along the river corridor.

Climate Change – Additional qualitative discussion of the potential effects of climate change on human health, erosion, water resources, air quality, ecological resources, and environmental justice has been added to Chapter 6 of this final EIS. Additional discussion of the types of regional climate change that could be expected has also been added to Chapter 6, Section 6.5.2, Global Climate Change. Appendix V has also been expanded. In the *Draft TC & WM EIS*, Appendix V focused on the potential impacts of a rising water table from a proposed Black Rock Reservoir. Following the retraction of this proposal, the focus of Appendix V was changed to analyze potential impacts of infiltration increases resulting from climate change under three different scenarios.

Steam Reforming Waste Form Performance – This *TC & WM EIS* has been updated to include more-current information by including (1) an analysis of the performance of steam reforming waste based on solid-phase solubility controls; (2) a discussion of the technical information regarding the characterization and performance of steam reforming waste; and (3) an analysis of the performance of steam reforming waste that would have to be achieved (in the context of Tank Closure Alternative 3C, with IDF-East) to result in groundwater concentrations at the Core Zone Boundary below benchmark standards. This additional material can be found in Chapter 7 of this *Final TC & WM EIS*.

Secondary-Waste-Form Performance – Additional sensitivity analyses have been performed and are included in this final EIS. The additional analyses evaluate the potential impacts of increasing the partitioning of contaminants in primary-waste forms, as well as improving secondary- and supplemental-waste-form performance. The discussion found in Chapter 7, Section 7.1, was expanded to summarize these results. The results of these analyses will aid DOE in formulating appropriate performance requirements for secondary- and supplemental-waste forms.

FFTF RH-SC Treatment Facility Location for the Idaho Option – DOE's *Finding of No Significant Impact for the ―Environmental Assessment for the Proposed Remote-Handled Waste Disposition Project"* (DOE 2009a) was issued on February 18, 2009, and acknowledged in the *Draft TC & WM EIS*, Chapter 1. DOE selected the Preferred Alternative of using INL's existing INTEC facilities, with modification, for waste-processing activities. DOE updated this *TC & WM EIS* to show that the treatment for FFTF's RH-SCs, if taken to Idaho, would likely be conducted at INTEC, consistent with the final environmental assessment and subsequent decision. The analysis in this *Final TC & WM EIS* has been updated to reflect this change through the addition of INTEC to the affected environment discussion in Chapter 3 and the incorporation of construction data at INTEC into Chapter 4 of this final EIS.

IHLW Interim Storage Facility – The Secretary of Energy has determined that a Yucca Mountain repository is not a workable option for permanent disposal of SNF and HLW. However, DOE remains committed to meeting its obligations to manage and ultimately dispose of these materials. The Administration has convened the BRC to conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle, including all alternatives for the storage, processing, and disposal of SNF and HLW. The BRC's final recommendations will form the basis of a new solution to managing and disposing of SNF and HLW.

DOE will need to store WTP IHLW and melters at Hanford until after the BRC completes its work and DOE has determined and implemented a path forward for disposition of the Nation's SNF and HLW, including the WTP IHLW and melters. Accordingly, DOE has expanded its analysis of storage capacity on site to account for this reality. Additional information regarding onsite storage of the HLW melters is included in Appendix E. This final EIS includes additional analyses on the impacts of safely storing the HLW melters and IHLW through the estimated operational timeframe for the WTP under each of the Tank Closure alternatives. Further, this EIS analysis shows that vitrified HLW can be safely stored at Hanford for up to 145 years until disposition decisions are made and implemented.

IDF Mitigation – Additional sensitivity analyses that evaluate improvements in IDF performance (e.g., infiltration rates) and in secondary- and supplemental-waste-form performance (e.g., release rates) were performed and are included in this final EIS. The discussion found in Chapter 7, Section 7.1, Mitigation, was expanded to summarize these results. The results of these analyses will aid DOE in formulating an appropriate mitigation action plan subsequent to this EIS and its associated ROD and in prioritizing future Hanford remedial actions that would be protective of human health and the environment and would reduce long-term impacts on groundwater.

Waste Inventories for Cumulative Impacts Analysis – Since publication of the *Draft TC & WM EIS*, additional revisions were made to the inventory database based on comments received on the draft EIS and on additional references or corrections to the source documents. These revisions include the following sites and are provided in Appendix S of this final EIS:

- T Plant complex (including 221-T Canyon Building)
- Z Area cribs and trenches (ditches)
- Proposed GTCC waste disposal site
- Environmental Restoration Disposal Facility
- Sites without reported total uranium inventories (e.g., LLBGs, the US Ecology Commercial Low-Level Radioactive Waste Disposal Site)
- Sites with carbon tetrachloride inventories

Tribal Interactions – Chapter 8 of this final EIS has been revised to include a summary of the consultations and communications between the various tribal representatives and DOE in regard to the entire *TC & WM EIS* development.

Updates to Technical Data, Additions, and Editorial Revisions

Incorporation of Updated Site-Specific Information – Data that emerged since the *Draft TC & WM EIS* publication were updated where consistent with existing cooperating agency agreements. In particular, Chapter 3, ―Affected Environment," and Appendix E, ―Descriptions of Facilities, Operations, and Technologies," were revised to ensure that this EIS contains the most recent time-sensitive data available. Data and references were updated, and other associated revisions were made (e.g., socioeconomic data). Environmental information used to develop, calibrate, and evaluate the groundwater model was updated. These data include boring logs, groundwater monitoring results, and water table elevation measurements that were developed between 2006 and 2010.

Additions to This *TC & WM EIS* – This *TC & WM EIS* has been changed by adding the CRD, which includes all public comments and DOE's responses to comments on the draft EIS, as Volume 3 of this final EIS. In addition, a new appendix, Appendix W, ―American Indian Tribal Perspectives and Scenarios," was added to this final EIS. This appendix contains the perspectives on proposed plans for cleanup of Hanford from three American Indian tribal groups: the Confederated Tribes and Bands of the Yakama Nation, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation. Included are copies of the treaties negotiated in June 1855 between representatives of the United States and leaders of various Columbia Plateau American Indian tribes and bands, as mentioned in Chapter 8 of this *TC & WM EIS*. Also provided are the results of DOE's risk analysis of exposure to radioactive and chemical constituents of potential concern using the American Indian tribal scenarios as provided to DOE.

Editorial Revisions and Clarifications of Text – Editorial errors that were identified have been corrected where appropriate throughout this EIS. In some cases, text was added to clarify the presentation of data or discussion of analyses.

S.2 DEVELOPMENT OF THE ALTERNATIVES

The alternatives presented in this *TC & WM EIS* were developed under NEPA to address the essential components of DOE's three sets of proposed actions (tank closure, FFTF decommissioning, and waste management) and to provide an understanding of the differences between the potential environmental impacts of the range of reasonable alternatives. In this *TC & WM EIS*, DOE evaluates the impacts associated with 11 Tank Closure alternatives, 3 FFTF Decommissioning alternatives, and 3 Waste Management alternatives. A No Action Alternative, required under CEQ regulations to provide a point of comparison against which the proposed actions and alternatives can be compared (40 CFR 1502.14(d)), is also evaluated.

Each alternative relies on a combination of technologies, processes, and facilities that could accomplish the desired outcome for that alternative. In many cases, those technologies were selected to provide bounding environmental consequences and do not necessarily represent the exact technologies or processes that could be implemented to achieve the desired outcome. This *TC & WM EIS* does not attempt to analyze all possible permutations of the alternatives (the alternatives analyzed in this EIS represent the range of reasonable approaches) using available technologies and processes, but instead groups activities logically into reasonable alternatives for analysis. The technologies, processes, and facilities analyzed in detail in this EIS have sufficient performance data to make conservative assumptions regarding construction, operations, and decommissioning impacts. However, comprehensive and specific engineering designs may still have to be developed once a series of technologies is selected for implementation.

For Tank Closure alternatives, impacts resulting from storage, retrieval, treatment, disposal, and closure activities at Hanford's HLW tank farms were evaluated, as were the impacts of a No Action Alternative. These Tank Closure alternatives represent the range of reasonable approaches to removing waste from the tanks to the extent that is technically and economically feasible; treating the waste by vitrifying it in the WTP and/or using one or more supplemental treatment processes; packaging the waste for either offsite shipment and disposal or onsite disposal; and closing the SST system to permanently reduce the potential risk to human health and the environment.

This *TC & WM EIS* also evaluates the impacts associated with three alternatives for decommissioning FFTF and associated support buildings; managing the resulting waste using existing capabilities; managing designated RH-SCs for which waste management capabilities do not currently exist without modifications; closing FFTF and its associated support buildings; and managing the disposition of the inventory of bulk sodium resulting from deactivation of FFTF, as well as bulk sodium from the Hallam Reactor and the Sodium Reactor Experiment, which is now in storage at Hanford. These FFTF Decommissioning alternatives represent the range of reasonable approaches to dismantling and removing the FFTF-related structures, equipment, and materials within the 400 Area Property Protected Area; treating and disposing of these components and equipment as necessary, either in place or at other facilities; treating RH-SCs either at a new facility at Hanford or at INL; converting Hanford bulk sodium to a concentrated caustic sodium hydroxide solution at Hanford or INL for reuse in the WTP to process

> **Dates for Alternatives**
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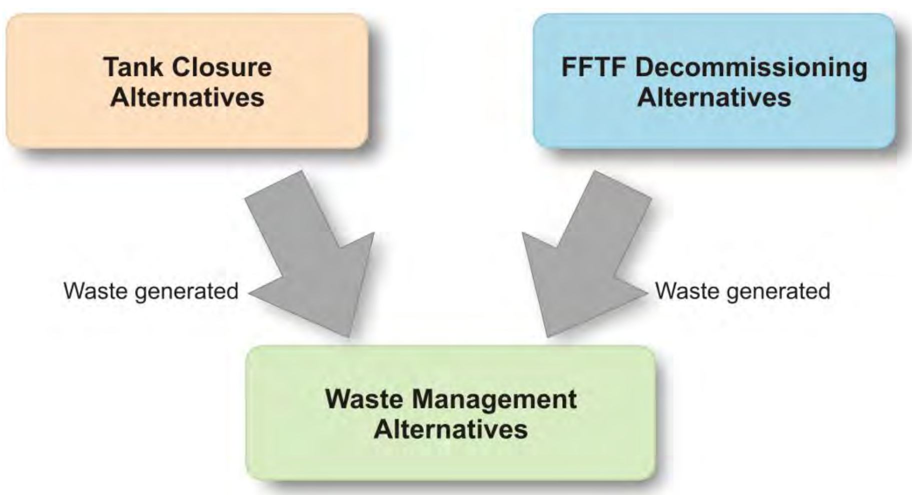
> The dates referenced in this environmental impact statement (EIS) for the alternatives were selected to support relationships between, and durations for, activities, thus allowing comparisons of the alternatives. Due to ongoing technical developments and their inherent uncertainties, they do not necessarily represent the current dates. For example, this EIS used a Waste Treatment Plant (WTP) startup date of 2018; the 2010 Consent Decree milestone for WTP startup is 2022. Note that the durations, rather than the startup dates, of the activities evaluated in this EIS are of the most significance. As this EIS evaluates modeling from 1944 through 11,944, the dates provide a reference for past, current, and future activities.

tank waste or to support Hanford tank corrosion control; and closing the area permanently to (1) reduce the potential risk to human health and the environment or (2) prepare the area for future industrial use.

This *TC & WM EIS* also provides analyses of the impacts associated with Waste Management alternatives for managing the storage, processing, and disposal of solid waste at Hanford, as well as the subsequent closure of associated disposal facilities. These Waste Management alternatives represent the range of reasonable approaches to continued storage of LLW, MLLW, and TRU waste at Hanford; onsite waste processing using two expansions of the Waste Receiving and Processing Facility (WRAP); onsite disposal of onsite LLW and MLLW in cribs and trenches (ditches); disposal of tank, onsite, FFTF decommissioning, waste management, and offsite LLW and MLLW in new onsite facilities; and closure of disposal facilities to reduce water infiltration and the potential for intrusion.

Sections S.2.1, S.2.2, and S.2.3 include a general overview of how the Tank Closure, FFTF Decommissioning, and Waste Management alternatives, respectively, were constructed to address the primary components of each set of proposed actions, a brief description of the range of activities that would occur under the No Action Alternatives and action alternatives for each set, and more-detailed descriptions of activities specific to each alternative. Tank closure, FFTF decommissioning, and waste management activities are organized by their essential components (e.g., disposal under waste management) in these sections.



Alternative Structure

S.2.1 Tank Closure Alternatives

The Tank Closure alternatives evaluated in this *TC & WM EIS* were constructed to address each of the primary tank closure components (storage, retrieval, treatment, and disposal of tank waste and closure of the SST farms) and to consider a range of options for each component. At the end of this section, Table S–1 compares each of the Tank Closure alternatives by component.

Tank Closure Alternatives

Alternative 1: No Action

Alternative 2: Implement the *Tank Waste Remediation System EIS* Record of Decision with Modifications

- ***Tank Closure Alternative 2A:*** Existing WTP Vitrification; No Closure
- ***Tank Closure Alternative 2B:*** Expanded WTP Vitrification; Landfill Closure

Alternative 3: Existing WTP Vitrification with Supplemental Treatment Technology; Landfill Closure

- ***Tank Closure Alternative 3A:*** Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure
- ***Tank Closure Alternative 3B:*** Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure
- ***Tank Closure Alternative 3C:*** Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure

Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure

Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

Alternative 6: All Waste as Vitrified HLW

- ***Tank Closure Alternative 6A:*** All Vitrification/No Separations; Clean Closure (Base and Option Cases)
- ***Tank Closure Alternative 6B:*** All Vitrification with Separations; Clean Closure (Base and Option Cases)
- ***Tank Closure Alternative 6C:*** All Vitrification with Separations; Landfill Closure

S.2.1.1 Tank Waste Storage

Tank farm waste storage operations (e.g., monitoring, routine maintenance, waste transfer) would be required under each Tank Closure alternative. Storage operations are considered a dependent function that varies with changes in the duration of waste retrieval and treatment operations. If tank waste were not retrieved and treated (the No Action Alternative), current, ongoing activities would continue and tank replacements and upgrades would be required.

Tank waste storage activities under each Tank Closure alternative would be as follows:

Alternative 1. Continue to store and monitor waste in the SSTs and DSTs for 100 years. Fill tanks that show signs of deterioration with grout/gravel. Continue to store cesium and strontium capsules in the WESF.

Alternative 2A. Continue current waste management operations using existing tank storage facilities. Replace DSTs in a phased manner—i.e., as each exceeds its 40-year design life—through 2054.

Alternative 2B. Continue current waste management operations using existing tank storage facilities. Construct four new WRFs; no new DSTs would be required.

Alternatives 3A, **3B**, **and 3C.** Same as Alternative 2B.

Alternative 4. Same as Alternative 2B.

Alternative 5. Same as Alternative 2B.

Alternative 6A. Continue current waste management operations using existing tank storage facilities, modifying those facilities as needed to support SST waste retrieval and treatment. Build new DSTs as the existing DSTs reach the end of their design life.

Alternatives 6B and 6C. Same as Alternative 2B.

S.2.1.2 Tank Waste Retrieval

Options range from retrieving none of the tank waste (the No Action Alternative) to retrieving the tank waste to the maximum extent technically practical and required to support clean closure of the SST system. Retrieval to 90, 99, and 99.9 percent are analyzed using different retrieval technologies.

Tank waste retrieval activities under each Tank Closure alternative would be as follows:

Alternative 1. Do not retrieve waste from the tanks.

Alternatives 2A and 2B. Retrieve tank waste to the 99 percent retrieval goal using currently available liquid-based waste retrieval and leak detection systems.

Alternatives 3A, **3B**, **and 3C.** Same as Alternatives 2A and 2B.

Alternative 4. Retrieve tank waste to the 99.9 percent retrieval goal using currently available liquid-based waste retrieval and leak detection systems and a final chemical wash step.

Alternative 5. Retrieve tank waste to the 90 percent retrieval goal using currently available liquid-based retrieval and leak detection systems.

Alternatives 6A and 6B. Same as Alternative 4.

Alternative 6C. Same as Alternatives 2A and 2B.

S.2.1.3 Tank Waste Treatment

Options range from treating none of the tank waste (the No Action Alternative) to treating all of the waste to the extent required to meet disposal requirements. Tank waste could be treated using a variety of technologies to make it safe for disposal, resulting in one or many waste forms. All of the action alternatives would continue to use the WTP in its current configuration, with some alternatives involving expansion.

Tank waste treatment activities under each Tank Closure alternative would be as follows:

Alternative 1. Stop construction of the WTP and isolate the WTP site pending some future use, if any. Do not build any vitrification or treatment capacity after 2008.

Alternative 2A. Complete construction of, and operate, the WTP in its existing configuration (two HLW melters and two LAW melters). Treat HLW and LAW over the period 2018–2093. Pretreat all waste streams routed to the WTP, excluding technetium-99 removal waste. Replace the WTP after 60 years. Provide no supplemental or TRU waste treatment. Retrieve cesium and strontium capsules from the WESF for de-encapsulation at the Cesium and Strontium Capsule Processing Facility and treatment in the WTP.

Alternative 2B. Supplement the existing WTP configuration (two HLW melters and two LAW melters) with expanded LAW vitrification capacity (an addition of four LAW melters) to increase the theoretical maximum capacity. Treat HLW over the period 2018–2040 and LAW over the period 2018–2043. Pretreat all waste streams routed to the WTP, and include technetium-99 removal in the pretreatment process. No facilities would have to be replaced. No supplemental or TRU waste treatment is proposed. Provide retrieval, de-encapsulation, and treatment of cesium and strontium as described for Alternative 2A.

Alternative 3A. Operate the WTP in its existing configuration (two HLW melters and two LAW melters). Treat HLW and LAW over the period 2018–2040. Pretreat all waste streams routed to the WTP, but exclude technetium-99 removal from the pretreatment process. Supplement WTP capacity with bulk vitrification treatment at facilities in the 200-East and 200-West Areas to immobilize a portion of the LAW. In the 200-East Area, pretreat the waste feed in the WTP, but exclude technetium-99 removal from the pretreatment process. In the 200-West Area, pretreat the waste feed in a new Solid-Liquid Separations Facility. Treat and package a portion of the tank waste designated as mixed TRU waste for disposal at WIPP. Provide retrieval, de-encapsulation, and treatment of cesium and strontium capsules as described for Alternative 2A.

Alternative 3B. Operate the WTP in its existing configuration (two HLW melters and two LAW melters). Treat HLW and LAW over the period 2018–2040. Pretreat all waste streams routed to the WTP, and include technetium-99 removal in the pretreatment process. Supplement WTP capacity with cast stone treatment at facilities in the 200-East and 200-West Areas to immobilize a portion of the LAW. In the 200-East Area, pretreat the waste feed in the WTP, and include technetium-99 removal in the pretreatment process. In the 200-West Area, pretreat the waste feed in a new Solid-Liquid Separations Facility. Treat and package a portion of the tank waste designated as mixed TRU waste for disposal at WIPP. Provide retrieval, de-encapsulation, and treatment of cesium and strontium capsules as described for Alternative 2A.

Alternative 3C. Operate the WTP in its existing configuration (two HLW melters and two LAW melters). Treat HLW and LAW over the period 2018–2040. Pretreat all waste streams routed to the WTP, but exclude technetium-99 removal from the pretreatment process. Supplement WTP capacity with steam reforming treatment at facilities in the 200-East and 200-West Areas to immobilize a portion of the LAW. In the 200-East Area, pretreat the waste feed in the WTP, but exclude technetium-99 removal from the pretreatment process. In the 200-West Area, pretreat the waste in a new Solid-Liquid Separations Facility. Treat and package a portion of the tank waste designated as mixed TRU waste for disposal at WIPP. Provide retrieval, de-encapsulation, and treatment of cesium and strontium capsules as described for Alternative 2A.

Alternative 4. Operate the WTP in its existing configuration (two HLW melters and two LAW melters). Treat HLW and LAW, including the highly contaminated waste stream resulting from clean closure of the BX and SX tank farms, over the period 2018–2043. Pretreat all waste streams routed to the WTP, but exclude technetium-99 removal from the pretreatment process. Supplement WTP capacity with a combination of cast stone and bulk vitrification treatment at facilities in the 200-East and 200-West Areas, respectively, to immobilize a portion of the LAW. Pretreat the waste stream feed for the 200-East Area Cast Stone Facility in the WTP, but exclude technetium-99 removal from the pretreatment process. Pretreat the waste stream feed for the 200-West Area Bulk Vitrification Facility in a new Solid-Liquid Separations Facility. Treat and package a portion of the tank waste designated as mixed TRU waste for disposal at WIPP. Provide retrieval, de-encapsulation, and treatment of cesium and strontium capsules as described for Alternative 2A.

Alternative 5. Supplement the existing WTP configuration (two HLW melters and two LAW melters) with expanded LAW vitrification capacity at the WTP (an addition of one LAW melter) and a combination of cast stone and bulk vitrification treatment at facilities in the 200-East and 200-West Areas, respectively, to immobilize a portion of the LAW. Treat HLW and LAW over the period 2018–2034. Pretreat all waste streams routed to the WTP, but exclude technetium-99 removal from the pretreatment process. Implement sulfate removal technology following WTP pretreatment to potentially reduce the amount of ILAW glass produced in the WTP. Pretreat the waste stream feed for the 200-East Area Cast Stone Facility in the WTP, but exclude technetium-99 removal from the pretreatment process. Pretreat the waste stream feed for the 200-West Area Bulk Vitrification Facility in a new Solid-Liquid Separations Facility. Treat and package a portion of the tank waste designated as mixed TRU waste for disposal at WIPP. Provide retrieval, de-encapsulation, and treatment of cesium and strontium capsules as described for Alternative 2A.

Alternative 6A. Modify the WTP configuration through expanded HLW vitrification capacity (five HLW melters and no LAW melters in the modified configuration) to allow for the processing of all waste as HLW. Treat waste over the period 2018–2163, replacing the WTP twice due to design-life constraints. Do not pretreat waste, remove technetium-99, treat LAW or TRU waste, or treat waste using supplemental technologies. Provide retrieval, de-encapsulation, and treatment of cesium and strontium capsules as described for Alternative 2A.

Alternatives 6B and 6C. Supplement the existing WTP configuration (two HLW melters and two LAW melters) with expanded LAW vitrification capacity (an addition of four LAW melters). Treat HLW over the period 2018–2040 and LAW over the period 2018–2043. Pretreat all waste streams routed to the WTP, but exclude technetium-99 removal from the pretreatment process. Do not treat waste using supplemental treatment, and do not treat TRU waste. Provide retrieval, de-encapsulation, and treatment of cesium and strontium capsules as described for Alternative 2A.

S.2.1.4 Tank Waste Disposal

Tank waste disposal options include on- and offsite disposal. Offsite disposal of TRU waste would be at WIPP. The amount of waste to be disposed of would vary depending on the volume retrieved and conformity of the treated waste with criteria for acceptance at the disposal facilities.

Tank waste disposal activities under each Tank Closure alternative would be as follows:

Alternative 1. Do not dispose of the waste in the SST and DST systems; retain it in the tank farms indefinitely.

Alternatives 2A and 2B. Dispose of LAW immobilized via the WTP on site in an IDF. Store IHLW on site in interim storage facilities until disposition decisions are made and implemented.

> **Tank Farm System End-State Management**
>
> **Administrative controls (Tank Closure Alternatives 1, 2A)** – Ensure safe operations through activities such as monitoring tanks for signs of deterioration that could lead to leaks.
>
> **Active institutional controls (active Government control) (Tank Closure Alternatives 2B–6C)** – Ensure safe storage of waste following treatment through activities such as erecting physical barriers or markers and through methods to preserve information to inform current and future generations of hazards and risks.
>
> **Postclosure care (Tank Closure Alternatives 2B, 3A, 3B, 3C, 4, 5, 6C)** – Monitor and maintain the disposal system (e.g., a landfill) to preserve system integrity and prevent or control releases.
>
> **10,000-year period of analysis –** The period of analysis used in this environmental impact statement for the long-term impacts analysis for groundwater, human health, and ecological risks.

Alternatives 3A, 3B, and 3C. Dispose of LAW immobilized both via the WTP and external to the WTP on site in an IDF. Store IHLW on site in interim storage facilities. Package and store mixed TRU waste on site in a new storage facility pending disposal at WIPP.

Alternative 4. Same as Alternatives 3A, 3B, and 3C.

Alternative 5. Same as Alternatives 3A, 3B, and 3C.

Alternative 6A. Store IHLW canisters on site in interim storage facilities until disposition decisions are made and implemented. Replace the canister storage facilities when they reach the end of their 60-year design life. Manage debris from clean closure as HLW and store it on site.

Alternative 6B. Store IHLW canisters on site in interim storage facilities until disposition decisions are made and implemented. Manage ILAW glass canisters as HLW and store them on site. Manage debris from clean closure as HLW and store it on site.

Alternative 6C. Store IHLW canisters on site in interim storage facilities until disposition decisions are made and implemented. Manage ILAW glass canisters as HLW and store them on site.

S.2.1.5 Tank Farm Closure

Options range from continuing tank farm operations (without closing the SST system) to closing the SST system under a landfill or clean closure configuration (or a combination of these two end states). In addition, each of these options may include one or more end-state management activities (administrative controls, active institutional controls, or postclosure care) that would take place at the completion of each closure action.

Tank farm closure activities under each Tank Closure alternative would be as follows:

Alternative 1. Do not close the tank farms. Maintain security and management of Hanford for a 100-year administrative control period ending in 2107. Continue to store waste and conduct routine monitoring of waste in tanks during this period.

Alternative 2A. Do not close the tank farms. Cease administrative control of the tank farms following a 100-year period ending in 2193.

Alternative 2B. As operations are completed, close the SST system and associated cribs and trenches (ditches) using a landfill barrier. Fill the tanks and ancillary equipment with grout to immobilize the residual waste, prevent future tank subsidence, and discourage intruder access. Remove 4.6 meters (15 feet) of soil from the BX and SX tank farms and replace it with clean soil from onsite sources. Dispose of contaminated soils and ancillary equipment on site in the proposed RPPDF. Monitor the site using postclosure care for 100 years.

Alternatives 3A, 3B, and 3C. Same as Alternative 2B.

Alternative 4. As operations are completed, close the SST system and associated cribs and trenches (ditches), except the BX and SX tank farms, using a landfill barrier. Fill the tanks and ancillary equipment with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. Clean-close the BX and SX tank farms by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Treat the removed tanks, ancillary equipment, and soils in the Preprocessing Facility (PPF). Dispose of the resulting MLLW on site in an IDF and process the resulting highly contaminated liquid waste stream in the WTP. Excavate deep soils, where necessary, to remove contamination within the soil column, and treat these soils in the PPF. Process the resulting contaminated liquid waste stream in the WTP. Dispose of the washed soils in the proposed RPPDF. Backfill the BX and SX tank farms with clean soil. Monitor the site using postclosure care for 100 years.

Closure Options Analyzed in This Environmental Impact Statement

Landfill Closure – Following tank waste retrieval, the single-shell tank (SST) system would be closed in accordance with state, Federal, and/or U.S. Department of Energy requirements for closure of a landfill. Landfill closure typically includes site stabilization and emplacement of a barrier, followed by a postclosure care period.

Clean Closure – Following tank waste retrieval, the tanks, ancillary equipment, and contaminated soils would be removed as necessary to protect human health and the environment and to allow unrestricted use of the tank farm area.

Selective Clean Closure/Landfill Closure – This hybrid closure approach would implement clean closure of a representative tank farm in each of the 200-East and 200-West Areas (i.e., the BX and SX tank farms), while implementing landfill closure for the balance of the SST farm system.

Alternative 5. As operations are completed, close the SST system and associated cribs and trenches (ditches) using a landfill barrier. Fill the tanks and ancillary equipment with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. Leave SST system ancillary equipment outside the surface barriers in place. Monitor the site using postclosure care for 100 years.

Alternatives 6A and 6B. Clean-close all 200-East and 200-West Area SST farms following deactivation by removing the tanks, associated ancillary equipment, and contaminated soil to a depth of 3 meters (10 feet) directly beneath the tank base. Package these materials as HLW for storage on site. Excavate deep soils, where necessary, to remove contamination plumes within the soil column, and treat these soils in the PPF. However, these treated soils would not be managed as HLW and would instead be made acceptable for disposal on site. Process the resulting liquid waste stream in the PPF and dispose of it on site in an IDF. Dispose of the washed soils in the proposed RPPDF. Cover the cribs and trenches (ditches) associated with the tank farms with a landfill barrier (Base Cases) or clean-close them (Option Cases). Clean closure of the tank farms would preclude the need for postclosure care.

Alternative 6C. As operations are completed, close the SST system and associated cribs and trenches (ditches) with a landfill barrier. Fill the tanks with grout to immobilize the residual waste, prevent long-term degradation of the tanks, and discourage intruder access. Remove 4.6 meters (15 feet) of soil from the BX and SX tank farms and replace it with clean soil from onsite sources. Dispose of the removed contaminated soils and ancillary equipment on site in the proposed RPPDF. Monitor the site using postclosure care for 100 years.

Table S–1. Comparison of the Tank Closure Alternatives

	Alternative 1: No Action	Alternative 2A: Existing WTP Vitrification; No Closure	Alternative 2B: Expanded WTP Vitrification; Landfill Closure	Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure	Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure	Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure	Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/ Landfill Closure	Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure	Alternative 6A: All Vitrification/No Separations; Clean Closure	Alternative 6B: All Vitrification with Separations; Clean Closure	Alternative 6C: All Vitrification with Separations; Landfill Closure
Storage											
Existing	✓										
New WRFs			✓	✓	✓	✓	✓	✓		✓	✓
New DSTs		✓						✓	✓		
Retrieval											
90 percent								✓			
99 percent		✓	✓	✓	✓	✓					✓
99.9 percent							✓		✓	✓	
Treatment											
WTP											
Existing vitrification only		✓		✓	✓	✓	✓				
Expanded LAW vitrification			✓					✓		✓	✓
Expanded HLW vitrification									✓		
Replacement of WTP		✓							✓		
Technetium-99 removal			✓		✓						
Sulfate removal								✓			
Cesium and strontium capsules		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Non-WTP											
Tank mixed TRU waste supplemental treatment				✓	✓	✓	✓	✓			
Thermal supplemental treatment				✓		✓	✓	✓			
Nonthermal supplemental treatment					✓		✓	✓			
Disposal (including post-treatment storage)											
On Site											
ILAW		✓	✓	✓	✓	✓	✓	✓		(a)	(a)
IHLW[b]		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sulfate grout								✓			
Contaminated soil			✓	✓	✓	✓	✓		✓	✓	✓
SSTs							(c)		(d)	(d)	
Off Site											
Tank mixed TRU waste to WIPP				✓	✓	✓	✓	✓			
Closure											
Clean closure									✓	✓	
Selective clean closure/landfill closure							✓				
Landfill closure			✓	✓	✓	✓		✓			✓
Modified RCRA Subtitle C barrier			✓	✓	✓	✓	✓		(e)	(e)	✓
Hanford barrier								✓			

[a] Under Alternatives 6B and 6C, ILAW glass would be interim-stored on site and managed as IHLW glass.
[b] Although disposition decisions have not been made and implemented, these alternatives do not assume the inventory in the IHLW canisters remains on site. However, the number of storage facilities needed to store all the IHLW is one more than the number of canister storage facilities analyzed under Tank Closure Alternative 2B.
[c] Under Alternative 4, SSTs at the BX and SX tank farms would be removed and treated in the Preprocessing Facility.
[d] Under Alternatives 6A and 6B, all SSTs would be removed and packaged in shielded boxes for onsite storage pending disposition.
[e] Base Case: Construct modified RCRA Subtitle C barrier over six sets of cribs and trenches (ditches) in B and T Areas. Option Case: Remove six sets of cribs and trenches (ditches) in the B and T Areas and remediate their deep-soil plumes.

Key: DST=double-shell tank; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; RCRA=Resource Conservation and Recovery Act; SST=single-shell tank; TRU=transuranic; WIPP=Waste Isolation Pilot Plant; WRF=waste receiver facility; WTP=Waste Treatment Plant.

S.2.2 FFTF Decommissioning Alternatives

> **FFTF Decommissioning Alternatives**
> **Alternative 1:** No Action
> **Alternative 2:** Entombment
> **Alternative 3:** Removal

The FFTF Decommissioning alternatives evaluated in this *TC & WM EIS* were constructed to address the disposition of facilities, RH-SCs, and bulk sodium. In developing these alternatives, DOE considered a range of options for each component.

S.2.2.1 Facility Disposition

Options for facility disposition range from leaving the deactivated FFTF and associated facilities and components in place (No Action Alternative) to removing radioactive materials in varying degrees. Materials left in place would either be covered by an inert gas blanket (No Action Alternative) or entombed (stabilized underground with grout). Both action alternatives would include backfilling, compacting, contouring, and revegetating the area. However, where more structures (e.g., remains of the Reactor Containment Building [RCB]) and equipment were left in place (Entombment Alternative), an engineered barrier would be constructed and postclosure care and institutional controls provided. Where no barrier was constructed, administrative or institutional controls would be put in place. All of the above options would require treatment and disposal of hazardous and radioactive materials.

S.2.2.2 Disposition of Remote-Handled Special Components

> **What are remote-handled special components (RH-SCs)?**
>
> RH-SCs are reactor system components that have high radiation levels (received during operation of the reactor) and/or cannot be effectively drained such that they require remote handling (i.e., they must be handled at a distance—remotely—to protect workers from unnecessary exposure), decontamination, and disposal.

Due to the inability to completely drain sodium from reactor components with high radiation levels (primarily cesium-137), these components would require remote handling, decontamination, and disposal. Options for disposition of these RH-SCs range from leaving the untreated materials on site (No Action Alternative) to treating RH-SCs (removing the sodium residuals) and disposing of them on or off site (Entombment and Removal Alternatives). Options for treatment include constructing an RTP near Hanford's T Plant in the 200-West Area for onsite treatment or transporting the RH-SCs to the RTP at INL's INTEC. Options for the disposal of treated RH-SCs include disposal in an IDF at Hanford or off site at DOE's Nevada National Security Site.

S.2.2.3 Disposition of Bulk Sodium

Options for the treatment and disposal of Hanford bulk sodium range from leaving the untreated materials on site in storage (No Action Alternative) to converting the bulk sodium to a caustic sodium hydroxide solution for reuse in processing tank waste at the WTP or for supporting Hanford tank corrosion control (Entombment and Removal Alternatives). Options for converting the sodium range from conducting conversion activities on site at Hanford in the proposed Sodium Reaction Facility (SRF) (Hanford Reuse Option) to shipping the sodium to INL for conversion in the existing SPF at the MFC, with modifications (Idaho Reuse Option).

Table S–2 outlines key activities under each of the three components (disposition of facilities, RH-SCs, and bulk sodium) and compares these parameters by alternative.

Table S–2. Comparison of the FFTF Decommissioning Alternatives

	Alternative 1: No Action	Alternative 2: Entombment	Alternative 3: Removal
Facility Disposition			
Facility equipment and components left in place under inert gas blanket	✓		
Dismantlement of RCB and adjacent support buildings		✓	✓
Removal of reactor vessel (internal piping and equipment, attached depleted-uranium shield)			✓
Onsite disposal of reactor vessel (internal piping and equipment, attached depleted-uranium shield)			✓
Removal and onsite disposal of radioactive or chemical waste	✓	✓	✓
Backfill and revegetation of ancillary facility areas		✓	
Backfill and revegetation of Property Protected Area			✓
Landfill barrier over RCB		✓	
Administrative controls for 100 years	✓		
Postclosure care and/or institutional controls for 100 years		✓	✓
Disposition of Remote-Handled Special Components			
Removal and storage on site per FONSI[a]	✓	✓	✓
Treatment at the Hanford Site		✓	✓
Treatment at Idaho National Laboratory		✓	✓
Onsite disposal		✓	✓
Offsite disposal		✓	✓
Disposition of Bulk Sodium			
Onsite storage	✓	✓	✓
Onsite conversion to caustic sodium hydroxide solution		✓	✓
Offsite conversion to caustic sodium hydroxide solution		✓	✓
Caustic sodium hydroxide solution shipped to the Waste Treatment Plant		✓	✓

[a] Per 2006 FONSI regarding *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington* (DOE 2006a:Appendix B).

Note: For a description of facilities and technologies, see Section S.3.2.

Key: FFTF=Fast Flux Test Facility; FONSI=Finding of No Significant Impact; RCB=Reactor Containment Building.

S.2.3 Waste Management Alternatives

The Waste Management alternatives evaluated in this *TC & WM EIS* were constructed to address the essential components of the proposed actions: onsite storage and disposal of waste from Hanford and other DOE sites and closure of waste disposal facilities. In developing these alternatives, DOE considered a range of options for each component.

> **Waste Management Alternatives**
>
> **Alternative 1:** No Action
>
> **Alternative 2:** Disposal in IDF, 200-East Area Only
>
> **Alternative 3:** Disposal in IDF, 200-East and 200-West Areas

S.2.3.1 Storage and Treatment

Waste storage options range from continued storage of LLW, MLLW, and TRU waste at existing facilities, with limited acceptance of offsite-waste shipments[2] (No Action Alternative), to expansion of Hanford facilities' storage capacity to accommodate limited shipments of LLW and MLLW from offsite

[2] Limited shipments of offsite LLW, MLLW, or TRU waste would continue to be sent to Hanford, consistent with the January 6, 2006, enforceable Settlement Agreement signed by DOE, Ecology, the Washington State Attorney General's Office, and the U.S. Department of Justice, as amended on June 5, 2008 (*State of Washington v. Bodman* [Civil No. 2:03-cv-05018-AAM]).

DOE sources (action alternatives). Hanford-generated waste would continue to be processed on site in existing facilities (No Action Alternative) or in expanded facilities (action alternatives). As appropriate, offsite waste would be treated off site prior to shipment to Hanford.

S.2.3.2 Disposal

Waste disposal options include disposal on or off site. Disposal of waste on site would be influenced by the volume of waste produced and whether the waste could meet the criteria for disposal in a near-surface onsite facility or at an offsite facility (e.g., WIPP). Options for onsite disposal include using existing disposal facilities such as the lined LLBG trenches, expanding existing disposal facilities (IDF-East), and building new facilities (IDF-West and the proposed RPPDF). The difference between the two action alternatives is that only IDF-East would be used to support Waste Management Alternative 2, but both IDFs would be used to support Waste Management Alternative 3. Under the No Action Alternative, any further construction of IDF-East would be discontinued, and the existing LLBG trenches would support planned activities.

Because of the large number of combinations of IDF and RPPDF configurations that could support the 11 Tank Closure alternatives and 3 FFTF Decommissioning alternatives, three waste disposal groups were analyzed under both action alternatives (Waste Management Alternatives 2 and 3). The size, capacity, and number of facilities associated with each disposal group were based on the amounts and types of waste generated under each of the three sets of action alternatives (Tank Closure, FFTF Decommissioning, and Waste Management). Table S–3 outlines Disposal Groups 1 through 3 under Waste Management Alternatives 2 and 3.

Table S–3. Waste Management Alternatives – Disposal Groups

	Facility	Capacity (million cubic meters)	Operations Through (year)	Tank Closure Alternatives Supported	FFTF Decommissioning Alternatives Supported
Waste Management Alternative 2					
Disposal Group 1	IDF-East RPPDF	1.2 1.08	2050	2B, 3A, 3B, 3C, 4, 5, 6C	2, 3
Disposal Group 2	IDF-East RPPDF	0.425 8.37	2100	2A, 6B	2, 3
Disposal Group 3	IDF-East RPPDF	0.425 8.37	2165	6A	2, 3
Waste Management Alternative 3					
Disposal Group 1	IDF-East RPPDF IDF-West	1.1 1.08 0.09	2050	2B, 3A, 3B, 3C, 4, 5, 6C	2, 3
Disposal Group 2	IDF-East RPPDF	0.340 8.37	2100	2A, 6B	2, 3
	IDF-West	0.09	2050		
Disposal Group 3	IDF-East RPPDF	0.340 8.37	2165	6A 6A	2, 3 2, 3
	IDF-West	0.09	2050	6A	2, 3

Note: For a description of facilities, see Section S.3.3. To convert cubic meters to cubic yards, multiply by 1.308.

Key: FFTF=Fast Flux Test Facility; IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; RPPDF=River Protection Project Disposal Facility.

S.2.3.3 Closure

Options range from operating the proposed RPPDF and IDF(s) indefinitely using administrative controls (No Action Alternative) to closing these facilities by covering them with landfill barriers followed by postclosure care. Closure type does not vary among the alternatives; both Waste Management Alternatives 2 and 3 include closing the proposed RPPDF and IDF(s) under engineered modified RCRA Subtitle C barriers.

Table S–4 outlines key activities by alternative for waste storage, treatment, and disposal, as well as facility closure.

Table S–4. Comparison of the Waste Management Alternatives

	Alternative 1: No Action	Alternative 2: Disposal in IDF, 200-East Area Only	Alternative 3: Disposal in IDF, 200-East and 200-West Areas
Storage and Treatment			
Existing storage and treatment of LLW, MLLW, and TRU waste at CWC	✓		
Expanded storage and treatment of LLW, MLLW, and TRU waste at CWC		✓	✓
Existing storage and treatment of LLW, MLLW, and TRU waste at WRAP and T Plant	✓		
Expanded storage and treatment of LLW, MLLW, and TRU waste at WRAP and T Plant		✓	✓
Disposal			
Continued disposal of onsite non-CERCLA, nontank LLW and MLLW in onsite lined trenches	✓	✓	✓
Construction of IDF-East terminated and facility deactivated	✓		
Disposal of tank, onsite non-CERCLA, FFTF decommissioning, waste management, and offsite LLW and MLLW at IDF-East		✓	
Disposal of tank waste only at IDF-East and onsite non-CERCLA, FFTF decommissioning, waste management, and offsite LLW and MLLW at IDF-West			✓
Disposal of rubble, ancillary equipment, and soils (not highly contaminated) from closure activities at proposed RPPDF		✓	✓
Closure			
None	✓		
Landfill closure of IDF(s) and RPPDF		✓	✓
Administrative control for 100 years	✓		
Postclosure care for 100 years		✓	✓

Note: For a description of facilities and technologies, see Section S.3.3.

Key: CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; CWC=Central Waste Complex; FFTF=Fast Flux Test Facility; IDF=Integrated Disposal Facility; IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WRAP=Waste Receiving and Processing Facility.

S.3 OVERVIEW OF FACILITIES AND TECHNOLOGIES

This section includes a discussion of the major existing and proposed facilities and technologies involved in the essential components of tank closure, FFTF decommissioning, and waste management.

S.3.1 Tank Closure

S.3.1.1 Tank Waste Storage

Single-Shell Tanks. SSTs were built in the 200 Areas of Hanford from 1943 to 1964 to store liquid radioactive waste created by the production and separation of plutonium (see Figure S–2). An SST is a single-wall underground storage tank with carbon steel sides and bottom surrounded by a reinforced-concrete shell. The total nominal holding capacity of the SSTs is approximately 356 million liters (94 million gallons) (DOE 2003a), and the tanks currently contain approximately 122 million liters (32 million gallons) of radioactive and hazardous waste (DOE 2003b). These tanks contain salt cake and sludge; most of their free liquids were evaporated or transferred to the newer DSTs to reduce the potential consequences of leaks.

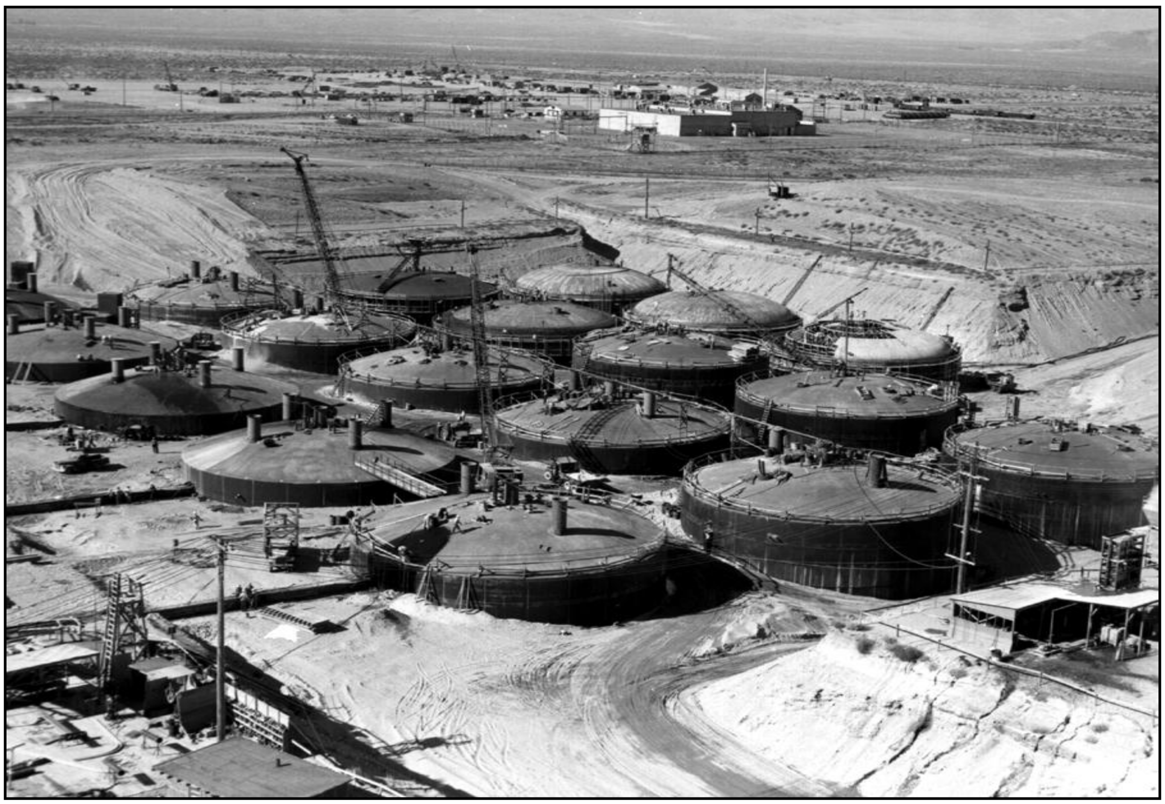


Figure S–2. Single-Shell Tanks Under Construction at the Hanford Site, 1947 to 1948

The tops of the tanks are buried approximately 2.4 meters (8 feet) below ground to provide radiation shielding. The larger tanks have multiple risers (shielded openings) that provide tank access from the surface. These risers provide access points for monitoring instrumentation, video observation, tank ventilation systems, and sampling. As analyzed in this *TC & WM EIS*, 67 of the 149 SSTs are known or suspected to have leaked liquid waste to the environment between the 1950s and the present, some of which has reached the groundwater. However, it is likely that some of the tanks have not actually leaked. Estimates of the total leak loss range from less than 2.8 million liters (750,000 gallons) to as much as 3.97 million liters (1,050,000 gallons) (Hanlon 2003).

Double-Shell Tanks. DSTs were built from 1968 to 1986. The DSTs contain a carbon steel tank inside a carbon steel–lined, reinforced-concrete tank. This design provides improved leak detection and waste containment. To date, no leaks have been detected in the annulus, the space between the inner and outer tanks that houses equipment to detect and recover waste in the event of a leak from the inner tank. Like the SSTs, the DSTs are buried below ground and have risers for tank monitoring and access. The 28 DSTs have a total nominal holding capacity of 121 million liters (32 million gallons) (DOE 2003a) and currently contain approximately 85 million liters (22.5 million gallons) of radioactive and hazardous waste, generally liquids and settled salts (DOE 2003b). Some tanks also contain a bottom layer of sludge.

Tank Farms. These SSTs and DSTs are distributed among 18 tank farms in the 200 Areas of Hanford. The 200 Areas are divided into east and west components (200-East Area and 200-West Area), and each tank farm contains 2 to 18 tanks. As shown in Figures S–3 and S–4, the 200-West Area includes 6 SST farms (S, SX, T, TX, TY, and U) and 1 DST farm (SY), and the 200-East Area includes 6 SST farms (A, AX, B, BX, BY, and C) and 5 DST farms (AN, AP, AW, AY, and AZ). Also shown in these figures are facilities proposed under the Tank Closure action alternatives.

S.3.1.2 Tank Waste Retrieval

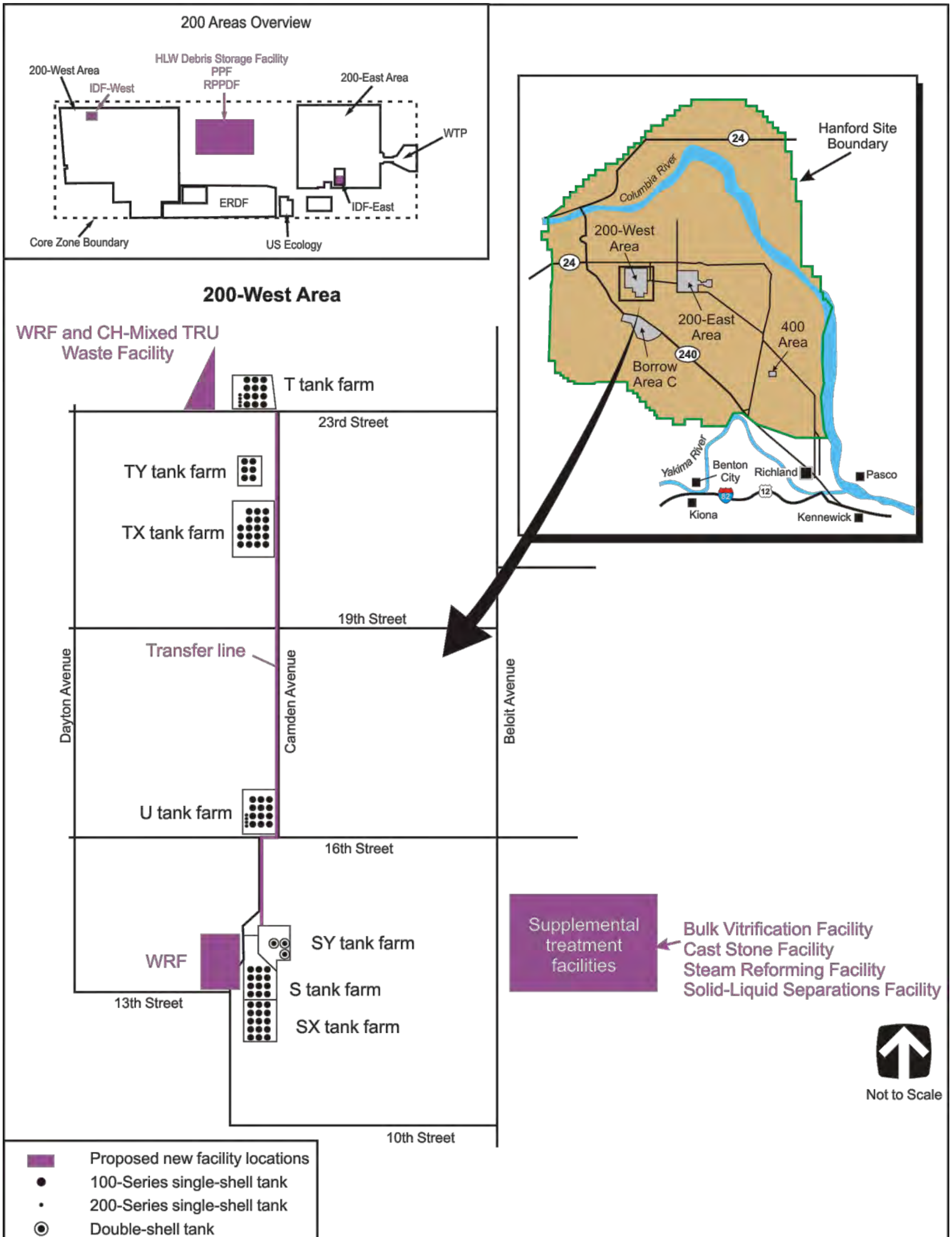
DOE evaluated four retrieval systems to determine whether they could achieve the goal of 90 percent (Tank Closure Alternative 5), 99 percent (Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, and 6C), or 99.9 percent (Tank Closure Alternatives 4, 6A, and 6B) retrieval of tank waste.

Modified Sluicing. Nozzles inserted into a tank pump liquid into it in a controlled manner. This sluicing liquid dissolves soluble waste materials and/or breaks down solids into waste slurry (watery mixture of insoluble waste materials), depending on its pressure and flow rate, and transfer pumps inside the tank pump the waste slurry to a receiver tank at approximately the same rate as sluice liquid is pumped into the tank (DOE 2003a). This system is expected to retrieve waste to levels consistent with the 90 and 99 percent retrieval goals.

Mobile Retrieval System. This system retrieves waste by mobilizing it physically, using an in-tank vehicle, or by pumping in sluicing liquid from nozzles on the vehicle or on an articulated-mast system, which is a rotating arm extending from a stationary mast positioned in the center of the tank. The mobilized waste is then pumped out of the tank using vacuum hose-and-nozzle assemblies that are part of the in-tank vehicle and articulated-mast system. After retrieval, the vehicle can be used to rinse the tank walls and in-tank equipment (DOE 2003a). This system is expected to retrieve waste to levels consistent with the 90 and 99 percent retrieval goals.

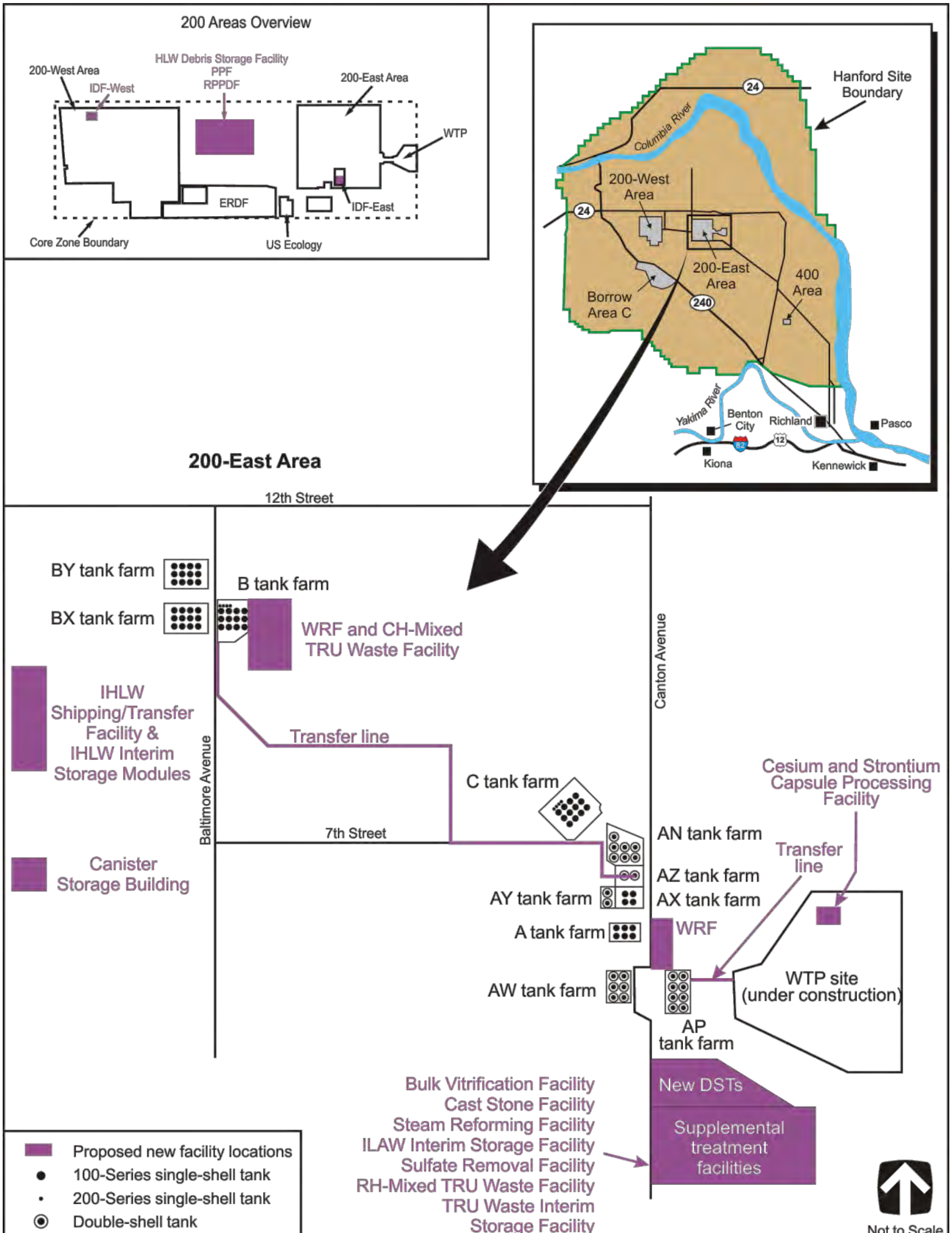
Vacuum-Based Retrieval. Instead of water, air is the conveyance medium for this vacuum system, which is deployed from an articulated-mast system in the center of the tank. The rotating arm can reach the entire tank base of one series of tanks, but only a portion of the base of another series, whose tanks have a larger diameter (DOE 2003a). This system is expected to retrieve waste to levels consistent with the 90 and 99 percent retrieval goals.

Chemical Wash System. If the foregoing retrieval methods were not adequate, chemicals could be introduced into a tank to dissolve the remaining waste into a solution that could be removed from the tank more easily. Chemicals could be introduced and solutions removed via the same equipment used to introduce and remove sluicing liquid or waste if the construction materials could withstand the chemicals and chemical cleaning solutions. Selection of chemicals would be tank specific (DOE 2003a). This system, coupled with the mobile retrieval and vacuum-based retrieval systems, is capable of retrieving 99.9 percent of the waste in the tanks.



Key: CH=contact-handled; ERDF=Environmental Restoration Disposal Facility; HLW=high-level radioactive waste; IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; PPF=Preprocessing Facility; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WRF=Waste Receiver Facility; WTP=Waste Treatment Plant.

Figure S–3. 200-West Area Proposed New Tank Closure Facility Locations



Key: CH=contact-handled; DST=double-shell tank; ERDF=Environmental Restoration Disposal Facility; HLW=high-level radioactive waste; IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; PPF=Preprocessing Facility; RH=remote-handled; RPPDF=River Protection Project Disposal Facility; TRU=transuranic; WRF=Waste Receiver Facility; WTP=Waste Treatment Plant.

Figure S–4. 200-East Area Proposed New Tank Closure Facility Locations

S.3.1.3 Tank Waste Transfer

Tank waste must be transferred between tanks and from tanks to treatment facilities. None of the existing SST transfer lines would be used. However, an extensive existing system of underground piping connecting all of the DSTs is operated routinely. The modified sluicing and mobile and vacuum-based retrieval systems would use hose-in-hose transfer lines on or near the surface, and new underground transfer lines would be built for distances that exceeded the reach of the hose-in-hose lines. WRFs would help facilitate waste transfers, when necessary, by temporarily storing waste; conditioning it by dissolution, dilution, or size reduction of particles in the waste slurry; and providing batches for subsequent transfer. These facilities could also recirculate sluicing liquids back to the tanks (DOE 2003a).

S.3.1.4 Tank Waste Treatment

Treatment technologies and associated facilities aim to change the physical or chemical character of the tank waste to make it less hazardous; reduce its volume; or make it safer for transport, storage, or disposal.

Waste Treatment Plant. The WTP is the cornerstone of tank waste treatment. It is designed to receive tank waste via pipelines from tank farms, pretreat waste, and convert the pretreated waste into a glass form (by a process called vitrification) for storage, pending disposal. WTP facilities include the following:

> **Waste Treatment Plant**
>
> The Waste Treatment Plant (WTP) is currently being constructed at the Hanford Site. Site work associated with the project began in late 2001. The project is more than 62 percent complete. When completed, the WTP will be the largest radiochemical processing facility in the world. It will occupy 26 hectares (65 acres) and be composed of 38,000 tons of steel, 300 kilometers (1 million feet) of piping, 1,500 kilometers (5 million feet) of electrical cable, and 203,000 cubic meters (265,000 cubic yards) of concrete. The WTP will consist of four major facilities: the Pretreatment Facility, Low-Activity Waste Vitrification Facility, High-Level Radioactive Waste Vitrification Facility, and an Analytical Laboratory.

- Pretreatment Facility – Removes selected radionuclides and HLW solids from retrieved tank waste to produce an HLW stream and a LAW stream
- HLW Vitrification Facility – Receives an HLW stream from the Pretreatment Facility, combines it with glass-forming materials, and melts (using HLW melters) the combination to produce a molten glass waste form to be poured into stainless steel containers for cooling into a solid for storage, pending disposal
- LAW Vitrification Facility – Receives a LAW stream from the Pretreatment Facility, combines it with glass-forming materials, and melts (using LAW melters) the combination to produce a molten glass waste form to be poured into stainless steel containers for cooling into a solid for storage, pending disposal
- Analytical Laboratory – Characterizes samples of tank waste and ensures that final glass products meet all regulatory requirements and standards

An illustration of these four main components, as well as various support facilities, is provided as Figure S–5.

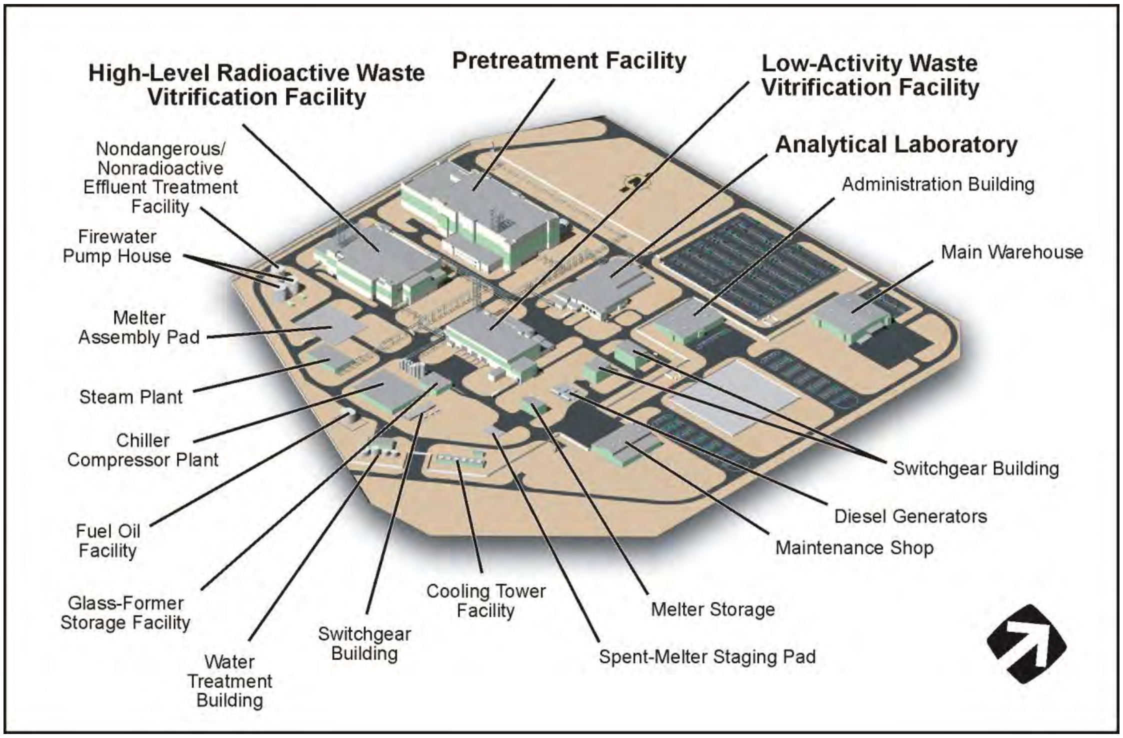


Figure S–5. Waste Treatment Plant Facilities

Thermal Supplemental Treatment: Bulk Vitrification and Steam Reforming. Thermal supplemental treatment would be used to treat a portion of the tank waste under certain alternatives (3A, 3C, 4, and 5). There are two representative thermal supplemental treatment processes analyzed in this *TC & WM EIS*: bulk vitrification and steam reforming.

Bulk Vitrification. Under Tank Closure Alternatives 3A, 4, and 5, the bulk vitrification process would convert LAW into a solid glass by drying the waste, mixing it with Hanford soils, and applying an electric current within a large steel container (electrodes would be inserted into the waste and sand/soil mixture). The electric current would melt the mixture of waste and soils into a liquid glass, and a temporary offgas hood would collect air emissions and direct them toward a treatment system. Waste would be processed in vitrification boxes, which would cool for 3 days before being transferred to a disposal site. The vitrified waste form would look similar to obsidian, a dark, volcanic glass. Glass performs well as a waste form for containment of radioactive and hazardous waste because it is durable and leach resistant. Bulk Vitrification Facilities are proposed for the 200-East and 200-West Areas.

Steam Reforming. Steam reforming is the thermal supplemental treatment technology that would be used under Tank Closure Alternative 3C. Steam reforming, a technology used for nonradioactive processing in the petroleum industry, can also be used to treat radioactive waste. Pretreated waste or LAW retrieved from the tanks (i.e., waste retrieved from the designated LAW stream) would be diluted with water so it could be pumped into a vessel. Within the vessel, the water would be heated into steam, and the LAW material would be converted to granular minerals. Offgas would be treated and discharged. The steam reforming waste would be placed in steel packages for storage or disposal. Steam Reforming Facilities are proposed for the 200-East and 200-West Areas.

Nonthermal Supplemental Treatment: Cast Stone. The cast stone process is the representative nonthermal supplemental treatment process that would be used under Tank Closure Alternatives 3B, 4, and 5 to treat a portion of the tank waste by mixing LAW with grout-formers (e.g., Portland cement), pumping the mix into disposal containers, and allowing it to solidify into a cement matrix. The formulation of grout-forming materials to be added to waste could be adjusted for batch-to-batch variations in waste retrieved from different tanks. Cast Stone Facilities are proposed for the 200-East and 200-West Areas.

Supplemental Treatment: Tank-Derived Mixed Transuranic Waste. Under Tank Closure Alternatives 3A, 3B, 3C, 4, and 5, waste that could be designated as mixed TRU waste would be retrieved from tanks, treated, and packaged for disposal at WIPP instead of being vitrified in the WTP. Mixed TRU waste would be categorized as CH- or RH-TRU waste. Retrieved mixed TRU waste would be transferred to the CH-Mixed TRU Waste Facilities, mobile facilities that could be moved between the tank farms in the 200-East and 200-West Areas, or to the RH-Mixed TRU Waste Facility, which would be permanently located in the 200-East Area, for dewatering and packaging. Liquids extracted during dewatering would be treated in the WTP, while solids would be packaged for eventual disposal at WIPP. Processed mixed TRU waste would have to meet the criteria for transportation, interim onsite storage in a new TRU Waste Interim Storage Facility, and disposal at WIPP.

Contact-handled transuranic waste has a radiation level less than or equal to 200 millirem* per hour at the surface of a waste container and can be safely handled by direct contact.

Remote-handled transuranic waste is packaged transuranic waste whose external surface dose rate exceeds 200 millirem per hour. This waste requires special shielding and handling to protect workers and the public.

* A millirem (one-thousandth of a rem) is a unit of measure of absorbed ionizing radiation used to assess the biological effects of a given dose of any type of radiation.

Solid-Liquid Separations Processes. The WTP would be used to pretreat tank waste before it was processed in supplemental treatment facilities in the 200-East Area. By contrast, a new Solid-Liquid Separations Facility in the 200-West Area would be used to pretreat tank waste that may contain low cesium-137 concentrations before it was processed in supplemental treatment facilities in the 200-West Area, avoiding the necessity of cross-site transport. After using gravity settling and decanting processes, half of the solids would go to the WTP for further processing. After chemical separation of strontium-90 and TRU radionuclides from the rest of the waste, a portion of these radionuclides would be forwarded to the WTP and the balance to a selected supplemental treatment facility in the 200-West Area.

Sulfate Removal. Sulfate removal, a pretreatment process considered under Tank Closure Alternative 5, could increase —waste loading” (i.e., the amount of waste per volume) in the glass produced in the WTP LAW Vitrification Facility, thereby reducing the amount of glass produced in the WTP over the life of the tank closure project by approximately 35 percent. Sulfate removal could also mitigate the risk of a corrosive molten sulfur salt layer that could build up in the LAW Vitrification Facility and potentially damage the LAW melter. First, strontium nitrate would be added to the tank waste, causing sulfate to separate out as a strontium sulfate precipitate, then this resulting strontium sulfate precipitate would be immobilized in a grout waste form. This process would be used between pretreatment at the WTP and treatment in the LAW Vitrification Facility. Waste destined for the supplemental treatment facilities would not be treated using this process. Two new facilities—a Sulfate Removal Facility and an associated grout facility—would be built in the 200-East Area adjacent to the WTP to implement this process.

Technetium-99 Removal. Technetium-99, a long-lived, mobile radionuclide present in the tank waste, is of particular interest with regard to the performance of waste forms over the long term. For this reason, Tank Closure Alternatives 2B and 3B call for removal of technetium-99 from the LAW stream during WTP pretreatment via ion exchange. Technetium-99 would then be transferred to the HLW stream and vitrified as glass. Under Tank Closure Alternatives 2A; 3A; 3C; 4; 5; 6B, Base and Option Cases; and 6C, the majority of the technetium-99 would remain in the LAW stream.

Cesium and Strontium Capsule Treatment. Cesium and strontium waste would be extracted from the cesium and strontium capsules currently in storage in the WESF in the 200-East Area and prepared into a slurry waste stream in a new Cesium and Strontium Capsule Processing Facility to be built in the 200-East Area. This stream would then be sent to the WTP for treatment. Under all Tank Closure alternatives except Alternative 1, these activities would occur during a separate campaign after all HLW from the tanks had been treated.

S.3.1.5 Interfacing Facilities – Tank Waste Storage, Retrieval, and Treatment

The following facilities would interface with storage, retrieval, and treatment of tank waste:

Liquid Waste Processing Facilities. These facilities process liquid waste. The ETF and Liquid Effluent Retention Facility process liquid waste streams (effluents) designated as radioactive and dangerous wastes. The Treated Effluent Disposal Facility disposes of nonradioactive, nondangerous liquid effluents. These three facilities would require life extension upgrades or replacements over the course of the tank closure project. Replacements of the ETF are analyzed in this EIS to support the Tank Closure alternatives. The Liquid Effluent Retention Facility and the Treated Effluent Disposal Facility are assumed to operate through the end of the WTP service life.

242-A Evaporator. This facility uses an evaporation system to reduce the volume of liquid tank waste, concentrating radioactive waste solutions so that fewer tanks are required to store liquid waste. This evaporation process supports tank farm management and WTP operations. The facility would have to be replaced multiple times under some Tank Closure alternatives.

222-S Analytical Laboratory. This facility supports tank waste characterization, tank waste retrieval, and waste feed delivery to the WTP. Upgrades to, or replacements of, this facility are not analyzed in this EIS because its use is expected to be limited following the start of operations of the WTP Analytical Laboratory.

S.3.1.6 Tank Waste Disposal

Onsite disposal of tank waste would occur in one or two IDFs and the proposed RPPDF (see Section S.3.3 for a discussion of these facilities).

Hanford would also provide onsite interim storage facilities for IHLW,[3] as well as a new TRU Waste Interim Storage Facility for interim storage of mixed TRU waste pending its shipment to WIPP.

S.3.1.7 Tank Farm Closure

Three approaches to SST farm closure are evaluated under various Tank Closure action alternatives, as follows:

Landfill Closure. Landfill closure of the SST system (Tank Closure Alternatives 2B, 3A–3C, 4 [selective landfill closure], 5, and 6C) would generally include the following:

- Grout-filling of tanks
- Grouting of ancillary equipment (e.g., waste transfer system piping, in-tank equipment) and WRFs

[3] The analyses in this EIS are not affected by recent DOE plans to study alternatives for the disposition of the Nation's SNF and HLW because the EIS analysis shows that vitrified HLW can be stored safely at Hanford for up to 145 years until disposition decisions are made and implemented.

- Removal of some ancillary equipment and near-surface contaminated soils

- Placement of a surface barrier (i.e., modified RCRA Subtitle C barrier or Hanford barrier)

- Postclosure care

Clean Closure. Clean closure of the SST system (Tank Closure Alternatives 4 [selective clean closure], 6A, and 6B) would include the following:

- Removal of ancillary equipment, WRFs, and SSTs.

- Deep soil removal.

- Additional waste preprocessing/packaging – Highly contaminated tank debris, ancillary equipment, rubble, and soils would receive further treatment in a new PPF and would be disposed of in the proposed RPPDF or stored in shielded boxes on concrete pads. Depending on the alternative selected, the contaminated liquid waste from the acid wash would be neutralized and treated in either the WTP, resulting in IHLW, or the PPF using a glass melter, resulting in an immobilized waste form similar to ILAW. The IHLW would require long-term onsite storage, and the PPF glass would be disposed of in an IDF.

Landfill Barriers

Landfill barriers are above-grade, multilayered engineered surface barriers that would be placed over the tank farms and associated ditches to provide long-term containment and hydrologic protection of the waste site as part of landfill closure. These barriers would be constructed as a set of five “lobes” (two in the 200-East Area and three in the 200-West Area). The two types considered in this environmental impact statement are the following:

- Modified Resource Conservation and Recovery Act Subtitle C barrier (Tank Closure Alternatives 2B, 3A–3C, 4, 6C) – 8 layers, 2.7 meters (9 feet) thick; designed to provide 500-year protection without maintenance
- Hanford barrier (Tank Closure Alternative 5) – 10 layers, 4.6 meters (15 feet) thick; assumed to be designed to provide 1,000-year protection without maintenance; added protection against wind and water erosion, as well as plant, animal, and human intrusion

Selective Clean Closure. Tank Closure Alternative 4 considers a hybrid approach to clean-close the BX and SX tank farms and landfill-close the balance of the SST system.

S.3.2 FFTF Decommissioning

FFTF is a DOE-owned, formerly operating thermal liquid-metal (sodium)-cooled research and test reactor (involved in projects such as fuel performance testing and medical isotope production) in the 400 Area of Hanford. Forty-five structures or buildings within the FFTF complex, shown in Figure S–6, would be decommissioned under the FFTF Decommissioning alternatives.

These buildings fall under the following groups:

Reactor Containment Building. The RCB is the major facility of the FFTF complex to be decommissioned. The building consists of a carbon steel cylindrical reactor-containment vessel 56.7 meters (186 feet) high by 41.1 meters (135 feet) in diameter, with reinforced-concrete cells from grade level to about 24 meters (78 feet) below grade. Below-grade structures containing the greatest radionuclide inventories include the reactor vessel, the Interim Examination and Maintenance Cell, the Test Assembly and Conditioning Station, and the Interim Decay Storage Vessel.

Reactor Support Buildings and Auxiliary Buildings. Surrounding the RCB are various buildings, structurally independent from it and designed to withstand natural forces such as earthquakes.

Figure S–6. Fast Flux Test Facility Complex

S.3.2.1 Facility Disposition

Under FFTF Decommissioning Alternative 1, sodium residuals would be left in the RCB under an inert gas blanket. Under FFTF Decommissioning Alternatives 2 and 3, all sodium residuals would be removed from the RCB systems or treated in place. The sodium would be drained from plant systems to the extent practicable, followed by passivation and/or flushing with water to stabilize the residuals. Sodium residuals in small-diameter piping would be treated in the 400 Area after the components were removed from the reactor plant.

> **Passivation**
>
> Treatment of a metal to reduce the chemical reactivity of its surface.

Demolition debris, radioactive waste, and other regulated hazardous waste would be handled in the same manner under both action alternatives; only the volume of waste would change. Debris not placed in the RCB or other voids or used as backfill would be transported to an IDF for disposal. The radioactive liquid waste volume resulting from treatment of the sodium residuals would be reduced at FFTF, either through ion exchange and reuse or evaporation. The remaining liquids would be transported to the 200 Area ETF for processing and disposal. It was assumed for analysis purposes that a 90 percent reduction in volume could be achieved prior to shipment to the ETF.

> **Ion Exchange**
>
> A physiochemical process that removes anions (negatively charged ions) and cations (positively charged ions), including radionuclides, from liquid streams (usually water) for the purpose of purification or decontamination.

Various end-state approaches were evaluated in accordance with the specific objectives of each FFTF Decommissioning alternative. Under the No Action Alternative, the facilities and infrastructure within the Property Protected Area, including the RCB, would undergo long-term surveillance with appropriate monitoring and controls to ensure that environmental and safety concerns are minimized for the foreseeable future. Under FFTF Decommissioning Alternative 2, Entombment, a landfill barrier, such as an engineered modified RCRA Subtitle C barrier, would be constructed over the remains of the demolished RCB and other buildings that contained radioactive and/or hazardous wastes. In addition, the barrier would extend over part or all of the immediately adjacent facility footprints. Postclosure care would include monitoring of air, groundwater, and the vadose zone. Under FFTF Decommissioning Alternative 3, Removal, no barrier would be built. The RCB and other buildings would be demolished, and the reactor vessel, including piping, equipment, and attached depleted uranium shield, would be removed. Below-grade portions of structures would be backfilled with soil and compacted to eliminate void spaces, contoured to prevent natural settling resulting in depressions, and revegetated. Institutional controls or postclosure care may be established and continue for 100 years after revegetation of the area was complete.

S.3.2.2 Disposition of Remote-Handled Special Components

The four FFTF traps that are considered RH-SCs are as follows:

- Sodium cold trap – part of the coolant system when FFTF operated. The sodium cannot be fully drained, and high dose rates make it impossible to do manual work. DOE is proposing to flush the system with sodium, drain it to the maximum extent possible, and allow any remaining sodium to freeze. The cold trap would be removed using remote operations and special shielding.
- Cesium trap – a filter designed to remove radioactive cesium from sodium. The sodium cannot be fully drained. Accordingly, it would be removed using remote operations and special shielding.
- Sodium vapor traps (two) – components in isolated cells within the RCB that served to minimize sodium vapor transport into the primary gas system piping. One vapor trap has large quantities of cesium-137, and considerable quantities have migrated beyond the trap into the downstream gas piping systems. Both of these traps would be remotely removed and shielded.

Removal of these RH-SCs from FFTF would be completed as part of the deactivation work and is evaluated in the *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington* (DOE 2006a). The removed components would be stored within the FFTF complex under all FFTF Decommissioning alternatives. Under FFTF Decommissioning Alternatives 2 and 3, the RH-SCs would then be sent to the selected treatment facility once it had been built and was ready to receive them. FFTF Decommissioning Alternatives 2 and 3 include two ―options" associated with treatment of RH-SCs at a Hanford or an INL facility: the Hanford Option and the Idaho Option.

Hanford Option. Because no facility currently exists at Hanford to treat these traps, under the Hanford Option, DOE proposes building a new facility (the RTP) similar to INL's RTP. RH-SCs would be removed from FFTF, stored on site at Hanford until the new RTP was permitted and built, then treated in the new RTP and disposed of in an IDF.

Idaho Option. DOE has an RTP at INL to handle similar INL waste streams. Under the Idaho Option, RH-SCs from Hanford would be removed and shipped to INL for treatment in this facility, then disposed of either at the Nevada National Security Site or in a Hanford IDF.

Remote Treatment Project

The Remote Treatment Project at the Hanford Site or Idaho National Laboratory would include these primary design features:

- A waste processing cell used to prevent the release of radioactive and hazardous contaminants to the environment
- Waste processing equipment designed to handle and process the remote-handled waste received in liners, drums, and large waste boxes

S.3.2.3 Disposition of Bulk Sodium

Bulk sodium would undergo a sodium reaction process to produce a caustic sodium hydroxide solution at either the proposed SRF at Hanford or the existing SPF at INL's MFC. These two options associated with treatment of bulk sodium at Hanford or INL are called, respectively, the Hanford Reuse Option and the Idaho Reuse Option. At either facility, the basic chemical reaction would be an exothermic (i.e., heat-emitting) reaction with water producing a caustic sodium hydroxide solution that yields hydrogen gas.

Sources of Radioactively Contaminated Bulk Sodium

- Fast Flux Test Facility reactor coolant systems and storage vessels
- Hallam Reactor
- Sodium Reactor Experiment

Process steps at the SRF or the existing SPF at INL's MFC would include the following:

- Transfer liquid sodium from the storage tank into the facility's reaction vessel.
- Control the reaction by adjusting the injection rate of liquid reactants.
- Manage offgases emitted (e.g., through filtration).
- Pump the final caustic solution to a fill station for storage in transportation tanks or drums.

Hanford Reuse Option. Because no facility currently exists at Hanford to process the bulk sodium, under the Hanford Reuse Option DOE proposes to build the SRF directly adjacent to the existing Sodium Storage Facility to reduce cost and integrate operations. The Sodium Storage Facility would store bulk sodium until it could be transferred to the SRF for processing. Following processing, the resulting caustic sodium hydroxide solution would be reused in processing tank waste at the WTP or controlling Hanford tank corrosion.

Idaho Reuse Option. Under the Idaho Reuse Option, the bulk sodium would be stored in the Sodium Storage Facility at Hanford until it was shipped via truck and/or rail to INL for processing in the existing SPF at INL's MFC. Following processing, the resulting caustic sodium hydroxide solution would be returned to Hanford for WTP waste processing or tank corrosion control.

S.3.3 Waste Management

S.3.3.1 Solid Waste Management Facilities

Solid Waste Operations Complex. Facilities within the Hanford Solid Waste Operations Complex (SWOC) perform functions consistent with primary-waste management processes: receipt, staging, storage, repackaging, treatment, and shipment of waste. Each process must be compliant with waste acceptance criteria. The five components of the existing SWOC are as follows:

Low-Level Radioactive Waste Burial Grounds. The LLBGs are waste disposal areas, two in the 200-East Area and six in the 200-West Area, containing lined and unlined trenches (see Figure S–7) of varying size and depth used for the disposal of LLW and MLLW and for retrievable storage of TRU waste. Particular trenches are dedicated to the receipt of LLW and MLLW, Navy reactor compartments, TRU waste, packages difficult to handle, or radioactive lead solids. The trenches receive, store, and dispose of waste in generally the same manner, regardless of waste type. TRU waste packages are occasionally retrieved from the LLBGs for assessment of the condition of the waste containers and their immediate surroundings as an aid in planning future operations.

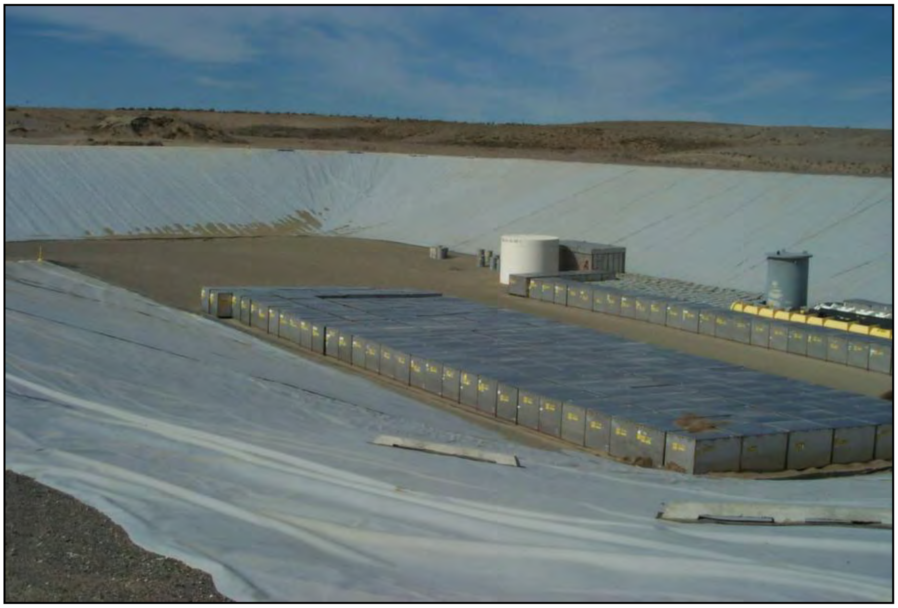


Figure S–7. Low-Level Radioactive Waste Burial Ground Lined Disposal Trench

Central Waste Complex. The Central Waste Complex (CWC) includes storage buildings and other structures that receive and store waste pending its processing at other waste management facilities. The buildings and structures shown in Figure S–8 provide segregated areas for safely separating groups of incompatible wastes.

Figure S–8. Aerial View of the Central Waste Complex

T Plant. Primary activities of the T Plant are waste storage, decontamination, treatment, repackaging, and verification. Solid-waste processing includes the addition of absorbent or grout material to the waste, neutralization of waste, and amalgamation of mercury or other metals. Additional services include the sampling of drum headspace to support the TRU waste program and the management of analytical samples returned from commercial laboratories. Major facilities include the 221-T Canyon, which has RH waste processing capabilities, and the 2706-T/TA/TB Facility. An overview of the complex is provided as Figure S–9.

Figure S–9. Aerial View of the T Plant Complex

Waste Receiving and Processing Facility. Primary activities at WRAP are confirming, sampling, repackaging, certifying, storing, and treating waste for shipment to a treatment, storage, and disposal unit. WRAP, shown in Figure S–10, receives CH waste containers from Hanford generators (e.g., LLBGs, the CWC) and offsite generators. Radioactive waste is processed in three operational areas, and inspections of sealed and open waste containers are conducted.

Figure S–10. Waste Receiving and Processing Facility

Integrated Disposal Facility (200-East or 200-West Area). The primary mission of an IDF is to dispose of LLW and MLLW. The existing facility, IDF-East (see Figure S–11), consists of two cells—one for LLW and one for MLLW—and is expandable. A similar facility is proposed for construction in the 200-West Area under Waste Management Alternative 3.

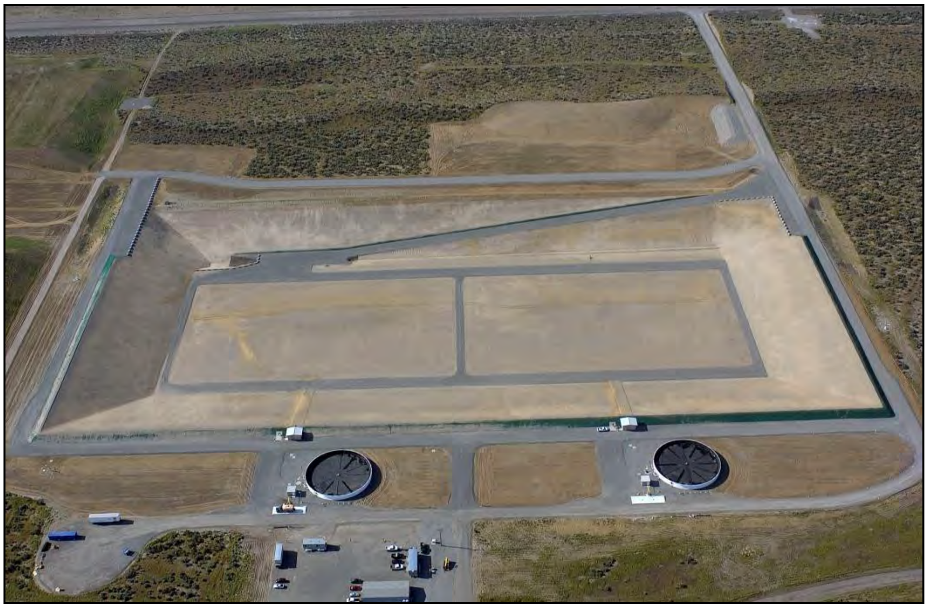


Figure S–11. 200-East Area Integrated Disposal Facility

Figures S–12 and S–13 show the locations of these waste management facilities in the 200-West and 200-East Areas, respectively.

S.3.3.2 Proposed Solid Waste Management Activities

A number of specific activities for the management of LLW and MLLW from Hanford and other DOE sources are proposed under the Waste Management alternatives. The following is a brief description of these activities:

- **Use existing LLBGs.** Continue using two lined trenches for the receipt and disposal of onsite LLW and MLLW. Under the No Action Alternative, use them through 2035. Under Alternatives 2 and 3, use them through 2050, though the waste would be disposed of in an IDF once it becomes operational.

- **Expand the CWC.** Add solid waste storage capacity.

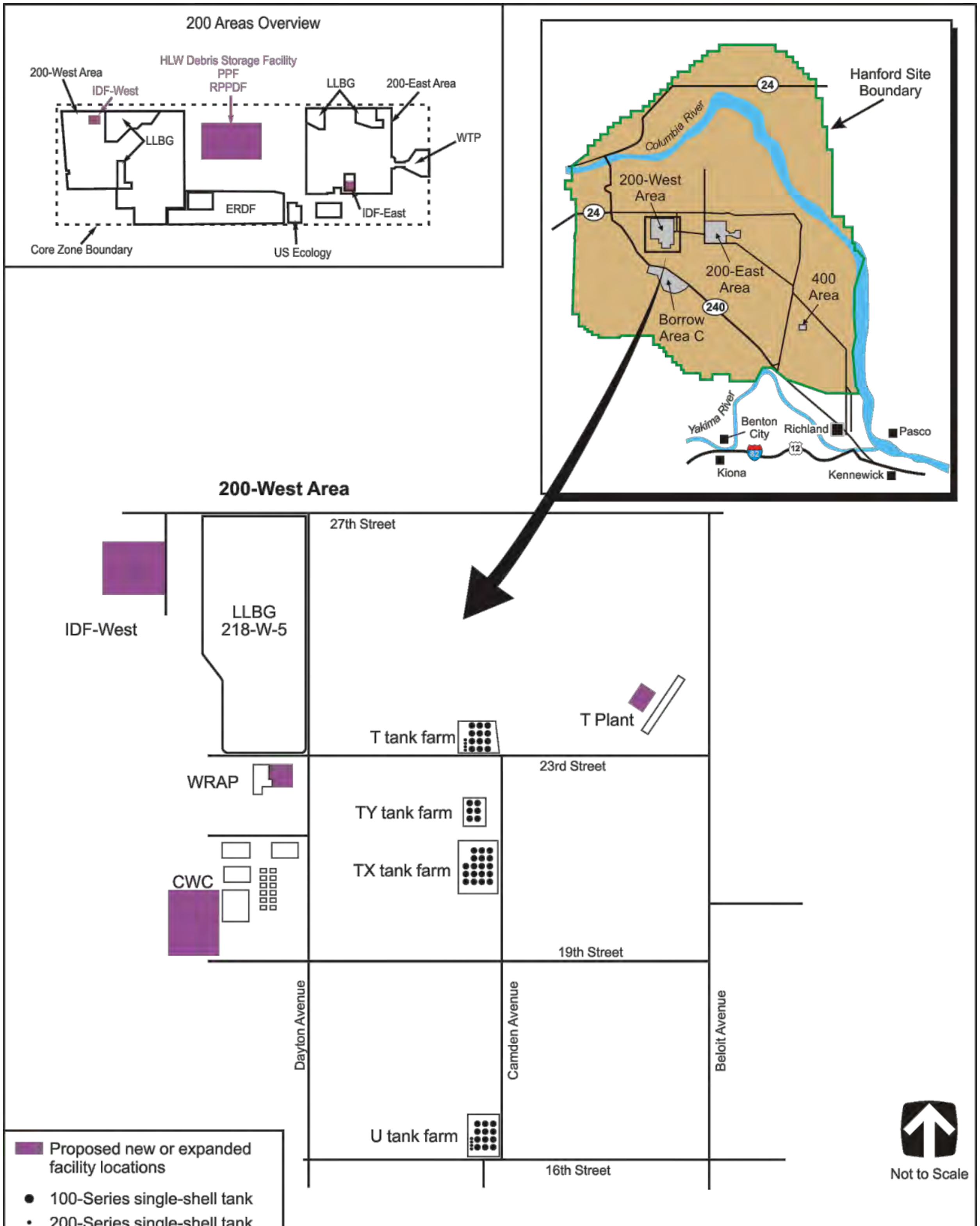
- **Expand the T Plant.** Add a new building to the T Plant complex to process high-dose (i.e., RH) or oversized waste packages.

- **Expand WRAP.** Add facilities to process additional LLW, MLLW, and CH-TRU waste at the CWC and RH-TRU waste at WRAP.

- **Deactivate (No Action Alternative), expand or reduce (Alternative 2), or build a second IDF (Alternative 3).** These IDF activities include the following:

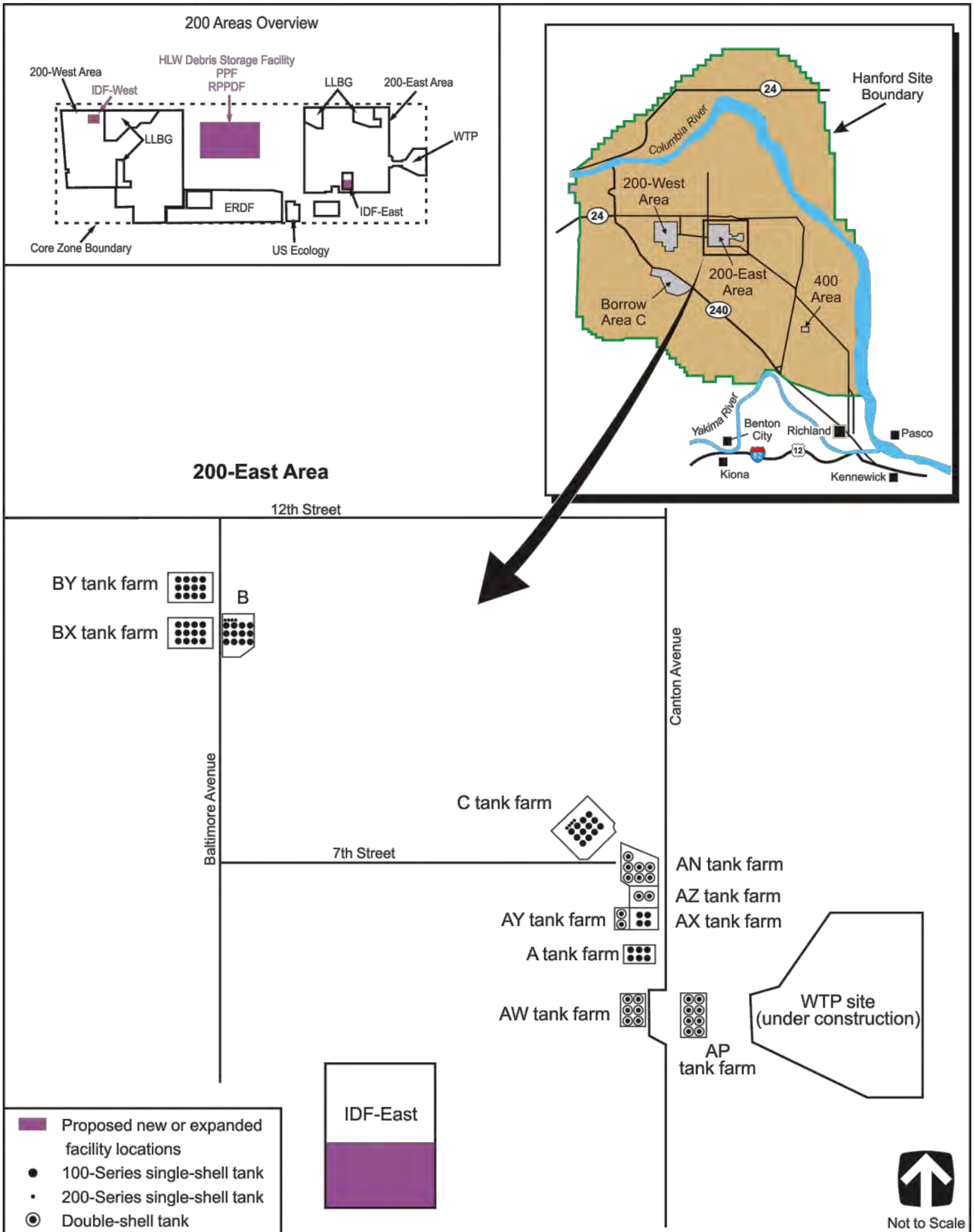
  – ***Alternative 1 (No Action Alternative).*** Deactivate the existing IDF site, remove the liner, and backfill the site to the natural grade.

  – ***Alternative 2.*** Expand or reduce the capacity of the existing 200-East Area facility, depending on the disposal group selected.



Key: CWC=Central Waste Complex; ERDF=Environmental Restoration Disposal Facility; HLW=high-level radioactive waste; IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; LLBG=low-level radioactive waste burial ground; PPF=Preprocessing Facility; RPPDF=River Protection Project Disposal Facility; WRAP=Waste Receiving and Processing Facility; WTP=Waste Treatment Plant.

Figure S–12. 200-West Area Waste Management Facility Locations



Key: ERDF=Environmental Restoration Disposal Facility; HLW=high-level radioactive waste; IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility; LLBG=low-level radioactive waste burial ground; PPF=Preprocessing Facility; RPPDF=River Protection Project Disposal Facility; WTP=Waste Treatment Plant.

Figure S–13. 200-East Area Waste Management Facility Locations

  - ***Alternative 3.*** Build a facility in the 200-West Area. Dispose of Tank Closure alternative waste in the 200-East Area facility (capacity depends on the disposal group), and dispose of FFTF decommissioning waste, other onsite waste, and offsite DOE waste in the 200-West Area facility (capacity is fixed under all disposal groups).

- **Build the proposed RPPDF (action alternatives).** Dispose of waste resulting from closure activities in a new facility between the 200-East and 200-West Areas. The size and capacity depends on the disposal group selected.

- **Close the IDF(s) and the proposed RPPDF.** Use a barrier, and manage closed facilities using postclosure care.

S.4 TECHNOLOGIES AND OPTIONS CONSIDERED BUT NOT EVALUATED IN DETAIL IN THE ALTERNATIVES

In developing the range of reasonable alternatives for tank closure, FFTF decommissioning, and waste management, DOE examined numerous technologies and options. The technologies and options discussed in this section were initially considered but were subsequently dismissed as reasonable alternatives under NEPA for meeting DOE‘s purpose and need. The following sections provide a brief discussion of these technologies and options as applicable to the three sets of proposed actions and the basis for why they were deemed unreasonable and not considered further. A discussion has been added to Chapter 2, Section 2.6.4, of this EIS to address these factors relative to the Oregon Department of Energy‘s proposal that DOE add an additional Tank Closure alternative.

S.4.1 Tank Closure

Evaluation of tank waste disposal alternatives has been ongoing since waste storage in underground tanks was first recognized as a temporary solution to a long-term problem. Numerous technologies and approaches have been examined for the storage, retrieval, treatment, and disposal of tank waste, as well as closure of the SST system. This section summarizes the alternatives and technologies that were considered but not evaluated in detail in this *TC & WM EIS*. The following criteria were used to determine whether an alternative or technology would be appropriate for detailed evaluation:

- Is the alternative or technology relevant to the purpose and need for agency action in this EIS?
- Is the alternative or technology technically viable and practicable?
- Can the alternative or technology be designed to be protective of human health and the environment, with practicable mitigation measures?
- Is the technology sufficiently mature to allow detailed evaluation? Would the costs and time required to develop the technology for application at Hanford be feasible?
- Is the technology appreciably different from an alternative already included in this EIS, or does it offer potential advantages in terms of effectiveness, costs, or impacts on human health and the environment?

If the answer to any of the above questions was no, DOE determined that the alternative or technology was not reasonable for further consideration and evaluation in this *TC & WM EIS*. Therefore, the following waste storage, retrieval, treatment, and disposal and tank closure approaches were deemed unreasonable and were not evaluated in detail.

S.4.1.1 Waste Storage

Some alternatives may require additional storage capacity above and beyond the current DST capacity. The selected storage arrangement is the construction of new below-grade DSTs. The following storage options were considered, but not evaluated:

Modification of Existing Canyon Facilities. This option was not evaluated in detail because (1) the existing canyon facilities are not designed for storage of large volumes of liquid waste; (2) the existing radiation and contamination levels would result in elevated personnel exposure; (3) the low volume of storage space would not be cost-effective; and (4) environmental permitting is highly uncertain.

New Above-Grade DSTs. This option was not evaluated in detail because (1) there are technical disadvantages associated with shielding large above-grade tanks and (2) the resources required for construction and operation of new above-grade tanks would be similar to those associated with below-grade tanks.

Staging Retrieved Waste in SSTs. This option was not evaluated in detail in this *TC & WM EIS* due to several factors, e.g., the SSTs have been declared unfit for use and cannot readily be made compliant with current regulations. However, DOE is considering staging waste in SSTs as an option to building additional DSTs. Ecology has identified a number of factors that would influence its potential acceptance of this approach, including (1) upgrades of systems with additional leak detection, monitoring, and mitigation capabilities; (2) replacement of waste transfer pumps, transfer lines, and ventilation systems; (3) maintenance of the interim stabilization criteria after the waste is staged; (4) development of a liquid waste management plan; and (5) agreement on selection criteria for the tanks to be used. At present, criteria for determining which tanks are suitable for staging have not been identified. Infrastructure needs have been identified at a system level, but specific design information related to a particular tank or tank farm has not been identified. In addition, liquid waste management issues associated with meeting the interim stabilization criteria would have to be addressed. If these issues were addressed, SST staging would be similar to the proposed waste transfers and waste storage activities for WRFs and/or DSTs. Near-term actions associated with these activities, as well as their impacts, are evaluated under Tank Closure Alternatives 2 through 6.

S.4.1.2 Waste Retrieval

A number of technologies were initially considered for deployment to retrieve waste from the SSTs. Each of these technologies is flexible regarding the general equipment configuration, fluid velocities and flow rates, and methods of operation. Some are better suited to tank-specific considerations such as riser availability, waste condition, or in-tank interferences. Although the following technologies were ultimately not considered reasonable for detailed analysis in this *TC & WM EIS*, that does not preclude their future consideration as potentially viable approaches for retrieving waste from the SSTs.

Past-Practice Sluicing, Fluidic Mixing, and Salt Cake Dissolution. These retrieval technologies were addressed in the *TWRS EIS*. However, they are very similar to, and effectively encompassed by, the retrieval technologies evaluated in this *TC & WM EIS*.

S.4.1.3 Treatment Technologies

The following treatment and pretreatment technologies were initially considered but were eliminated from detailed consideration in this *TC & WM EIS*:

Active Metal Reduction. This LAW treatment technology was not evaluated in detail in this *TC & WM EIS* primarily due to its relative technical immaturity and complexities, as well as operational safety issues related to flammable gas generation.

Fractional Crystallization. This technology was not evaluated in detail as a supplemental pretreatment process due to concerns over waste form performance with respect to nitrate, difficulty of operations, complexity of the process, and lack of deployment history.

HLW and LAW Vitrification with Phosphate Glass. This technology was not evaluated in detail because the phosphate glass formula has not been proven compatible with production-scale melters, and the resulting product glass has not been shown to meet the waste acceptance technical requirements for DOE's Civilian Radioactive Waste Management System (DOE 2007). Other WTP melter configurations and waste forms were not evaluated in detail in this *TC & WM EIS* because of DOE's intention to construct and operate the WTP as currently designed, using current melter technology and glass formulations.

Preprocessing Tank Waste with a Plasma Mass Separator. This technology was not evaluated in detail in this *TC & WM EIS* due to its present immaturity and the need for further testing and demonstration of its applicability to managing Hanford tank waste.

S.4.1.4 Disposal

The following disposal approaches were initially considered, but were eliminated from detailed evaluation in this *TC & WM EIS*:

Disposal of Hanford Waste to Offsite Facilities. The *WM PEIS* (DOE 1997a) provided analysis of potential environmental impacts of broad alternatives for DOE's waste management program to provide a basis for DOE decisions on programmatic configurations of sites for waste management activities. One of DOE's decisions based on the *WM PEIS* addressed disposal of LLW and MLLW, and DOE decided that Hanford would dispose of its own LLW and MLLW on site (65 FR 10061). There is no new information that would compel reconsideration of this decision. Therefore, the option of disposing of these wastes off site was eliminated from further consideration in this EIS.

Disposal of HLW Melters Taken Out of Service. As the HLW melters have not been installed or operated, a high degree of uncertainty exists about their operation, lifespan, waste characterization and waste classification. As a result, this *TC & WM EIS* assumed a conservative (i.e., economically and with consideration of the human health impacts of melter storage, transportation, and disposal) disposition of the melters; the HLW melters would be stored on site. Thus, onsite disposal was eliminated from further consideration in this EIS.

S.4.1.5 Tank System Closure

The following technologies, each of which could provide in situ (in place) soil remediation and offer alternatives to support tank farm closure, were considered but not selected for detailed analysis in this *TC & WM EIS*:

Subsurface Barriers. This option was not evaluated in detail because (1) use of subsurface barriers would reduce only a small amount of the risk associated with waste retrieval, tank stabilization, and surface-barrier technologies; (2) the performance of subsurface barriers is highly uncertain, so their use is expected to have a limited impact on risk, but would carry a high cost-benefit ratio; and (3) the potential risks to workers involved in implementing subsurface-barrier approaches would increase substantially compared to the risks associated with using surface barriers and waste retrieval.

In Situ Soil Remediation. A variety of in situ soil remediation technologies were initially considered but were not evaluated in detail because of the difficulties and uncertainties associated with placement of treatment zones and their performance verification. In situ treatment generally requires long periods of time and provides questionable uniformity of treatment because of the variability in soil and aquifer characteristics. The overall efficacy of in situ processes is also relatively difficult to verify.

Gravel-Filling of Tanks. Although gravel or grout could be used to adequately stabilize waste tanks structurally, and both are considered viable as a potential corrective action or emergency response, this *TC & WM EIS* does not evaluate this option in detail for closure purposes, primarily because the gravel would not prevent water intrusion and possible mobilization of contaminants from stabilized residual waste. In addition, the use of grout, rather than gravel, represents a more conservative estimate for commitment of resources.

S.4.1.6 The Oregon Proposal

On January 4 and March 18, 2010, the Oregon State Department of Energy submitted comments on the *Draft TC & WM EIS* that included a proposal (which they referred to as the ―Oregon proposal") to combine various tank closure elements to form a new Tank Closure alternative, and suggested that this proposed new alternative be analyzed in this *TC & WM EIS*.

DOE has reviewed Oregon's proposal for a new Tank Closure alternative and has determined that the proposal is technically infeasible as defined. Accordingly, the Oregon proposal cannot be considered a reasonable alternative and was not analyzed in detail in this *TC & WM EIS*. In its entirety, the Oregon proposal fails to account for the required tradeoffs inherent in the design, capacity, and implementation schedule associated with its storage, retrieval, treatment, disposal, and closure elements. DOE reached this conclusion based upon a number of factors. The WTP, which is currently designed and more than 62 percent constructed, has inadequate waste treatment throughput capacity to support completing the processing of the tank waste through LAW treatment by the year 2040, as suggested in the Oregon proposal. Technical and resource shortcomings for meeting the required waste throughput in 18 years of operation include inadequate tank waste storage, retrieval, and pretreatment capacity. The Oregon proposal also assumes the implementation of iron phosphate (i.e., phosphate glass) and fractional crystallization treatment technologies. However, both of these technologies have been assessed by DOE repeatedly over the last decade with the conclusion remaining that they are not mature enough for implementation and therefore do not merit further analysis in this EIS. Additional discussions on these two treatment technologies are included in Appendix E, Section E.1.3.3.3. Further, the Oregon proposal assumes that DOE is making a decision on the closure of the cribs and trenches (ditches) through this EIS; however, their closure is not within the scope of the EIS proposed actions, as described in Section S.1.3.2.

Several elements of the Oregon proposal were included in the alternatives analyses, sensitivity analyses, and/or potential mitigation measures. These include additional tank waste storage capacity, dry storage of the cesium and strontium capsules, onsite interim storage of all IHLW canisters, and selective clean closure of a number of SST farms, as well as clean closure of all the SST farms. Clean closure of the cribs and trenches (ditches) is analyzed in the cumulative impacts analysis sections of this EIS.

S.4.2 Fast Flux Test Facility

This section describes the potential alternatives that were considered, but not evaluated in detail, for decommissioning the FFTF complex, managing and disposing of one or more of the FFTF waste streams, or disposing of Hanford's radioactively contaminated bulk sodium inventory. These alternatives were not evaluated in detail because DOE determined they are not reasonable due to current Hanford activities, likely environmental impacts, public and worker safety considerations, and implementation issues and concerns.

Restart FFTF to Support Isotope Production or Research Missions. On the basis of previous NEPA evaluations, DOE decided to shut down and deactivate FFTF (DOE 1995a, 2000a). Deactivation of the facility is currently in progress; therefore, restart is not considered to be a reasonable alternative.

Turn the FFTF Complex into a Museum or Find Another Alternative Use. During the public scoping meetings for this *TC & WM EIS*, some of the comments received suggested cleaning out FFTF and turning it into a publicly accessible museum. Because the structures would need to be maintained for an indefinite period of time, this approach would be closely analogous to the No Action Alternative. This suggestion was not considered a reasonable alternative due to the radiological and unique chemical hazards associated with the facility, the age of the buildings, and the lack of a financial sponsor. However, any documentation necessary to preserve information regarding FFTF‘s historic aspects will be developed in conjunction with the State Historic Preservation Officer and applicable regulations.

Interim Safe Storage. The production reactors along the Columbia River are undergoing a cleanout process, referred to as ―interim safe storage." As part of that process, all SNF is being removed, surrounding buildings are being demolished, the main reactor building is being cleaned and partially dismantled (to the shield walls), and a new roof is being installed. In the interim safe storage configuration, storage and maintenance costs are very low and the reactor can be left for up to 75 years, allowing radionuclides to decay before further action would be needed, thus reducing worker exposure during waste disposal. With respect to decommissioning FFTF, the interim safe storage approach would be closely analogous to the No Action Alternative, with enhanced isolation of the RCB. Because of the chemical hazards associated with the reactive sodium coolant and the relatively low cumulative doses associated with the proposed decommissioning activities, as well as DOE‘s desire to accelerate and complete the required cleanup actions, this approach was not deemed a reasonable alternative.

Recycle Debris. One option for disposal of some of the demolition debris would be to recycle the steel and concrete. The potential presence of radioactivity and hazardous chemicals and the expense required to decontaminate the debris and ensure its suitability for unrestricted release made this option impractical. Therefore, it was not considered a reasonable alternative.

Convert Bulk Sodium to a Solid Waste. DOE previously decided to convert Hanford‘s bulk sodium to a caustic sodium hydroxide solution for use in tank waste processing at the WTP (Ecology, EPA, and DOE 2002), thus avoiding the expense of converting the reactive sodium to a solid form and disposing of it as radioactive waste, as well as the cost of procuring additional resources needed to treat Hanford‘s tank waste. DOE did not consider this option, primarily based on the loss of a beneficial use of the sodium, to be a reasonable alternative that required further evaluation.

Alternative Barrier Concepts. Under FFTF Decommissioning Alternative 2, a closure barrier would be constructed over the FFTF buildings in accordance with applicable regulations. Because the final design of the barrier is still to be determined, various design options were considered. For the *TC & WM EIS* analysis, the modified RCRA Subtitle C barrier was assumed.

S.4.3 Waste Management

As discussed in Section S.1, DOE and Washington State executed a Settlement Agreement on January 6, 2006, ending the NEPA litigation (*State of Washington v. Bodman* [Civil No. 2:03-cv-05018-AAM]) regarding the state‘s concerns about the groundwater-related and other analyses presented in the *HSW EIS* (DOE 2004). This agreement and the concurrent MOU between DOE and Ecology (DOE and Ecology 2006) directed DOE to revise or update analyses from the *HSW EIS*, as appropriate, in the new *TC & WM EIS*. The new EIS would also ensure all waste types addressed in the *HSW EIS* alternatives and cumulative impact analyses are integrated. The alternatives evaluated in this *TC & WM EIS* represent the range of reasonable alternatives covering a full spectrum of tank closure, FFTF decommissioning, and waste management activities. In addition, any combination of the Waste Management No Action Alternative with waste-generating Tank Closure or FFTF Decommissioning alternatives was considered unreasonable, and therefore activities necessary to support such alternative combinations were not evaluated in this *TC & WM EIS*.

S.5 SUMMARY OF ENVIRONMENTAL IMPACTS AND KEY FINDINGS

S.5.1 Approach to Impacts Analysis

Methods of assessing environmental impacts for this *TC & WM EIS* varied for each resource area. For example, pollutant emissions from tank waste retrieval, treatment, disposal, and closure activities were evaluated for their effect on ambient concentrations and their compliance with ambient standards. Comparison with regulatory standards is a commonly used method for benchmarking environmental impacts, and appropriate comparisons have been made in a number of resource analyses to provide perspective on the magnitude of identified impacts. For waste management, waste generation rates were compared with the capacities or expected capacities of waste management facilities. Impacts on all resource areas were estimated using a consistent set of input variables and computations. Moreover, efforts were made to ensure that calculations in all areas used accepted protocols and up-to-date models.

Resources Analyzed in This Environmental Impact Statement

- Land resources
- Infrastructure
- Noise and vibration
- Air quality
- Geology and soils
- Water resources
- Ecological resources
- Cultural and paleontological resources
- Socioeconomics
- Public and occupational health and safety
  - Normal operations
  - Facility accidents/intentional destructive acts
  - Transportation
- Environmental justice
- Waste management
- Industrial safety

Potential environmental impacts were analyzed for each resource area by alternative, as well as by a combination of alternatives, referred to in this *TC & WM EIS* as “alternative combinations.” Combined impact analyses were not performed for noise or facility accidents due to the nature of these resource areas. This *TC & WM EIS* also analyzed potential cumulative impacts (i.e., impacts that can result from individually minor, but collectively significant, actions taking place over a period of time). The cumulative impacts analysis involved combining the impacts on key resource indicators (within select alternative combinations) with the impacts of other past, present, and reasonably foreseeable activities in the region of influence (ROI). The ROIs for different resources can vary widely in extent. For example, the ROI for geology and soils would be confined to Hanford and nearby offsite areas, whereas the air quality ROI would include more-distant areas that could be affected by activities proposed for each *TC & WM EIS* alternative. In general, cumulative impacts were calculated by adding the impacts values for the baseline affected environment (i.e., conditions attributable to past and present actions by DOE and other public and private entities), the *TC & WM EIS* alternatives, and other future actions. These cumulative values were then weighed against appropriate impact indicators (e.g., regulatory standards, capacity limits, current usage) to determine the potential for impact.

Region of Influence

A site-specific geographic area in which the principal direct and indirect effects of actions are likely to occur and are expected to be of consequence for local jurisdictions.

Alternative Combinations Used in the Cumulative Impacts Analysis

Several hundred impacts scenarios could result from the potential combinations of the 11 Tank Closure, 3 FFTF Decommissioning, and 3 Waste Management alternatives when factored with their associated option cases and waste disposal groups. For purposes of the cumulative impacts analysis, the following combinations of alternatives were chosen to capture the range of actions and associated overall short- and long-term impacts that could result from implementation of the three sets of proposed actions:

- **Alternative Combination 1:** All No Action Alternatives
- **Alternative Combination 2:** Tank Closure Alternative 2B (Expanded WTP Vitrification; Landfill Closure), FFTF Decommissioning Alternative 2 (Entombment) with the Idaho Option for disposition of RH-SCs and the Hanford Reuse Option for disposition of bulk sodium; and Waste Management Alternative 2 (Disposal in IDF, 200-East Area Only) with Disposal Group 1
- **Alternative Combination 3:** Tank Closure Alternative 6B, Base Case (All Vitrification with Separations; Clean Closure); FFTF Decommissioning Alternative 3 (Removal) with the Idaho Option for disposition of RH-SCs and the Hanford Reuse Option for disposition of bulk sodium; and Waste Management Alternative 2 (Disposal in IDF, 200-East Area Only) with Disposal Group 2

Alternative Combination 1 represents the potential short-term impacts resulting from minimal U.S. Department of Energy (DOE) action and the greatest long-term impacts with respect to groundwater. Alternative Combination 2 is a midrange case representative of DOE's Preferred Alternative(s). Alternative Combination 3 would result in maximum reasonably foreseeable short-term impacts on most resource areas in terms of the intensity of the potential impact and therefore represents, on the whole, a combination that would result in maximum potential short-term impacts, but would likely have the lowest long-term impacts on groundwater.

S.5.2 Analytical Uncertainties

The following sections describe the technical and regulatory uncertainties inherent in the analysis of the Tank Closure, FFTF Decommissioning, and Waste Management alternatives evaluated in this *TC & WM EIS*.

S.5.2.1 Tank Closure

Even with the knowledge and experience gained over the past decade of managing Hanford‘s tank system, there are still many technical and regulatory uncertainties. Some of these uncertainties cannot be fully resolved until tank waste storage, retrieval, treatment, and disposal and tank closure activities have been demonstrated. A major focus of the RPP is managing these uncertainties while making progress toward tank closure. The following is a brief discussion, by primary component, of the overarching technical and programmatic uncertainties facing the RPP in its tank waste management program.

S.5.2.1.1 Tank Waste Storage

There is uncertainty associated with tank waste inventories in terms of both chemical and radioactive contaminants. A prioritized sampling and estimation process, the BBI process, was developed for estimation of the inventories present in the HLW tanks. However, in some cases, the number of available measurements was limited and estimates of the tank inventories for some waste constituents were supplemented by process modeling techniques. Thus, due to the spatial variability in the characteristics and concentrations of the waste, and gaps in knowledge of separations processes and waste management conditions, uncertainty exists regarding the estimated waste inventories in the HLW tanks. In addition, records that were kept on the waste that was put into the tanks, waste that was transferred between tanks, and waste that was decanted off and discharged into shallow subsurface cribs and trenches (ditches) were not always complete. Although the overall quantities of radioactive constituents generated at Hanford are relatively well known, the actual amounts in specific waste sites are more uncertain. Also, the tank waste contains a complex mix of chemical and radioactive constituents that is constantly changing as chemical reactions and radioactive decay occur. This results in an uncertain and continuously changing inventory of waste. This *TC & WM EIS* addresses this uncertainty by making conservative assumptions regarding the waste inventories based on process knowledge, assay results of sampled waste, or other available information from waste generators.

S.5.2.1.2 Tank Waste Retrieval

The efficiency and effectiveness of current methods for retrieving waste from the tanks (e.g., modified sluicing) and the quantity of liquid waste that may be released to the environment during retrieval are uncertain. For example, it is not certain whether the modified sluicing technique can retrieve all types of sludge or the dense, highly compacted waste on the tank bottom. Using large volumes of liquids during modified sluicing also may cause liquids to be released through cracks in the tanks. Other retrieval techniques such as the mobile retrieval system, vacuum-based retrieval, and chemical washing have been used on only a limited basis at Hanford and other DOE sites, so those technologies carry potential uncertainties as well.

S.5.2.1.3 Tank Waste Treatment

Separation of waste into HLW and LAW streams and vitrification of these waste streams have been conducted at other DOE sites. However, these treatment processes have not been performed on Hanford tank waste on a production scale; therefore, the impacts and operating efficiencies are uncertain. Full-scale production of ILAW using the LAW melter, bulk vitrification, cast stone, and steam reforming processes has not been conducted anywhere within the DOE complex. As a result, uncertainties exist regarding waste loading and waste form quality and performance. The adequacy of the ETF to treat anticipated secondary waste from the WTP and supplemental treatment facilities is also uncertain.

S.5.2.1.4 Tank Waste Disposal

The waste classifications of certain waste streams have not yet been determined by DOE. For analysis purposes, this *TC & WM EIS* assumes for some of the alternatives that historical processing data will support management of some of the tank waste as non-HLW. For other alternatives (e.g., Alternatives 6A and 6B), the opposite is assumed (i.e., all tank waste is assumed to be HLW).

An IHLW glass disposal location has not been established at this time. This EIS assumed the use of a thin-wall, IHLW glass canister to maximize the volume of IHLW put into each canister and minimize the number of canisters needed. Due to uncertainties regarding final canister design and capacity, as well as offsite shipping schedules, the EIS analysis included assumptions for onsite (interim) storage of IHLW glass until disposition decisions are made and implemented.

The impacts associated with disposal of ILAW are also uncertain at this time. Because the release rates for ILAW glass are low and are supported by experiment, there is less uncertainty regarding this waste form compared to bulk vitrification glass, cast stone waste, and steam reforming waste. Of these supplemental treatment ILAW forms, the least amount of characterization and testing has been performed for steam reforming waste. Thus, the greatest degree of uncertainty relative to waste form performance is associated with the steam reforming waste.

S.5.2.1.5 Tank System Closure

Clean closure of the tank farms requires construction and use of containment structures during the removal of 149 SSTs, ancillary equipment, and deep soil. There is substantial uncertainty associated with the technical feasibility, schedules, costs, and worker impacts associated with these clean closure activities. This *TC & WM EIS* evaluated the use of engineered structures, including shielding and remote equipment, to minimize worker exposure when removing the tanks. Even with these mitigation measures, the worker radiation dose would be an order of magnitude higher compared to that under landfill closure. Containment of air releases would be needed to mitigate impacts due to tank, ancillary equipment, and soil removal, requiring construction of movable containment structures. Although the technology for installation of such containment structures is understood, there is a large degree of uncertainty concerning the feasibility of installing these structures over a large area the size of a tank farm and, under some alternatives, of constructing and using multiple structures. There is also uncertainty related to the pathway identified for disposition of the tanks, which would need to be cut up and packaged. This EIS assumed that the tanks would be packaged and disposed of on site; however, they would have to go through the DOE Manual 435.1-1 process to determine the appropriate disposition pathway (i.e., whether waste is HLW, TRU waste, or LLW).

Selective clean closure/landfill closure evaluated in Tank Closure Alternative 4 would remove two of the tank farms, one in the 200-East Area and one in the 200-West Area, reducing the volume of material that is removed. However, this volume reduction would not lessen the high degree of technical uncertainties related to how soils would be removed and treated, or to the infrastructure and additional capability needed to manage the new waste generated from the removal. Although not to the same levels as those for clean closure, the following technical uncertainties exist: characteristics of borrow material, land and terrestrial resource disturbances, waste generation, and worker safety and health issues.

The technical uncertainties associated with tank removal and deep soil remediation beneath the tanks under the selective clean closure and clean closure alternatives would have to be weighed against the order(s)-of-magnitude increase in short-term impacts on resource areas that would result from implementing these alternatives.

The *TC & WM EIS* analyses rely on various modeling approaches to predict the consequences of RPP mission activities that DOE may undertake in the future. Some of these models are complex and rely on assumptions that are subject to a large degree of uncertainty, particularly when trying to predict potential impacts out to 10,000 years. One such uncertainty is how waste moves in the vadose zone and groundwater. The *TC & WM EIS* analyses assumed that both the groundwater flow field and infiltration rate will remain constant over 10,000 years, and that the location of the river channel will remain the same over the same period. These assumptions affect the ability to accurately predict when groundwater impacts would reach their peak. Long-term impacts analysis indicates that the largest potential impact on human health may be due to past-practice discharges to cribs and trenches (ditches) and past leaks from SSTs. Contaminant movement rates through the vadose zone for such releases strongly depend on the area saturated by the initial release and subsequent horizontal spreading of the released volume of liquid. These two sensitive variables cannot be known with certainty and, coupled with natural variability in precipitation, recharge, and vadose zone hydraulic conditions, make any estimate of a rate of release to the unconfined aquifer highly uncertain. Contaminant movement rates in the unconfined aquifer were projected with greater certainty by measuring past and current contaminant concentrations and calibrating the water-movement models to hydraulic-head measurements.

S.5.2.2 FFTF Decommissioning

It was assumed under FFTF Decommissioning Alternatives 2 and 3 that Hanford‘s bulk sodium inventory would be converted to a caustic solution for use in processing tank waste at the WTP or for Hanford tank corrosion control. However, there is uncertainty regarding whether these processing or corrosion control demands would require reuse of the entire available inventory or whether an alternative disposition pathway for this material would be necessary. There is also uncertainty regarding the potential shipment of RH-SCs to INL for processing, as no NRC-licensed transportation cask currently exists with the capacity to handle these components for shipment. For analysis purposes, this EIS assumes that a suitable transportation cask or other shielded container would be available at the time of removal to transport these components.

S.5.2.3 Waste Management

There is substantial uncertainty associated with the sources, volumes, and potential long-term performance of radioactive and chemical offsite waste inventories forecast for disposal at Hanford. Because similar uncertainties also exist regarding potential volumes and characteristic of the waste that would be generated on site, it was assumed for analysis purposes that proposed expansions to the Hanford waste management facilities (e.g., the CWC, T Plant, WRAP) would be required as soon as possible following issuance of the ROD for this *TC & WM EIS*.

S.5.3 Summary of Short-Term Environmental Impacts

The following section provides a summary-level comparison of the potential environmental impacts of implementing each of the *TC & WM EIS* alternatives. This section focuses on potential short-term impacts on the resource areas identified in Section S.5.1. Mitigation measures that could be used to avoid or reduce environmental impacts resulting from implementation of the alternatives are described in Chapter 7, (—Environmental Consequences and Mitigation Discussion"), Section 7.1, of this EIS.

Short-term impacts are associated with the active project phase during which construction, operations, deactivation, and closure activities would take place and extend through the applicable 100-year administrative control, institutional control, or postclosure care period. The comparison of impacts is presented to aid the decisionmakers and public in understanding the potential short-term environmental consequences of proceeding with each of these alternatives. Short-term impacts of Tank Closure alternatives are summarized in Table S–5; of FFTF Decommissioning alternatives, in Table S–6; and of Waste Management alternatives, in Table S–7.

Maximally Exposed Individual (MEI)

A hypothetical individual whose location and habits result in the highest total radiological or chemical exposure (and thus dose) from a particular source for all exposure routes (e.g., inhalation, ingestion, direct exposure). As used in this environmental impact statement, the MEI refers to an individual located off site, unless characterized otherwise in terms of time or location.

Latent Cancer Fatalities

Deaths from cancer resulting from, and occurring sometime after, exposure to ionizing radiation or other carcinogens.

Rem

A rem is a unit of dose equivalent that allows comparison of the biological effects of radionuclides that emit different types of radiation.

Person-rem

A person-rem is a unit of collective radiation dose applied to populations or groups; it is a unit for expressing dose when summed across all persons in a specified population or group.

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Land Resources											
Land use (Percent of total land commitment within either the Industrial-Exclusive Zone or Borrow Area C, as appropriate)	17 hectares (0.3 percent) committed to tank closure within the Industrial-Exclusive Zone. 2 hectares (0.2 percent) affected within Borrow Area C.	51 hectares (1 percent) committed to tank closure within the Industrial-Exclusive Zone. 29.1 hectares (3.1 percent) affected within Borrow Area C.	101 hectares (2 percent) committed to tank closure within the Industrial-Exclusive Zone. 95.1 hectares (10 percent) affected within Borrow Area C.	100 hectares (2 percent) committed to tank closure within the Industrial-Exclusive Zone. 100 hectares (11 percent) affected within Borrow Area C.	102 hectares (2 percent) committed to tank closure within the Industrial-Exclusive Zone. 92.3 hectares (10 percent) affected within Borrow Area C.	101 hectares (2 percent) committed to tank closure within the Industrial-Exclusive Zone. 92.7 hectares (10 percent) affected within Borrow Area C.	80.5 hectares (1.6 percent) committed to tank closure within the Industrial-Exclusive Zone. 102 hectares (11 percent) affected within Borrow Area C.	104 hectares (2.1 percent) committed to tank closure within the Industrial-Exclusive Zone. 117 hectares (13 percent) affected within Borrow Area C.	149 hectares (2.9 percent) committed to tank closure within and adjacent to the Industrial-Exclusive Zone. 86.2 hectares required outside of the Industrial-Exclusive Zone. 381 hectares (41 percent) affected within Borrow Area C. <u>*Option Case*</u> 126 hectares (2.5 percent) committed to tank closure within and adjacent to the Industrial-Exclusive Zone. 86.2 hectares required outside of the Industrial-Exclusive Zone. 458 hectares (49 percent) affected within Borrow Area C.	144 hectares (2.9 percent) committed to tank closure within and adjacent to the Industrial-Exclusive Zone. 240 hectares (26 percent) affected within Borrow Area C. <u>*Option Case*</u> 121 hectares (2.4 percent) committed to tank closure within and adjacent to the Industrial-Exclusive Zone. 316 hectares (34 percent) affected within Borrow Area C.	146 hectares (2.9 percent) committed to tank closure within the Industrial-Exclusive Zone. 104 hectares (11 percent) affected within Borrow Area C.

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

	Tank Closure Alternative										
Parameter/ Resource	**1 No Action**	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Land Resources *(continued)*											
Visual resources	Little change in the overall visual character of the 200 Areas and Borrow Area C.	Little change in the overall visual character of the 200 Areas and moderate change to Borrow Area C.	Little change in the overall visual character of the 200 Areas and a highly noticeable change to Borrow Area C, especially as seen from State Route 240 and nearby higher elevations.						Highly noticeable change in the visual character of both the 200 Areas and Borrow Area C, especially as seen from State Route 240 and nearby higher elevations.	Noticeable change to the visual character of the 200 Areas and a highly noticeable change to Borrow Area C, especially as seen from State Route 240 and nearby higher elevations.	
Infrastructure											
Total Requirements											
Electricity (million megawatt-hours)	0.12	35.6	17.9	14.1	12.1	20.1	14.8	12.2	185 *188*	21.1 *23.8*	17.9
Diesel fuel (million liters)	35.9	4,960	4,040	1,860	1,870	1,980	2,050	4,110	23,000 *23,100*	4,360 *4,440*	4,040
Gasoline (million liters)	4.61	221	156	116			133	124	714 *711*	216 *212*	156
Water (million liters)	3,300	208,000	86,300	77,300			82,200	92,500	643,000 *643,000*	92,600 *92,800*	86,300
Peak Annual Demand											
Electricity (million megawatt-hours)	0.035	0.56	1.18	0.79	0.48	0.84	0.55	0.63	1.93 *1.97*	1.25 *1.30*	1.18
Diesel fuel (million liters)	11.8	112	271	80.8	81.2	86.1	76.2	229	232 *235*	255 *259*	271
Gasoline (million liters)	1.0	5.36	8.23	5.03			10.9	5.89	8.92 *7.49*	6.61 *6.63*	8.23
Water (million liters)	1,090	3,720	3,590	2,220		2,210	2,180	3,830	6,570 *6,580*	3,530 *3,530*	3,590

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Noise and Vibration											
	Current noise levels reduced following WTP construction.	Negligible offsite impact of onsite activities. Minor traffic noise impacts.									
Air Quality											
Peak Year Incremental Criteria Pollutant Concentrations as Compared to Most Stringent Guideline or Standard (micrograms per cubic meter)[a]											
Carbon monoxide (1-hour) standard=40,000	23,300	**44,900**	**40,500**	**60,900**	**62,000**	**61,900**	40,000	**51,600**	35,100 *26,100*	38,500 *38,500*	37,900
Nitrogen oxides (1-hour) standard=188	**15,200**	**36,500**	**35,200**	**37,800**	**38,000**		**28,400**	**38,600**	**36,400** ***27,000***	**33,200** ***26,200***	**35,300**
PM_{10} (24-hour) standard=150	**546**	**1,990**	**4,910**				**3,360**	**5,320**	**5,150** ***3,880***	**5,510** ***2,080***	**4,960**
$PM_{2.5}$ (24-hour) standard=35	**546**	**1,990**	**4,910**				**3,360**	**5,320**	**5,150** ***3,880***	**5,510** ***2,080***	**4,960**
Sulfur oxides (1-hour) standard=197	24.0	70.7	105	132	88.2	87.6	77.9	112	58.9 *47.4*	71.5 *76.4*	105
Peak Year Incremental Toxic Chemical Concentrations (micrograms per cubic meter)[a]											
Ammonia (24-hour) ASIL[b]=70.8	26.1	19.9	12.0	12.2		12.3	12.1	12.3	10.5 *10.2*	12.2 *12.2*	11.7
Benzene (annual) ASIL[b]=0.0345	0.00252	0.00588	0.00459	0.00597	0.00622	0.00598	0.00354	0.00601	0.0048 *0.00311*	0.00460 *0.0037*	0.0046

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Air Quality *(continued)*											
Peak Year Incremental Toxic Chemical Concentrations (micrograms per cubic meter)[a] (continued)											
Mercury (24-hour) ASIL[b]=0.09	0.0	0.0059	**0.117**	0.0169	0.00786	0.0129	0.013	0.0182	0.00237 *0.00236*	**0.117** ***0.117***	**0.117**
Toluene (24-hour) ASIL[b]=5,000	1.69	4.3	3.62	6	6.26	6	3	5.42	3.72 *2.56*	3.96 *2.8*	3.63
Xylene (24-hour) ASIL[b]= NL	0.506	1.29	1.1	1.78	1.86	1.78	0.896	1.62	1.14 *0.747*	1.2 *0.84*	1.11
Geology and Soils											
Construction impacts	Negligible, incremental impact on geology and soils.	Small impact from construction, including potential for short-term soil erosion. Excavation depths limited to 12 meters.					Similar to Alternatives 2A through 3C, except extensive excavation work required for clean closure of BX and SX tank farms, with excavation depths of 20 meters to as much as 78 meters.	Similar to Alternatives 2A through 3C.	Similar to Alternatives 2A through 3C, except extensive excavation work required for clean closure of all tank farms, with excavation depths of 20 meters to as much as 78 meters.		Similar to Alternatives 2A through 3C.
New permanent land disturbance (hectares)	2	63.1	112	116	110	110	122	138	591 *668*	359 *437*	166
Geologic resource requirements, i.e., fill from Borrow Area C (cubic meters)	92,800	1,320,000	4,360,000	4,570,000	4,240,000	4,230,000	4,660,000	5,380,000	17,400,000 *20,900,000*	10,900,000 *14,400,000*	4,780,000

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	2A Existing WTP Vitrification; No Closure	2B Expanded WTP Vitrification; Landfill Closure	3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure	3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure	3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure	4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure	5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure	6A Base *6A Option* All Vitrification/No Separations; Clean Closure	6B Base *6B Option* All Vitrification with Separations; Clean Closure	6C All Vitrification with Separations; Landfill Closure
Water Resources											
Surface water	No additional impact on surface water in the short term. Water use and wastewater generation and discharges would decrease from current levels.	Short-term increase in stormwater runoff during construction, but no direct disturbance to surface-water features. No direct, routine discharge of effluents during operations to surface waters or to the subsurface. Water use would not exceed site capacity. Activities in Borrow Area C could encroach on the probable maximum flood zone associated with Cold Creek, especially under Alternatives 6A and 6B.									
Vadose zone and groundwater	No additional impact in the short term.	Potential for SST retrieval leaks in the short term without any recovery once in the subsurface. Groundwater mounds could begin to re-expand due to increased discharge of sanitary wastewater, nonhazardous process wastewater, and treated radioactive liquid effluents to onsite treatment and disposal facilities during waste treatment.					Potential for retrieval leaks similar to Alternatives 2A through 3B. Deep soil excavation for selective clean closure would require dewatering and could locally affect groundwater flow and contaminant plumes.	Similar to Alternatives 2A through 3C.	Potential for SST retrieval leaks in the short term. Deep soil excavation for clean closure would require dewatering and could locally affect groundwater flow and contaminant plumes.		Similar to Alternatives 2A through 3C.

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	2A Existing WTP Vitrification; No Closure	2B Expanded WTP Vitrification; Landfill Closure	3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure	3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure	3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure	4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure	5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure	6A Base *6A Option* All Vitrification/No Separations; Clean Closure	6B Base *6B Option* All Vitrification with Separations; Clean Closure	6C All Vitrification with Separations; Landfill Closure
Ecological Resources											
Terrestrial resources	No additional disturbance to sagebrush habitat in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	14.2 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	1.2 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	4 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	4.9 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	4.8 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	6.3 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	4.4 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	182 hectares of sagebrush habitat affected within the 200 Areas under the Base Case. 184 hectares of sagebrush habitat affected within the 200 Areas under the Option Case. No sagebrush habitat affected within Borrow Area C.	100 hectares of sagebrush habitat affected within the 200 Areas under the Base Case. 102 hectares of sagebrush habitat affected within the 200 Areas under the Option Case. No sagebrush habitat affected within Borrow Area C.	46.1 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.
Wetlands	No impact on wetlands within 200 Areas or Borrow Area C.										
Aquatic resources	No impact on aquatic resources within 200 Areas or Borrow Area C.										

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Ecological Resources *(continued)*											
Threatened and endangered species	No impact on any federally or state-listed threatened or endangered species.	No impact on any federally or state-listed threatened or endangered species.	No impact on any federally or state-listed threatened or endangered species.	No impact on any federally or state-listed threatened or endangered species.					No impact on any federally or state-listed threatened or endangered species under both Base and Option Cases.		No impact on any federally or state-listed threatened or endangered species.
	No impact on state-listed species within the 200 Areas.	Potential impacts on 4 state-listed species.	Potential impacts on 2 state-listed species.	Potential impacts on 6 state-listed special status species.					Potential impacts on 6 state-listed special status species under both Base and Option Cases.		Potential impacts on 4 state-listed special status species.
	Minimum potential for impact on 4 state-listed species within Borrow Area C.	Potential impacts on 4 state-listed species within Borrow Area C.	Potential impacts on 4 state-listed species within Borrow Area C.	Potential impacts on 4 state-listed special status species within Borrow Area C.					Potential impacts on 4 state-listed special status species within Borrow Area C under both Base and Option Cases.		Potential impacts on 4 state-listed special status species within Borrow Area C.
Cultural and Paleontological Resources											
Prehistoric resources	No impact on prehistoric resources.										
Historic resources	No impact on historic resources.								Impact on National Register–ineligible resources (i.e., areas where old cans and bottles were disposed of).		

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Cultural and Paleontological Resources *(continued)*											
American Indian interests	The 2 hectares of Borrow Area C that would be excavated would be noticeable from higher elevations but would not dominate the view.	The 29.1 hectares excavated from Borrow Area C would be readily visible from Rattlesnake Mountain and higher elevations. Upon completion of work, the area would be recontoured and revegetated, lessening the visual impact.	The 200-East and 200-West Area containment structures and closure barriers would be visible from higher elevations. 95.1 hectares of Borrow Area C would be excavated. Upon completion of work, the area would be recontoured and revegetated, lessening the visual impact.	Impacts would be similar to Alternative 2B. An additional 4.9 hectares of land would be disturbed within Borrow Area C.	Impacts would be similar to Alternative 2B. Excavated land in Borrow Area C would be slightly less (2.8 hectares), but the visual impacts would be similar.	Impacts would be similar to Alternative 2B. Nearly the same amount of geologic material would be required from Borrow Area C (92.7 hectares).	Impacts would be similar to Alternative 2B. An additional 6.9 hectares of land would be disturbed.	Impacts would be similar to Alternative 2B. 117 hectares of Borrow Area C would be excavated. This would be readily visible from Rattlesnake Mountain and higher elevations. Upon completion of work, the area would be recontoured and revegetated, lessening the visual impact.	Construction of facilities would noticeably add to the industrial nature of the 200 Areas; 381 hectares of Borrow Area C would be excavated under the Base Case, and 458 hectares of Borrow Area C would be excavated under the Option Case. This would be readily visible from Rattlesnake Mountain. Upon completion of work, the area would be recontoured and revegetated, lessening the visual impact.	Impacts would be similar to, but less than, those under Alternative 6A, Base Case. Land impact of construction of facilities and material excavated from Borrow Area C would be approximately 63 percent as much as under 6A. This would be readily visible from Rattlesnake Mountain. Upon completion of work, the area would be recontoured and revegetated, lessening the visual impact.	There would be an overall increase to the industrial appearance of the 200 Areas. 104 hectares of Borrow Area C would be excavated. These areas would be visible from nearby higher elevations.

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Cultural and Paleontological Resources *(continued)*											
American Indian interests *(continued)*									<u>*Option Case*</u> Impacts would be similar to those under the Base Case. An additional 76.5 hectares would be excavated from Borrow Area C, further impacting the viewshed.	<u>*Option Case*</u> Impacts would be similar to those under the Base Case. An additional 76.5 hectares would be excavated from Borrow Area C, further impacting the viewshed.	
Paleontological resources	No impact on paleontological resources.										
Socioeconomics											
Peak annual workforce (FTEs)	1,730	4,920	6,860	5,330	5,260	5,460	8,000	6,100	7,790 *10,200*	7,860 *10,000*	6,860
Peak daily commuter traffic (vehicles per day)	1,400	4,000	5,500	4,300	4,200	4,300	6,400	4,900	6,200 *8,100*		5,500
Peak daily truck loads – off site	4	15	48	24	36	142	64	57	49 *67*	66 *83*	50
Impact on the ROI	Potential for immediate decrease in FTEs.	Potential for change in the socioeconomic ROI, including increases in population, demand and cost for housing and community services, and level-of-service impacts on local transportation.									

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Public and Occupational Health and Safety – Normal Operations											
Offsite Population Impact – Life of the Project											
Dose (person-rem)	74	1,700	1,600		1,200	1,700	1,400		1,700 *1,800*	1,700 *1,700*	1,600
LCF[c]	0 (4×10^{-2})	1	1		1	1	1		1 *1*	1 *1*	1
Peak Year Maximally Exposed Individual Impact											
Dose (millirem per year)	0.041	8.5	10	8.6	8.5	8.6	8.5	8.6	8.6 *8.6*	9.8 *9.8*	9.7
Increased risk of an LCF	2×10^{-8}	5×10^{-6}	6×10^{-6}	5×10^{-6}					5×10^{-6} *5×10^{-6}*	6×10^{-6} *6×10^{-6}*	6×10^{-6}
Peak Year Onsite Maximally Exposed Individual Impact											
Dose (millirem per year)	0.033	1.4	1.7	1.4					1.4 *1.4*	1.7 *1.7*	1.6
Increased risk of an LCF	2×10^{-8}	8×10^{-7}	1×10^{-6}	8×10^{-7}					8×10^{-7} *8×10^{-7}*	1×10^{-6} *1×10^{-6}*	1×10^{-6}
Radiation Worker Population Impact – Life of the Project											
Dose (person-rem)	280	22,000	11,000	10,000	9,800	11,000	43,000	8,500	120,000 *120,000*	82,000 *85,000*	11,000
LCF[c]	0 (2×10^{-1})	13	7	6			26	5	72 *75*	49 *51*	7
Average Annual Impact per Radiation Worker											
Dose (millirem per year)	140	170	160				530	150	420 *400*	890 *800*	160
Increased risk of an LCF	9×10^{-5}	1×10^{-4}					3×10^{-4}	9×10^{-5}	2×10^{-4} *2×10^{-4}*	5×10^{-4} *5×10^{-4}*	1×10^{-4}

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Public and Occupational Health and Safety – Normal Operations *(continued)*											
Peak Year Noninvolved Worker Impact											
Dose (millirem per year)	0.27	3.0	3.4	3.0					3.0 *3.0*	3.5 *3.6*	3.4
Increased risk of an LCF	2×10^{-7}	2×10^{-6}							2×10^{-6} *2×10^{-6}*		2×10^{-6}
Public and Occupational Health and Safety – Facility Accidents											
Offsite Population Consequences											
Dose (person-rem)	1.3	75,000							1,000	75,000	
Number of LCFs[c]	0 (8×10^{-4})	50							0 (6×10^{-1})	50	
Maximally Exposed Offsite Individual Consequences											
Dose (rem)	0.00021	4.3							0.058	4.3	
Increased risk of an LCF	1×10^{-7}	3×10^{-3}							4×10^{-5}	3×10^{-3}	
Noninvolved Worker Consequences											
Dose (rem)	0.22	13,000							180	13,000	
Increased risk of an LCF[d]	1×10^{-4}	1							2×10^{-1}	1	
Offsite Population Risk											
Annual number of LCFs[c]	0 (4×10^{-7})	0 (2×10^{-2})							0 (3×10^{-4})	0 (2×10^{-2})	
Number of LCFs over life of the project[c]	0 (4×10^{-5})	2	1	1 5×10^{-1}			1	0 (4×10^{-1})	0 (4×10^{-2})	0	
Maximally Exposed Offsite Individual Risk											
Annual increased risk of an LCF	6×10^{-11}	1×10^{-6}							2×10^{-8}	1×10^{-6}	
Increased risk of an LCF over life of the project	6×10^{-9}	1×10^{-4}	3×10^{-5}					2×10^{-5}	3×10^{-6}	3×10^{-5}	

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Public and Occupational Health and Safety – Facility Accidents *(continued)*											
Noninvolved Worker Risk											
Annual increased risk of an LCF	7×10^{-8}	8×10^{-3}							1×10^{-4}	8×10^{-3}	
Increased risk of an LCF over life of the project	7×10^{-6}	6×10^{-1}	2×10^{-1}					1×10^{-1}	2×10^{-2}	2×10^{-1}	
Public and Occupational Health and Safety – Transportation											
Traffic accidents[e] (nonradiological fatalities)	0 (0.01)	1 (0.69)	1 (0.89)	2 (1.57)	2 (1.58)	6 (5.69)	2 (2.0)	2 (1.53)	4 (3.95) *10* *(9.55)*	2 (1.95) *4* *(3.85)*	1 (0.97)
Offsite Population											
Dose (person-rem)	0	73		350	270	340	300	260	60 *100*	89 *130*	73
LCFs	0	4.4×10^{-2}		2×10^{-1}	1.6×10^{-1}	2.1×10^{-1}	1.8×10^{-1}	1.5×10^{-1}	4×10^{-2} *6×10^{-2}*	5×10^{-2} *8×10^{-2}*	4×10^{-2}
Worker											
Dose (person-rem)	0	260		840	1,080	1,220	1,090	790	450 *870*	560 *980*	260
LCFs	0	1.6×10^{-1}		5×10^{-1}	6.5×10^{-1}	7.3×10^{-1}	6.5×10^{-1}	4.7×10^{-1}	2.7×10^{-1} *5.2×10^{-1}*	3.4×10^{-1} *5.9×10^{-1}*	1.6×10^{-1}
Environmental Justice											
Human health impacts	No disproportionately high and adverse human health impacts on minority or low-income populations due to normal facility operations or postulated facility accidents.										

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A** Existing WTP Vitrification; No Closure	**2B** Expanded WTP Vitrification; Landfill Closure	**3A** Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure	**3B** Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure	**3C** Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure	**4** Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure	**5** Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure	**6A Base** ***6A Option*** All Vitrification/No Separations; Clean Closure	**6B Base** ***6B Option*** All Vitrification with Separations; Clean Closure	**6C** All Vitrification with Separations; Landfill Closure
Waste Management (all values are in cubic meters unless otherwise noted; values rounded to no more than three significant digits)											
Disposed of Off Site and/or Stored On Site											
IHLW glass (No. of canisters)	N/A	14,200 (12,000)		10,300 (8,700)			12,800 (10,800)	9,240 (7,800)	203,000 (171,000) *203,000* *(171,000)*	14,200 (12,000) *14,200* *(12,000)*	14,200 (12,000)
IHLW cesium and strontium glass (No. of canisters)	N/A	400 (340)							400 (340) *400* *(340)*		400 (340)
Other HLW	N/A								337,000 *337,000*		N/A
HLW melters (No. of melters)	N/A	3,680 (30)	1,350 (11)	1,100 (9)			1,230 (10)	858 (7)	17,800 (145) *17,800* *(145)*	1,350 [f] (11) *1,350* *(11)*	1,350[e] (11)
Mixed TRU waste (includes tank and secondary, CH and RH)	N/A	219	206	3,850			4,080	277	530 *530*	412 *412*	206
Hazardous waste	12	79,200	79,600	79,700			79,900	79,200	82,000 *82,000*	80,900 *81,000*	79,700
Disposed of On Site											
ILAW glass (No. of canisters)	N/A	213,000 (92,300)		65,800 (28,500)			66,200 (28,700)	71,800 (31,100)	N/A	215,000[g] (93,000) *215,000* *(93,000)*	213,000[g] (92,300)
PPF melters (No. of melters)	N/A								3,060 (25) *17,900* *(146)*	1,960 (16) *11,400* *(93)*	N/A
Bulk vitrification glass	N/A			103,000	N/A		40,500	36,600	N/A		

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A** Existing WTP Vitrification; No Closure	**2B** Expanded WTP Vitrification; Landfill Closure	**3A** Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure	**3B** Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure	**3C** Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure	**4** Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure	**5** Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure	**6A Base** *6A Option* All Vitrification/No Separations; Clean Closure	**6B Base** *6B Option* All Vitrification with Separations; Clean Closure	**6C** All Vitrification with Separations; Landfill Closure
Waste Management (all values are in cubic meters unless otherwise noted; values rounded to no more than three significant digits) *(continued)*											
Disposed of On Site (continued)											
Cast stone waste	N/A				233,000	N/A	144,000	50,000	N/A		
Sulfate grout waste	N/A							19,800	N/A		
Steam reforming waste	N/A					261,000	N/A				
PPF glass (No. of canisters)	N/A								1,600 (700) *42,300* *(18,300)*		N/A
LAW melters (No. of melters)	N/A	7,700 (30)	8,000 (31)	2,260 (9)			2,570 (10)	2,460 (10)	N/A	8,000[f] (31) *8,000* *(31)*	8,000[f] (31)
LLW (secondary)	35	34,300	37,600	28,600	22,100	21,800	38,800	20,600	93,000 *136,000*	99,900 *143,000*	34,700
Liquid LLW (liters)	N/A	9,690							9,690 *9,690*		9,690
Closure LLW	N/A		679				2,400	N/A	4,070 *5,430*		53
MLLW (secondary)	21	39,200	36,900	41,700	35,100	21,100	43,500	22,600	109,000 *152,000*	105,000 *149,000*	40,000
Closure MLLW	N/A		468,000				1,010,000	3,060	2,410,000 *8,310,000*		468,000

Table S–5. Tank Closure Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/ Resource	Tank Closure Alternative										
	1 No Action	**2A Existing WTP Vitrification; No Closure**	**2B Expanded WTP Vitrification; Landfill Closure**	**3A Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure**	**3B Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure**	**3C Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure**	**4 Existing WTP Vitrification with Thermal Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure**	**5 Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure**	**6A Base *6A Option* All Vitrification/No Separations; Clean Closure**	**6B Base *6B Option* All Vitrification with Separations; Clean Closure**	**6C All Vitrification with Separations; Landfill Closure**
Industrial Safety											
Worker Population Impact – Total Project											
Total recordable cases (fatalities)	163 (0)	7,080 (0.92)	3,880 (0.50)	3,490 (0.45)	3,440 (0.45)	3,570 (0.46)	4,500 (0.59)	3,250 (0.42)	20,600 (2.67) *21,300 (2.77)*	5,150 (0.67) *5,720 (0.74)*	3,890 (0.51)

[a] Concentrations exceeding applicable standards, discussed in the air quality sections of Chapter 4 of this *TC & WM EIS*, are presented in **bold** text. The Federal standard for $PM_{2.5}$ is 35 micrograms per cubic meter (24-hour average). No specific data for $PM_{2.5}$ were available, but for analysis purposes, concentrations were assumed to be the same as for PM_{10}. Radiological air quality impacts are included separately under the public and occupational health and safety sections.

[b] Acceptable Source Impact Levels (ASILs) are used by the state in the permitting process and represent concentrations sufficiently low to protect human health and safety from potential carcinogenic and other toxic effects (WAC 173-460).

[c] The number of LCFs in a population is presented as an integer; where the value is 0, the calculated value (dose × 0.0006 LCFs per person-rem) is presented in parentheses.

[d] Increased likelihood of a latent cancer fatality, assuming the accident occurs, except at high individual doses (hundreds of rem or more) where acute radiation injury may cause death within weeks. Value cannot exceed 1.

[e] Nearest whole integer (calculated value in parentheses).

[f] Under Alternatives 6B and 6C, HLW and LAW melters from the WTP would be managed as HLW.

[g] Under Alternatives 6B and 6C, ILAW glass would be produced but would be managed as IHLW.

Note: To convert cubic meters to cubic yards, multiply by 1.308; hectares to acres, by 2.471; liters to gallons, by 0.26417; meters to yards, by 1.0936.

Key: ASIL=Acceptable Source Impact Level; Base=Base Case; CH=contact-handled; FTE=full-time equivalent; HLW=high-level radioactive waste; IHLW=immobilized high-level radioactive waste; ILAW=immobilized low-activity waste; LAW=low-activity waste; LCF=latent cancer fatality; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; N/A=not applicable; National Register=National Register of Historic Places; Option=Option Case; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers; PPF=Preprocessing Facility; RH=remote-handled; ROI=region of influence; SST=single-shell tank; *TC & WM EIS*=*Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*; TRU=transuranic; WTP=Waste Treatment Plant.

Source: Chapter 4 of this *TC & WM EIS*.

Table S–6. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Land Resources							
Land use (total land commitment)	No change in land use in the 400 Area, 200 Areas, or Borrow Area C.	2.1 hectares affected within the 400 Area. 2.8 hectares (0.3 percent) affected within Borrow Area C.	2.4 hectares affected within the 400 Area. 3.2 hectares (0.3 percent) affected within Borrow Area C.	0.1 hectares affected in 200-West Area.	No change in land use at INL.	0.1 hectares affected in 400 Area.	No change in land use at INL.
Visual resources	No change in the visual character of the 400 Area or 200 Areas.	Overall improvement in visual character of 400 Area. Minor change in visual character of Borrow Area C.		No meaningful change in the visual character of the 200-West Area.	No meaningful change in the visual character at INL.	No meaningful change in the visual character of the 400 Area.	No change in the visual character at INL.
Infrastructure							
Total Requirements							
Electricity (million megawatt-hours)	0.60	0.0032	0.0064	0.0000011		0.0013	
Diesel fuel (million liters)	0.0	4.02	3.76	0.24	0.0020	1.09	0.12
Gasoline (million liters)	0.11	0.36	0.37	0.090	0.0	0.42	0.012
Water (million liters)	795	19.6	18.9	8.53	1.04	2.92	2.72
Peak Annual Demand							
Electricity (million megawatt-hours)	0.006	0.0032		0.00000071		0.00069	0.00068
Diesel fuel (million liters)	0.0	1.74	1.11	0.0012	0.0020	0.47	0.058
Gasoline (million liters)	0.0011	0.098	0.050	0.045	0.0	0.18	0.0088
Water (million liters)	7.95	11.4	10.5	3.75	0.69	1.36	
Noise and Vibration							
	Negligible offsite impact of onsite activities. Minor traffic noise impacts.						

Table S–6. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Air Quality							
Peak Year Incremental Criteria Pollutant Concentrations as Compared with Most Stringent Guideline or Standard (micrograms per cubic meter)[a]							
Carbon monoxide (1-hour) standard=40,000	31.3	435	381	39.3	0	5,160	66.6
Nitrogen oxides (1-hour) standard=188	0.812	**3,590**	**2,570**	Does not occur in peak year	0	Does not occur in peak year	9.64
PM_{10} (24-hour) standard=150	0.00272	31.3	72	41.9	0	22.5	13.5
$PM_{2.5}$ (24-hour) standard=35	0.00272	31.3	**72**	**41.9**	0	22.5	13.5
Sulfur oxides (1-hour) standard=197	0.0419	30.6	50.4	0.062	0	6.97	0.0896
Peak Year Incremental Toxic Chemical Concentrations (micrograms per cubic meter)[a]							
Ammonia (24-hour) ASIL=70.8	0.000132	0.196	0.0264	0.0157	0	14.0	0.007
Benzene (annual) ASIL=5,000	0.00000327	0.0109		Does not occur in peak year	0	Does not occur in peak year	0.000805
Toluene (24-hour) ASIL=400	0.00338	11.3		Does not occur in peak year	0	Does not occur in peak year	0.0517
Xylene (24-hour) ASIL=NL	0.000954	3.18		Does not occur in peak year	0	Does not occur in peak year	0.0147

Table S–6. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Geology and Soils							
Construction impacts	No incremental impact on geology and soils.	Minimal impact associated with facility demolition in previously disturbed area. Potential for short-term soil loss from wind and water erosion during demolition, backfilling, and barrier construction. Excavation depths generally limited to 0.91 meters in the 400 Area.	Similar to, but somewhat greater than, Alternative 2: Entombment, due to reactor vessel removal and greater demands for geologic and soil resources from Borrow Area C.	Impacts of construction limited to previously disturbed area in 200-West Area. Excavation depths to 6 meters within the Hanford formation.	Limited or no impact on geology and soils within the INTEC at INL.	Limited impact on geology and soils in the Hanford 400 Area.	Minimal impact on geology and soils within the MFC at INL.
New permanent land disturbance (hectares)	0.0	3.5	3.2	0.1	0.0	0.1	<0.1
Geologic resource requirements (cubic meters)	0.0	122,000	143,000	4,670	0.0	202	35.5
Water Resources							
Surface water	No additional impacts on surface water in the short term. Wastewater generation and discharges would decrease from current levels.	No impact expected on surface-water features. Potential for contaminated runoff from demolition and work areas with no effect expected beyond the 400 Area.	Similar to, but somewhat greater than, Alternative 2: Entombment, due to reactor vessel removal and slightly larger area of disturbance and associated runoff.	Little or no impact on surface-water features or quality in the 200-West Area.	Little or no impact on surface-water features or quality within INTEC.	Limited impact on surface-water features or quality in the Hanford 400 Area.	No impacts on surface-water resources from construction and operations within the MFC at INL.

Table S–6. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Water Resources *(continued)*							
Vadose zone and groundwater	No additional impact in the short term. Groundwater use would decrease following deactivation.	Barrier emplacement would delay contaminant migration from the 400 Area.	Short-term, positive impact of removal of sources of residual contamination associated with the FFTF RCB.	No direct discharge of effluents from facility operations to the vadose zone or groundwater.			
Ecological Resources							
Terrestrial resources	No impact within 400 Area or Borrow Area C.	No impact within 400 Area. No disturbance to sagebrush habitat within Borrow Area C.		No impact within the 200-West Area.	No impact at INL.	No impact within the 400 Area.	No impact at INL.
Wetlands	No impact within 400 Area or Borrow Area C.			No impact within the 200-West Area.	No impact at INL.	No impact within the 400 Area.	No impact at INL.
Aquatic resources	No impact within 400 Area or Borrow Area C.			No impact within the 200-West Area.	No impact at INL.	No impact within the 400 Area.	No impact at INL.
Threatened and endangered species	No impact on federally or state-listed threatened or endangered species within the 400 Area or Borrow Area C.	No impact on any federally or state-listed threatened or endangered species. No impact on state-listed special status species within the 400 Area. Minimal potential for impact on 4 state-listed special status species within Borrow Area C.		No impact on federally or state-listed threatened, endangered, or special status species within the 200-West Area.	No impact on federally or state-listed threatened, endangered, or special status species within INTEC at INL.	No impact on federally or state-listed threatened, endangered, or special status species within the 400 Area.	No impact on federally or state-listed threatened, endangered, or special status species within MFC at INL.

Table S–6. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Cultural and Paleontological Resources							
Prehistoric resources	No impact on prehistoric resources.						
Historic resources	No impact on historic resources.						
American Indian interests	No impact on American Indian interests.	Excavation activities would impact the view from State Route 240 and higher elevations, including Rattlesnake Mountain.		No impact on American Indian interests.			
Paleontological resources	No impact on paleontological resources.						
Socioeconomics							
Peak annual workforce (FTEs)	1	50	85	53	40	65	55
Peak daily commuter traffic (vehicles per day)	1	40	68	43	40	52	55
Peak daily truck loads – off site	Less than 1	3	2	1	Less than 1	Less than 1	Less than 1
Impact on the ROI	Little or no impact on socioeconomic ROI.	The impact on the Hanford and INL socioeconomic ROIs would be small.					
Public and Occupational Health and Safety – Normal Operations							
Offsite Population Impact – Life of the Project							
Dose (person-rem)	0.027	0.00000067	(b)	0.00019	0.000048	0.022	0.0021
LCF[c]	0 (2×10^{-5})	0 (4×10^{-10})	(b)	0 (1×10^{-7})	0 (3×10^{-8})	0 (1×10^{-5})	0 (1×10^{-6})
Peak Year Maximally Exposed Individual Impact							
Dose (millirem per year)	0.000017	0.000000058	(b)	0.0000078	0.0000044	0.00046	0.00037
Increased risk of an LCF	1×10^{-11}	3×10^{-14}	(b)	5×10^{-12}	3×10^{-12}	3×10^{-10}	2×10^{-10}
Peak Year Onsite Maximally Exposed Individual Impact							
Dose (millirem per year)	0.000011	0.000000010	(b)	0.000018	N/A	0.00044	N/A
Increased risk of an LCF	6×10^{-12}	6×10^{-15}	(b)	1×10^{-11}	N/A	3×10^{-10}	N/A

Table S–6. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Public and Occupational Health and Safety – Normal Operations *(continued)*							
Radiation Worker Population Impact – Life of the Project							
Dose (person-rem)	1	0.37	6.3	1.2		3.7	3.6
LCF[c]	0 (6×10^{-4})	0 (2×10^{-4})	0 (4×10^{-3})	0 (7×10^{-4})		0 (2×10^{-3})	
Average Annual Impact per Radiation Worker							
Dose (millirem per year)	50	100		20		39	
Increased risk of an LCF	3×10^{-5}	6×10^{-5}		1×10^{-5}		2×10^{-5}	
Peak Year Noninvolved Worker Impact							
Dose (millirem per year)	0.0000064	0.0000000059	(b)	0.011	0.00000029	0.00025	0.069
Increased risk of an LCF	4×10^{-12}	4×10^{-15}	(b)	6×10^{-9}	2×10^{-13}	2×10^{-10}	4×10^{-8}
Public and Occupational Health and Safety – Facility Accidents							
Offsite Population Consequences							
Dose (person-rem)	0.0064	(d)		4.3	0.30[e]	0.0064	0.000058[e]
Number of LCFs[c]	0 (4×10^{-6})	(d)		0 (3×10^{-3})	0 (2×10^{-4})[e]	0 (4×10^{-6})	0 (3×10^{-8})[e]
Maximally Exposed Offsite Individual Consequences							
Dose (rem)	0.0000011	(d)		0.00012	0.00025[e]	0.0000011	0.000000030
Increased risk of an LCF	6×10^{-10}	(d)		7×10^{-8}	2×10^{-7}[e]	6×10^{-10}	2×10^{-11}[e]
Noninvolved Worker Consequences							
Dose (rem)	0.00000087	(d)		0.00073	0.00018[e]	0.00000087	0.0000000039
Increased risk of an LCF	5×10^{-10}	(d)		4×10^{-7}	1×10^{-7}[e]	5×10^{-10}	2×10^{-12}[e]
Offsite Population Risk							
Annual number of LCFs[c]	0 (4×10^{-11})	(d)		0 (3×10^{-5})	0 (2×10^{-6})[e]	0 (4×10^{-11})	0 (3×10^{-13})[e]
Number of LCFs over the life of the project[c]	0 (4×10^{-9})	(d)		0 (1×10^{-4})	0 (9×10^{-6})[e]	0 (5×10^{-10})	0 (7×10^{-13})[e]
Maximally Exposed Offsite Individual Risk							
Annual increased risk of an LCF	6×10^{-15}	(d)		7×10^{-10}	2×10^{-9}[e]	6×10^{-15}	2×10^{-16}[e]
Increased risk of an LCF over the life of the project	6×10^{-13}	(d)		4×10^{-9}	8×10^{-9}[e]	8×10^{-14}	4×10^{-16}[e]

Table S–6. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Public and Occupational Health and Safety – Facility Accidents *(continued)*							
Noninvolved Worker Risk							
Annual increased risk of an LCF	5×10^{-15}	(d)		4×10^{-9}	1×10^{-9}[e]	5×10^{-15}	2×10^{-17}[e]
Increased risk of an LCF over the life of the project	5×10^{-13}	(d)		2×10^{-8}	6×10^{-9}[e]	7×10^{-14}	5×10^{-17}[e]
Public and Occupational Health and Safety – Transportation							
Traffic accidents[f] (nonradiological fatalities)	0 (0.0004)	0 (0.034)		0 (0.005)	0 (0.00035)	0 (0.0006)	0 (0.0082)
Offsite Population							
Dose (person-rem)	0	(f)	0.003	0.005	0.33	0.01	0.96
LCFs	0	N/A	1.5×10^{-6}	2.9×10^{-6}	2.0×10^{-4}	6.7×10^{-6}	5.7×10^{-4}
Worker							
Dose (person-rem)	0	(g)	0.03	0.03	0.84	0.12	3.5
LCFs	0	N/A	2×10^{-5}	1.9×10^{-5}	5.0×10^{-4}	6.9×10^{-5}	2.1×10^{-3}
Environmental Justice							
Human health impacts	No disproportionately high and adverse human health impacts on minority or low-income populations due to normal facility operations or postulated facility accidents.						
Waste Management (cubic meters unless otherwise noted; values rounded to no more than three significant digits)							
Disposed of Off Site and/or Stored On Site							
LLW	1,700	7	692	68		10	N/A
MLLW	57	N/A	8	7		421	275
Hazardous	396	N/A	73	4		454	N/A
Liquid LLW (liters)	623,000	182,000	324,000	N/A			

Table S–6. FFTF Decommissioning Alternatives – Summary of Short-Term Environmental Impacts *(continued)*

Parameter/Resource	FFTF Decommissioning Alternatives and Options						
				Alternative 2 or 3			
	Alternative 1: No Action	Alternative 2: Entombment–Facility Disposition	Alternative 3: Removal–Facility Disposition	Disposition of RH-SCs (Hanford Option)	Disposition of RH-SCs (Idaho Option)	Disposition of Bulk Sodium (Hanford Reuse Option)	Disposition of Bulk Sodium (Idaho Reuse Option)
Industrial Safety							
Worker Population Impact – Total Project							
Total recordable cases (fatalities)	0.42 (0)	8.1 (0)	9.5 (0)	4.7 (0)	0.9 (0)	5.8 (0)	2.0 (0)

[a] Concentrations associated with FFTF Decommissioning alternatives and options are not projected to exceed applicable standards. The Federal standard for $PM_{2.5}$ is 35 micrograms per cubic meter (24-hour average). No specific data for $PM_{2.5}$ were available, but for analysis purposes, concentrations were assumed to be the same as for PM_{10}. Radiological air quality impacts are included separately under the public and occupational health and safety sections.

[b] Impacts on remote receptors would be negligible under Alternatives l and 3.

[c] The number of LCFs in a population is presented as an integer; where the value is 0, the calculated value (dose × 0.0006 LCFs per person-rem) is presented in parentheses.

[d] Impacts of accidents associated with facility disposition (building entombment or removal) would be less than those for disposition of RH-SCs or bulk sodium.

[e] Impacts are only for accidents that could occur at INL. Impacts identified for disposition of RH-SCs or bulk sodium at Hanford could also occur under the Idaho options during removal and preparation of material for shipment.

[f] Nearest whole integer (calculated value in parentheses).

[g] All transported materials are sanitary and hazardous waste, not radioactive.

Note: To convert cubic meters to cubic yards, multiply by 1.308; hectares to acres, by 2.471; liters to gallons, by 0.26417; meters to yards, by 1.0936.

Key: ASIL=acceptable source impact level; FFTF=Fast Flux Test Facility; FTE=full-time equivalent; Hanford=Hanford Site; INL=Idaho National Laboratory; INTEC=Idaho Nuclear Technology and Engineering Center; LCF=latent cancer fatality; LLW=low-level radioactive waste; MFC=Materials and Fuels Complex; MLLW=mixed low-level radioactive waste; N/A=not applicable; NL=not listed; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers; RCB=Reactor Containment Building; RH-SCs=remote-handled special components; ROI=region of influence; RTP=Remote Treatment Project; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington;* wt=weight.

Source: Chapter 4 of this *TC & WM EIS*.

Table S–7. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a]

Parameter/ Resource	Waste Management Alternatives and Disposal Groups							
	Alternative 1: No Action	Alternatives 2 and 3: Treatment and Storage	Alternative 2: Disposal Group 1	Alternative 2: Disposal Group 2	Alternative 2: Disposal Group 3	Alternative 3: Disposal Group 1	Alternative 3: Disposal Group 2	Alternative 3: Disposal Group 3
Land Resources								
Land use (total land commitment)	No change in land use within the 200 Areas or Borrow Area C.	2.7 hectares affected within the 200-West Area.	63.9 hectares affected within and adjacent to the 200-East Area. 41.7 hectares affected within Borrow Area C.	247 hectares affected within and adjacent to the 200-East Area. 159 hectares affected within Borrow Area C.		76.9 hectares affected within and adjacent to the 200 Areas. 36.8 hectares affected within Borrow Area C.	253 hectares affected within and adjacent to the 200 Areas. 157 hectares affected within Borrow Area C.	
Visual resources	No change in the visual character of the 200 Areas.	No meaningful change in the visual character of the 200-West Area.	Noticeable change in the visual character of the 200 Areas and Borrow Area C, especially from nearby higher elevations, or, in the case of Borrow Area C, State Route 240.					
Infrastructure								
Total Requirements								
Electricity (million megawatt-hours)	0.0056	0.55	0.0085					
Diesel fuel (million liters)	13.9	42.0	215	1,420	2,180	215	1,410	2,170
Gasoline (million liters)	1.23	8.48	13.2	74.6	100	13.2	74.6	100
Water (million liters)	35.7	430	2,620	20,800	36,800	2,610	20,700	36,500
Peak Annual Demand								
Electricity (million megawatt-hours)	0.00019	0.018	0.00019					
Diesel fuel (million liters)	3.46	2.60	39.0	151		38.9	149	
Gasoline (million liters)	0.012	1.01	3.68	14.2		3.66	14.1	
Water (million liters)	25.5	23.9	67.0	259		66.7	256	
Noise and Vibration								
	Negligible offsite impact of onsite activities. Minor traffic noise impacts.							

Table S–7. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/ Resource	Waste Management Alternatives and Disposal Groups							
	Alternative 1: No Action	**Alternatives 2 and 3: Treatment and Storage**	**Alternative 2: Disposal Group 1**	**Alternative 2: Disposal Group 2**	**Alternative 2: Disposal Group 3**	**Alternative 3: Disposal Group 1**	**Alternative 3: Disposal Group 2**	**Alternative 3: Disposal Group 3**
Air Quality								
Peak Year Incremental Criteria Pollutant Concentrations as Compared with Most Stringent Guideline or Standard (micrograms per cubic meter)[b]								
Carbon monoxide (1-hour) standard=40,000	462	12,200	**49,800**	**257,000**		**50,300**	**256,000**	
Nitrogen oxides (1-hour) standard=188	**2,020**	**6,940**	**34,600**	**179,000**		**35,000**	**178,000**	
PM_{10} (24-hour) standard=150	**507**	**717**	**3,360**	**17,200**		**3,420**	**17,300**	
$PM_{2.5}$ (24-hour) standard=35	**507**	**717**	**3,360**	**17,200**		**3,420**	**17,300**	
Sulfur oxides (1-hour) standard=197	0.723	16.5	68.4	**353**		69.2	**352**	
Peak Year Incremental Toxic Chemical Concentrations (micrograms per cubic meter)[b]								
Ammonia (24-hour) ASIL=70.8	0.216	0.874	3.84	20.0		3.91	19.9	
Benzene (annual) ASIL=0.345	0.000288	0.00128	0.00701	0.0323		0.00704	0.0321	
Toluene (24-hour) ASIL=5,000	0.0265	1.84	6.00	31.2		6.1	31.1	
Xylene (24-hour) ASIL=NL	0.00999	0.526	1.78	9.27		1.81	9.23	
Geology and Soils								
Construction impacts	Little additional impact on geology and soils.	Limited impact on geology and soils from construction of new/expanded facilities in previously disturbed areas. Excavation depths up to 3 meters.	Small-to-moderate impact of construction, including potential for short-term soil erosion. Excavation depths to 14 meters.	Impacts similar in nature to, but greater than, those under Alternative 2, Disposal Group 1. Excavation depths to 14 meters.	The impacts would be identical to those under Alternative 2, Disposal Group 2.	Similar to those under Alternative 2, Disposal Group 1, but impacts more dispersed across the 200 Areas.	Similar to those under Alternative 2, Disposal Group 2, but impacts more dispersed across the 200 Areas.	Similar to those under Alternative 2, Disposal Group 3, but impacts more dispersed across the 200 Areas.

Table S–7. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/ Resource	Alternative 1: No Action	Alternatives 2 and 3: Treatment and Storage	Alternative 2: Disposal Group 1	Alternative 2: Disposal Group 2	Alternative 2: Disposal Group 3	Alternative 3: Disposal Group 1	Alternative 3: Disposal Group 2	Alternative 3: Disposal Group 3
Geology and Soils *(continued)*								
New permanent land disturbance (hectares)	0.0	2.7	108	409		117	413	
Geologic resource requirements (cubic meters)	6,230	10,600	1,980,000	7,610,000		1,760,000	7,550,000	
Water Resources								
Surface water	No additional impacts on surface water in the short term.	Negligible potential impact on surface water from stormwater runoff.	Short-term increase in stormwater runoff during construction, but little-to-no impact on surface-water features. Water use would not exceed site capacity.	Similar to those under Alternative 2, Disposal Group 1, with greater potential for stormwater runoff during construction. Longer period of operations than under Alternative 2, Disposal Group 1. Water use would not exceed site capacity.	Potential construction impacts would be similar to those under Alternative 2, Disposal Group 2. Longer period of operations than under Alternative 2, Disposal Group 2. Water use would not exceed site capacity.	Similar to those under Alternative 2, Disposal Group 1.	Similar to those under Alternative 2, Disposal Group 2.	Similar to those under Alternative 2, Disposal Group 3.
Vadose zone and groundwater	No additional impact in the short term.	No direct discharge of effluents from facility operations to the vadose zone or groundwater.	No impact on groundwater flow from construction. No impact on groundwater in the short term from collection and treatment of leachate.	Similar to those under Alternative 2, Disposal Group 1.	The potential for impacts during operations would increase proportionally to the lifespan of the disposal facilities.	Similar to those under Alternative 2, Disposal Group 1.	Similar to those under Alternative 2, Disposal Group 2.	Similar to those under Alternative 2, Disposal Group 3.

Table S–7. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/ Resource	Waste Management Alternatives and Disposal Groups							
	Alternative 1: No Action	Alternatives 2 and 3: Treatment and Storage	Alternative 2: Disposal Group 1	Alternative 2: Disposal Group 2	Alternative 2: Disposal Group 3	Alternative 3: Disposal Group 1	Alternative 3: Disposal Group 2	Alternative 3: Disposal Group 3
Ecological Resources								
Terrestrial resources	No impact within the 200 Areas or Borrow Area C.	0.4 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	63.9 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	247 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.		76.9 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	253 hectares of sagebrush habitat affected in the 200 Areas. No sagebrush habitat affected within Borrow Area C.	
Wetlands	No impact on wetlands within the 200 Areas or Borrow Area C.							
Aquatic resources	No impact on aquatic resources within the 200 Areas or Borrow Area C.							
Threatened and endangered species	No impact on federally or state-listed threatened, endangered, or special status species.	No impact on federally or state-listed threatened, endangered, or special status species within the 200 Areas.	No impact on federally or state-listed threatened or endangered species. Potential impact on 4 state-listed special status species within the 200 Areas. Potential impact on 4 state-listed special status species within Borrow Area C.	No impact on federally or state-listed threatened or endangered species. Somewhat greater potential to impact 4 state-listed special status species within the 200 Areas than under Disposal Group 1, as more sagebrush habitat would be disturbed. Potential impact on 4 state-listed special status species within Borrow Area C.		No impact on federally or state-listed threatened or endangered species. Potential impact on 5 state-listed special status species within the 200 Areas. Potential impact on 4 state-listed special status species within Borrow Area C.	No impact on federally or state-listed threatened or endangered species. Somewhat greater potential impact on 5 state-listed special status species within the 200 Areas than under Disposal Group 1, as more sagebrush habitat would be disturbed. Potential impact on 4 state-listed special status species within Borrow Area C.	

Table S–7. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/ Resource	Waste Management Alternatives and Disposal Groups							
	Alternative 1: No Action	**Alternatives 2 and 3: Treatment and Storage**	**Alternative 2: Disposal Group 1**	**Alternative 2: Disposal Group 2**	**Alternative 2: Disposal Group 3**	**Alternative 3: Disposal Group 1**	**Alternative 3: Disposal Group 2**	**Alternative 3: Disposal Group 3**
Cultural and Paleontological Resources								
Prehistoric resources	No impact on prehistoric resources.							
Historic resources	No impact on historic resources.							
American Indian interests	No impact on American Indian interests.	Impacts on viewshed from higher elevations, including Rattlesnake Mountain.	Expansion of IDF-East and construction of the proposed RPPDF would affect 62.3 hectares. Excavation of Borrow Area C would involve 41.7 hectares. This would change the viewscape from Rattlesnake Mountain and higher elevations.	Expansion of IDF-East and construction of the proposed RPPDF would affect 240 hectares. Excavation of Borrow Area C would involve 159 hectares. This would change the viewscape from Rattlesnake Mountain and higher elevations.		The impact would be similar to those under Alternative 2, Disposal Group 1.	The impact would be similar to those under Alternative 2, Disposal Groups 2 and 3.	
Paleontological resources	No impact on paleontological resources.							
Socioeconomics								
Peak annual workforce (FTEs)	109	449	1,180	4,540		1,170	4,500	
Peak daily commuter traffic (vehicles per day)	88	360	943	3,640		940	3,600	
Peak daily truck loads – off site	Less than 1	2	28	34		28	33	
Impact on the ROI	Little impact on socioeconomic ROI.	Potential for change in the socioeconomic ROI, including level-of-service impacts on local transportation. Impacts would be similar under both alternatives.						

Table S–7. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/ Resource	Waste Management Alternatives and Disposal Groups							
	Alternative 1: No Action	Alternatives 2 and 3: Treatment and Storage	Alternative 2: Disposal Group 1	Alternative 2: Disposal Group 2	Alternative 2: Disposal Group 3	Alternative 3: Disposal Group 1	Alternative 3: Disposal Group 2	Alternative 3: Disposal Group 3
Public and Occupational Health and Safety – Normal Operations[c]								
Offsite Population Impact – Life of the Project								
Dose (person-rem)	(d)	0.000077	(e)					
LCF[f]	(d)	0 (5×10^{-8})	(e)					
Peak Year Maximally Exposed Individual Impact								
Dose (millirem per year)	(d)	0.00000015	(e)					
Increased risk of an LCF	(d)	9×10^{-14}	(e)					
Peak Year Onsite Maximally Exposed Individual Impact								
Dose (millirem per year)	(d)	0.00000064	(e)					
Increased risk of an LCF	(d)	4×10^{-13}	(e)					
Radiation Worker Population Impact – Life of the Project								
Dose (person-rem)	37	3,000	360	3,600	6,400	360	3,500	6,400
LCF[f]	0 (2×10^{-2})	2	0 (2×10^{-1})	2	4	0 (2×10^{-1})	2	4
Average Annual Impact per Radiation Worker								
Dose (millirem per year)	200		200					
Increased risk of an LCF	1×10^{-4}		1×10^{-4}					
Peak Year Noninvolved Worker Impact								
Dose (millirem per year)	(d)	0.00039	(e)					
Increased risk of an LCF	(d)	2×10^{-10}	(e)					

Table S–7. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/ Resource	Waste Management Alternatives and Disposal Groups							
	Alternative 1: No Action	Alternatives 2 and 3: Treatment and Storage	Alternative 2: Disposal Group 1	Alternative 2: Disposal Group 2	Alternative 2: Disposal Group 3	Alternative 3: Disposal Group 1	Alternative 3: Disposal Group 2	Alternative 3: Disposal Group 3
Public and Occupational Health and Safety – Facility Accidents								
Offsite Population Consequences								
Dose (person-rem)	1,500	(g)	1,500					
Number of LCFs	1		1					
Maximally Exposed Offsite Individual Consequences								
Dose (rem)	0.25	(g)	0.25					
Increased risk of an LCF	1×10^{-4}		1×10^{-4}					
Noninvolved Worker Consequences								
Dose (rem)	260	(g)	260					
Increased risk of an LCF	3×10^{-1}		3×10^{-1}					
Offsite Population Risk								
Annual number of LCFs[f]	0 (9×10^{-3})	(g)	0 (9×10^{-3})					
Number of LCFs over the life of the project[f]	0 (3×10^{-1})		0 (4×10^{-1})	1	1	0 (4×10^{-1})	1	1
Maximally Exposed Offsite Individual Risk								
Annual increased risk of an LCF	1×10^{-6}	(g)	2×10^{-6}					
Increased risk of an LCF over the life of the project	4×10^{-5}		6×10^{-5}	1×10^{-4}	2×10^{-4}	6×10^{-5}	1×10^{-4}	2×10^{-4}
Noninvolved Worker Risk								
Annual increased risk of an LCF	3×10^{-3}	(g)	3×10^{-3}					
Increased risk of an LCF over the life of the project	9×10^{-2}		1×10^{-1}	3×10^{-1}	5×10^{-1}	1×10^{-1}	3×10^{-1}	5×10^{-1}

Table S–7. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/ Resource	Waste Management Alternatives and Disposal Groups							
	Alternative 1: No Action	**Alternatives 2 and 3: Treatment and Storage**	**Alternative 2: Disposal Group 1**	**Alternative 2: Disposal Group 2**	**Alternative 2: Disposal Group 3**	**Alternative 3: Disposal Group 1**	**Alternative 3: Disposal Group 2**	**Alternative 3: Disposal Group 3**
Public and Occupational Health and Safety – Transportation								
Traffic accidents[h] (nonradiological fatalities)	0 (0.0064)	2 (1.75)	0 (0.11)	0 (0.38)	0 (0.49)	0 (0.10)	0 (0.38)	0 (0.49)
Offsite Population								
Dose (person-rem)	0.08	350	(i)					
LCFs	5×10^{-5}	2.1×10^{-1}	(i)					
Worker								
Dose (person-rem)	2.6	2,500	(i)					
LCFs	2×10^{-3}	1.5	(i)					
Environmental Justice								
Human health impacts	No disproportionately high and adverse human health impacts on minority or low-income populations due to normal facility operations or postulated facility accidents.							
Waste Management (all values are in cubic meters unless otherwise noted; values rounded to no more than three significant digits)								
LLW	38	1,460	58					
MLLW	N/A	98	N/A					
Hazardous	38	N/A	147	401	401	147	402	402

Table S–7. Waste Management Alternatives – Summary of Short-Term Environmental Impacts[a] *(continued)*

Parameter/ Resource	Waste Management Alternatives and Disposal Groups							
	Alternative 1: No Action	Alternatives 2 and 3: Treatment and Storage	Alternative 2: Disposal Group 1	Alternative 2: Disposal Group 2	Alternative 2: Disposal Group 3	Alternative 3: Disposal Group 1	Alternative 3: Disposal Group 2	Alternative 3: Disposal Group 3
Industrial Safety								
Worker Population Impact – Total Project								
Total recordable cases (fatalities)	10 (0)	379 (0.05)	199 (0.03)	1,280 (0.17)	2,040 (0.27)	214 (0.03)	1,290 (0.17)	2,050 (0.27)

[a] Total impacts associated with each action alternative would be equal to the sum of the (1) treatment and storage and (2) disposal group values.
[b] Concentrations exceeding applicable standards, discussed in the air quality sections of Chapter 4 of this *TC & WM EIS* are presented in **bold** text. The Federal standard for $PM_{2.5}$ is 35 micrograms per cubic meter (24-hour average). No specific data for $PM_{2.5}$ were available, but for analysis purposes, concentrations were assumed to be the same as for PM_{10}. Radiological air quality impacts are included separately under the public and occupational health and safety sections.
[c] Disposal group radiological impacts of normal operations are additive to the treatment and storage impacts under Alternatives 2 and 3.
[d] Impacts of the Waste Management No Action Alternative are from existing, permitted facilities and are included in current annual dose estimates.
[e] Regardless of disposal group, emissions from burial ground operations would have a negligible impact on distant receptors.
[f] The number of LCFs in a population is presented as a whole number; where the value is less than 0, the calculated value (dose × 0.0006 LCFs per person-rem) is presented in parentheses.
[g] Treatment and storage accident consequences and risks are encompassed in the values presented for disposal.
[h] Nearest whole integer (calculated value in parentheses).
[i] The impacts of transporting the materials under these disposal groups have already been considered under the Tank Closure and FFTF Decommissioning alternatives.

Note: To convert cubic meters to cubic yards, multiply by 1.308; hectares to acres, by 2.471; liters to gallons, by 0.26417; meters to yards, by 1.0936.

Key: ASIL=acceptable source impact level; FFTF=Fast Flux Test Facility; FTE=full-time equivalent; IDF-East=200-East Area Integrated Disposal Facility; LCF=latent cancer fatality; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; N/A=not applicable; NL=not listed; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers; ROI=region of influence; RPPDF=River Protection Project Disposal Facility; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*.

Source: Chapter 4 of this *TC & WM EIS*.

S.5.4 Summary of Long-Term Environmental Impacts

The following section provides a summary-level comparison of the potential long-term environmental impacts on water quality, human health, ecological risk, and environmental justice associated with implementing each of the *TC & WM EIS* alternatives. Long-term impacts would occur following the active project phase defined for each alternative and the assumed end of the associated 100-year administrative control, institutional control, or postclosure care period, as appropriate. This comparison of impacts is presented to aid decisionmakers and the public in understanding the potential long-term environmental consequences of proceeding with each of the *TC & WM EIS* alternatives. Long-term impacts of Tank Closure alternatives are presented in Section S.5.4.1; FFTF Decommissioning alternatives, in Section S.5.4.2; and Waste Management alternatives, in Section S.5.4.3.

S.5.4.1 Tank Closure Alternatives

S.5.4.1.1 Water Quality

Three assessment boundaries were selected for the groundwater analysis based on a combination of regulatory, permit, and land use requirements. For Tank Closure alternatives, the innermost (i.e., closest to the source) area of analysis comprises the engineered barriers that would be installed above the tank farms. Very little groundwater transport would occur between the time the contaminants encounter the aquifer and the time they pass beneath the outer perimeter of the barriers; in general, the greatest water quality impacts would occur at the innermost assessment boundaries.

The second area of analysis is established by the location of the Core Zone Boundary. The Core Zone Boundary is approximated by a rectangle encompassing the entire area that would be directly affected by project facilities. The Core Zone Boundary represents the —fence line" of the projected tank closure operational facilities for each of the alternatives. Groundwater beneath the western portions of the northern and southern Core Zone Boundary would be impacted by contaminants released at the S, T, and U Barriers; because the western portion of the aquifer has relatively low groundwater flux (the rate of flow through the unit area), these impacts would be relatively high (although lower than at the barriers themselves). The eastern portion of the Core Zone Boundary is in an area of high groundwater flux, and peak groundwater impacts along the eastern part of the Core Zone Boundary would be correspondingly lower.

Core Zone Boundary

The Core Zone is a portion of the Central Plateau within the Hanford Site, encompassing the 200-East and 200-West Areas, that lies within the Industrial-Exclusive land use designation. The Core Zone Boundary is the perimeter of the Core Zone that is used as a line of analysis for groundwater transport calculations.

The third area of analysis is the Columbia River nearshore (shoreline closest to Hanford). It approximates the location where contaminants in the groundwater system discharge into the surface-water system. Water quality impacts at the Columbia River reflect the superimposition of releases from individual sources.

Groundwater impacts are described in terms of the concentrations of the constituent of potential concern (COPC) drivers at the assessment boundaries under the alternatives considered. The COPC drivers are iodine-129, technetium-99, chromium, nitrate, hydrogen-3 (tritium), uranium-238, and total uranium. They fall into three categories, characterized by mobility and decay rate: (1) iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. (2) Tritium is also mobile, but short-lived. The half-life of tritium is less than 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. (3) Uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater.

The other COPCs that were analyzed do not significantly contribute to risk or hazard during the period of analysis because of limited inventory, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

Benchmark

—Benchmark" refers to a dose or concentration known or accepted to be associated with a specific level of effect. Thus, Federal drinking water standards (40 CFR 141 and 143) are used as benchmarks against which potential contamination can be compared. Drinking water standards for Washington State are found in *Washington Administrative Code* 246-290. Benchmark standards used in this environmental impact statement represent dose or concentration levels that correspond to known or established human health effects. For groundwater, the benchmark is the maximum contaminant level (MCL) if an MCL is available. For constituents with no available MCL, additional sources for benchmark standards include Washington State guidance and relevant regulatory standards, e.g., Clean Water Act, Safe Drinking Water Act. For example, the benchmark for iodine-129 is 1 picocurie per liter; for technetium-99, it is 900 picocuries per liter. These benchmark standards for groundwater impacts analysis were agreed upon by both the U.S. Department of Energy and the Washington State Department of Ecology as the basis for comparing the alternatives and representing potential groundwater impacts.

Table S–8 presents the maximum concentrations of the COPC drivers under each of the Tank Closure alternatives at the Core Zone Boundary; Table S–9, at the Columbia River nearshore. Note that maximum concentrations during the period calendar years (CYs) 2050 through 11,940 are reported in Tables S–8 and S–9 and compared to the benchmark concentration. Maximum concentrations during the period CYs 1940 through 2049 are omitted to facilitate comparison of the Tank Closure alternatives. Concentrations prior to CY 2049 reflect past-practice conditions rather than conditions applicable to the alternatives.

The importance of retrieval of tank farm residuals can be seen in the maximum concentrations (and year of peak impact) of iodine-129 at the Core Zone Boundary (Table S–8). There is a clear differentiation between Tank Closure Alternative 1 (with no retrieval) and all other Tank Closure alternatives (with retrieval). The peak concentration of iodine-129 at the Core Zone Boundary under Tank Closure Alternative 1 is an order of magnitude greater than under the other Tank Closure alternatives. The years of peak impact for Tank Closure Alternatives 2A through 6C occur between CY 2056 and CY 2092, which is an indication that these peaks are dominated by historical discharges to cribs and trenches (ditches) and past leaks. Retrieval of tank farm residuals lowers the peak impact by an order of magnitude and switches the dominant contributor to impacts from a future source (tank farm residuals) to historical sources (discharges to cribs and trenches [ditches] and past leaks).

Table S–8. Tank Closure Alternatives – Maximum COPC Concentrations in the Peak Year at the Core Zone Boundary

Contaminant	Tank Closure Alternative									
	1	**2A**	**2B, 3A, 3B, 3C, 6C**	**4**	**5**	**6A, Base Case**	**6A, Option Case**	**6B, Base Case**	**6B, Option Case**	**Benchmark Concentration**
Radionuclide (picocuries per liter)										
Hydrogen-3 (tritium)	639 (2123)	561 (2053)	628 (2051)				660 (2050)	627 (2051)	661 (2050)	20,000
Technetium-99	**26,500** (3957)	**4,000** (2068)	**3,570** (2056)	**3,500** (2056)	**3,880** (3616)	**3,480** (2056)	**3,650** (2066)	**3,480** (2056)	**3,760** (2065)	900
Iodine-129	**58.8** (3577)	**5.8** (2069)	**4.5** (2056)	**4.3** (2056)	**4.4** (2056)	**4.8** (2092)		**4.6** (2092)	**5.0** (2064)	1
Uranium isotopes (includes uranium-233, -234, -235, -238)	**32.1** (11,777)	5.1 (11,789)	3.2 (11,913)	2.6 (11,913)	3.4 (11,938)	0.2 (11,835)	0 N/A	0.2 (11,835)	0 N/A	15
Chemical (micrograms per liter)										
Chromium	**864** (3882)	**228** (2158)	**215** (2050)			**214** (2050)	**208** (2050)	**215** (2050)	**196** (2087)	100
Nitrate	**187,000** (2066)	**192,000** (2068)	**171,000** (2055)				**188,000** (2051)	**171,000** (2055)	**200,000** (2077)	45,000
Total uranium	**41.3** (11,778)	7.4 (11,797)	4.4 (11,827)	3.7 (11,827)	4.6 (11,793)	0.2 (11,754)	0 N/A	0.2 (11,754)	0 N/A	30

Note: Calendar year of peak concentration shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern; N/A=not applicable.

Table S–9. Tank Closure Alternatives – Maximum COPC Concentrations in the Peak Year at the Columbia River Nearshore

Contaminant	Tank Closure Alternative									
	1	**2A**	**2B, 3A, 3B, 3C, 6C**	**4**	**5**	**6A, Base Case**	**6A, Option Case**	**6B, Base Case**	**6B, Option Case**	**Benchmark Concentration**
Radionuclide (picocuries per liter)										
Hydrogen-3 (tritium)	502 (2050)	494 (2050)	477 (2051)				501 (2050)	477 (2051)	490 (2050)	20,000
Technetium-99	**1,700** (2999)	418 (2317)	396 (2254)	392 (2254)	479 (4918)	382 (2251)	396 (2239)	358 (2221)	351 (2275)	900
Iodine-129	**6.8** (4840)	0.8 (2303)	0.7 (2240)	0.7 (2240)	0.8 (2334)	0.7 (2265)		0.7 (2217)		1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0.6 (11,928)	0.3 (11,935)	0.1 (11,937)		0.1 (11,935)		0 N/A	0.1 (11,935)	0 N/A	15
Chemical (micrograms per liter)										
Chromium	84 (4498)	74 (2079)	71 (2076)				64 (2076)	71 (2076)	60 (2074)	100
Nitrate	16,200 (2111)	17,500 (2131)	17,200 (2122)				17,400 (2146)	17,200 (2122)	15,500 (2138)	45,000
Total uranium	0.6 (11,931)	0.2 (11,929)	0.1 (11,937)		0.1 (11,938)	0 N/A				30

Note: Calendar year of peak concentration impact shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; N/A=not applicable.

S.5.4.1.2 Human Health

Implementation of activities defined for the Tank Closure alternatives could lead to releases of radioactive and chemical constituents to the environment over long periods of time. In the case of Tank Closure Alternatives 1 and 2A, these releases would not be controlled by engineered closure of the tanks, but, under Tank Closure Alternative 2A, waste generated by retrieval activities would be stabilized. Under the other Tank Closure alternatives, releases would be controlled by stabilization of the tanks and the waste generated by retrieval and closure activities. Potential human health impacts due to releases of radioactive constituents are estimated as dose and as lifetime risk of incidence of cancer (i.e., radiological risk). Potential human health effects due to releases of chemical constituents include both carcinogenic effects and other forms of toxicity. Impacts of carcinogenic chemicals are estimated as lifetime risk of incidence of cancer. Noncarcinogenic effects are estimated as a (1) Hazard Quotient, the ratio of the long-term intake of a single chemical to intake that produces no observable effect, and (2) Hazard Index, the sum of the Hazard Quotients of a group of chemicals.

The four measures of human health impacts considered in this EIS analysis—lifetime risks of developing cancer from radioactive and chemical constituents, dose from radionuclides, and Hazard Index from noncarcinogenic chemical constituents—were calculated for each year for 10,000 years for each receptor (described below) at eight locations. The locations are the disposal facility barriers (A, B, S, T, and U), the Core Zone Boundary, Columbia River nearshore, and Columbia River surface water.

Consistent with DOE guidance (DOE Guide 435.1-1:Section IV.P.(2)), the potential consequences of loss of administrative or institutional control are considered by estimation of impacts on onsite receptors. Because DOE does not anticipate loss of control of the site, these onsite receptors are considered hypothetical and are applied to develop estimates for past and future periods of time. Four types of receptors are considered. The first type, a drinking-water well user, uses groundwater as a source of drinking water. The second type, a resident farmer, uses either groundwater or surface water, but not both, for drinking water consumption and irrigation of crops. Garden size and crop yield are adequate to produce approximately 25 percent of average requirements of crops and animal products. The third type, an American Indian resident farmer, also uses either groundwater or surface water, but not both, for drinking water consumption and irrigation of crops. Garden size and crop yield are adequate to produce the entirety of average requirements of crops and animal products. The fourth type, an American Indian hunter-gatherer, is impacted by both groundwater and surface water because he uses surface water for drinking water consumption and consumes wild plant materials, which use groundwater, and game, which use surface water. A summary of the results for the drinking-water well user at the Core Zone Boundary is provided below. Impacts on other types of receptors vary in proportion to the impacts on the drinking-water well user and do not provide additional information to discriminate among alternatives.

This is a large amount of information that must be summarized to allow interpretation of results. The method chosen is to present dose for the year of maximum dose, risk for the year of maximum risk, and Hazard Index for the year of maximum Hazard Index. This choice is based on regulation of radiological impacts expressed as dose and the observation that peak risk and peak noncarcinogenic impacts expressed as a Hazard Index may occur at times other than that of peak dose. The significance of dose impacts is evaluated by comparison against the 100-millirem-per-year all-exposure-modes standard specified for protection of the public and the environment in *Radiation Protection of the Public and the Environment* (DOE Order 458.1). Population doses are compared against a total effective dose equivalent from ubiquitous, primarily natural, background sources of 311 millirem per year for a member of the population of the United States (NCRP 2009). The significance of noncarcinogenic chemical impacts is evaluated by comparison against a guideline value of unity (1) for Hazard Index. Estimation of Hazard Index less than unity indicates that observable effects would not occur. Impacts related to tank farm operations, tank waste retrieval, and tank closure would be due to three types of release. The first type is the past practice of directly discharging waste liquid to cribs and trenches (ditches). The second type is past leaks from damaged tanks. The third type results from other tank farm sources, such as leaks during tank waste retrieval and long-term leaching of waste material from tanks and ancillary equipment.

Table S–10 provides the maximum dose and maximum Hazard Index for the drinking-water well user by alternative according to the groundwater analysis results. The importance of retrieval of tank farm residuals can be seen in the peak radiation dose (and year of peak dose) to the drinking-water well user at the Core Zone Boundary (Table S–10). There is a clear differentiation between Tank Closure Alternative 1 (with no retrieval) and all other Tank Closure alternatives (with retrieval). The peak dose at the Core Zone Boundary under Tank Closure Alternative 1 is almost an order of magnitude greater than under the other Tank Closure alternatives. The years of peak dose for Tank Closure Alternatives 2A through 6C occur between CY 2056 and CY 2069, which is an indication that these peaks are dominated by historical discharges to cribs and trenches (ditches) and past leaks. Retrieval of tank farm residuals lowers the peak dose by an order of magnitude and switches the dominant contributor to dose from a future source (tank farm residuals) to historical sources (discharges to cribs and trenches [ditches] and past leaks).

Table S–10. Tank Closure Alternatives – Summary of Radiation Dose and Hazard Index at Year of Peak Dose/Hazard Index for the Drinking-Water Well User

Tank Closure Alternative	Core Zone Boundary		Columbia River Nearshore	
	Radiation Dose (millirem per year)	Hazard Index	Radiation Dose (millirem per year)	Hazard Index
1	5.88×10^{1} (4313)	9.20 (3696)	4.37 (4978)	1.01 (4498)
2A	8.64 (2069)	5.26 (2068)	9.41×10^{-1} (2317)	1.01 (2079)
2B, 3A, 3B, 3C, 6C	7.58 (2056)	4.81 (2050)	8.85×10^{-1} (2242)	9.71×10^{-1} (2076)
4	7.41 (2056)	4.80 (2050)	8.82×10^{-1} (2242)	9.71×10^{-1} (2076)
5	7.57 (2056)	4.81 (2050)	8.94×10^{-1} (4809)	9.71×10^{-1} (2076)
6A, Base Case	7.37 (2056)	4.80 (2050)	8.76×10^{-1} (2251)	9.71×10^{-1} (2076)
6A, Option Case	7.64 (2066)	5.22 (2051)	8.99×10^{-1} (2251)	9.12×10^{-1} (2076)
6B, Base Case	7.35 (2056)	4.80 (2050)	8.22×10^{-1} (2218)	9.72×10^{-1} (2076)
6B, Option Case	7.92 (2065)	5.23 (2083)	8.07×10^{-1} (2218)	8.30×10^{-1} (2074)

Note: Calendar year of peak impact shown in parentheses.

S.5.4.1.3 Ecological Risk

Risk indices for ecological receptors exposed to COPCs as a result of air releases and groundwater discharges were used in this *TC & WM EIS* to compare Tank Closure alternatives. For ecological receptors, the risk indices are the Hazard Quotient for each chemical COPC and the Hazard Index, which is the sum of Hazard Quotients for all radioactive COPCs. Risk indices less than 1 indicate little to no likelihood of adverse impact on the receptor. Table S–11 provides a summary of the potential long-term impacts under Tank Closure alternatives of contaminant releases to groundwater on ecological resources.

Table S–11 shows that the greatest potential ecological impacts would be on aquatic biota/salmonids (driven by chromium) and the least weasel (driven by nitrate). The long-term impacts on ecological receptors are not a primary differentiating factor among the Tank Closure alternatives.

Table S–11. Tank Closure Alternatives – Long-Term Impacts of Contaminant Releases to Groundwater on Aquatic and Riparian Receptors at the Columbia River

Alternative	Hazard Quotient of Highest-Value COPC by Receptor						
	Benthic Invertebrates	Aquatic Biota/ Salmonids	Spotted Sandpiper	Bald Eagle	Raccoon	Muskrat	Least Weasel
	Chromium[a]					Nitrate	
1	**1.69×10^{-1}**	4.32×10^{1}	**1.15**	**3.71×10^{-2}**	**1.39×10^{-1}**	1.41×10^{-2}	1.36
2A	1.62×10^{-1}	4.31×10^{1}	1.10	3.66×10^{-2}	1.33×10^{-1}	1.38×10^{-2}	1.36
2B, 3A, 3B, 3C, 6C	1.67×10^{-1}	4.31×10^{1}	1.13	3.69×10^{-2}	1.37×10^{-1}	**1.43×10^{-2}**	**1.37**
4	1.67×10^{-1}	4.31×10^{1}	1.13	3.69×10^{-2}	1.37×10^{-1}	**1.43×10^{-2}**	**1.37**
5	1.67×10^{-1}	4.31×10^{1}	1.13	3.69×10^{-2}	1.37×10^{-1}	**1.43×10^{-2}**	**1.37**
6A, Base Case	1.67×10^{-1}	4.31×10^{1}	1.13	3.69×10^{-2}	1.37×10^{-1}	**1.43×10^{-2}**	**1.37**
6A, Option Case	1.45×10^{-1}	4.44×10^{1}	9.84×10^{-1}	3.63×10^{-2}	1.19×10^{-1}	1.37×10^{-2}	**1.37**
6B, Base Case	1.67×10^{-1}	4.31×10^{1}	1.13	3.69×10^{-2}	1.37×10^{-1}	**1.43×10^{-2}**	**1.37**
6B, Option Case	1.41×10^{-1}	**4.45×10^{1}**	9.59×10^{-1}	3.61×10^{-2}	1.16×10^{-1}	1.38×10^{-2}	1.36

[a] For purposes of long-term impacts, it was assumed that this is hexavalent chromium.

Note: The maximum Hazard Quotient for each receptor is indicated by **bold** text.

Key: COPC=constituent of potential concern.

S.5.4.1.4 Environmental Justice

The long-term human health analysis determined that the impacts of tank closure actions would be greatest under Tank Closure Alternative 1. This alternative could result in radiation doses in excess of regulatory limits and chemical exposures with a Hazard Index greater than 1 for receptors located on site at the A, B, S, T, or U Barriers; the Core Zone Boundary; or the Columbia River nearshore. There are no such onsite receptors currently at Hanford. The onsite exposure scenarios do not currently exist and have never existed during Hanford operations. Therefore, the estimated high health risks for past years are hypothetical risks only; no persons were ever exposed at these levels. While it is possible for these receptor scenarios to develop in the future, none are expected within a reasonably foreseeable timeframe because the Core Zone is designated for Industrial-Exclusive land use, the Columbia River nearshore location for Preservation (Hanford Reach National Monument), and the area between them for Conservation (Mining) (DOE 1999b). However, exposures of such individuals were evaluated using the exposure scenarios discussed in Section S.5.4.1.2. The greatest risk would be to the American Indian resident farmer at the Core Zone Boundary. During the year of peak dose, this receptor would receive a radiation dose of 2.6×10^2 millirem. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index greater than 1. The adverse impacts would also be applicable to non–American Indian receptors at the same locations, but to a lesser extent due primarily to their assumed lower consumption of locally grown food. No adverse impacts were identified for any receptors at offsite locations; therefore, there would be no disproportionately high and adverse impacts on American Indian populations at offsite locations.

S.5.4.2 FFTF Decommissioning Alternatives

S.5.4.2.1 Water Quality

This section discusses the long-term impacts on groundwater quality resulting from FFTF sources (i.e., any residual contaminants left within the FFTF barrier boundary under each FFTF Decommissioning alternative). Long-term impacts on groundwater quality of sources remaining within the tank farm barrier boundaries and of waste management sources are discussed in Sections S.5.4.1.1 and S.5.4.3.1, respectively. Three assessment boundaries were selected for the groundwater analysis based on a combination of regulatory, permit, and land use requirements. For the FFTF Decommissioning alternatives, the FFTF fence line and proposed engineered barrier were selected as the innermost (i.e., closest to the source) assessment boundary. Very little groundwater transport would occur between the time the contaminants encounter the aquifer and the time they pass beneath the outer perimeter of the barrier; in general, this innermost assessment boundary shows the greatest water quality impacts.

The second area of groundwater analysis in this *TC & WM EIS* was established by the location of the Core Zone Boundary. However, because FFTF is outside of, and downgradient from, the Core Zone Boundary, the FFTF Decommissioning alternatives would not have an effect on potential impacts at this assessment boundary.

The third area of analysis is the Columbia River nearshore. It approximates the location where contaminants in the groundwater system discharge into the surface-water system. Water quality impacts at the Columbia River reflect the superimposition of releases from individual sources.

Groundwater impacts are described in terms of the concentrations of the COPC drivers at the assessment boundaries under the alternatives considered. The COPC drivers are tritium, iodine-129, technetium-99, uranium-238, chromium, nitrate, and total uranium. Table S–12 presents the maximum concentrations of the COPC drivers under each of the FFTF Decommissioning alternatives at the FFTF barrier; Table S–13, at the Columbia River nearshore. Long-term groundwater impacts under the FFTF Decommissioning alternatives are dominated by technetium-99. Qualitatively, all of the FFTF Decommissioning alternatives are at least a factor of 2 below the benchmark concentration at the Core Zone Boundary, and at least a factor of 30 at the Columbia River nearshore. Quantitatively, there is a difference between FFTF Decommissioning Alternative 3 (which involves complete removal of source materials) and FFTF Decommissioning Alternatives 1 and 2 (which involve no removal or partial removal of source material).

Table S–12. FFTF Decommissioning Alternatives – Maximum COPC Concentrations in the Peak Year at the FFTF Barrier

Contaminant	FFTF Decommissioning Alternative			Benchmark Concentration
	1	2	3	
Radionuclide (picocuries per liter)				
Hydrogen-3 (tritium)	0 N/A			20,000
Technetium-99	411 (2790)	401 (3137)	0 N/A	900
Iodine-129	0 N/A			1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A			15
Chemical (micrograms per liter)				
Chromium	0 N/A			100
Nitrate	0 N/A			45,000
Total uranium	20 (11,842)	0 N/A		30

Note: Calendar year of peak concentration shown in parentheses.
Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility; N/A=not applicable.

Table S–13. FFTF Decommissioning Alternatives – Maximum COPC Concentrations in the Peak Year at the Columbia River Nearshore

Contaminant	FFTF Decommissioning Alternative			Benchmark Concentration
	1	2	3	
Radionuclide (picocuries per liter)				
Hydrogen-3 (tritium)	0 N/A			20,000
Technetium-99	32 (2978)	34 (3307)	0 N/A	900
Iodine-129	0 N/A			1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A			15
Chemical (micrograms per liter)				
Chromium	0 N/A			100
Nitrate	0 N/A			45,000
Total uranium	0.8 (11,788)	0 N/A		30

Note: Calendar year of peak concentration shown in parentheses.
Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility; N/A=not applicable.

S.5.4.2.2 Human Health

Implementation of activities defined for the FFTF Decommissioning alternatives could lead to releases of radioactive and chemical constituents to the environment over long periods of time. Under FFTF Decommissioning Alternative 1, these releases would not be controlled by final decommissioning activities. Under FFTF Decommissioning Alternative 2, these releases would be controlled by removal of all aboveground structures and minimal removal of below-grade structures, equipment, and materials. An RCRA-compliant barrier would be constructed over the RCB and any other remaining below-grade structures (including the reactor vessel). Under FFTF Decommissioning Alternative 3, these releases would be further controlled by removal of all aboveground structures and contaminated below-grade structures (including the reactor vessel), equipment, and materials.

The four measures of human health impacts considered in this analysis—lifetime risks of developing cancer from radioactive and chemical constituents, dose from radionuclides, and Hazard Index from noncarcinogenic chemical constituents—were calculated for each year for 10,000 years for each receptor at three locations (the FFTF barrier, Columbia River nearshore, and surface water of the Columbia River).

The results of the analysis for the drinking-water well user at the FFTF barrier and Columbia River nearshore for FFTF Decommissioning Alternatives 1, 2, and 3 are summarized below. Impacts on other types of receptors vary in proportion to the impacts on the drinking-water well user and do not provide additional information to discriminate among alternatives. Table S–14 provides the maximum dose and maximum Hazard Index for the drinking-water well user by alternative according to the groundwater analysis results. Long-term human health impacts under the FFTF Decommissioning alternatives are all at least two orders of magnitude smaller than impacts associated with the Tank Closure alternatives (Table S–10). There is a relatively small difference between FFTF Decommissioning Alternative 3 (which involves complete removal of source materials) and FFTF Decommissioning Alternatives 1 and 2 (which involve no removal or partial removal of source material).

Table S–14. FFTF Decommissioning Alternatives – Summary of Radiation Dose and Hazard Index at Year of Peak Dose/Hazard Index for the Drinking-Water Well User

FFTF Decommissioning Alternatives	FFTF Barrier		Columbia River Nearshore	
	Radiation Dose (millirem per year)	Hazard Index	Radiation Dose (millirem per year)	Hazard Index
1	7.9×10^{-1} (2790)	1.91×10^{-1} (11,842)	5.57×10^{-2} (2978)	7.99×10^{-3} (11,788)
2	7.02×10^{-1} (3137)	N/A	5.86×10^{-2} (3307)	N/A
3	N/A	N/A	N/A	N/A

Note: Calendar year of peak impact shown in parentheses.
Key: FFTF=Fast Flux Test Facility; N/A=not applicable (inventory completely removed under Alternative 3).

S.5.4.2.3 Ecological Risk

Risk indices for ecological receptors exposed to COPCs as a result of air releases and groundwater discharges are used in this *TC & WM EIS* to compare the FFTF Decommissioning alternatives. Risk indices less than 1 indicate little to no likelihood of adverse impact on the receptor. Table S–15 provides a summary of the potential long-term impacts under FFTF Decommissioning alternatives of contaminant releases to groundwater on ecological resources. Table S–15 shows that the potential ecological risk associated with FFTF Decommissioning alternatives would be small compared with the potential ecological risk associated with Tank Closure alternatives. The long-term impacts on ecological receptors are not a primary differentiating factor among the FFTF Decommissioning alternatives.

Table S–15. FFTF Decommissioning Alternatives – Long-Term Impacts of Contaminant Releases to Groundwater on Aquatic and Riparian Receptors at the Columbia River

FFTF Decommissioning Alternative	Hazard Quotient of Highest-Value COPC by Receptor						
	Benthic Invertebrates	Muskrat	Spotted Sandpiper	Raccoon	Least Weasel	Bald Eagle	Aquatic Biota/ Salmonids
	Technetium-99	Uranium[a]					
1	2.20×10^{-7}	**2.73×10^{-5}**	**1.30×10^{-2}**	**2.91×10^{-2}**	**1.28×10^{-3}**	**8.07×10^{-5}**	**5.46×10^{-3}**
2	**2.32×10^{-7}**	0	0	0	0	0	0
3	8.78×10^{-14}	0	0	0	0	0	0

a Uranium as chemical.

Note: The maximum Hazard Quotient for each receptor is indicated by **bold** text.

Key: COPC=constituent of potential concern; FFTF=Fast Flux Test Facility.

S.5.4.2.4 Environmental Justice

The long-term human health analysis determined that the impacts of FFTF decommissioning actions would be greatest under FFTF Decommissioning Alternative 1. Under this alternative, none of the hypothetical receptors at any of the assessment boundaries would receive a radiation dose in excess of regulatory limits or a chemical exposure with a Hazard Index greater than 1. The greatest risk would be to the American Indian resident farmer at the FFTF barrier. During the year of peak dose, this receptor would receive a radiation dose of 3.8 millirem compared to the regulatory limit of 100 millirem from all sources. During the year of peak Hazard Index, this receptor would be exposed to chemicals resulting in a Hazard Index less than 1. Therefore, none of the FFTF Decommissioning alternatives would pose a disproportionately high and adverse long-term human health risk to the American Indian population at offsite locations.

S.5.4.3 Waste Management Alternatives

For analysis purposes, three disposal groups were identified to support Hanford waste management needs. These groups (Disposal Groups 1, 2, and 3) were developed to limit the number of iterations of analysis; support reader understanding; and encompass the sizing and associated construction, operations, and closure requirements for IDF-East, IDF-West, and the proposed RPPDF that would be necessary to accommodate the various waste volumes considered under each disposal configuration. These disposal groups were further separated into subgroups reflecting the different types and volumes of waste generated by activities under the 10 Tank Closure action alternatives and 2 FFTF Decommissioning action alternatives to better analyze the long-term impacts associated with disposal of the various waste types and volumes.

S.5.4.3.1 Water Quality

This section discusses the long-term impacts on groundwater quality from waste management sources (i.e., contaminants from disposal at LLBG 218-W-5, trenches 31 and 34; IDF-East; IDF-West; and the proposed RPPDF). Long-term impacts on groundwater quality resulting from sources remaining within the tank farm barrier boundaries and sources within the FFTF barrier boundary are discussed in Sections S.5.4.1.1 and S.5.4.2.1, respectively. Three assessment boundaries were selected for the groundwater analysis based on a combination of regulatory, permit, and land use requirements. For Waste Management alternatives, the innermost (i.e., closest to the source) area of analysis comprises the engineered barriers that would be installed above the IDFs, the proposed RPPDF, and trenches 31 and 34. The second area of analysis was established by the location of the Core Zone Boundary, and the third area of analysis is the Columbia River nearshore.

Under Waste Management Alternative 1, no wastes would be disposed of in an IDF or the proposed RPPDF, and the sources of groundwater contamination are trenches 31 and 34. Note that Waste Management Alternative 1 is predicated on, and can be considered only in conjunction with, Tank Closure Alternative 1 and FFTF Decommissioning Alternative 1 (the No Action Alternatives). The maximum concentrations of the COPC drivers are reported at the trenches 31 and 34 barrier under Waste Management Alternative 1 in Table S–16. All of the projected maximum groundwater concentrations are near (or below) two orders of magnitude lower than benchmark concentrations. Waste Management Alternative 1 impacts at the Core Zone Boundary and the Columbia River nearshore are essentially negligible.

Under Waste Management Alternative 2, wastes would be disposed of in IDF-East and the proposed RPPDF. Under Waste Management Alternative 3, wastes would be disposed of in IDF-East, IDF-West, and the proposed RPPDF. Waste Management Alternatives 2 and 3 are considered in conjunction with one of the Tank Closure action alternatives (i.e., 2A through 6C) and FFTF Decommissioning Alternative 2 or 3. Tables S–17 and S–18 show the maximum concentrations at the Core Zone Boundary under Waste Management Alternatives 2 and 3, respectively. Under Waste Management Alternative 2, concentrations of technetium-99 and iodine-129 are within an order of magnitude of benchmark standards for all disposal groups and exceed the benchmark in several cases. Under Waste Management Alternative 3, concentrations of technetium-99 and iodine-129 exceed benchmark standards for all disposal groups. Because of the higher infiltration rate at IDF-West, dividing the waste load between IDF-East and IDF-West (Waste Management Alternative 3) does not result in lower groundwater impacts at the Core Zone Boundary. Tables S–19 and S–20 show the maximum concentrations at the Columbia River nearshore under Waste Management Alternatives 2 and 3, respectively. Groundwater concentration levels are mildly attenuated (relative to concentrations at the Core Zone Boundary), but the results again indicate that disposing of some wastes in IDF-West does not result in lower groundwater impacts.

Table S–16. Waste Management Alternative 1 Maximum COPC Concentrations in the Peak Year at Trenches 31 and 34

Contaminant	Waste Management Alternative 1	Benchmark Concentration
Radionuclide (picocuries per liter)		
Hydrogen-3 (tritium)	0 N/A	20,000
Technetium-99	7 (3443)	900
Iodine-129	0 N/A	1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A	15
Chemical (micrograms per liter)		
Chromium	1 (3490)	100
Nitrate	18 (3514)	45,000
Total uranium	0 N/A	30

Note: Calendar year of peak concentration shown in parentheses.
Key: COPC=constituent of potential concern; N/A=not applicable.

Table S–17. Waste Management Alternative 2 Maximum COPC Concentrations in the Peak Year at the Core Zone Boundary

Contaminant	Waste Management Alternative 2												
	Disposal Group 1							Disposal Group 2			Disposal Group 3		Benchmark Concentration
	Subgroup							Subgroup					
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	Base Case	Option Case	
Radionuclide (picocuries per liter)													
Hydrogen-3 (tritium)	0 N/A												20,000
Technetium-99	497 (7709)	748 (7848)	**1,050** (8334)	610 (8237)	**1,390** (9662)	696 (8302)	497 (7709)	556 (7328)	557 (7328)		577 (7891)	577 (7723)	900
Iodine-129	0.9 (7856)			**1.0** (7856)	0.9 (7856)			0.9 (8116)	0.9 (7972)	0.9 (8060)	**1.0** (7914)		1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A												15
Chemical (micrograms per liter)													
Chromium	0.7 (3846)		**102** (8680)	6.1 (10,691)	52.5 (8873)	77.9 (9057)	0.7 (3846)	0.7 (8053)	3.4 (3977)	28.6 (3901)	3.3 (3701)	28.4 (3865)	100
Nitrate	3,010 (8248)	2,790 (8095)	16,100 (8973)	3,150 (8121)	8,960 (8189)	6,250 (7810)	3,010 (8248)	2,920 (8291)	3,130 (7860)	7,220 (3814)	3,130 (7860)	7,820 (3782)	45,000
Total uranium	0 N/A												30

Note: Calendar year of peak concentration shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern; N/A=not applicable.

Table S–18. Waste Management Alternative 3 Maximum COPC Concentrations in the Peak Year at the Core Zone Boundary

Contaminant	Waste Management Alternative 3												
	Disposal Group 1							Disposal Group 2			Disposal Group 3		Benchmark Concentration
	Subgroup							Subgroup					
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	Base Case	Option Case	
Radionuclide (picocuries per liter)													
Hydrogen-3 (tritium)	0 N/A												20,000
Technetium-99	**1,370** (3859)												900
Iodine-129	**2** (3937)												1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A												15
Chemical (micrograms per liter)													
Chromium	0.7 (3846)		**102** (8680)	6.1 (10,691)	52.5 (8873)	78 (9057)	0.7 (3846)	0.7 (8053)	3.4 (3977)	28.6 (3901)	3.3 (3701)	28.4 (3865)	100
Nitrate	3,010 (8248)	2,790 (8095)	16,100 (8973)	3,150 (8121)	8,960 (8189)	6,250 (7810)	3,010 (8248)	2,918 (8123)	3,130 (7860)	7,220 (3814)	3,130 (7860)	7,820 (3782)	45,000
Total uranium	0 N/A												30

Note: Calendar year of peak concentration shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: COPC=constituent of potential concern; N/A=not applicable.

Table S–19. Waste Management Alternative 2 Maximum COPC Concentrations in the Peak Year at the Columbia River Nearshore

Contaminant	Waste Management Alternative 2												
	Disposal Group 1							Disposal Group 2			Disposal Group 3		Benchmark Concentration
	Subgroup							Subgroup					
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	Base Case	Option Case	
Radionuclide (picocuries per liter)													
Hydrogen-3 (tritium)	0 N/A												20,000
Technetium-99	377 (8130)	608 (8014)	**904** (10,429)	486 (8130)	**1,170** (10,639)	559 (8014)	379 (8130)	373 (7754)	377 (7754)	379 (7754)	370 (8233)	373 (8233)	900
Iodine-129	0.7 (8067)	0.6 (7796)	0.6 (7749)	0.7 (7749)	0.6 (7749)	0.6 (8067)	0.7 (8067)	0.6 (8221)	0.6 (7780)	0.6 (7973)	0.6 (7755)		1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A												15
Chemical (micrograms per liter)													
Chromium	0.4 (8236)	0.3 (4250)	78.5 (8594)	4.7 (11,049)	39.8 (8827)	59.6 (8241)	0.4 (8735)	0.5 (7640)	2.0 (4632)	19.1 (4558)	1.9 (4608)	20.8 (4487)	100
Nitrate	2,030 (7535)	2,210 (7940)	12,240 (8783)	2,400 (7899)	6,820 (9059)	4,140 (7984)	2,030 (7535)	1,860 (8406)	2,140 (7994)	4,340 (4606)	2,140 (7994)	5,190 (4701)	45,000
Total uranium	0 N/A												30

Note: Calendar year of peak concentration shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; N/A=not applicable.

Table S–20. Waste Management Alternative 3 Maximum COPC Concentrations in the Peak Year at the Columbia River Nearshore

Contaminant	Waste Management Alternative 3												
	Disposal Group 1							Disposal Group 2			Disposal Group 3		
	Subgroup							Subgroup					
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	Base Case	Option Case	Benchmark Concentration
Radionuclide (picocuries per liter)													
Hydrogen-3 (tritium)	0 N/A												20,000
Technetium-99	**1,670** (3920)												900
Iodine-129	**2** (3872)												1
Uranium isotopes (includes uranium-233, -234, -235, -238)	0 N/A												15
Chemical (micrograms per liter)													
Chromium	0.5 (4481)		78.5 (8594)	4.7 (11,049)	39.8 (8827)	59.6 (8241)	0.5 (4481)	0.4 (7640)	2.2 (4632)	19.3 (4558)	2.1 (4608)	20.9 (4487)	100
Nitrate	2,030 (7535)	2,210 (7940)	12,240 (8783)	2,400 (7899)	6,820 (9059)	4,140 (7984)	2,030 (7535)	1,860 (8406)	2,140 (7994)	4,340 (4606)	2,140 (7994)	5,190 (4701)	45,000
Total uranium	0 N/A												30

Note: Calendar year of peak concentration shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern; N/A=not applicable.

S.5.4.3.2 Human Health

Implementation of activities defined for the Waste Management alternatives could lead to releases of radioactive and chemical constituents to the environment over long periods of time. Under Waste Management Alternative 1, these releases would come from LLBG 218-W-5, trenches 31 and 34; under Waste Management Alternative 2, from IDF-East and the proposed RPPDF; and under Waste Management Alternative 3, from IDF-East, IDF-West, and the proposed RPPDF.

The four measures of human health impacts considered in this analysis—lifetime risks of developing cancer from radioactive and chemical constituents, dose from radionuclides, and Hazard Index from noncarcinogenic chemical constituents—were calculated for each year for 10,000 years for each receptor at six locations (IDF-East, IDF-West, the proposed RPPDF, Core Zone Boundary, Columbia River nearshore, and surface water of the Columbia River). This is a large amount of information that must be summarized to allow interpretation of results. The method chosen is to present dose for the year of maximum dose, risk for the year of maximum risk, and Hazard Index for the year of maximum Hazard Index. This choice is based on regulation of radiological impacts expressed as dose and the observation that peak risk and peak noncarcinogenic impacts expressed as a Hazard Index may occur at times other than that of peak dose. The significance of the dose impacts is evaluated by comparison against the 100-millirem-per-year all-exposure-modes standard specified for protection of the public and the environment in DOE Order 458.1. Population doses are compared against a total effective dose equivalent from natural background sources of 311 millirem per year for a member of the population of the United States (NCRP 2009). The level of protection provided for the drinking water pathway was evaluated by comparison against applicable drinking water standards, as presented in Appendix O. To reduce their size, the following tables present only those radionuclides and chemical constituents that resulted in a lifetime risk greater than 1×10^{-10}. The significance of noncarcinogenic chemical impacts is evaluated by comparison against a Hazard Index guideline value of less than unity (1). Estimation of Hazard Index less than unity indicates that observable effects would not occur.

Results of the analysis for the drinking-water well user at the Core Zone Boundary are summarized below. Impacts on other types of receptors vary in proportion to the impacts on the drinking-water well user and do not provide additional information to discriminate among alternatives. The maximum dose and maximum Hazard Index from the groundwater analysis of Waste Management Alternative 1 for the drinking-water well user at the Core Zone Boundary and Columbia River nearshore are summarized in Table S–21; of Waste Management Alternative 2, in Table S–22; and of Waste Management Alternative 3, in Table S–23.

Under Waste Management Alternative 1, no waste would be disposed of in an IDF or the proposed RPPDF, and the sources of groundwater contamination are trenches 31 and 34. Note that Waste Management Alternative 1 is predicated on, and can be considered only in conjunction with, Tank Closure Alternative 1 and FFTF Decommissioning Alternative 1 (the No Action Alternatives). The human health impacts at the Core Zone Boundary and the Columbia River nearshore are essentially negligible (Table S–21).

Table S–21. Waste Management Alternative 1 Summary of Radiation Dose at Year of Peak Dose and Hazard Index at Year of Peak Hazard Index for the Drinking-Water Well User

Location	Radiation Dose (millirem per year)	Hazard Index
Core Zone Boundary	9.90×10^{-4} (3462)	6.87×10^{-4} (3519)
Columbia River nearshore	2.42×10^{-3} (3980)	1.66×10^{-3} (3993)

Note: Calendar year of peak impacts shown in parentheses.

Table S–22. Waste Management Alternative 2, All Disposal Groups and Subgroups, Summary of Radiation Dose at Year of Peak Dose and Hazard Index at Year of Peak Hazard Index for the Drinking-Water Well User

	Waste Management Alternative 2											
	Disposal Group 1							Disposal Group 2			Disposal Group 3	
	Subgroup							Subgroup				
Location	**1-A**	**1-B**	**1-C**	**1-D**	**1-E**	**1-F**	**1-G**	**2-A**	**2-B, Base Case**	**2-B, Option Case**	**Base Case**	**Option Case**
Radiation Dose at Year of Peak Dose (millirem per year)												
Core Zone Boundary	1.01 (7439)	1.43 (7848)	1.94 (8334)	1.18 (8237)	2.49 (9662)	1.34 (8302)	1.01 (7439)	1.16 (7328)		1.17 (7328)	1.21 (7891)	1.17 (7723)
Columbia River nearshore	7.56×10^{-1} (7847)	1.17 (8014)	1.60 (10,429)	9.66×10^{-1} (8174)	2.07 (10,639)	1.07 (8014)	7.46×10^{-1} (7847)	7.43×10^{-1} (7754)	7.66×10^{-1} (7754)	7.70×10^{-1} (7754)	7.52×10^{-1} (8233)	7.65×10^{-1} (8233)
Hazard Index at Year of Peak Hazard Index												
Core Zone Boundary	5.76×10^{-2} (8248)	5.16×10^{-2} (8095)	1.11 (8680)	9.26×10^{-2} (8317)	6.26×10^{-1} (8873)	8.21×10^{-1} 8588)	5.78×10^{-2} (8248)	5.65×10^{-2} (8123)	6.05×10^{-1} (7860)	3.56×10^{-1} (3688)	6.05×10^{-1} (7860)	3.75×10^{-1} (3865)
Columbia River nearshore	3.80×10^{-2} (7927)	4.05×10^{-2} (7940)	8.56×10^{-1} (8594)	6.38×10^{-2} (8284)	4.68×10^{-1} (8827)	6.12×10^{-1} (8535)	3.81×10^{-2} (8798)	3.58×10^{-2} (8406)	3.95×10^{-1} (7994)	2.34×10^{-1} (4560)	3.96×10^{-2} (7994)	2.58×10^{-1} (4487)

Note: Calendar year of peak impact shown in parentheses.

Table S–23. Waste Management Alternative 3, All Disposal Groups and Subgroups, Summary of Radiation Dose at Year of Peak Dose and Hazard Index at Year of Peak Hazard Index for the Drinking-Water Well User

Location	Waste Management Alternative 3											
	Disposal Group 1 (millirem per year)							Disposal Group 2 (millirem per year)			Disposal Group 3 (millirem per year)	
	Subgroup							Subgroup				
	1-A	1-B	1-C	1-D	1-E	1-F	1-G	2-A	2-B, Base Case	2-B, Option Case	Base Case	Option Case
Radiation Dose (millirem per year) at Year of Peak Dose												
Core Zone Boundary	2.92 (3859)											
Columbia River nearshore	3.52 (3920)											
Hazard Index at Year of Peak Hazard Index												
Core Zone Boundary	5.76×10^{-2} (8248)	5.15×10^{-2} (8095)	1.11 (8680)	9.23×10^{-2} (8317)	6.26×10^{-1} (8873)	8.20×10^{-1} (8588)	5.77×10^{-2} (8248)	5.64×10^{-2} (8123)	6.02×10^{-2} (7860)	3.56×10^{-1} (3688)	6.02×10^{-2} (7860)	3.75×10^{-1} (3865)
Columbia River nearshore	3.77×10^{-2} (7927)	4.04×10^{-2} (7940)	8.56×10^{-1} (8594)	6.35×10^{-2} (8284)	4.68×10^{-1} (8827)	6.11×10^{-1} (8535)	3.78×10^{-2} (7927)	3.57×10^{-2} (8406)	3.95×10^{-2} (7994)	2.36×10^{-1} (4560)	3.95×10^{-2} (7994)	2.60×10^{-1} (4487)

Note: Calendar year of peak impact shown in parentheses.

Under Waste Management Alternative 2, wastes would be disposed of in IDF-East and the proposed RPPDF. Under Waste Management Alternative 2, wastes would be disposed of in IDF-East, IDF-West, and the proposed RPPDF. Waste Management Alternatives 2 and 3 are considered in conjunction with one of the Tank Closure action alternatives (i.e., 2A through 6C), and FFTF Decommissioning Alternative 2 or 3. Tables S–22 and S–23 show the maximum concentrations at the Core Zone Boundary under Waste Management Alternatives 2 and 3, respectively. Under both Waste Management Alternatives 2 and 3, there is not a strong discrimination among the disposal groups in terms of potential human health impacts. Because of the higher infiltration rate at IDF-West, dividing the waste load between IDF-East and IDF-West (Waste Management Alternative 3) does not result in lower peak doses or Hazard Indices at the Core Zone Boundary.

S.5.4.3.3 Ecological Risk

Risk indices for ecological receptors exposed to COPCs as a result of air releases and groundwater discharge were used in this *TC & WM EIS* to compare Waste Management alternatives. Risk indices less than 1 indicate little to no likelihood of adverse impact on the receptor. Table S–24 provides a summary of the potential long-term impacts under Waste Management alternatives of contaminant releases to groundwater on ecological resources.

Table S–24. Waste Management Alternatives – Long-Term Impacts of Contaminant Releases to Groundwater on Aquatic and Riparian Receptors at the Columbia River

Waste Management Alternative	Hazard Quotient of Highest-Value COPC by Receptor						
	Benthic Invertebrates	Spotted Sandpiper	Raccoon	Bald Eagle	Aquatic Biota/ Salmonids	Muskrat	Least Weasel
	Chromium[a]					Nitrate	
1	1.15×10^{-4}	7.82×10^{-4}	9.47×10^{-5}	9.34×10^{-6}	3.14×10^{-3}	6.24×10^{-7}	7.73×10^{-6}
2, DG 1, SG 1-A	3.10×10^{-4}	2.10×10^{-3}	2.55×10^{-4}	3.24×10^{-5}	2.05×10^{-2}	4.01×10^{-4}	1.10×10^{-2}
2, DG 1, SG 1-B	2.06×10^{-4}	1.40×10^{-3}	1.69×10^{-4}	2.33×10^{-5}	1.66×10^{-2}	4.35×10^{-4}	1.00×10^{-2}
2, DG 1, SG 1-C	**5.73×10^{-2}**	**3.89×10^{-1}**	**4.71×10^{-2}**	**5.46×10^{-3}**	**2.90**	**2.41×10^{-3}**	**5.66×10^{-2}**
2, DG 1, SG 1-D	3.40×10^{-3}	2.31×10^{-2}	2.79×10^{-3}	3.30×10^{-4}	1.83×10^{-1}	4.74×10^{-4}	1.15×10^{-2}
2, DG 1, SG 1-E	2.91×10^{-2}	1.97×10^{-1}	2.39×10^{-2}	2.87×10^{-3}	1.63	1.34×10^{-3}	3.42×10^{-2}
2, DG 1, SG 1-F	4.35×10^{-2}	2.95×10^{-1}	3.58×10^{-2}	4.35×10^{-3}	2.55	8.16×10^{-4}	2.32×10^{-2}
2, DG 1, SG 1-G	3.03×10^{-4}	2.05×10^{-3}	2.49×10^{-4}	3.21×10^{-5}	2.07×10^{-2}	4.01×10^{-4}	1.10×10^{-2}
2, DG 2, SG 2-A	3.29×10^{-4}	2.23×10^{-3}	2.70×10^{-4}	3.36×10^{-5}	2.04×10^{-2}	3.68×10^{-4}	1.04×10^{-2}
2, DG 2, SG 2-B, Base Case	1.49×10^{-3}	1.01×10^{-2}	1.23×10^{-3}	1.59×10^{-4}	1.03×10^{-1}	4.22×10^{-4}	1.05×10^{-2}
2, DG 2, SG 2-B, Option Case	1.39×10^{-2}	9.45×10^{-2}	1.14×10^{-2}	1.49×10^{-3}	9.72×10^{-1}	8.56×10^{-4}	3.20×10^{-2}
2, DG 3, Base Case	1.39×10^{-3}	9.40×10^{-3}	1.14×10^{-3}	1.52×10^{-4}	1.04×10^{-1}	4.22×10^{-4}	1.05×10^{-2}
2, DG 3, Option Case	1.52×10^{-2}	1.03×10^{-1}	1.25×10^{-2}	1.56×10^{-3}	9.60×10^{-1}	1.02×10^{-3}	3.20×10^{-2}
3, DG 1, SG 1-A	3.48×10^{-4}	2.36×10^{-3}	2.86×10^{-4}	3.61×10^{-5}	2.25×10^{-2}	4.01×10^{-4}	1.10×10^{-2}
3, DG 1, SG 1-B	3.48×10^{-4}	2.36×10^{-3}	2.86×10^{-4}	3.61×10^{-5}	2.25×10^{-2}	4.35×10^{-4}	1.00×10^{-2}
3, DG 1, SG 1-C	**5.73×10^{-2}**	**3.89×10^{-1}**	**4.71×10^{-2}**	5.45×10^{-3}	**2.90**	**2.41×10^{-3}**	**5.66×10^{-2}**
3, DG 1, SG 1-D	3.40×10^{-3}	2.31×10^{-2}	2.79×10^{-3}	3.30×10^{-4}	1.83×10^{-1}	4.74×10^{-4}	1.15×10^{-2}
3, DG 1, SG 1-E	2.91×10^{-2}	1.97×10^{-1}	2.39×10^{-2}	2.86×10^{-3}	1.63	1.34×10^{-3}	3.42×10^{-2}
3, DG 1, SG 1-F	4.35×10^{-2}	2.95×10^{-1}	3.57×10^{-2}	4.35×10^{-3}	2.54	8.16×10^{-4}	2.32×10^{-2}
3, DG 1, SG 1-G	3.48×10^{-4}	2.36×10^{-3}	2.86×10^{-4}	3.61×10^{-5}	2.25×10^{-2}	4.01×10^{-4}	1.10×10^{-2}
3, DG 2, SG 2-A	3.12×10^{-4}	2.11×10^{-3}	2.56×10^{-4}	3.13×10^{-5}	1.85×10^{-2}	3.68×10^{-4}	1.04×10^{-2}
3, DG 2, SG 2-B, Base Case	1.62×10^{-3}	1.10×10^{-2}	1.33×10^{-3}	1.71×10^{-4}	1.09×10^{-1}	4.22×10^{-4}	1.05×10^{-2}
3, DG 2, SG 2-B, Option Case	1.41×10^{-2}	9.54×10^{-2}	1.16×10^{-2}	1.50×10^{-3}	9.77×10^{-1}	8.56×10^{-4}	3.20×10^{-2}
3, DG 3, Base Case	1.51×10^{-3}	1.02×10^{-2}	1.24×10^{-3}	1.64×10^{-4}	1.10×10^{-1}	4.22×10^{-4}	1.05×10^{-2}
3, DG 3, Option Case	1.53×10^{-2}	1.04×10^{-1}	1.26×10^{-2}	1.57×10^{-3}	9.66×10^{-1}	1.02×10^{-3}	3.21×10^{-2}

[a] For purposes of long-term impacts, it was assumed that this is hexavalent chromium.
Note: The maximum Hazard Quotient for each receptor is indicated by **bold** text.
Key: COPC=constituent of potential concern; DG=Disposal Group; SG=Subgroup.

Under Waste Management Alternative 1, no waste would be disposed of an in IDF or the proposed RPPDF, and the sources of groundwater contamination are trenches 31 and 34. Note that Waste Management Alternative 1 is predicated on, and can be considered only in conjunction with, Tank Closure Alternative 1 and FFTF Decommissioning Alternative 1 (the No Action Alternatives). The projected risk to ecological receptors is essentially negligible.

Under Waste Management Alternative 2, wastes would be disposed of in IDF-East and the proposed RPPDF. Under Waste Management Alternative 2, wastes would be disposed of in IDF-East, IDF-West, and the proposed RPPDF. Waste Management Alternatives 2 and 3 are considered in conjunction with one of the Tank Closure action alternatives (i.e., 2A through 6C), and FFTF Decommissioning Alternative 2 or 3. In terms of ecological risk, there is essentially no discrimination between Waste Management Alternative 2 and Waste Management Alternative 3 across all disposal groups.

S.5.4.3.4 Environmental Justice

The long-term human health analysis determined that the impacts of waste management actions would be greatest under Waste Management Alternative 3, Disposal Group 1, Subgroup 1-C. This alternative could result in radiation doses in excess of regulatory limits and chemical exposures with a Hazard Index greater than 1 for receptors on site at the IDF-East barrier, the IDF-West barrier, the Core Zone Boundary, or the Columbia River nearshore. There are no such onsite receptors currently at Hanford. The onsite exposure scenarios do not currently exist and have never existed during Hanford operations. Therefore, the estimated high health risks for past years are hypothetical risks only; no persons were ever exposed at these levels. While it is possible for these receptor scenarios to develop in the future, none are expected within a reasonably foreseeable timeframe because the Core Zone is designated for Industrial-Exclusive land use, the Columbia River nearshore location for Preservation (Hanford Reach National Monument), and the area between them for Conservation (Mining) (DOE 1999b). However, exposures of such individuals were evaluated using the exposure scenarios discussed in Section S.5.4.1.2. The greatest risk would be to the American Indian resident farmer at the IDF-West boundary. During the year of peak dose, this receptor would receive a radiation dose of 131 millirem, which is above the 100-millirem-per-year all-exposure-modes standard specified for protection of the public and the environment in DOE Order 458.1. During the year of peak Hazard Index, this receptor would not be exposed to chemicals resulting in a Hazard Index greater than 1; however, the risk from the radiation dose at this location outweighs the nonradiological risk from chemical releases at the other reporting locations. The adverse impacts would also be applicable to non–American Indian receptors at the same locations, but to a lesser extent due primarily to their assumed lower consumption of locally grown food. No adverse impacts were identified for any receptors at offsite locations; therefore, there would be no disproportionately high and adverse impacts on American Indian populations at offsite locations.

S.5.5 Key Environmental Findings

The following sections present an overview of the key findings associated with the Tank Closure, FFTF Decommissioning, and Waste Management alternatives. Both short- and long-term impact analyses are included in this key findings discussion; however, the majority of the findings focus on long-term impacts.

Provision of a concise description of human health impacts is facilitated by selection of a single measure of impact and a single type of receptor. Radiological risk is selected as the measure of impact for the summary descriptions because radiological risk accounts for nearly the entirety of combined radiological and chemical risk and subsumes the contributions of multiple constituents to overall impacts. The drinking-water well user is selected as the receptor type for the summary descriptions because the drinking water exposure pathway generally contributes the majority of impacts for all receptor types; the impact for this exposure pathway is directly proportional to the concentration of constituents in groundwater; and interpretation of results involves consideration of the least number of contributing processes and environmental pathway parameters.

S.5.5.1 Tank Closure Alternatives

The Tank Closure action alternatives described in this *TC & WM EIS* represent the range of reasonable approaches to storing Hanford tank waste; removing the waste from the tanks to the extent technically and economically feasible; treating the waste through vitrification in the existing WTP, in an expanded WTP, and/or in conjunction with one or more supplemental treatment technologies; packaging the waste for onsite storage or disposal or offsite shipment and disposal; and closing the SST system to permanently reduce the potential risk to human health and the environment. These alternatives were developed in part to allow comparisons of the short-term impacts of the construction, operation, and deactivation of the additional facilities proposed for storage, retrieval, treatment, and disposal of waste from the SST system, and for closure of the SST system. These action alternatives were also developed to allow similar comparisons of the long-term water quality, human health, and ecological risk impacts resulting from completion of these activities. The following is a brief discussion of the key findings for the Tank Closure alternatives.

Tank Farm Waste Retrieval. The Tank Closure alternatives allow the range of retrieval options to be evaluated. Under Tank Closure Alternative 1, the tank waste would not be retrieved. Under Tank Closure Alternative 5, retrieval of 90 percent of the waste would occur. Tank Closure Alternatives 2A, 2B, 3A, 3B, 3C, and 6C would achieve 99 percent retrieval. Tank Closure Alternatives 4, 6A, and 6B would retrieve 99.9 percent of the tank waste.

Continued storage of tank waste with no removal or treatment would have negligible additional short-term impacts but significant long-term impacts. Retrieving the tank waste rather than leaving it in place would reduce long-term impacts on groundwater and human health.

For potential short-term impacts, resource requirements and human health effects associated with tank waste retrieval are similar, and rather small compared with other construction-, operations-, and closure-related impacts under all Tank Closure alternatives.

The influence of degree of retrieval on the magnitude of long-term human health impacts is most clearly discernible through consideration of impacts due to tank farm sources other than past leaks. Potential long-term impacts due to sources in SST and DST farms include losses from residual waste remaining in tanks and ancillary equipment following retrieval, as well as retrieval leaks at SST farms and past unplanned releases at SST farms. Figure S–14 reflects estimates of lifetime radiological risk for a drinking-water well user at the Core Zone Boundary for these tank farm sources consistent with the following waste retrieval options: Tank Closure Alternative 1 (no retrieval); Tank Closure Alternative 5 (90 percent retrieval); Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C (99 percent retrieval); and Tank Closure Alternative 4 (99.9 percent retrieval). Note: Tank Closure Alternative 2A is not included in Figure S–14 because tank closure is not included under this alternative. Tank Closure Alternatives 6A and 6B are not included in Figure S–14 because long-term human health impacts are negligible; three groundwater sources (tank and ancillary equipment residuals and tank retrieval leaks) are completely removed under these alternatives; and impacts of the fourth groundwater source (past unplanned releases at the SST farms) are negligible.

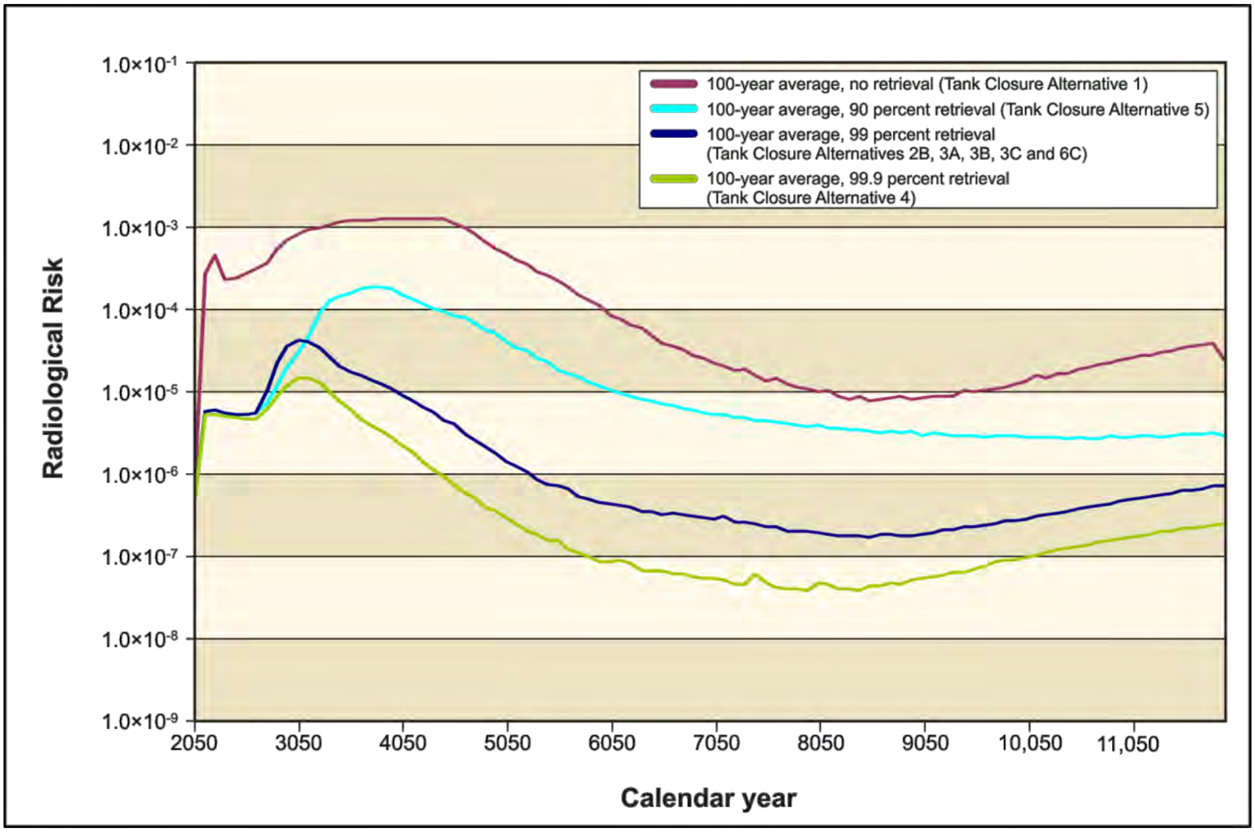


Figure S–14. Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary due to Releases from Tank Farm Sources Other Than Past Leaks

The results show that failure to retrieve waste under Tank Closure Alternative 1 would have the greatest potential impact on human health. This conclusion validates DOE's decision in the *TWRS EIS* ROD (62 FR 8693) to retrieve the tank waste from the SSTs. For Tank Closure alternatives that include retrieval of waste, peak impacts are dominated by tank farm residuals and ancillary equipment, while retrieval leaks and unplanned releases at SST farms are the important contributors to the much lower level of impacts estimated for times prior to CY 4000. Tank Closure Alternative 4 has the lowest estimate of risk due to selective clean closure (complete removal of SST farms BX and SX). Estimates of impacts over longer periods are reduced in approximate proportion to the degree of retrieval, indicating that retrieval has a positive effect of reducing potential human health impacts.

WTP Configuration. Use of the WTP would be required under each of the Tank Closure action alternatives, with the WTP configuration (i.e., number of HLW and LAW melters) varying among these alternatives, as follows:

- Under Tank Closure Alternative 1, construction of the WTP would not be completed and no tank waste would be treated.
- Tank Closure Alternatives 2A, 3A, 3B, 3C, and 4 would use the existing WTP configuration (two HLW melters and two LAW melters).
- Tank Closure Alternatives 2B, 5, 6B, and 6C would use the existing WTP configuration (two HLW melters and two LAW melters) supplemented with expanded LAW treatment capacity (an addition of four LAW melters).
- Tank Closure Alternative 6A would require modification of the WTP to provide HLW vitrification capacity (five HLW melters) only—that is, no LAW vitrification capacity.

Potential short-term impacts, including resource demands (e.g., land, utilities, geologic resources, workforce), air pollutant emissions, human health impacts, and waste generation, vary roughly in proportion to the magnitude of construction, with total operational impacts generally proportional to the duration of waste treatment. Using the existing WTP treatment configuration would extend treatment time and require replacement DSTs, which would increase short-term impacts. Using the existing WTP configuration supplemented by expanded LAW treatment capacity would reduce the treatment time and result in minor impacts on most resources. Alternative 6A would have the highest demands for, and thus the greatest short-term impacts on, most resources. This is because this alternative would have the highest construction demands coupled with the longest period of WTP operations. It would be necessary to construct replacement WTP facilities twice as the predecessor facilities reached the end of their operational lifetimes. Varying the WTP configuration (i.e., number of HLW and LAW melters) in a given alternative would not change the quantity and performance of waste forms and, therefore, would have minor influence on long-term impacts (except for Alternative 6A, which has no onsite disposal of treated tank waste).

Primary-, Supplemental-, and Secondary-Waste Forms. The Tank Closure alternatives were also developed to evaluate potential impacts of the primary-waste form and a range of thermal and nonthermal supplemental-waste forms. The primary-waste form planned for disposal on site is ILAW glass. The thermal supplemental treatment waste forms are represented in this EIS by bulk vitrification glass and steam reforming waste, and the nonthermal supplemental treatment waste form is represented by cast stone waste. Waste processing using each of the primary or supplemental treatment technologies that generate these waste forms also produces secondary waste, whose impacts are included as part of the evaluation. The Tank Closure alternatives that use these various supplemental treatment technology configurations are as follows:

- Tank Closure Alternative 2B – Thermal (ILAW glass) primary treatment in the 200-East Area
- Tank Closure Alternative 3A – Thermal (ILAW glass) primary treatment in the 200-East Area and thermal (bulk vitrification) supplemental treatment in both the 200-East and 200-West Areas
- Tank Closure Alternative 3B – Thermal (ILAW glass) primary treatment in the 200-East Area and nonthermal (cast stone) supplemental treatment in both the 200-East and 200-West Areas
- Tank Closure Alternative 3C – Thermal (ILAW glass) primary treatment in the 200-East Area and thermal (steam reforming) supplemental treatment in both the 200-East and 200-West Areas

Secondary Waste

Secondary waste is waste generated as a result of other activities, e.g., waste retrieval or waste treatment, that is not further treated by the Waste Treatment Plant or supplemental treatment facilities, and includes liquid and solid wastes. Liquid-waste sources could include process condensates, scrubber wastes, spent reagents from resins, offgas and vessel vent wastes, vessel washes, floor drain and sump wastes, and decontamination solutions. Solid-waste sources could include worn filter membranes, spent ion exchange resins, failed or worn equipment, debris, analytical laboratory waste, high-efficiency particulate air filters, spent carbon adsorbent, and other process-related wastes. Secondary waste can be characterized as low-level radioactive waste, mixed low-level radioactive waste, transuranic waste, or hazardous waste.

Differences in potential short-term impacts of facility construction and supplemental treatment operations among the Tank Closure alternatives identified above are relatively small for most resource areas. Volumetrically, Tank Closure Alternative 2B would produce no supplemental treatment waste for disposal, while Alternative 3C would produce the highest amount (i.e., approximately 260,000 cubic meters [340,000 cubic yards]). While Tank Closure Alternative 3C would be similar to other supplemental treatment alternatives in its demands for, and thus total short-term construction and operational impacts on, most resources, it would have higher impacts in some resource areas, such as electric power consumption. Tank Closure Alternative 2B would have higher short-term resource impacts on water and fuel (diesel and gasoline) demand than Tank Closure Alternatives 3A, 3B, and 3C.

Estimates of potential long-term human health impacts due to disposal at the IDF-East barrier are presented in Figure S–15 for the combined effect of primary, supplemental, and secondary wastes under the Waste Management alternatives and disposal groups that include the Tank Closure alternatives described above. The results show that segregation of the maximum amount of waste into the primary-waste form (ILAW glass for Tank Closure Alternative 2B) produces the lowest estimate of risk. Because of the low rate of release from ILAW glass, the major impact of this treatment process is attributable to releases from secondary waste, including the release of iodine-129 captured in the offgas of the melters that is solidified in the ETF-generated secondary waste. A combination of the ILAW glass primary-waste form with the steam reforming supplemental-waste form (Tank Closure Alternative 3C) results in an increase in risk for this alternative relative to Tank Closure Alternative 2B due to the order-of-magnitude increases in release of both technetium-99 and iodine-129 from steam reforming waste compared with ILAW glass. The estimate of risk for steam reforming waste is derived from a solubility-limited release model sensitivity analysis (see Appendix M, Section M.5.5.2, of this EIS) that considered a range of conditions reflecting the early stages of experimental qualification of finely divided steam reforming waste as a waste form for long-term disposal. A combination of the thermal treatment primary-waste form (ILAW glass) with the thermal treatment bulk vitrification glass and secondary waste (Tank Closure Alternative 3A) results in an increase in risk relative to the Tank Closure Alternative 2B primary-waste form (ILAW glass) due to the release from the inventory of technetium-99 deposited in the castable refractory block surrounding the bulk vitrification glass waste form. The treatment process resulting in the nonthermal cast stone waste form (Tank Closure Alternative 3B) produces higher estimates of impact than Alternative 2B due to the remaining inventory of technetium-99 not immobilized into IHLW glass and the relatively poor performance of the current Hanford site-specific grout formulation in retaining this radionuclide.

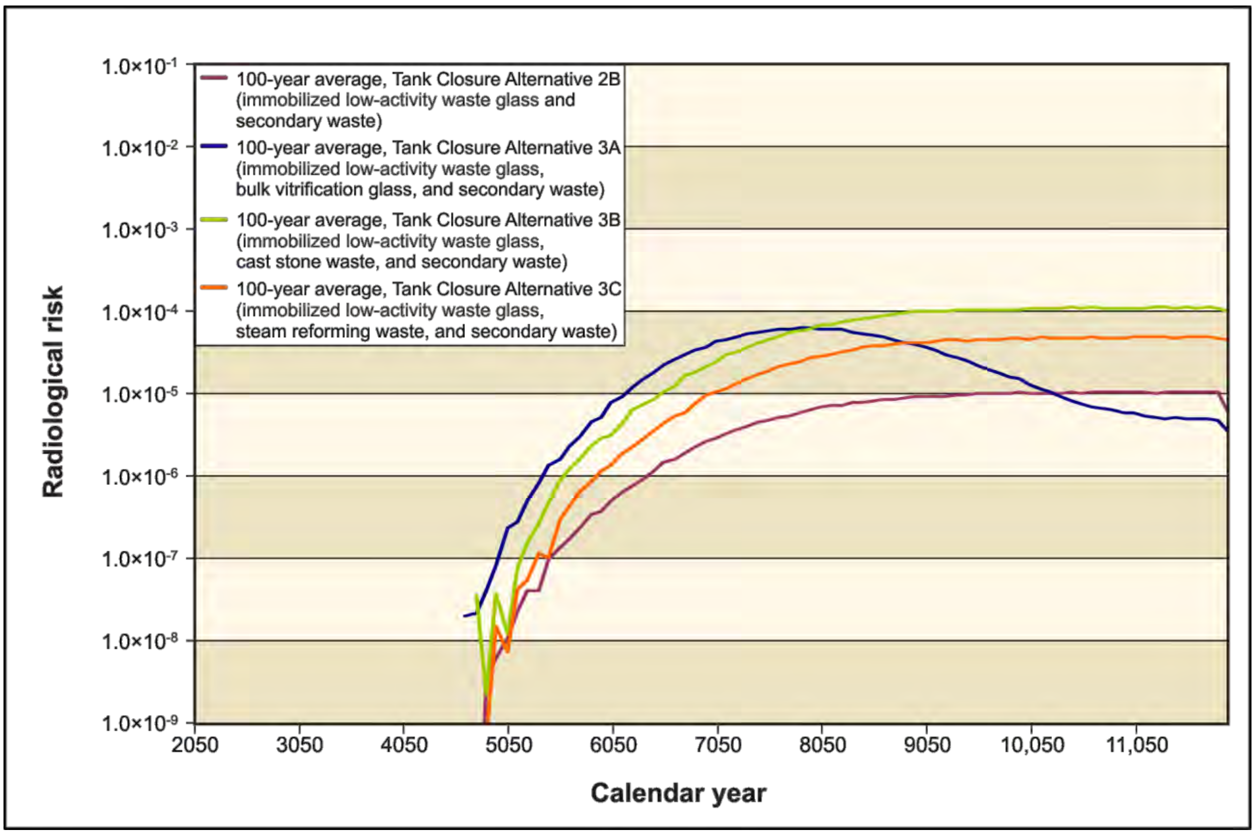


Figure S–15. Lifetime Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier due to Tank Closure Treatment Process–Generated Waste Forms

The analysis suggests that additional treatment or waste form development may be needed for secondary waste. DOE is currently evaluating potential secondary-waste form research and development activities, which include ceramic and other waste forms. It is anticipated that research and development efforts will continue to address treatment of the liquid secondary waste, as this stream would not be generated until the WTP was operational. Measures could also be pursued involving the increased capture of iodine-129, technetium-99, or other target constituents in ILAW glass. Sensitivity analyses demonstrating the effectiveness of iodine recycling and technetium removal in transferring mobile constituents from grouted secondary-waste forms to the higher-performing ILAW glass primary-waste form are presented in Appendix M, Section M.5.7.

Tank-Derived TRU Waste. Under Tank Closure Alternatives 3A, 3B, 3C, 4, and 5, the waste in some selected tanks would be managed as mixed TRU waste and therefore disposed of at WIPP. These alternatives were developed to determine the environmental impacts related to that approach.

Treating tank-derived TRU waste decreases the WTP and supplemental treatment process timeframes and reduces the volume of waste to be disposed of on site in an IDF, as well as the associated long-term impacts. While treatment of some tank waste as TRU waste increases short-term impacts (e.g., air emissions, worker dose), the total incremental impact over the tank-derived TRU waste treatment period is negligible compared with other waste treatment impacts.

Technetium-99 Removal in the WTP. The Tank Closure action alternatives were also developed to compare WTP pretreatment with and without technetium-99 removal. Tank Closure Alternatives 2B and 3B include technetium-99 removal within the WTP pretreatment process, while Tank Closure Alternatives 2A, 3A, 3C, 4, 5, and 6A through 6C do not.

Tank Closure Alternatives 2B and 3B include technetium-99 removal in the WTP, a pretreatment activity that separates technetium-99 and sends it for immobilization into IHLW glass. By contrast, Tank Closure Alternative 2A assumes no technetium-99 removal in the WTP; therefore, most of the technetium-99 is immobilized in ILAW glass and disposed of on site in an IDF. Comparison of estimates of impacts at the IDF-East barrier under Tank Closure Alternative 2A with those under Tank Closure Alternatives 2B and 3B indicates that ILAW glass with technetium-99 has similar potential impacts, both short- and long-term, to ILAW glass without technetium-99. The analysis further indicates that removal of technetium-99 and its disposal off site as IHLW glass would provide little reduction in the concentrations of technetium-99 compared with disposal as ILAW glass at either the Core Zone Boundary or the Columbia River nearshore. This is because the release rate of technetium-99 from ILAW glass is much lower than that from other sources such as ETF-generated secondary waste and tank closure secondary waste. Thus, technetium-99 removal under Tank Closure Alternative 2B would provide little benefit.

Comparison of estimates of impacts at the IDF-East barrier also indicates that releases of technetium-99 from the cast stone waste form under Tank Closure Alternative 3B increase radiological dose and risk relative to impacts estimated for Tank Closure Alternative 2A. Thus, technetium-99 removal under Tank Closure Alternative 3B would provide substantial benefit.

Sulfate Grout. Under Tank Closure Alternative 5, an additional sulfate removal technology is evaluated after WTP pretreatment to increase the waste loading in ILAW glass, thereby reducing the amount of ILAW glass produced in the WTP and allowing earlier completion of treatment. This alternative was developed to determine the environmental impact of a shorter treatment timeframe. Use of the sulfate removal technology results in a reduced treatment timeframe and reduced ILAW glass volume, with minimal potential short-term impacts, no long-term radiological impacts, and minor long-term chemical impacts. Tank Closure Alternative 5 short-term construction and operational impacts would be very similar to those of other Tank Closure alternatives, although impacts of Sulfate Removal Facility operation would result in higher demands for some resources such as liquid fuels and water.

Closure of the Six Sets of Cribs and Trenches (Ditches). Although the scope of this *TC & WM EIS* does not include decisions to be made for six sets of cribs and trenches (ditches) that are contiguous to the SST farms, they are included in the alternatives analysis because of their close proximity to the SST farms and because it is difficult to distinguish sources of contamination in the vadose zone or groundwater. Tank Closure Alternatives 1 and 2A assume no closure of the SST system, including the cribs and trenches (ditches), while all the remaining Tank Closure alternatives assume landfill closure of the cribs and trenches (ditches) except for Tank Closure Alternatives 6A and 6B, Option Cases. These two alternatives analyze clean closure of the cribs and trenches (ditches).

> **Closure Options Analyzed in This Environmental Impact Statement**
>
> **Landfill closure** – Following tank waste retrieval, the single-shell tank (SST) system would be closed in accordance with state, Federal, and/or U.S. Department of Energy requirements for closure of a landfill. Landfill closure typically includes site stabilization and emplacement of a barrier, followed by a postclosure care period.
>
> **Clean closure** – Following tank waste retrieval, the tanks, ancillary equipment, and contaminated soils would be removed as necessary to protect human health and the environment and to allow unrestricted use of the tank farm area.
>
> **Selective clean closure/landfill closure** – This hybrid closure approach would implement clean closure of a representative tank farm in each of the 200-East and 200-West Areas (i.e., the BX and SX tank farms), while implementing landfill closure for the balance of the SST farm system.

Overall potential short-term environmental impacts of closure activities would exceed facility construction impacts under most alternatives, especially in terms of air emissions and resource demands. For closure of the cribs and trenches (ditches), there would be some impact tradeoffs between landfill closure of the cribs and trenches (ditches) under the Base Cases and clean closure under the Option Cases. Landfill barrier construction would result in higher peak and total nonradioactive air pollutant emissions than tank farm clean closure would. By contrast, clean closure of the cribs and trenches (ditches) under Tank Closure Alternatives 6A and 6B, Option Cases, would increase the total closure impacts, such as demands for geologic materials, workforce requirements, and secondary-waste generation, to levels measurably higher than those of the Base Cases.

Cribs and trenches (ditches) are major contributors to potential long-term groundwater impacts for all Tank Closure alternatives due to their early discharges in the 1950s and 1960s. As shown in Figure S–16, estimates of human health impacts (radiological risk to the drinking-water well user) correlate with the closure options under Tank Closure Alternative 1 (no landfill closure of the cribs and trenches [ditches]); Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C (landfill closure of the cribs and trenches [ditches]); and Tank Closure Alternative 6B, Option Case (clean closure of the cribs and trenches [ditches]). For example, Tank Closure Alternative 1 and Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C have similar radiological risk to the drinking-water well user at the Core Zone Boundary throughout the period of analysis because the contaminants have already reached the vadose zone or groundwater and, therefore, there is minimal benefit to the addition of a landfill closure barrier. By contrast, results for Tank Closure Alternative 6B, Option Case, indicate that clean closure of the cribs and trenches (ditches) significantly reduces radiological risk to the drinking-water well user at the Core Zone Boundary after CY 2150. The variability in lifetime radiological risk represented in Figure S–16 is attributable primarily to the release of multiple constituents at differing times and rates from 33 sources (see Appendix D, Section D.1.5, of this EIS for a list of these sources) comprising these sets of cribs and trenches (ditches).

Effect of Closure on SST Past Leaks. Currently, 67 of Hanford's 149 SSTs are listed as "known or suspected" leakers. The Tank Closure alternatives were developed to compare the long-term impacts on groundwater of closing the SST system, including the SST farm past leaks. Tank Closure Alternatives 1 and 2A assume no closure of the SST system, and past leaks would remain. Tank Closure Alternatives 2B, 3A, 3B, 3C, 5, and 6C assume landfill closure of the entire SST system, and past leaks would remain. Tank Closure Alternative 4 assumes selective clean closure/landfill closure, which includes clean closure of the BX and SX SST farms and landfill closure of the remaining SST farms, and past leaks would be removed at the two clean-closed SST farms. The Base and Option Cases of both Tank Closure Alternatives 6A and 6B assume clean closure of the SST farms, and past leaks would be removed at all the SST farms.

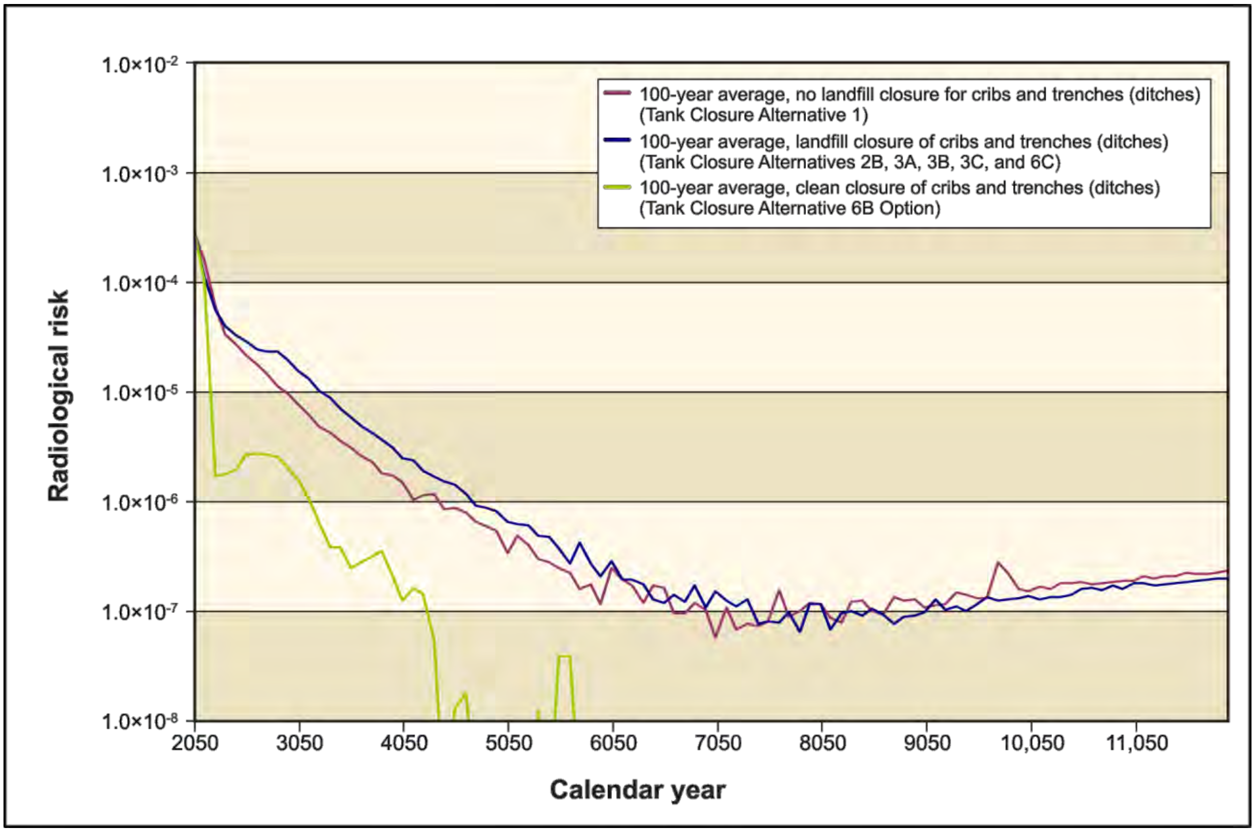


Figure S–16. Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary due to Releases from the Six Sets of Cribs and Trenches (Ditches)

Over the short term, past leaks in and around the SST farms could affect clean closure activities. For example, construction dewatering would likely be necessary in some tank farm excavations to allow clean closure to proceed and, depending on the amount of pumping required and the levels of contamination found, may increase worker dose. Also, the water could require special handling and treatment at the ETF prior to release to the environment due to the expected high contamination levels.

Past leaks are major contributors to potential long-term groundwater impacts. Figure S–17 shows estimates of human health impacts (radiological risk to the drinking-water well user) under Tank Closure Alternative 2A (no landfill closure); Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C (landfill closure); Tank Closure Alternative 4 (selective clean closure/landfill closure); and Tank Closure Alternative 6B, Base Case (clean closure of the SST system). For example, Tank Closure Alternative 2A has the highest radiological risk to the drinking-water well user at the Core Zone Boundary; Tank Closure Alternative 6B, Base Case, the lowest. Estimates of impacts under Tank Closure Alternative 4 do not show a reduction in risk due to selective clean closure of BX and SX tank farm past leaks in comparison with landfill closure. However, selective clean closure or remediation of the deep vadose zone with landfill closure of other SST farms with more-significant past leak radionuclide inventory may result in reducing long-term human health impacts. Risk reduction would be greatest when the remediation of the deep vadose zone occurs in the near term. Remediation of past leaks would be addressed through an RCRA corrective action under the landfill closure plan.

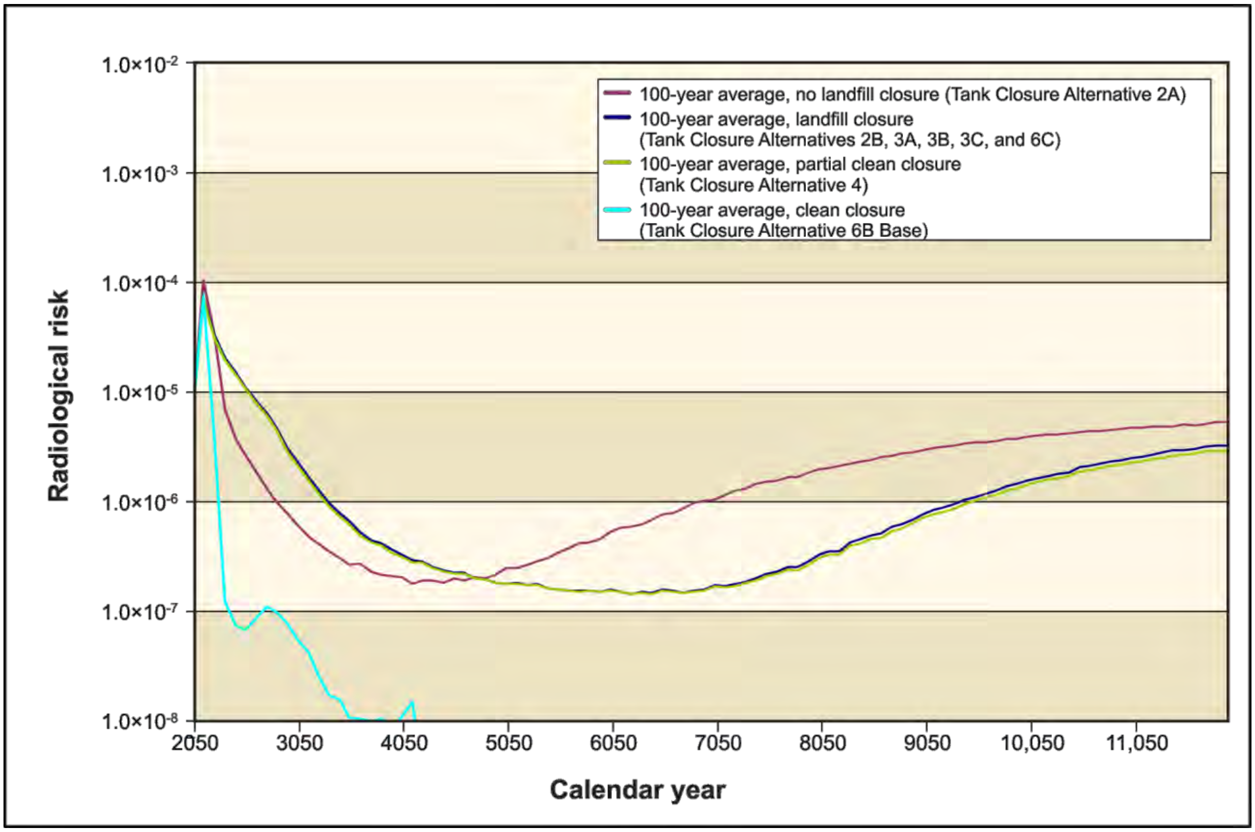


Figure S–17. Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary due to Past Leaks at Single-Shell Tank Farms

Closure of the SST System. The Tank Closure alternatives were also developed to compare the potential long-term impacts on groundwater of closing the SST system. Proposed closure options range from clean closure or selective clean closure/landfill closure to landfill closure with or without any contaminated soil removal. The closure assumptions of the Tank Closure alternatives are summarized below.

- Tank Closure Alternatives 1 and 2A assume no closure of the SST system.
- Tank Closure Alternatives 2B, 3A, 3B, 3C, and 6C assume landfill closure using an engineered modified RCRA Subtitle C barrier and removal of 4.6 meters (15 feet) of contaminated soils (which includes ancillary equipment) from two SST farms (BX and SX).
- Tank Closure Alternative 4 assumes selective clean closure of two SST farms (BX and SX) and landfill closure of the remaining SST farms using an engineered modified RCRA Subtitle C barrier.
- Tank Closure Alternative 5 assumes landfill closure of the SST farms using a Hanford barrier without removal of contaminated soils or ancillary equipment.
- Tank Closure Alternatives 6A and 6B assume clean closure of the SST system. The Base Cases would place an engineered modified RCRA Subtitle C barrier over the six sets of cribs and trenches (ditches) in the B and T tank farms, while the Option Cases would include deep soil removal and remediation of these six sets of cribs and trenches (ditches).

As previously mentioned, total short-term and peak short-term environmental impacts of SST farm closure activities would exceed total facility construction impacts under most alternatives, and would substantially add to short-term environmental impacts overall, especially in terms of emissions, worker doses, and resource demands. In terms of land resources, clean closure would allow future use of the tank farm areas, but, unlike all other Tank Closure alternatives, would require significant new, permanent land disturbance for new facilities to treat, store, and dispose of tank waste. In addition, geologic resource requirements (mainly for Borrow Area C material to backfill tank farm excavations) under Alternatives 6A and 6B would be higher than those under the landfill closure alternatives. The peak workforce would increase by as much as 70 percent to support clean closure, as compared with the landfill closure alternatives. Also, the worker population radiation dose would increase by up to a factor of 10 in association with clean closure activities. Landfill closure using the Hanford barrier under Tank Closure Alternative 5 would result in higher peak and total nonradioactive air pollutant emissions than landfill closure employing the engineered modified RCRA Subtitle C barrier, as well as increased demands for utility resources and geologic materials.

Clean closure of the SST system compared with landfill closure would have the following potentially adverse short-term impacts:

- Total land commitments would increase twofold.
- Electricity use would increase by one order of magnitude.
- Geologic resource requirements would increase as much as fivefold.
- Sagebrush habitat affected would increase by as much as two orders of magnitude.
- Radiation worker population dose from normal operations would increase over twofold.
- LLW and MLLW generation volumes would increase threefold.
- Total recordable cases would increase as much as fivefold.[4]

These comparisons are representative of Tank Closure Alternative 6A, where utility increases are attributable to the clean closure approach of treating all waste as HLW through the use of HLW melters. This clean closure approach differs under Alternative 6B, where the corresponding comparative increases in potentially adverse short-term impacts are projected to be somewhat less.

One other significant uncertainty of clean closure in terms of technical feasibility and risk is the depth of excavation and soil exhumation that would be required. At a minimum, deep soil removal, including excavation to a depth of about 20 meters (65 feet) below land surface, would be required. This excavation depth should be sufficient to remove soils and sediments contaminated by retrieval-related leaks, as well as contamination from historic waste releases that have accumulated horizontally on compacted strata beneath the waste tanks. For some SST sites, excavation to depths of up to 78 meters (255 feet) below the land surface may be required to remediate contaminant plumes from past-practice discharges that have migrated through the vadose zone soils and sediments and possibly to the water table. Since an effort of this scale in a radioactive environment has never been undertaken in the United States, it is unclear whether this operation could be conducted with adequate considerations for worker safety.

Tank Closure Alternatives 4 and 6 present significant challenges, as mentioned above. The flux reduction evaluation addressed in this EIS examines whether long-term impacts on groundwater could be improved (similar to Alternative 4) by removing contaminants from the soil column at more locations in the Central Plateau as compared to excavation of the BX and SX tank farms and the corresponding contamination down to the groundwater. The sensitivity analysis evaluated what is, in some respects, a hypothetical future site condition, because CERCLA actions are ongoing in the Central Plateau and all seven of the tank farm waste management areas have not been closed. See Chapter 7, Section 7.5, of this EIS for a discussion of sensitivity analyses. Waste Management Area C is the first tank farm to be closed

[4] Recordable cases include work-related deaths, as well as work-related illnesses or injuries leading to loss of consciousness, lost work days, or transfer to another job, and/or requiring medical treatment beyond first aid.

(scheduled for 2019). The sensitivity analysis indicated that more technetium-99, iodine-129, and uranium-238 was removed in the flux reduction 50 percent removal case than under Tank Closure Alternative 4. The 50 percent removal case was applied to 5 ponds, 3 river corridor sites, the BC cribs and trenches (ditches), 3 REDOX [Reduction-Oxidation] waste sites, 4 PUREX [Plutonium-Uranium Extraction] waste sites, and 12 tank farms. While the results were interesting and highlighted the influence of these potential activities on high-, medium-, and low-discharge sites, achieving these results is not without its own set of technical challenges. This type of soil removal has the potential to lower waste volumes generated, worker dose, and worker accidents, but it must be balanced with the technical challenges of implementing the concept.

Characterization must be sufficient to potentially treat contamination in the vadose zone and enable decisionmakers to ascertain the (1) extent and depth of the contamination; (2) timeframe in which vadose zone remedies could be effective (e.g., prior to the contaminants reaching the groundwater); (3) available remediation technologies capable of effectively removing specific COPCs; and (4) potential need to develop additional remediation technologies. A potential impact of not treating the vadose zone contamination is that it may reach the unconfined aquifer.

With these technical uncertainties in mind, and as indicated in the Preferred Alternatives discussion in Section S.7, DOE prefers landfill closure; this could include implementation of corrective/mitigation actions, which may require soil removal or treatment of the vadose zone. It is anticipated that the specific actions to be taken for the tank farms will be identified in the closure plan that will be submitted for each waste management area.

As shown by the radiological risk curves presented in Figure S–18, the radiological risk peak occurs at approximately CYs 3800 and 3000 under Tank Closure Alternatives 5 and 2B, respectively. The magnitude difference between the two curves is not a result of barrier performance, but of the volume of tank farm residuals (due to different retrieval assumptions). Thus, the Hanford barrier has negligible human health benefits (i.e., radiological risk to the drinking-water well user) at the Core Zone Boundary when measured against the engineered modified RCRA Subtitle C barrier; it would delay release from landfills for only several hundred years.

Figure S–18, which also includes retrieval leaks and releases from the SST residuals and ancillary equipment for Tank Closure Alternatives 2B (landfill closure) and 4 (selective clean closure/landfill closure), shows that the human health impacts (radiological risk to the drinking-water well user) at the Core Zone Boundary correlate to the closure actions. For example, Tank Closure Alternative 2B has a higher radiological risk than Tank Closure Alternative 4. Note: Tank Closure Alternative 2A is not included in Figure S–18 because tank closure is not included under this alternative. Tank Closure Alternatives 6A and 6B are not included in Figure S–18 because long-term human health impacts are negligible; the three groundwater sources (tank retrieval leaks, releases from the tank residuals, and releases from ancillary equipment) are completely removed under this alternative; and impacts of past unplanned releases at the SST farms are negligible. Results presented for closure alternatives in Figures S–17 (past leaks) and S–18 (other tank farm sources) indicate that, for the next several hundred years, peak impacts would be due primarily to past leaks, i.e., to contamination already present in the vadose zone. The sensitivity analysis presented in Appendix N, Section N.5, of this EIS indicates that the reduction of solute flux to the water table using advanced technologies, such as dewatering or sequestering, could be useful in mitigation of these impacts. However, the effectiveness of such advanced technologies is uncertain due to insufficient knowledge of the past leaks' magnitude and timing, the current distribution of contamination in the vadose zone, and the limited experience with candidate technologies.

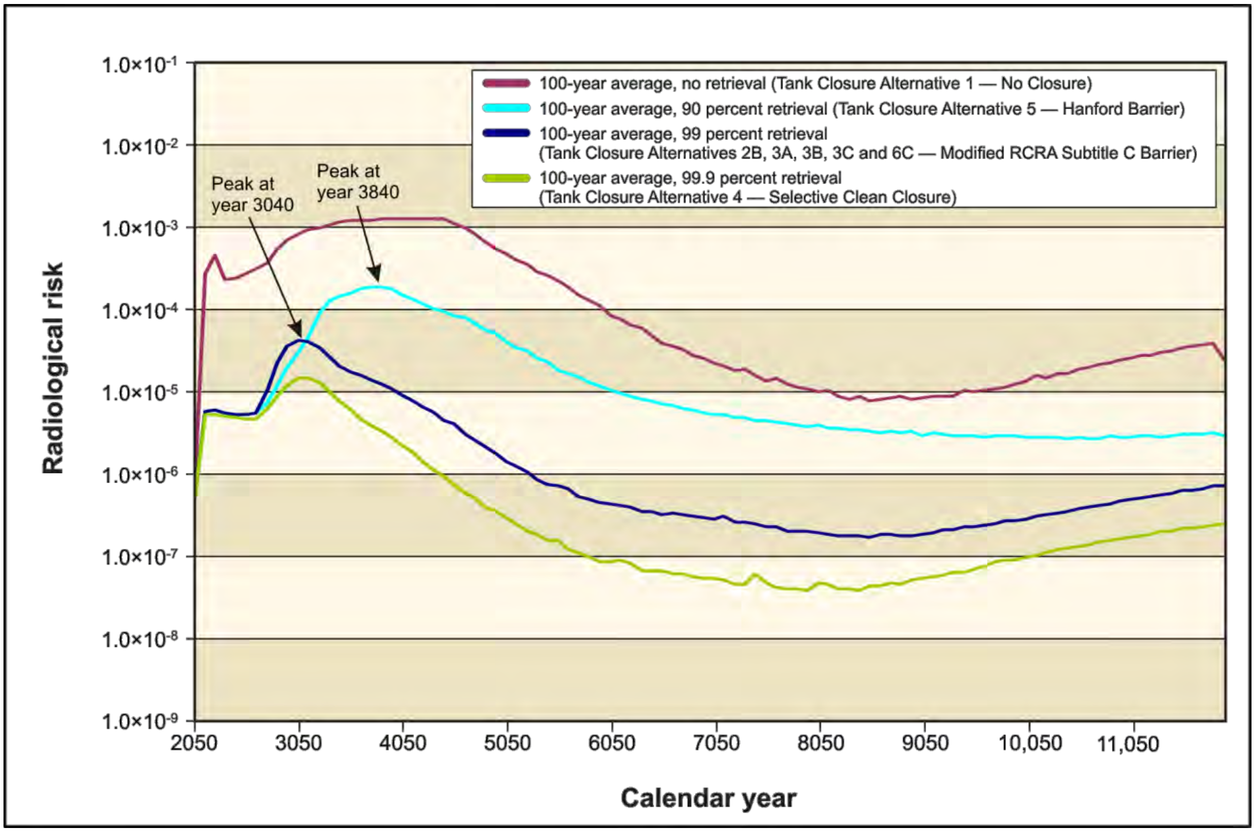


Figure S–18. Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary due to Releases from Tank Farm Residuals and Ancillary Equipment and to Retrieval Leaks

Figures S–16 and S–17, which include the releases from the six sets of cribs and trenches (ditches) and the past leaks from the SSTs, respectively, also show that clean closure of the SST farms (Tank Closure Alternative 6B, Base and Option Cases) provides some beneficial long-term impacts on groundwater after CY 2100.

The *TC & WM EIS* analysis further shows that clean closure of the SST farms and contaminated soil (Tank Closure Alternative 6A, Option Case) would not reduce the concentrations of iodine-129 and technetium-99 at the Core Zone Boundary below their respective benchmark concentrations until CY 2100; concentrations will remain within an order of magnitude of the benchmark concentrations (i.e., 1 picocurie per liter and 900 picocuries per liter, respectively) at that location until approximately CY 2600. Thus, there would still be groundwater impacts under the clean closure alternatives due to the early releases from past leaks and intentional releases through the cribs and trenches (ditches).

As a result of the above findings and the excessive cost (see Table S–31), DOE believes that clean closure may not be a viable alternative. Therefore, DOE prefers landfill closure. Hanford represents somewhat of a unique situation compared with other DOE sites such as West Valley, New York. Some of the tanks at Hanford have leaked and discharged contaminants to the soil column. In addition, there were intentional discharges to the soil column through the six sets of cribs and trenches (ditches) from the 1940s through the 1970s. Hanford also used many different separations processes, which produced a heterogeneous waste. In some cases, select radioactive constituents at Hanford exist in amounts that are orders of magnitude higher than those at other DOE sites. As stated previously, remediation of past leaks would be addressed through an RCRA corrective action under a landfill closure plan.

S.5.5.2 FFTF Decommissioning Alternatives

The FFTF Decommissioning alternatives were structured to encompass the range of facility disposition options. Under FFTF Decommissioning Alternative 1 (No Action), the facilities would be left in place and stabilized under a blanket of inert gas. By contrast, under FFTF Decommissioning Alternatives 2 (Entombment) and 3 (Removal), radioactive materials would be removed in varying degrees. FFTF Decommissioning Alternative 2 would remove and dispose of a minimal amount of radioactive materials and entomb the rest. All above-grade RCB and adjacent support facilities would be dismantled and either consolidated, entombed in below-grade spaces, or disposed of in an IDF. FFTF Decommissioning Alternative 3 would remove nearly all radioactive materials, including the reactor vessel, internal piping and equipment, and attached depleted-uranium shield, and dispose of these materials on site in an IDF. Though the treatment of the RH-SCs and the disposition of bulk sodium are analyzed in FFTF Decommissioning Alternatives 2 and 3, they are nondiscriminating activities and, therefore, are not included in this discussion on key findings.

As shown in Table S–6, potential short-term impacts on most resource areas would be similar under FFTF Decommissioning Alternatives 2 and 3, with a few notable exceptions. Emissions of nonradioactive air pollutants, particularly particulate matter, associated with construction of facilities to support decommissioning activities and geologic resource requirements for backfill and site regrading following completion of removal activities would be higher under FFTF Decommissioning Alternative 3. Worker radiation doses and waste generation due to removal activities would also be higher under this alternative.

Because of the relatively small inventory of hazardous constituents at FFTF relative to that of facilities within the Core Zone Boundary and because of the low rate of recharge to groundwater, potential long-term health impacts under all alternatives would be minimal and there would be little difference between the No Action and Entombment Alternatives, except that Entombment would delay any impacts for 500 years. From a facility disposition perspective, other than the need to treat the bulk sodium and RH-SCs so the recovered sodium could be used in the WTP or for Hanford corrosion control, there would be little environmental impact on groundwater under any of the FFTF Decommissioning alternatives. FFTF could remain in surveillance and maintenance status.

S.5.5.3 Waste Management Alternatives

The Waste Management alternatives described in this *TC & WM EIS* represent the range of reasonable approaches to storing and treating onsite LLW, MLLW, and TRU waste; disposing of onsite and offsite LLW and MLLW (at Hanford) and onsite TRU waste (at WIPP); and closing the disposal facilities to reduce water infiltration and the potential for intrusion. The Waste Management alternatives were developed partly to compare the potential short-term impacts of the expansion of existing facilities and construction of new facilities, as well as the operation and deactivation of facilities used to store, treat, and dispose of waste. They were also developed to compare the potential long-term water quality, human health, and ecological risk impacts resulting from these activities.

Waste disposal would be required under all three Waste Management alternatives. The disposal options for waste and the amount of waste vary among the alternatives. Waste Management Alternative 1 would continue disposal of onsite non-CERCLA, nontank LLW and MLLW in LLBG 218-W-5, trenches 31 and 34. For conservative analysis purposes, both Waste Management Alternatives 2 and 3 would provide for continued operation of these trenches through 2050, though the waste would be disposed of in an IDF once it becomes operational. Waste Management Alternative 2 would provide for completion of IDF-East for the disposal of tank, onsite non-CERCLA, FFTF decommissioning, waste management, and offsite LLW and MLLW. Waste Management Alternative 3 would provide for the disposal of these waste types in two IDFs: IDF-East and IDF-West. Only waste from tank treatment operations would be disposed of in IDF-East. All other wastes would be disposed of in IDF-West. Both Waste Management

Alternatives 2 and 3 would include construction and operation of the proposed RPPDF for the disposal of lightly contaminated equipment and soils from closure activities.

For the disposal groups under Waste Management Alternatives 2 and 3, potential demands for, and short-term impacts on, most resources would vary primarily in direct relation to the size (i.e., disposal capacity) and operational lifespan of the disposal facilities. Potential total short-term and peak short-term environmental impacts of disposal activities are projected to be very similar for Waste Management Alternatives 2 and 3. Thus, for short-term impacts, disposal facility configuration and location are not discriminators.

Low-Level Radioactive Waste Burial Ground 218-W-5, Trenches 31 and 34. Under Waste Management Alternative 1 (No Action), the existing LLBG 218-W-5, trenches 31 and 34, would continue to accept onsite non-CERCLA, nontank LLW and MLLW. The analysis indicates that it would be safe to continue to dispose of LLW and MLLW in these trenches. Potential short-term impacts of ongoing disposal operations would be negligible.

Estimates of potential long-term impacts expressed as radiological risk to the drinking-water well user at the Core Zone Boundary due to LLBG 218-W-5, trenches 31 and 34, are presented in Figure S–19. The estimated radiological risk is low, well below 1×10^{-7}, especially compared to the risks associated with the sources remaining at the SST farms under the Tank Closure alternatives (see Figure S–14).

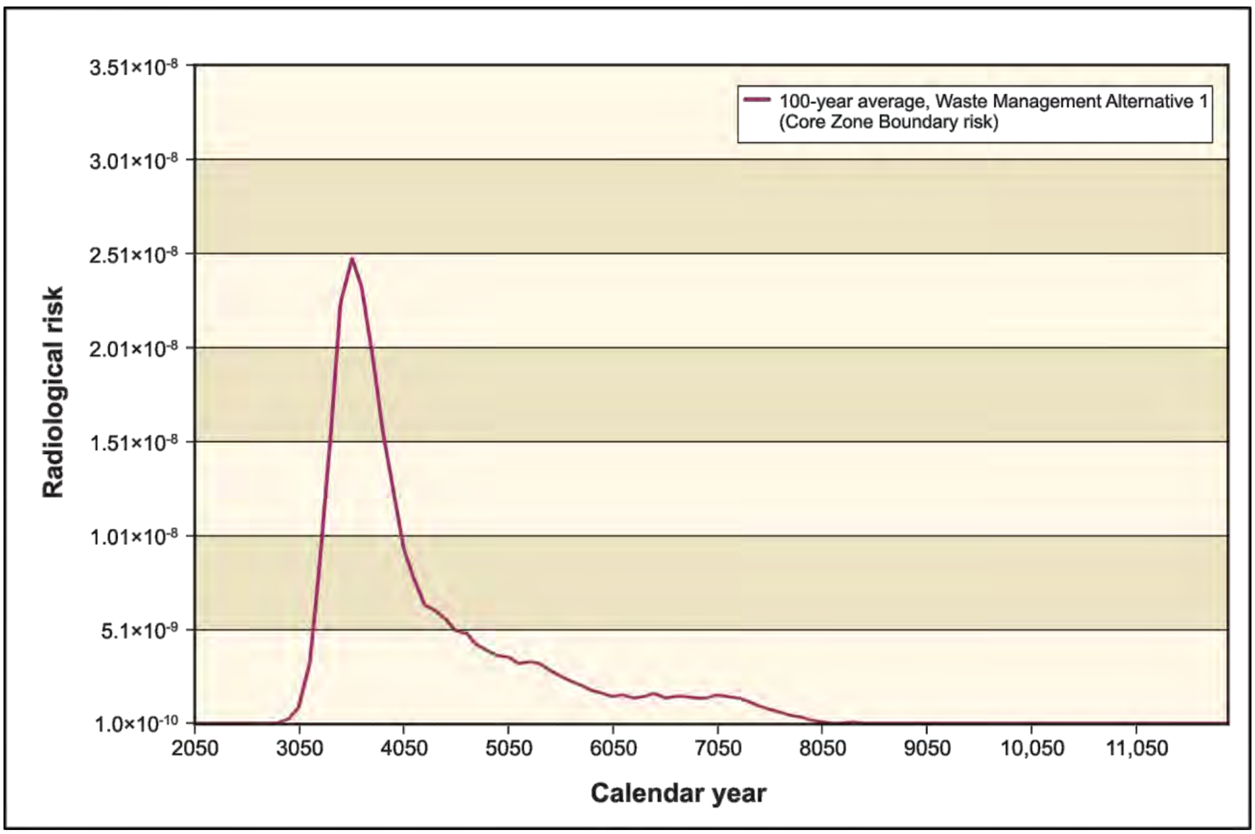


Figure S–19. Waste Management Alternative 1 (No Action) Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary due to Low-Level Radioactive Waste Burial Ground 218-W-5, Trenches 31 and 34

Disposal of Waste in IDF-East and IDF-West. Under Waste Management Alternative 2, tank closure–generated waste (primary, supplemental, and secondary wastes) and non-tank-farm waste (from onsite non-CERCLA sources; FFTF decommissioning; waste management; and other DOE sites, i.e., offsite LLW and MLLW) would be disposed of in IDF-East. Under Waste Management Alternative 3, the tank closure–generated waste would be disposed of in IDF-East; the non-tank-farm waste, in IDF-West. Under both Waste Management alternatives, rubble, soil, and equipment generated by tank farm closure would be disposed of in the RPPDF. Note: Waste Management Alternative 1 does not include the operation of IDF-East or IDF-West. Therefore, it is not relevant to this discussion.

Total short-term impacts of constructing and operating two IDFs under Waste Management Alternative 3 would be substantially the same as those under Waste Management Alternative 2 across nearly all resource areas. This is because no economy of scale is estimated to be achieved by having two IDFs, and short-term impacts would be generally proportional to the total size (i.e., disposal capacity) and operational lifespan of disposal facilities rather than the number or location thereof.

The long-term analysis indicates that IDF-West would not perform as well as IDF-East because of the higher assumed infiltration rate for the 200-West Area location. As indicated in Figure S–20, long-term human health impacts (radiological risk to the drinking-water well user) at the Core Zone Boundary due to combined releases from the proposed RPPDF and the IDFs would be greater under Waste Management Alternative 3 (IDF-West) than under Waste Management Alternative 2 (IDF-East) prior to CY 6000. For the IDF-East/RPPDF case, the early peak projected around CY 4000 is due to releases from the proposed RPPDF, while the later peak occurring around CY 8000 is due to releases from IDF-East. For the IDF-West/RPPDF case, the peak projected around CY 4000 is due primarily to releases from IDF-West, with secondary contributions due to releases from the proposed RPPDF. Table S–25 provides the estimated concentration at the year of peak concentration for two of the predominant contaminants, technetium-99 and iodine-129, at the IDF-East and IDF-West barriers due to releases from all sources. To investigate the uncertainty due to variability in infiltration estimates, the performance of the IDF-East and IDF-West locations was investigated for the case of a background infiltration rate of 3.5 millimeters per year at both locations. In addition, to provide a balanced comparison, impacts due solely to releases from the non-tank-farm sources listed above were considered in this sensitivity analysis. Estimates of radiological risk at the IDF-East and IDF-West barrier boundaries are presented in Figure S–21. The results indicate that, due to differences in facility size and configuration and in local unconfined-aquifer flow conditions, impacts estimated for the IDF-East location are lower than those for the IDF-West location.

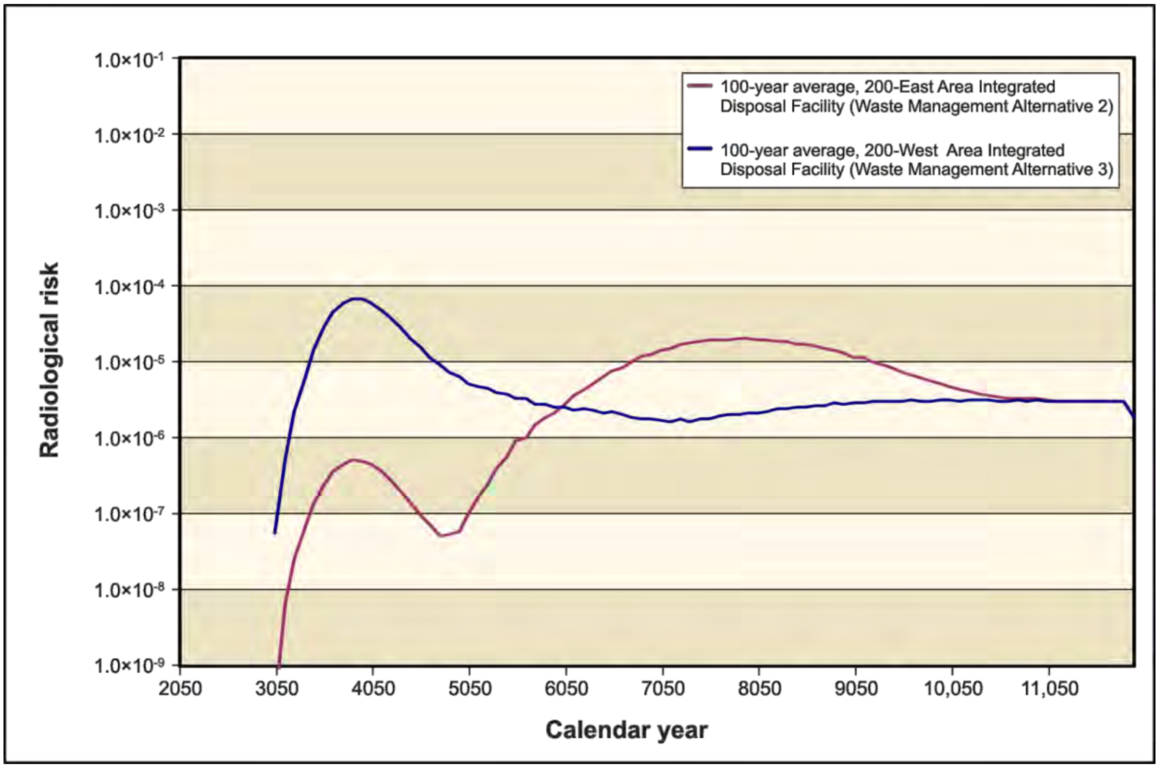


Figure S–20. Lifetime Radiological Risk for the Drinking-Water Well User at the 200-East and 200-West Area Integrated Disposal Facility Barriers

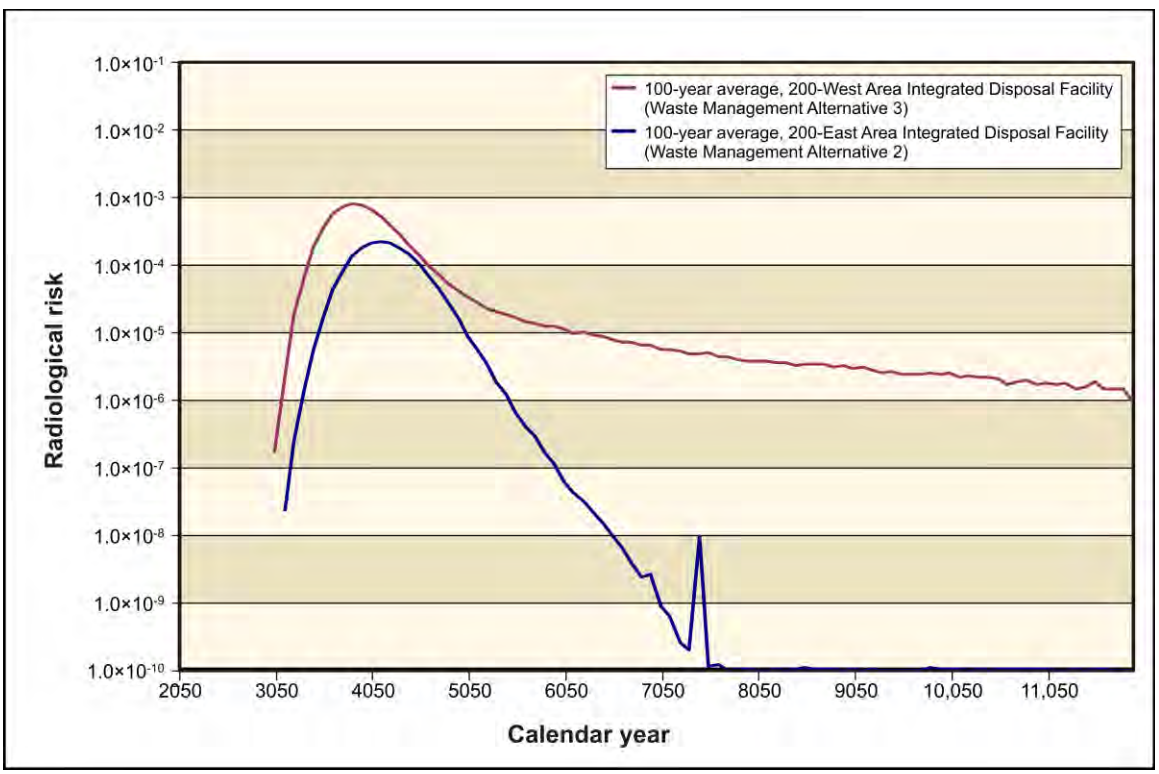


Figure S–21. Time Series of Radiological Risk for Non-Tank-Farm Sources at 200-East and 200-West Area Integrated Disposal Facility Barriers at an Infiltration Rate of 3.5 Millimeters per Year

Table S–25. Waste Management Alternatives 2 and 3 – Maximum Concentrations of Technetium-99 and Iodine-129 in the Peak Year at the IDF-East and IDF-West Barriers

Contaminant	Concentration (picocuries per liter)		
	IDF-East (Waste Management Alternative 2)	IDF-West (Waste Management Alternative 3)	Benchmark Concentration
Technetium-99	**1,259** (7826)	**13,220** (3818)	900
Iodine-129	**2.1** (7907)	**21** (3794)	1

Note: Corresponding calendar years are shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: IDF-East=200-East Area Integrated Disposal Facility; IDF-West=200-West Area Integrated Disposal Facility.

Disposal of Offsite Waste. Under Waste Management Alternative 2, waste from other DOE facilities (i.e., offsite waste) would be accepted and disposed of on site in an IDF. The analysis shows that receipt of offsite waste streams that contain specified amounts of certain radionuclides, specifically iodine-129 and technetium-99, could have an adverse impact on the environment. Comparison of human health impact estimates at the IDF-East barrier under Waste Management Alternative 2 for Tank Closure Alternative 2B, with and without offsite waste (see Figure S–22), illustrates this finding. Estimates of peak radiological risk for Waste Management Alternative 2, including the disposal of offsite waste at IDF-East, are a factor of approximately six higher than those under Waste Management Alternative 2, with offsite waste removed. Table S–26 provides the estimated concentrations at the year of peak concentration for two of the predominant contaminants, technetium-99 and iodine-129, at the IDF-East barrier. Under both cases (with and without offsite waste), technetium-99 and iodine-129 are major contributors to groundwater impacts and offsite waste is the major contributor of peak concentrations.

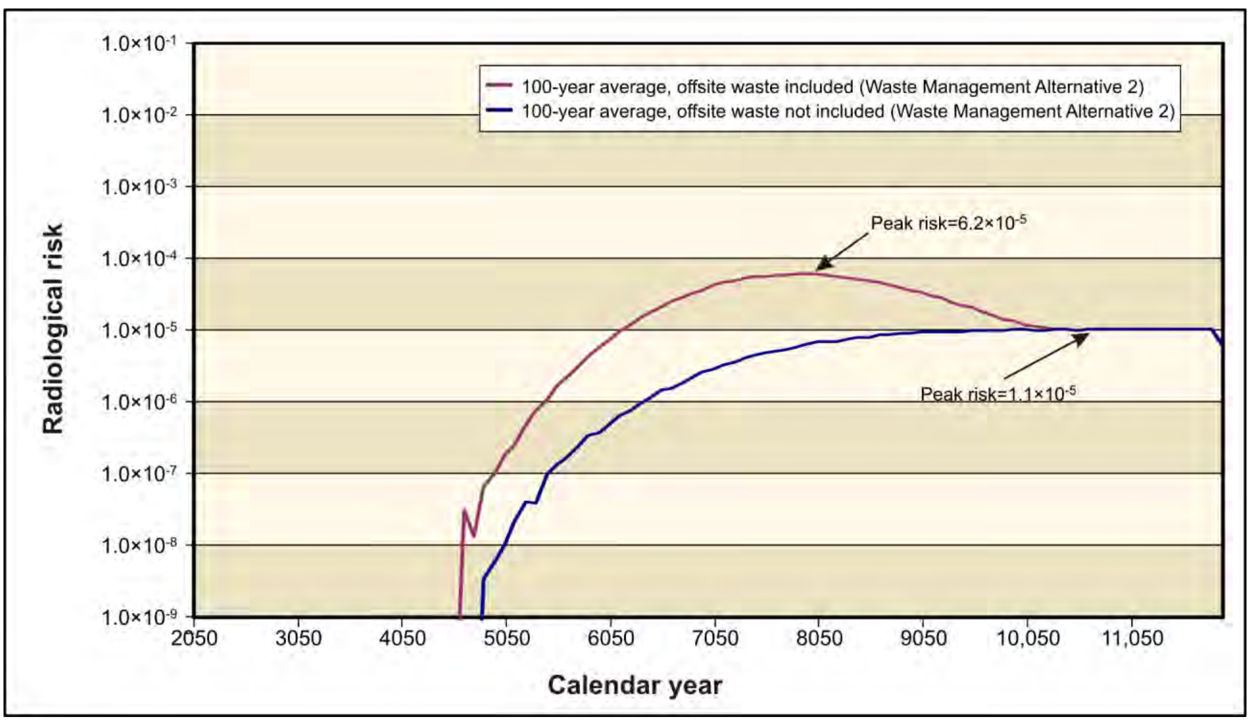


Figure S–22. Tank Closure Alternative 2B Lifetime Radiological Risk for the Drinking-Water Well User at the 200-East Area Integrated Disposal Facility Barrier

Table S–26. Waste Management Alternative 2 – Maximum Concentrations of Technetium-99 and Iodine-129 in the Peak Year at the IDF-East Barrier With and Without Offsite Waste

Contaminant	Concentration (picocuries per liter)		
	Waste Management Alternative 2 (offsite waste included)	Waste Management Alternative 2 (offsite waste not included)	Benchmark Concentration
Technetium-99	**1,259** (7826)	206 (10,129)	900
Iodine-129	**2.1** (7907)	**1.0** (10,177)	1

Note: Corresponding calendar years are shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.
Key: IDF-East=200-East Area Integrated Disposal Facility.

Disposal of Tank Closure Waste in the Proposed RPPDF. Waste Management Alternatives 2 and 3 would include construction and operation of the proposed RPPDF for the disposal of lightly contaminated equipment and soils from closure activities. As shown in Figure S–23, the proposed RPPDF is a secondary contributor to human health impacts (radiological risk to the drinking-water well user) at the Core Zone Boundary throughout the period of analysis; the estimated radiological risks are less than 1×10^{-5}. The figure shows higher lifetime radiological risk (approaching 1×10^{-5}) under Tank Closure Alternative 6B, Base Case, which is due to the disposal of large amounts of vadose zone sediments excavated from all SST farms, compared with the estimated risk under Tank Closure Alternative 4, which is due to disposal of vadose zone sediments from only two SST farms (BX and SX).

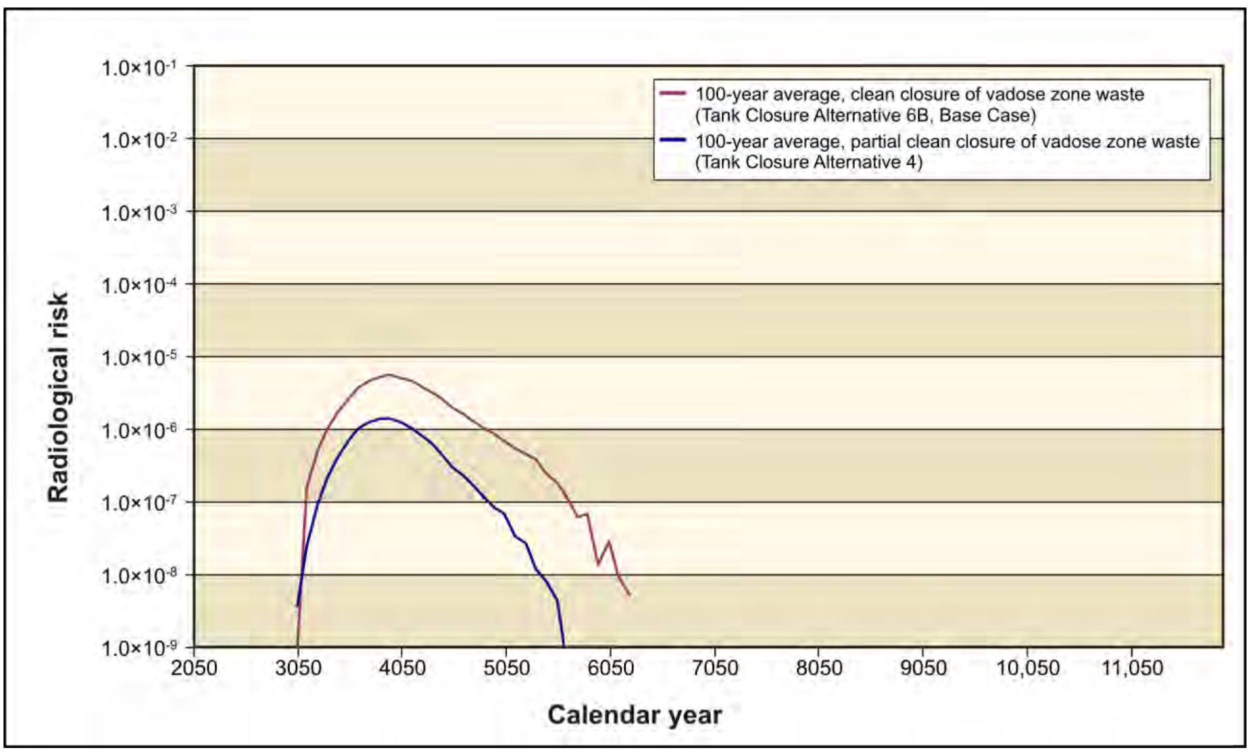


Figure S–23. Lifetime Radiological Risk for the Drinking-Water Well User at the Core Zone Boundary from River Protection Project Disposal Facility Releases

S.5.5.4 Cumulative Impacts

CEQ NEPA regulations (40 CFR 1500–1508) define cumulative impacts as impacts on the environment that result from the proposed actions when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions (40 CFR 1508.7). Thus, the cumulative impacts of an action can be viewed as the total effects on a resource (e.g., land, air, water, soil), ecosystem, or human community of that action and all other activities affecting that resource, no matter what entity (Federal, non-Federal, or private) is taking the action (EPA 1999). This *TC & WM EIS* considers three categories of past, present, and reasonably foreseeable future actions: (1) DOE actions at Hanford, (2) non-DOE actions at Hanford, and (3) other actions in the ROI (see Section S.5.1 for a definition of ROI). Approximately 60 present or reasonably foreseeable future actions, or sets of actions, were evaluated for their contributions to cumulative impacts at Hanford.

Cumulative impacts are estimated by summing three major components: (1) baseline impacts, (2) impacts of each alternative combination in this *TC & WM EIS*, and (3) impacts of reasonably foreseeable future actions. Information on baseline impacts was taken largely from the description of the Hanford affected environment in this *TC & WM EIS*. The impacts of each alternative combination are from the environmental consequences sections of this *TC & WM EIS*. Information on the impacts of reasonably foreseeable future DOE and non-DOE actions was obtained from various sources, including other NEPA documents, RCRA and CERCLA reports, annual environmental reports, planning documents, databases, and interviews with state and local officials.

For purposes of cumulative impacts analysis, three combinations of alternatives were chosen to represent key points within the range of actions and associated overall impacts that could result from full implementation of the three sets of proposed actions (see text box in Section S.5.1 for a description of the alternative combinations). Alternative Combination 1 represents the potential impacts resulting from minimal DOE action; Alternative Combination 2 is a midrange case representative of DOE‘s Preferred Alternatives (see Section S.7); and Alternative Combination 3 represents a combination that generally results in maximum potential short-term impacts but the least long-term impacts. These three alternative combinations were selected for cumulative impacts analysis in this EIS only to establish overall cumulative impacts reference cases for stakeholders and decisionmakers and does not preclude the selection and implementation of different combinations of the various alternatives in support of final agency decisions.

Generally, short-term cumulative impacts would be highest when Alternative Combination 3 is included and lowest when Alternative Combination 1 is included. This is because Alternative Combination 3 generally would use the most resources and produce the most effluents and wastes, and Alternative Combination 1, the least. By contrast, long-term, cumulative, groundwater-related impacts generally would be highest with Alternative Combination 1 and lowest with Alternative Combination 3. This is largely because Alternative Combination 1 would leave the most untreated waste and contaminants in the ground, and Alternative Combination 3, the least.

Cumulative impacts at INL were considered and found to be insignificant. Few actions could substantially contribute to cumulative impacts at INL because (1) there would be no marked increase in daily effluent emissions from, or waste generation by, the facilities; (2) sodium hydroxide, produced at INL, would be returned to Hanford for use in processing tank waste; (3) hazardous and radioactive wastes would not be disposed of at INL; and (4) impacts of the activities would be minor. The transportation of materials and waste to and from INL is, however, included in the cumulative impacts analysis.

S.5.5.4.1 Short-Term Cumulative Impacts

The short-term cumulative impacts were assumed to occur during the active project phase for each of the three *TC & WM EIS* alternative combinations and were assessed for a period of approximately 200 years. As analyzed in this EIS, alternative combinations would contribute little to short-term cumulative impacts on the following resource areas: land use; infrastructure (e.g., water use); water resources; ecological resources; cultural and paleontological resources (i.e., prehistoric, historic, and paleontological resources); socioeconomic resources; public and occupational health and safety – population dose; public and occupational health and safety – transportation; waste management; and industrial safety. Cumulative impacts on the remaining resources areas are described below.

Visual Resources. Activities associated with Alternative Combination 1 would contribute the least to cumulative visual impacts, and Alternative Combination 3, the most. In most cases, activities at Hanford would not result in a change in the U.S. Bureau of Land Management visual contrast rating, as projects would be located in, or adjacent to, areas already developed. However, the rating for Borrow Area C would change from Class II to Class III under Alternative Combination 1, and to Class IV under Alternative Combinations 2 and 3. In the latter case, mining would dominate an area that had previously undergone minimal development. Many activities at Hanford would not be visible from public viewpoints (e.g., nearby higher elevations, highways, the Columbia River) and, thus, would contribute little to overall cumulative impacts on visual resources.

Infrastructure (Electricity Use). The capacity of the Hanford electric power transmission system (1.74 million megawatt-hours per year) (Uecker 2007) would not be exceeded on a cumulative basis for the three alternative combinations analyzed. Peak cumulative demands would range from about 10 percent of capacity under Alternative Combination 1 to 81 percent under Alternative Combination 3. An alternative combination that would include Tank Closure Alternative 6A, Base or Option Case, could exceed the current Hanford electric power transmission capacity. See Section S.5.6 for potential mitigation measures.

Noise and Vibration. Cumulative noise impacts would result primarily from increased vehicle traffic on access roads to Hanford. The cumulative traffic in the region is expected to result in some increase in traffic noise. Traffic associated with Alternative Combination 1 would contribute the least to cumulative sound levels, and Alternative Combination 3, the most. Because of the distance to the site boundary, little or no change is expected in overall noise levels off site due to construction, operations, and decommissioning activities at Hanford.

It is expected that vibrations from heavy vehicles, large construction equipment, and blasting during building, road construction, and mining could have an impact on the Laser Interferometer Gravitational-Wave Observatory. Although DOE would coordinate vibration-producing activities with the operators of the facility, cumulative impacts of these activities are expected to result in some interference with facility operation.

Air Quality. Cumulative concentrations of carbon monoxide, nitrogen oxides, and sulfur oxides could be up to 499, 109, and 251 percent of applicable standards, respectively. Cumulative concentrations of PM_{10} [particulate matter with an aerodynamic diameter less than or equal to 10 micrometers] could be up to 157 times the applicable standard. The cumulative carbon monoxide concentration under Alternative Combinations 2 and 3 could exceed the 8-hour standard of 10,000 micrograms per cubic meter. The cumulative nitrogen oxides concentration under Alternative Combination 3 could exceed the annual standard of 100 micrograms per cubic meter. Cumulative PM_{10} concentrations under all *TC & WM EIS* alternative combinations could exceed the 24-hour standard of 150 micrograms per cubic meter. The peak cumulative concentrations of carbon monoxide and nitrogen oxides under the *TC & WM EIS* alternatives would result primarily from fuel-burning activities. The peak cumulative concentration of PM_{10} under the *TC & WM EIS* alternatives would result primarily from construction and earthmoving activities.

Geology and Soils. Projected cumulative demands for geologic and soil resources range from about 19 to 51 percent in excess of established reserves under Alternative Combinations 1, 2, and 3. At 68.4 million cubic meters (89.5 million cubic yards), the projected cumulative demands for other DOE activities would exceed the 49.6 million cubic meters (64.9 million cubic yards) of available geologic and soil reserves in Borrow Area C and gravel pit No. 30 at Hanford (DOE 1999b:D-4; SAIC 2006), even without the additional resource use under the *TC & WM EIS* alternative combinations.

Although the projected volumes for geologic and soil resources are believed to be conservative, the analysis indicates that completion of all contemplated future actions could require use and development of geologic and soil resources beyond the reserves of Borrow Area C and gravel pit No. 30. Geologic and soil resources, including relatively large volumes of gravel, sand, and silt, are available from the suprabasalt sediments and associated soils across Hanford and elsewhere in the region. Rock in the form of basalt is also plentiful. Alternatively, any shortfall could be fully or partially provided from offsite commercial sources, but would result in additional small transportation impacts due to increased truck transportation to and from Hanford, as well as additional costs for obtaining these materials from commercial sources.

Cultural and Paleontological Resources (American Indian Interests). Cumulative impacts that include Alternative Combination 1 would be the least disruptive, and Alternative Combination 3, the greatest. This is because activities under Alternative Combination 3 would disturb the greatest land area and alter the existing viewshed to the greatest degree. Some Hanford and offsite activities would be visible from Rattlesnake Mountain, Gable Mountain, or Gable Butte, areas of noted cultural and religious significance to American Indians. Onsite DOE activities that could be visible include the excavation and use of geologic materials from borrows pits, transport of materials on the borrow-site haul road from Borrow Area C to State Route 240, construction and operation of the Environmental Restoration Disposal Facility, and construction and operation of a GTCC LLW disposal facility.

Many of the non-DOE activities considered in the cumulative impacts analysis are of limited size, are in or near presently developed areas, or are at a distance from Hanford. These activities would have little to no effect on the viewshed. Some offsite activities such as the Red Mountain American Viticultural Area may be visible from Rattlesnake Mountain.

Public and Occupational Health and Safety—Normal Operations. The worker population dose of 320 person-rem under Alternative Combination 1 would represent a negligible contribution to the total cumulative dose of 97,000 person-rem received by workers since the beginning of Hanford operations in 1944. Alternative Combination 2 and 3 doses of 14,000 and 89,000 person-rem, respectively, would represent 13 and 48 percent of the cumulative doses of 111,000 and 186,000 person-rem, respectively. The cumulative worker population dose would occur to several generations of workers and would not impact the same worker population.

The cumulative dose to the offsite maximally exposed individual would be about 2 millirem per year under Alternative Combination 1 and about 11 millirem under Alternative Combinations 2 and 3. Under Alternative Combinations 2 and 3, the dose due to DOE activities would be below the 10-millirem-per-year limit for offsite doses (40 CFR 61.90–61.97, Subpart H; WAC 173-480-040). This analysis assumes that the doses to the maximally exposed individual for each action are additive, despite the fact that the maximally exposed individual location for most actions is different. For comparison, the natural background radiation dose a person would receive is estimated at 311 millirem per year (NCRP 2009).

Person-rem

A unit of collective radiation dose applied to populations or groups of individuals; that is, a unit for expressing the dose when summed across all persons in a specified population or group.

S.5.5.4.2 Long-Term Cumulative Impacts

Long-term cumulative impacts occur following the project phase for each alternative. For this *TC & WM EIS*, long-term cumulative impacts were assessed out to approximately 10,000 years in the future. Long-term cumulative impacts of contaminant releases to groundwater are conservatively estimated without consideration of future remedial actions. The potential effects of future remedial actions are described in Chapter 7 of this EIS.

As analyzed in this *TC & WM EIS*, alternative combinations would contribute little to long-term cumulative impacts on environmental justice. Cumulative impacts on groundwater quality, human health, and ecological risk are described below.

Groundwater Quality. The concentrations for the selected indicator parameters presented in Table S–27 show that the non–*TC & WM EIS* actions are responsible for the bulk of the peak groundwater concentrations, with most of these concentrations having already occurred. These peak concentrations are largely associated with past liquid releases to cribs and trenches (ditches) in the 200 Areas and to production reactor retention basins and cooling ponds in the 100 Areas. Only for technetium-99 is the maximum cumulative groundwater concentration appreciably higher after adding in the contributions from the *TC & WM EIS* alternative combinations.

Table S–27. Non–*TC & WM EIS* and Alternative Combinations – Maximum COPC Concentrations at the Columbia River Nearshore

Contaminant	Total of Non–*TC & WM EIS* Actions	Cumulative Total		
		With Alternative Combination 1	With Alternative Combination 2	With Alternative Combination 3
Radionuclide (picocuries per liter				
Hydrogen-3 (tritium)	4,140,000 (1986)	4,140,000 (1986)	4,140,000 (1986)	4,140,000 (1986)
Technetium-99	212 (1991)	1,790 (2999)	868 (1965)	868 (1965)
Iodine-129	19.8 (2017)	20.1 (2017)	20.0 (2017)	20.0 (2017)
Uranium isotopes	6,190 (1979)	6,190 (1979)	6,190 (1979)	6,190 (1979)
Chemical (micrograms per liter)				
Carbon tetrachloride	208 (2067)	208 (2067)	208 (2067)	208 (2067)
Chromium	7,210 (1979)	7,210 (1979)	7,210 (1979)	7,210 (1979)
Nitrate	846,000 (1976)	846,000 (1976)	846,000 (1976)	846,000 (1976)
Total uranium	1,910 (1979)	1,910 (1979)	1,910 (1979)	1,910 (1979)

Note: The peak cumulative concentration for some constituents occurs in the past. Corresponding peak calendar years are shown in parentheses.

Key: COPC=constituent of potential concern; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*.

Peak groundwater concentrations, although a useful measure to show the maximum predicted impacts, tell only part of the story. Peak concentrations may occur for only a short period of time and may be localized, affecting only a small area near the source of the contamination. Long-term impacts figures in Appendix U, Chapter 5, and Chapter 6 of this EIS show how groundwater concentrations vary with time and space for non–*TC & WM EIS* sources; Alternative Combinations 1, 2, and 3; and cumulative impacts, respectively. The figures in these sections were compared to evaluate the relative contribution to cumulative impacts of non–*TC & WM EIS* sources and the alternative combinations and how they change over time. The results of this evaluation are briefly summarized below.

The long-term cumulative impacts on groundwater quality that include Alternative Combination 1 are dominated by Tank Closure Alternative 1 sources (for releases of technetium-99), non–*TC & WM EIS* sources (for releases of tritium and carbon tetrachloride), or a combination of both (for releases of iodine-129, uranium-238, chromium, nitrate, and total uranium). COPC contributions from Waste Management Alternative 1 sources and FFTF Decommissioning Alternative 1 sources account for well under 1 percent of the total amount of COPCs released to the environment.

The long-term cumulative impacts on groundwater quality that include Alternative Combination 2 are dominated by non–*TC & WM EIS* sources (for releases of tritium, uranium-238, carbon tetrachloride, chromium, and total uranium); a combination of non–*TC & WM EIS* sources and Waste Management Alternative 2 sources (for releases of iodine-129); a combination of non–*TC & WM EIS* sources and tank closure sources (for releases of nitrate); or all three (for releases of technetium-99). COPC contributions from FFTF Decommissioning Alternative 2 sources account for well under 1 percent of the total amount of COPCs released to the environment.

> **Hazard Quotient**
>
> The value used as an assessment of non-cancer-associated toxic effects of chemicals (e.g., kidney or liver dysfunction).

The long-term cumulative impacts on groundwater quality that include Alternative Combination 3 are dominated by non–*TC & WM EIS* sources (for releases of tritium, uranium-238, carbon tetrachloride, chromium, and total uranium); a combination of non–*TC & WM EIS* sources and Waste Management Alternative 2 sources (for releases of iodine-129); a combination of non–*TC & WM EIS* sources and tank closure sources (for releases of nitrate); or all three (for releases of technetium-99). COPC contributions from FFTF Decommissioning Alternative 3 sources account for well under 1 percent of the total amount of COPCs released to the environment.

Human Health. The bulk of the peak cumulative human health impacts would result from releases of contaminants attributable to past leaks and releases. The impacts of the alternative combinations generally would not exceed the peak impacts produced by past leaks and releases from non–*TC & WM EIS* sources. Peak human health impacts, as described above for long-term cumulative impacts on groundwater quality, although a useful measure to show the maximum predicted impacts, do not illustrate how the relative impacts of alternative combinations and non–*TC & WM EIS* sources change over time. Long-term impacts figures in Appendix U of this EIS show how human health risk varies with time for non–*TC & WM EIS* sources and Alternative Combinations 1, 2, and 3.

Ecological Risk. As described in detail in Chapter 6 of this EIS, the predicted cumulative concentrations due to deposition of airborne mercury to onsite soil, mercury to Columbia River surface water and sediment, and benzene to surface water could potentially result in adverse impacts on ecological receptors. For mercury in soil, most of the elevated concentration is attributable to air emissions associated with *TC & WM EIS* Alternative Combinations 2 and 3. Conversely, the majority of the elevated concentrations of mercury in surface water and sediment and of benzene in surface water are from past leaks and releases. In general, offsite sources of air emissions are not expected to contribute significantly to the cumulative ecological risk at Hanford.

Estimated peak contaminant concentrations of groundwater discharging to the Columbia River nearshore would exceed benchmark concentrations for carbon tetrachloride, chromium, fluoride, nitrate, lead, and uranium. Predicted peak concentrations from groundwater releases not associated with the *TC & WM EIS* alternatives (e.g., past leaks) are generally greater than those from releases associated with the EIS alternatives. For chromium, for example, predicted peak concentrations resulting from groundwater releases not associated with the EIS alternatives are approximately four times those associated with the

EIS alternatives. Chromium and nitrate are the only COPCs with a Hazard Quotient exceeding 1 (for the spotted sandpiper and aquatic biota, including salmonids, and for the least weasel, respectively) under the *TC & WM EIS* alternative combinations. Hazard Quotients less than 1 indicate little to no risk to the receptor.

Peak ecological risk estimates, as described above for long-term cumulative impacts on groundwater quality, although a useful measure to show the maximum predicted impacts, do not illustrate how the relative impacts of alternative combinations and non–*TC & WM EIS* sources change over time. Long-term impacts on ecological receptors exposed to groundwater discharging at the Columbia River would vary through time with the variation in groundwater concentrations (see Appendix U and Chapters 5 and 6 of this *TC & WM EIS*). For some COPCs with peaks that have already occurred (chromium, nitrate, uranium), future contributions to cumulative impacts from *TC & WM EIS* alternative combinations dominate those from non–*TC & WM EIS* sources. For chromium and nitrate, the contribution to cumulative impacts from Alternative Combination 1 dominates that of non–*TC & WM EIS* sources after CY 2150, whereas Alternative Combinations 2 and 3 dominate non–*TC & WM EIS* sources between CYs 2150 and 3500. The contribution to cumulative impacts from sources of uranium (total uranium, uranium-238) associated with Alternative Combination 1 dominates non–*TC & WM EIS* sources after 10,000 years. Nitrate concentrations from sources associated with *TC & WM EIS* alternative combinations would drop below benchmarks by CY 2050. Chromium concentrations associated with *TC & WM EIS* alternative combinations would drop below benchmarks much later, between CYs 3500 and 7000 for Alternative Combination 1 and between CYs 2150 and 3500 for Alternative Combinations 2 and 3. Concentrations associated with releases unrelated to the *TC & WM EIS* alternative combinations would remain above benchmarks until sometime between CYs 2500 and 3500 for lead and chromium and CYs 1975 and 2050 for uranium. Concentrations of nitrate in Columbia River water associated with releases unrelated to the *TC & WM EIS* alternative combinations would drop below benchmarks by CY 2050.

S.5.5.4.3 Regional and Global Cumulative Impacts

Ozone Depletion. The use of ozone-depleting compounds has been phased out, and they are no longer routinely used. Any release of ozone-depleting compounds, as may occur during the demolition of older air conditioning systems, would be incidental to the conduct of *TC & WM EIS* activities. In any case, emissions of ozone-depleting compounds would be very small and would represent a negligible contribution to destruction of Earth‘s protective ozone layer.

Global Climate Change. The ―greenhouse effect" is the process by which part of terrestrial radiation is absorbed by gases in the atmosphere, warming Earth‘s surface and atmosphere. This greenhouse effect and Earth‘s radiation balance are affected largely by water vapor, carbon dioxide, and trace gases, which absorb infrared radiation and are referred to as ―greenhouse gases." Other greenhouse gases include nitrous oxide, halocarbons, and methane. Some greenhouse gases occur in nature, while others are exclusively manmade; human activity may cause emissions of both naturally occurring and manmade greenhouse gases.

The *TC & WM EIS* alternatives could produce 913 metric tons (under FFTF Decommissioning Alternative 1 over a period of 100 years) to 0.429 million metric tons (under Tank Closure Alternative 6A, Option Case, over a period of 257 years) of carbon dioxide per year. Based on Hanford fuel use in 2006 and INL fuel consumption averages, baseline carbon dioxide emissions are 14,200 and 35,200 metric tons per year, respectively. The emissions under the alternatives would add to global annual emissions of carbon dioxide, which were 26.4 billion metric tons from fossil fuel use worldwide in 2000–2005 (IPCC 2007) and increased to 32.1 billion metric tons worldwide in 2008 (preliminary estimates for 2010 were 33.5 billion metric tons) (CDIAC 2011a, 2011b). The emission estimates for the *TC & WM EIS* alternatives account for facility-specific fuel-burning and process sources from construction and operations activity and mobile-source emissions from material and waste shipments. Emissions from employee vehicles and indirect emissions from electricity use were not estimated. Table S–28 summarizes the estimated annual average cumulative carbon dioxide emissions by *TC & WM EIS* alternative combination. DOE is proposing to substantially reduce future greenhouse gas emissions from the WTP and the Central Plateau by using natural gas rather than diesel fuel.

Table S–28. Estimated Cumulative Carbon Dioxide Emissions

Actions/Activities	Annual Average Emissions (metric tons per year)	Project Total Emissions (metric tons)
***TC & WM EIS* Combined Impacts**		
Alternative Combination 1	25,300	2,610,000
Alternative Combination 2	207,000	24,100,000
Alternative Combination 3	231,000	38,000,000
Other Actions		
Global baseline[a]	26,400,000,000	N/A
Cumulative Total		
Alternative Combination 1	26,400,000,000	N/A
Alternative Combination 2	26,400,000,000	N/A
Alternative Combination 3	26,400,000,000	N/A

[a] Based on fossil fuel use worldwide in 2006. Since 2006 the global baseline emissions has increased from 26.4 billion metric tons to 32.1 billion metric tons as of 2010.

Note: Carbon dioxide emissions under each alternative are presented in Appendix G, Table G–167.

Key: N/A=not applicable; *TC & WM EIS=Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*.

S.5.6 Mitigation

DOE has identified potential mitigation measures that would prevent or reduce potential environmental impacts resulting from implementation of the *TC & WM EIS* alternatives. These mitigation measures may be features incorporated in the alternatives analyzed in this EIS or they may be long-term strategies designed to reduce potential groundwater impacts. As specified in CEQ NEPA regulations (40 CFR 1508.20), mitigation includes the following:

- Avoiding the impact altogether by not taking a certain action or parts of an action
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action
- Compensating for the impact by replacing or providing substitute resources or environments

In 2011, CEQ issued final guidance on the ―Appropriate Use of Mitigation and Monitoring and Clarifying the Appropriate Use of Mitigated Findings of No Significant Impact" (Sutley 2011). The guidance clarifies the appropriate use of performance-based mitigation and encourages the use of internal processes for postdecision monitoring to ensure the implementation and effectiveness of the mitigation. The guidance also stresses that mitigation is an ongoing and ever-evolving process that should continue well after an action is selected and implemented to ensure mitigation commitments are fully met.

All of the *TC & WM EIS* alternatives—i.e., the alternatives for Tank Closure, FFTF Decommissioning, and Waste Management, including the No Action Alternatives—have the potential to impact one or more resource areas over the timeframes analyzed in this EIS. Various measures could be implemented across all alternatives, regardless of impact severity, to mitigate environmental impacts to the maximum extent practical. DOE intends to select a combination of Tank Closure, FFTF Decommissioning, and Waste Management alternatives along with development and implementation of a mitigation action plan that would be protective of human health and the environment and would be compliant with applicable regulations (10 CFR 1021.331) and operable permits.

S.5.6.1 Mitigation Measures Incorporated in the Alternatives

DOE has incorporated a number of design features, or strategic elements, into the development of the action alternatives to determine what reduction of resource area impacts may be realized. The following are examples of such design features analyzed in this *TC & WM EIS*:

Separations Technology. Several WTP pretreatment steps considered for the alternatives would enable the separation of tank waste in preparation for appropriate treatment and disposal. Liquid-solid separations, cesium removal, and strontium and TRU waste separations are examples of pretreatment technologies.

Sulfate and/or Technetium-99 Removal. Additional pretreatment technologies considered for some alternatives may increase waste loading in the WTP, thereby reducing the volume of primary-waste forms, or enhance the long-term performance of waste forms in a landfill.

Engineered Barriers. The emplacement of engineered barriers over permanent disposal facilities and in-place closure of tank farms, cribs and trenches (ditches), and other facilities were analyzed to determine potential long-term benefits. Furthermore, the differences between an RCRA Subtitle C barrier and the more robust Hanford barrier design were considered for certain alternatives.

Tank Waste Retrieval. The potential benefits of various levels of tank waste retrieval—i.e., retrieval conducive to the achievement of 10, 1, and 0.1 percent residual waste in the SSTs—were analyzed. Consistent with the various levels of tank waste retrieval, several different retrieval technologies were considered, including modified sluicing, mobile retrieval systems, vacuum-based retrieval, and chemical washing.

Potential Mitigation Measures That Could Be Pursued

Research/select tank waste retrieval technologies that avoid or minimize leakage.

Use existing buildings, rights-of-way, and infrastructure or construct new facilities on previously disturbed land.

Adhere to standard best management practices for soil erosion and sediment control during construction to minimize wind and water erosion.

Implement spill prevention and control and stormwater pollution prevention plans.

Continue to implement the as-low-as-is-reasonably-achievable principle during construction and operations to reduce radiological exposure of workers.

Continue safety training to help protect workers and prepare for possible emergencies and accidents.

Continue to perform cultural and biological surveys prior to and during construction.

Incorporate high-efficiency motors, pumps, lights, and other energy conservation measures into the design of new facilities.

Sequence facility operations to minimize peak use of utilities.

Implement ambient air monitoring for construction zones to monitor effectiveness of engineering controls.

Excavate soil beneath domed containment structures to ensure that contaminated fugitive dust is not released to the atmosphere.

Provide programs for employees that include flexible hours or staggered work shifts for workers to reduce peak traffic volumes.

Incorporate water conservation practices into routine operations.

Expedite restoration of land upon completion of its use.

Continue implementing the U.S. Department of Energy's pollution prevention and waste minimization program.

Supplemental Tank Waste Treatment. For some alternatives, the effectiveness of supplemental treatment technologies in expediting the treatment of tank waste was assessed. Configurations include the addition of WTP LAW melters or the construction and operation of bulk vitrification, cast stone, and/or steam reforming treatment facilities.

Clean Closure. Some alternatives were analyzed for the utility of clean closure of the SST farms, which includes complete exhumation of the SSTs and removal of underlying impacted soils. An option for clean closure of the B and T cribs and trenches (ditches) was also analyzed.

Tank Waste Treatment and Disposal. Some alternatives analyzed the reduction in onsite long-term environmental impacts that may be achieved by treating and/or managing all tank waste as HLW, requiring onsite storage in aboveground IHLW storage facilities. This option would not require disposal in an onsite IDF.

A potential for impacts on certain resource areas may require aggressive mitigation measures. Operation of the WTP HLW and LAW melters, for example, would require a significant amount of electric power. Mitigating such a potential disruption in the electricity supply could require development of an energy consumption plan that would identify energy conservation practices, as well as explore options for providing supplemental electricity. Additional pretreatment or treatment technologies, targeted at specific COPCs, that have the potential to enhance waste performance and mitigate long-term environmental impacts may have to be considered.

Under the Waste Management action alternatives, where an IDF would be constructed and operated in the 200-East and/or the 200-West Areas, COPCs that would leach from the IDF(s) would result in the majority of long-term groundwater impacts compared with other *TC & WM EIS* sources (e.g., Tank Closure and FFTF Decommissioning action alternatives). As such, the performance of waste forms that would be disposed of in an IDF becomes very important when predicting long-term groundwater impacts. Generally, secondary-waste-form performance is predicted to be a larger contributor to long-term groundwater impacts when compared to the contribution from primary waste forms. DOE recognizes the importance of improving secondary-waste-form performance and has already taken steps to address this need. From July 21 through July 23, 2008, DOE held a workshop to identify risks and uncertainties associated with the treatment and disposal of secondary waste and to develop a roadmap for addressing those risks and uncertainties. Representatives from DOE, EPA, Ecology, the Oregon State Department of Energy, and NRC, as well as technical experts from the DOE national laboratories, academia, and private industry attended the workshop. As a result of the individual contributions at the workshop, DOE published the *Hanford Site Secondary Waste Roadmap* in January 2009. This secondary-waste roadmap includes elements addressing regulatory and performance requirements, waste composition, preliminary waste form screening, waste form development, process design and support, and validation. Implementation of the secondary-waste roadmap will ensure compliant, effective, timely, and cost-effective disposal of secondary waste (PNNL 2009).

As for long-term impacts on groundwater resources and, subsequently, any ecological and human receptors that may come into contact with groundwater through various exposure scenarios, the COPCs that account for almost 100 percent of the risk and hazard drivers include tritium, iodine-29, technetium-99, uranium-238, chromium, nitrate, and total uranium. Several of these constituents are projected to exceed benchmark standards at the Core Zone Boundary or Columbia River at various times. Iodine-129 and technetium-99 that leach from an IDF under the Waste Management action alternatives would be the largest contributor to groundwater impacts when compared to other *TC & WM EIS* sources.

Offsite-Waste Disposal. A potential contributing factor to the groundwater-related impacts of the Waste Management alternatives is the disposal of offsite waste from other DOE facilities. This *TC & WM EIS* shows that receipt of offsite waste streams that contain specific amounts of certain isotopes, specifically iodine-129 and technetium-99, could have an adverse impact on the environment. Mitigation measures that would increase the capture of iodine-129 and technetium-99 (e.g., use of robust, long-term-performing waste forms such as ILAW glass) could reduce potential long-term impacts. Another means of mitigating such impacts would be for DOE to limit or restrict disposal of waste streams containing iodine-129 or technetium-99 at Hanford.

S.5.6.2 Additional Long-Term Mitigation Strategies

DOE recognizes the need for more-robust mitigation strategies and has undertaken initial steps to address these concerns. DOE conducted a series of sensitivity analyses to identify and evaluate additional long-term mitigation actions that may have the potential to reduce long-term groundwater impacts. The sensitivity analyses conducted as part of this *Final TC & WM EIS* are only examples of areas that could be investigated; there may be other areas that may warrant further study. More than one mitigation action may be warranted in the near, mid-, and long term, depending on the details of a particular waste management area unit of concern. The sensitivity analyses that were conducted as part of this final EIS and summarized in Chapter 7, Section 7.5, were used to determine which factors may contribute the most to groundwater impacts and where mitigation strategies may yield the most benefit. The overall purpose of conducting these sensitivity analyses is to understand the major impact drivers and the magnitude and timing of impacts.

> **Additional Long-Term Mitigation Strategies**
>
> Target vadose zone remediation at certain constituents of potential concern (COPCs) at low- and moderate-discharge sites.
>
> Require pretreatment of, or restrict, offsite waste prior to disposal in an Integrated Disposal Facility.
>
> Reduce the partitioning of target COPCs (e.g., iodine-129) in grouted waste forms.
>
> Improve secondary-waste-form performance.
>
> Improve knowledge and performance of supplemental treatment technology waste forms.
>
> Develop a set of primary- and secondary-waste-form performance criteria.
>
> Improve knowledge concerning background infiltration rates at the Hanford Site.

The sensitivity analyses evaluated several COPCs that are considered hazard or risk drivers (e.g., iodine-129, technetium-99, uranium-238); however, the same general principles and conclusions discussed in this section could apply to most COPCs, as would any mitigation planning and monitoring. In considering strategies for mitigating groundwater impacts, various sensitivity analyses were conducted under the following three general areas:

- **Reduce the inventory of COPCs available for discharge into the environment.**
  - Flux reduction
  - Offsite-waste acceptance
  - Capture-and-removal scenario
  - Cribs and trenches (ditches) partial clean closure
- **Modify processes for retrieval and treatment of tank waste.**
  - Iodine recycle
  - Technetium removal
  - Leak loss of 15,142 liters (4,000 gallons) per tank
- **Understand and manage the fate and transport of COPCs.**
  - Waste form performance (e.g., ILAW glass, bulk vitrification glass, steam reforming waste, grouted waste)
  - Infiltration rates
  - Climate change and recharge assumptions

S.5.6.3 Resource Management and Mitigation Plans

The 1996 *TWRS EIS* (DOE and Ecology 1996) described possible mitigation measures for the projected short- and long-term impacts of the proposed action alternatives for tank waste retrieval and treatment. DOE committed to these mitigation measures, as documented in the 1997 *TWRS EIS* ROD (62 FR 8693). These mitigation measures would continue to be implemented, as applicable, for the tank waste retrieval and treatment activities discussed in this *TC & WM EIS*.

The 1999 *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement (Hanford Comprehensive Land-Use Plan EIS)* (DOE 1999b) identifies specific mitigation measures, policies, and management controls that direct land use at Hanford. DOE committed to these mitigation measures, as documented in the *Hanford Comprehensive Land-Use Plan EIS* ROD (64 FR 61615). These commitments were reaffirmed in the 2008 *Supplement Analysis, Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 2008c) and in the associated ROD (73 FR 55824). These mitigation measures would continue to be implemented, as applicable, for the tank waste retrieval and treatment activities discussed in this *TC & WM EIS*. DOE has prepared, or will potentially prepare, a number of area and resource management plans. These plans are currently in draft form, have been completed, are being revised, or are waiting for available funds and program prioritization (DOE 2008c).

DOE published the *Long-Range Deep Vadose Zone Program Plan* in October 2010 (DOE 2010). This program plan summarizes the current state of knowledge regarding deep vadose zone remediation challenges beneath the Central Plateau at Hanford and DOE‘s approach to solving these challenges. The challenges faced are the result of contaminant depth and spread; the presence of multiple contaminants and comingled waste chemistries; physical, chemical, and biological fate and transport mechanisms; uncertain contaminant behavior; limited availability and effectiveness of cleanup remedies; and the unknown efficacy of remediation performance over the periods and spatial scales needed for making decisions. Remediation of the deep vadose zone is central to Hanford cleanup; unless permanent solutions are developed and implemented, the deep vadose zone will provide an ongoing source of contamination to the underlying aquifer and the Columbia River. The limited sensitivity analysis related to flux reduction that was conducted for this final EIS could be expanded and integrated with DOE vadose zone remediation programs to coordinate and prioritize the near-term remediation of some sites while providing for the timely development and availability of technologies for remediating other sites in the midterm.

Following completion of this *TC & WM EIS* and its associated ROD, DOE would be required to prepare a mitigation action plan that addresses the mitigation commitments expressed in the ROD (10 CFR 1021.331). This mitigation action plan would be prepared before DOE implemented any *TC & WM EIS* alternative actions that are the subject of a mitigation commitment expressed in the ROD. The mitigation action plan would address both short- and long-term mitigation actions, designed to mitigate adverse environmental impacts that are appropriate for the tank closure, FFTF decommissioning, and waste management actions selected for implementation. After implementation, DOE will periodically evaluate the efficacy of mitigation actions and, if necessary, will change or revise these mitigation actions to maintain the ability to achieve desired environmental outcomes.

S.6 COST OF THE ALTERNATIVES

The *Cost Report for —Tank Closure and Waste Management Environmental Impact Statement" Alternatives* was prepared to estimate the consolidated costs for continued operation of existing facilities; construction, operations, and deactivation of new or modified facilities; and associated activities (e.g., waste form disposal) to support the proposed actions (DOE 2009b).[5] The costs were calculated using constant 2008 dollars. Because the alternatives cover a broad range of remediation and closure pathways, the estimates developed for the various alternatives span a wide range of potential costs.[6]

Each of the *TC & WM EIS* Tank Closure, FFTF Decommissioning, and Waste Management alternatives is affected by uncertainties that influence confidence in the cost estimates. The following are among the uncertainties common to most of the alternatives (DOE 2009b):

- **Conservative estimates.** NEPA analysis provides an understanding of the potential environmental impacts associated with the proposed actions and the alternatives. Conservative estimates of labor and material requirements, technology performance, and other aspects of the alternatives were adopted. To the extent that conservatism is inherent in components of the alternatives, the cost estimate for the alternatives reflects higher costs than the point estimates developed for allocation of budgets and other planning exercises.

- **Scope definition.** The level of definition associated with the alternatives and/or specific work elements contributes to uncertainty. Cost estimates based on limited definition (planning-level estimates or preconceptual data) are more uncertain than estimates based on detailed design information. Furthermore, there may be greater uncertainty regarding cost estimates for activities involving unspecified radionuclide and chemical inventories (e.g., resulting from soil remediation) because of the unknown impact the actual inventory may have on remediation costs.

- **Schedule and duration of activities.** Except for the No Action Alternatives, each alternative includes durations for completing the waste retrieval and treatment, storage, and disposal components of the RPP mission, as well as the deactivation and closure components, which vary among the alternatives. Cost estimates based on projecting current costs (i.e., 2008 dollars) far into the future introduce other significant uncertainties. These uncertainties are driven by economic conditions and labor and material markets; changes in regulatory, technical, and safety requirements; political, scientific, and cultural conditions; and technological advances. All of the alternatives also assume a 100-year period of administrative controls/postclosure care following completion of decontamination and decommissioning and/or closure activities. Cost estimates for activities extending into the next century are inherently uncertain and should be interpreted as only rough estimates used to describe the total cost of an alternative and the relative cost differences among the alternatives.

[5] In an EIS, the costs estimated and presented for each alternative are different in nature than the cost estimates used to support the annual DOE budget process (such as the budget estimates for RPP contracts). Budgets to support DOE contracts typically address a near-term timeframe (generally within 5 years) because more-specific information regarding discrete work activities is usually available with a higher degree of certainty.

[6] Because of the wide range of potential costs, the higher Tank Closure alternatives' costs are presented in billions of 2008 dollars, whereas the lower FFTF Decommissioning and Waste Management alternatives costs' are presented in millions of 2008 dollars.

- **Development and use of technologies.** Except for the No Action Alternatives, each alternative involves development and use of unique, specialty technologies to address complex problems. These technologies are in varying stages of completion, ranging from conceptual design to pilot demonstration to full-scale construction. Consequently, in estimating costs, technology performance (e.g., facility throughputs, waste loading, separations efficiencies) was assumed based upon the design criteria. Should these key performance assumptions be found invalid, impacts on the alternatives' cost, schedule, and scope would occur.

- **Dependence upon external interfaces.** Many of the alternatives depend on the ability of WIPP and onsite disposal facilities to accept and dispose of waste forms (e.g., CH- and RH-mixed TRU waste). Impacts on various alternatives' cost, schedule, and scope would occur if the adopted assumptions for each of the alternatives proved invalid.

- **Embedded costs.** Efforts were made to remove embedded escalation costs, management reserves, contingency fees, and other fees (e.g., WTP estimate-at-completion values) from the source data when the contributions of these overall cost additions were clearly identified in source documentation.

- **Disposal costs.** Actual disposal costs are not currently available. Only estimated disposal costs based on the assumed waste types, quantities, and radiological content have been published. The estimated disposal costs will continue to vary as disposal facilities near completion, disposal quantities and types are modified, and cost bases are refined.

S.6.1 Tank Closure Alternatives

Cost estimates for each Tank Closure alternative are provided in Tables S–29 through S–31. Table S–29 provides the estimated potential costs of construction, operations, and deactivation for each of the primary components of the proposed actions (storage, retrieval, treatment, disposal, and closure); costs for final-waste-form disposal on or off site are excluded. Table S–30 provides the costs of final-waste-form disposal, both on and off site, by alternative. These costs represent the post-treatment disposal costs for ILAW, mixed TRU waste, MLLW, LLW, melters taken out of service, and contaminated soils. The costs associated with on- or offsite disposal of HLW shielded boxes are not included in the cost data, nor are the offsite disposal costs for IHLW. Alternatives that generate higher volumes of IHLW could ultimately have proportionally higher transportation and disposal costs. No credit was taken for cost-reducing actions such as waste volume reduction, alternative waste packaging, or use of alternative disposal sites.

Table S–29. Tank Closure Alternatives – Summary Cost Estimates,[a] Excluding Waste Form Disposal Costs (billions of 2008 dollars)

Work Element	Storage	Retrieval	Treatment	Disposal[b]	Closure	Total[c]
Alternative 1: No Action						
Construction	0.02	--	1.9	8.4	--	2.0
Operations	0.6	--	--	8.7	--	0.6
Deactivation	0.4	--	--	0.6	--	0.4
Total[c]	**1.0**	**--**	**1.9**	**17.7**	**--**	**3.0**
Alternative 2A: Existing WTP Vitrification; No Closure						
Construction	3.5	2.8	14.7	1.2	--	22.1
Operations	16.0	2.1	24.5	1.0	0.7	44.3
Deactivation	0.4	0.1	0.9	<0.01	--	1.4
Total[c]	**19.8**	**5.1**	**40.2**	**2.2**	**0.7**	**67.9**
Alternative 2B: Expanded WTP Vitrification; Landfill Closure						
Construction	1.5	2.6	8.7	1.5	2.3	16.6
Operations	7.1	1.5	11.3	0.7	0.5	21.1
Deactivation	--	0.1	0.6	<0.01	1.8	2.5
Total[c]	**8.6**	**4.2**	**20.6**	**2.1**	**4.6**	**40.1**
Alternative 3A: Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure						
Construction	1.5	2.6	8.1	1.6	2.3	16.2
Operations	6.4	1.4	11.0	0.7	0.5	19.9
Deactivation	--	0.1	0.5	<0.01	1.8	2.4
Total[c]	**7.9**	**4.2**	**19.6**	**2.3**	**4.6**	**38.5**
Alternative 3B: Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure						
Construction	1.5	2.6	7.9	1.6	2.3	15.9
Operations	6.4	1.4	11.2	0.7	0.5	20.1
Deactivation	--	0.1	0.5	<0.01	1.8	2.4
Total[c]	**7.9**	**4.2**	**19.6**	**2.3**	**4.6**	**38.4**
Alternative 3C: Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure						
Construction	1.5	2.6	9.5	1.6	2.3	17.5
Operations	6.4	1.4	11.0	0.7	0.5	19.9
Deactivation	--	0.1	0.5	<0.01	1.8	2.4
Total[c]	**7.9**	**4.2**	**21.0**	**2.3**	**4.6**	**39.8**
Alternative 4: Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure						
Construction	1.5	3.6	8.0	1.6	3.0	17.8
Operations	6.9	1.8	11.9	0.7	2.5	23.7
Deactivation	--	0.2	0.5	<0.01	1.4	2.1
Total[c]	**8.4**	**5.6**	**20.4**	**2.3**	**6.9**	**43.6**
Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure						
Construction	1.8	2.1	8.4	1.3	2.2	15.9
Operations	5.4	1.1	8.7	0.7	0.3	16.3
Deactivation	--	0.1	0.6	<0.01	0.8	1.5
Total[c]	**7.3**	**3.4**	**17.7**	**1.9**	**3.4**	**33.7**

Table S–29. Tank Closure Alternatives – Summary Cost Estimates,[a] Excluding Waste Form Disposal Costs (billions of 2008 dollars) *(continued)*

Work Element	Storage	Retrieval	Treatment	Disposal[b]	Closure	Total[c]
Alternative 6A: All Vitrification/No Separations; Clean Closure[d]						
Construction	8.1 *8.1*	5.1 *5.1*	21.8 *21.8*	69.9 *69.9*	2.6 *3.8*	107.5 *108.7*
Operations	28.7 *28.7*	3.4 *3.4*	48.6 *48.6*	36.2 *36.2*	10.9 *21.0*	127.8 *138.0*
Deactivation	--	0.3 *0.3*	1.4 *1.4*	<0.01 *<0.01*	3.2 *3.6*	4.9 *5.3*
Total[c]	**36.8** ***36.8***	**8.8** ***8.8***	**71.8** ***71.8***	**106.1** ***106.1***	**16.6** ***28.4***	**240.1** ***251.9***
Alternative 6B: All Vitrification with Separations; Clean Closure[d]						
Construction	1.5 *1.5*	3.6 *3.6*	8.8 *8.8*	3.2 *3.2*	2.6 *3.8*	19.7 *20.9*
Operations	7.1 *7.1*	1.8 *1.8*	12.3 *12.3*	0.7 *0.7*	9.3 *19.5*	31.1 *41.3*
Deactivation	--	0.2 *0.2*	0.6 *0.6*	<0.01 *<0.01*	3.2 *3.6*	4.0 *4.4*
Total[c]	**8.6** ***8.6***	**5.6** ***5.6***	**21.7** ***21.7***	**3.8** ***3.8***	**15.1** ***26.9***	**54.8** ***66.6***
Alternative 6C: All Vitrification with Separations; Landfill Closure						
Construction	1.5	2.6	8.7	2.3	2.3	17.3
Operations	7.1	1.5	11.2	0.7	0.5	20.9
Deactivation	--	0.1	0.6	<0.01	1.8	2.5
Total[c]	**8.6**	**4.2**	**20.4**	**2.9**	**4.6**	**40.7**

[a] Estimates are costs to the Hanford Site only.
[b] Includes post-treatment storage. Costs for disposal of the final waste forms (e.g., immobilized low-activity waste and transuranic waste) are presented separately in Table S–30.
[c] Total may not equal the sum of the contributions due to rounding.
[d] Values presented are for the Base Case. Values for the Option Case (additional clean closure of six adjacent cribs and trenches [ditches]) are presented in *italics*.

Note: Costs associated with the 100-year administrative and/or institutional control periods were assigned in the following manner: Alternatives 1 and 2A under ―Storage" and all other alternatives under ―Closure."
Key: WTP=Waste Treatment Plant.
Source: DOE 2009b.

Table S–30. Tank Closure Alternatives – Costs for Final-Waste-Form Disposal[a] (billions of 2008 dollars)

Tank Closure Alternative		Final-Waste-Form Disposal Costs
1	No Action	--
2A	Existing WTP Vitrification; No Closure	0.3
2B	Expanded WTP Vitrification; Landfill Closure	0.8
3A	Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure	1.3
3B	Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure	1.5
3C	Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure	1.5
4	Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure	2.0
5	Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure	0.8

Table S–30. Tank Closure Alternatives – Costs for Final-Waste-Form Disposal[a] (billions of 2008 dollars) *(continued)*

Tank Closure Alternative		Final-Waste-Form Disposal Costs
6A	All Vitrification/No Separations; Clean Closure[b]	2.8 *9.2*
6B	All Vitrification with Separations; Clean Closure[b]	2.8 *9.1*
6C	All Vitrification with Separations; Landfill Closure	0.6

[a] Offsite-disposal costs for immobilized high-level radioactive waste are not included.
[b] Values presented are for the Base Case. Values for the Option Case (additional clean closure of six adjacent cribs and trenches [ditches]) are presented in *italics*.
Key: WTP=Waste Treatment Plant.
Source: DOE 2009b.

The highest relative costs would apply to Tank Closure alternatives with more-restrictive scopes (i.e., 99.9 percent retrieval of SST waste and/or clean closure components [Alternatives 4, 6A, and 6B]), extended schedules (Alternatives 2A and 6A), and high waste form disposal costs (Alternatives 6A and 6B). These higher costs would be driven by required construction of treatment systems, longer relative operating schedules for waste treatment and tank farm facilities, and clean closure of the SST farms (Alternatives 6A and 6B).

DOE would proceed with onsite disposal of some of the final waste forms (e.g., ILAW) only if their disposal complied with applicable laws. Table S–31 combines the cost data in Tables S–29 and S–30 to project a total cost for each Tank Closure alternative.

Table S–31. Tank Closure Alternatives – Total Cost Projections, Including Waste Disposal Costs[a] (billions of 2008 dollars)

	Tank Closure Alternative	Total Cost
1	No Action	3.0
2A	Existing WTP Vitrification; No Closure	68.2
2B	Expanded WTP Vitrification; Landfill Closure	40.9
3A	Existing WTP Vitrification with Thermal Supplemental Treatment (Bulk Vitrification); Landfill Closure	39.8
3B	Existing WTP Vitrification with Nonthermal Supplemental Treatment (Cast Stone); Landfill Closure	39.9
3C	Existing WTP Vitrification with Thermal Supplemental Treatment (Steam Reforming); Landfill Closure	41.3
4	Existing WTP Vitrification with Supplemental Treatment Technologies; Selective Clean Closure/Landfill Closure	45.6
5	Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure	34.5
6A	All Vitrification/No Separations; Clean Closure[b]	242.9 *261.1*
6B	All Vitrification with Separations; Clean Closure[b]	57.6 *75.7*
6C	All Vitrification with Separations; Landfill Closure	41.3

[a] Offsite-disposal costs for immobilized high-level radioactive waste are not included.
[b] Values presented are for the Base Case. Values for the Option Case (additional clean closure of six adjacent cribs and trenches [ditches]) are presented in *italics*.
Key: WTP=Waste Treatment Plant.
Source: Tables S–29 and S–30.

S.6.2 FFTF Decommissioning Alternatives

Table S–32 provides summary cost estimates for each of the FFTF Decommissioning alternatives in terms of construction, operations, and deactivation. Table S–33 presents the separate projected waste disposal costs for each alternative, as well as the projected waste volumes produced under each alternative, as the disposal costs depend on the types and quantities of waste produced. Table S–34 combines the data in Tables S–32 and S–33 to provide the total estimated cost of each FFTF Decommissioning alternative.

Table S–32. FFTF Decommissioning Alternatives – Summary Cost Estimates, Excluding Waste Form Disposal Costs (millions of 2008 dollars)

Work Element	FFTF Decommissioning Alternatives				
	Alternative 1: No Action[a]	Alternative 2: Entombment		Alternative 3: Removal	
Facility Disposition					
Construction	--	3.9		2.5	
Operations	--	99.1		109.2	
Deactivation	492.5	0.7		0.3	
Subtotal[b, c]	**492.5**	**103.7**		**112.1**	
		Hanford Option[d]	**Idaho Option[e, f]**	**Hanford Option[d]**	**Idaho Option[e, f]**
Disposition of Bulk Sodium	--	**64.3**	**33.9**	**64.3**	**33.9**
Disposition of RH-SCs	--	**121.1**	**121.2**	**121.1**	**121.2**

a The No Action Alternative includes 100 years of surveillance and maintenance activities.
b Costs for disposal of the final waste forms are presented separately in Table S–33.
c Subtotal may not equal the sum of the contributions due to rounding.
d Hanford Reuse Option for disposition of bulk sodium.
e Idaho Reuse Option for disposition of bulk sodium.
f Cost estimates for the Idaho Option for disposition of RH-SCs conservatively assume construction of a new facility.

Key: FFTF=Fast Flux Test Facility; RH-SC=remote-handled special component.

Source: DOE 2009b.

Table S–33. FFTF Decommissioning Alternatives – Waste Form Disposal Cost Estimates

Waste Category (cubic meters disposed of)	Alternative 1: No Action[a]	Alternative 2: Entombment[b]	Alternative 3: Removal[b]
Low-level radioactive waste	1,700	140	750
Mixed low-level radioactive waste	60	670	280
Hazardous waste	400	--	60
Nonhazardous waste	--	460	460
Disposal Cost (millions of 2008 dollars)	**2.1**	**0.9**	**1.1**

a Waste volumes of secondary solid waste only.
b Waste volumes are a summation of primary and secondary solid waste and are not expected to differ between the Hanford or Idaho options for disposition of remote-handled special components and bulk sodium.

Note: To convert cubic meters to cubic feet, multiply by 35.315.

Key: FFTF=Fast Flux Test Facility.

Source: DOE 2009b.

Table S–34. FFTF Decommissioning Alternatives – Total Cost Projections, Including Waste Disposal Costs (millions of 2008 dollars)

FFTF Decommissioning Alternatives		Total Cost
1	No Action	494.6
2	Entombment	
	Disposition of RH-SCs: Idaho Option Disposition of bulk sodium: Hanford Reuse Option	290.1
	Disposition of RH-SCs: Hanford Option Disposition of bulk sodium: Idaho Reuse Option	259.6
	Disposition of RH-SCs: Hanford Option Disposition of bulk sodium: Hanford Reuse Option	289.9
	Disposition of RH-SCs: Idaho Option Disposition of bulk sodium: Idaho Reuse Option	259.7
3	Removal	
	Disposition of RH-SCs: Idaho Option Disposition of bulk sodium: Hanford Reuse Option	298.7
	Disposition of RH-SCs: Hanford Option Disposition of bulk sodium: Idaho Reuse Option	268.1
	Disposition of RH-SCs: Hanford Option Disposition of bulk sodium: Hanford Reuse Option	298.5
	Disposition of RH-SCs: Idaho Option Disposition of bulk sodium: Idaho Reuse Option	268.3

Key: FFTF=Fast Flux Test Facility; RH-SCs=remote-handled special components.
Source: Tables S–32 and S–33.

S.6.3 Waste Management Alternatives

Table S–35 provides the summary cost estimates for each of the Waste Management alternatives in terms of construction, operations, and deactivation of treatment and storage activities, as well as the construction, operations, closure, and transportation activities that would occur in association with each disposal group. Table S–36 presents the separate costs for disposal of offsite LLW and MLLW; onsite non-CERCLA, nontank waste; and secondary waste from disposal operations. These disposal costs do not differentiate between on- and offsite waste generators and are presented only for Waste Management Alternatives 2 and 3 (no waste would be received for disposal under Waste Management Alternative 1: No Action). Table S–37 combines the data in Tables S–35 and S–36 to provide the total estimated cost of each Waste Management alternative.

Table S–35. Waste Management Alternatives – Summary Cost Estimates, Excluding Waste Form Disposal Costs (millions of 2008 dollars)

Work Element	Alternative 1: No Action	Alternative 2: Disposal in IDF, 200-East Area Only			Alternative 3: Disposal in IDF, 200-East and 200-West Areas		
Treatment and Storage							
Construction	--	337.9			337.9		
Operations	17.5	2,016.0			2,016.0		
Deactivation	451.3	30.7			30.7		
Subtotal	468.8	2,384.5			2,384.5		
Disposal		**Group 1**	**Group 2**	**Group 3**	**Group 1**	**Group 2**	**Group 3**
Construction	--	118.9	459.3	459.3	118.5	459.7	459.7
Operations	--	649.9	5,268.9	9,465.3	647.0	5,242.0	9,399.8
Closure	--	946.2	1,128.9	1,128.9	1,386.4	1,570.3	1,570.3
Transportation[a]	--	521.5	521.5	521.5	521.5	521.5	521.5
Subtotal	--	2,236.5	7,378.5	11,575.0	2,673.4	7,793.6	11,951.3
Total[b]	**468.8**	**4,621.1**	**9,763.1**	**13,959.5**	**5,057.9**	**10,178.1**	**14,335.9**

[a] Costs associated with transportation of offsite low-level radioactive waste and mixed low-level radioactive waste to the Hanford Site for disposal. The waste quantity, generation location, and transportation distance are the same for each disposal group.

[b] Total may not equal the sum of the contributions due to rounding. Costs for disposal of the final waste forms are presented separately in Table S–36.

Key: IDF=Integrated Disposal Facility.

Source: DOE 2009b.

Table S–36. Waste Management Alternatives – Waste Form Disposal Costs

Waste Category (cubic meters disposed of)	Alternative 1: No Action[a]	Alternative 2: Disposal in IDF, 200-East Area Only	Alternative 3: Disposal in IDF, 200-East and 200-West Areas
Offsite LLW and MLLW	--	82,000	82,000
Onsite non-CERCLA, nontank waste	--	5,300	5,300
Secondary waste	--	3,000	3,000
Disposal Cost (millions of 2008 dollars)	**--**	**96.1**	**96.1**

[a] No waste would be received for disposal under this alternative.

Note: To convert cubic meters to cubic feet, multiply by 35.315.

Key: CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; IDF=Integrated Disposal Facility; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste.

Source: DOE 2009b.

Table S–37. Waste Management Alternatives – Total Cost Projections, Including Waste Disposal Costs (millions of 2008 dollars)

Waste Management Alternatives		Total Cost
1	No Action	468.8
2	Disposal in IDF, 200-East Area Only	
	Disposal Group 1	4,717.2
	Disposal Group 2	9,859.2
	Disposal Group 3	14,055.6
3	Disposal in IDF, 200-East and 200-West Areas	
	Disposal Group 1	5,154.0
	Disposal Group 2	10,274.2
	Disposal Group 3	14,432.0

Key: IDF=Integrated Disposal Facility.

Source: Tables S–35 and S–36.

S.7 PREFERRED ALTERNATIVES

The preferred alternative is the alternative that the agency believes would fulfill its statutory mission while giving consideration to environmental, economic, technical, and other factors.

This *Final TC & WM EIS* considers three sets of actions: tank closure, FFTF decommissioning, and waste management. The range of reasonable approaches to these three sets of actions is covered by a total of 17 alternatives. DOE has clarified and/or revised its Preferred Alternatives since the *Draft TC & WM EIS* was issued in the three major areas.

S.7.1 Tank Closure

Eleven alternatives for potential tank closure actions are evaluated in this final EIS. These alternatives cover tank waste retrieval and treatment, as well as closure of the SSTs. DOE has identified the following Preferred Alternatives: for retrieval, DOE prefers Tank Closure alternatives that would retrieve at least 99 percent of the tank waste. All Tank Closure alternatives would do this except Alternatives 1 (No Action) and 5. For closure of the SSTs, DOE prefers landfill closure; this could include implementation of corrective/mitigation actions as described in Section S.5.5.1, which may require soil removal or treatment of the vadose zone. Decisions on the extent of soil removal or treatment, if needed, will be made on a tank farm or waste management area basis through the RCRA closure permitting process. These landfill closure considerations would apply to Tank Closure Alternatives 2B, 3A, 3B, 3C, 5, and 6C. DOE does not prefer alternatives that include removal of the tanks as evaluated in Tank Closure Alternatives 4, 6A, and 6B. As described in Section S.5.5.1, DOE believes that removal of the tank structures is technically infeasible and, due to both the depth of the contamination and the technical issues associated with removal of the tank structures, that it presents significant uncertainty in terms of worker exposure risk and waste generation volume.

DOE does not have a preferred alternative regarding supplemental treatment for LAW; DOE believes it beneficial to study further the potential cost, safety, and environmental performance of supplemental treatment technologies. Nevertheless, DOE is committed to meeting its obligations under the TPA regarding supplemental LAW treatment. When DOE is ready to identify its preferred alternative regarding supplemental treatment for LAW, this action will be subject to NEPA review as appropriate. DOE will provide a notice of its preferred alternative in the *Federal Register* at least 30 days before issuing a ROD. For the actions related to tank waste retrieval, treatment and closure, DOE prefers Tank Closure Alternative 2B, without removing technetium in the Pretreatment Facility.

Although DOE previously expressed its preference that no Hanford tank waste would be shipped to WIPP (74 FR 67189), DOE now prefers to consider the option to retrieve, treat, and package waste that may be properly and legally designated as mixed TRU waste from specific tanks for disposal at WIPP, as analyzed in Tank Closure Alternatives 3A, 3B, 3C, 4, and 5. Initiating retrieval of tank waste identified as mixed TRU waste would be contingent on DOE‘s obtaining the applicable disposal and other necessary permits and ensuring that the WIPP Waste Acceptance Criteria and all other applicable regulatory requirements have been met. Retrieval of tank waste identified as mixed TRU waste would commence only after DOE had issued a *Federal Register* notice of its preferred alternative and a ROD.

S.7.2 FFTF Decommissioning

There are three FFTF Decommissioning alternatives from which the Preferred Alternative was identified: (1) No Action, (2) Entombment, and (3) Removal. DOE‘s Preferred Alternative for FFTF Decommissioning is Alternative 2: Entombment, which would remove all above-grade structures, including the reactor building. Below-grade structures, the reactor vessel, piping, and other components would remain in place and be filled with grout to immobilize the remaining radioactive and hazardous constituents. Waste generated from these activities would be disposed of in an IDF, and an engineered modified RCRA Subtitle C barrier would be constructed over the filled area. The RH-SCs would be processed at INL and returned to Hanford. Bulk sodium inventories would be processed at Hanford for use in the WTP.

S.7.3 Waste Management

Three Waste Management alternatives were identified for the proposed actions: (1) Alternative 1: No Action, under which all onsite LLW and MLLW would be treated and disposed of in the existing, lined LLBG 218-W-5 trenches and no offsite waste would be accepted; (2) Alternative 2, which would continue treatment of onsite LLW and MLLW in expanded, existing facilities and dispose of onsite and previously treated, offsite LLW and MLLW in a single IDF (IDF-East); and (3) Alternative 3, which also would continue treatment of onsite LLW and MLLW in expanded, existing facilities, but would dispose of onsite and previously treated, offsite LLW and MLLW in two IDFs (IDF-East and IDF-West). DOE's Preferred Alternative for waste management is Alternative 2, disposal of onsite LLW and MLLW streams in a single IDF (IDF-East). Disposal of SST closure waste that is not highly contaminated, such as rubble, soils, and ancillary equipment, in the proposed RPPDF is also included under this alternative. After completion of disposal activities, IDF-East and the proposed RPPDF would be landfill-closed under an engineered modified RCRA Subtitle C barrier. The final EIS analyses show that, even when mitigation is applied to certain offsite waste streams (e.g., removal of most of the iodine-129), some environmental impacts of small quantities of iodine-129 would still occur and, therefore, limitations on that constituent should apply regardless of the alternative selected.

DOE will continue to defer the importation of offsite waste at Hanford, at least until the WTP is operational, subject to appropriate NEPA review and consistent with its previous Preferred Alternative for waste management (74 FR 67189). The limitations and exemptions defined in DOE's January 6, 2006, Settlement Agreement with the State of Washington (as amended on June 5, 2008) regarding *State of Washington v. Bodman* (Civil No. 2:03-cv-05018-AAM), signed by DOE, Ecology, the Washington State Attorney General's Office, and the U.S. Department of Justice, will remain in place.

S.8 GUIDE TO THE CONTENTS OF THIS *TC & WM EIS*

The organization and contents of this *TC & WM EIS* are provided in this section. A separate Reader's Guide has also been published that serves as an introduction and guide to the contents of this EIS. It includes roadmaps to the Tank Closure, FFTF Decommissioning, and Waste Management alternatives and summarizes the key features of each alternative. The guide also identifies where related discussions can be found in the various chapters and appendices of this *TC & WM EIS* and assists the reader to navigate through this EIS.

Summary—This separate volume summarizes this entire *TC & WM EIS*.

Chapter 1—Proposed Actions: Background, Purpose and Need. Chapter 1 provides background information regarding the preparation of this *TC & WM EIS*, including the purpose and need for agency action regarding SST system closure, FFTF decommissioning, and final waste disposition; the cooperating agencies; the decisions to be made based on the EIS analyses; a summary of the issues identified during scoping; a description of the changes since the *Draft TC & WM EIS* publication; the scope of this EIS, including brief summaries of the alternatives; the relationship of the proposed actions to other actions or programs; and the organization of this EIS.

Chapter 2—Proposed Actions and Alternatives. Chapter 2 describes the alternatives evaluated in this EIS and identifies the Preferred Alternatives. This chapter also includes a description of the processes and facilities that could be used to implement each of the alternatives and a summary of the short- and long-term environmental impacts, key environmental findings, and cost estimates of each alternative.

Chapter 3—Affected Environment. Chapter 3 describes the existing Hanford and INL environments that may be affected by the alternatives under consideration. In general, Hanford as a whole is described first, followed by the 200 and 400 Areas. The existing environments described include human, air, and surface and subsurface media that could be affected by activities related to tank waste storage, retrieval, treatment, and disposal; SST system closure; FFTF decommissioning; and waste management.

Chapter 4—Short-Term Environmental Consequences. Chapter 4 discusses the short-term environmental impacts associated with the various EIS alternatives for tank closure, FFTF decommissioning, and waste management. Impacts produced by construction, operations, decontamination, and decommissioning are considered.

Chapter 5—Long-Term Environmental Consequences. Chapter 5 discusses the long-term environmental impacts associated with the various EIS alternatives for tank closure, FFTF decommissioning, and waste management, focusing on long-term environmental impacts on groundwater and human health, as well as ecological risks.

Chapter 6—Cumulative Impacts. Chapter 6 discusses the cumulative impacts associated with the various EIS alternatives.

Chapter 7—Environmental Consequences and Mitigation Discussion. Chapter 7 discusses possible measures to mitigate impacts identified in Chapters 4, 5, and 6; unavoidable, adverse environmental impacts; irreversible and irretrievable resource commitments; and the relationship between short-term use of the environment and long-term productivity.

Chapter 8—Potentially Applicable Laws, Regulations, and Other Requirements. Chapter 8 describes the environmental laws, regulations, permits, and consultations that are potentially applicable to the various activities related to tank waste storage, retrieval, treatment, and disposal and SST system closure; FFTF decommissioning; and waste management associated with the alternatives. Federal laws and regulations; Executive orders; DOE directives, orders, and guidance; and other compliance actions related to protection of the environment also are described.

Chapter 9—Glossary. Chapter 9 contains definitions of important technical terms that may not be commonly used, including both discipline-specific and DOE- and Hanford-unique terms.

Chapter 10—List of Preparers. Chapter 10 identifies the DOE and contractor preparers of this EIS. Information is provided for each preparer in the following areas: (1) affiliation, (2) name, (3) EIS responsibility, (4) education, and (5) experience.

Chapter 11—Distribution List. Chapter 11 contains the external distribution list for this EIS, which includes Federal, state, and local elected and appointed officials and agencies; American Indian representatives; environmental and public interest groups; and organizations and individuals who requested/were sent a copy of this EIS.

Chapter 12—Index. Chapter 12 contains the index of key words and terms found in this EIS.

In addition, the following appendices are provided to support these chapters:

- Appendix A *Federal Register* and Other Public Notices
- Appendix B Contractor and Subcontractor National Environmental Policy Act Disclosure Statements

- Appendix C Cooperating Agency, Consultation, and Other Interaction Documentation
- Appendix D Waste Inventories
- Appendix E Descriptions of Facilities, Operations, and Technologies
- Appendix F Direct and Indirect Impacts: Assessment Methodology
- Appendix G Air Quality Analysis
- Appendix H Transportation
- Appendix I Workforce Estimates
- Appendix J Environmental Justice
- Appendix K Short-Term Human Health Risk Analysis
- Appendix L Groundwater Flow Field Development
- Appendix M Release to Vadose Zone
- Appendix N Vadose Zone Flow and Transport
- Appendix O Groundwater Transport Analysis
- Appendix P Ecological Resources and Risk Analysis
- Appendix Q Long-Term Human Health Dose and Risk Analysis
- Appendix R Cumulative Impacts: Assessment Methodology
- Appendix S Waste Inventories for Cumulative Impact Analyses
- Appendix T Supporting Information for the Short-Term Cumulative Impact Analyses
- Appendix U Supporting Information for the Long-Term Cumulative Impact Analyses
- Appendix V Recharge Sensitivity Analysis
- Appendix W American Indian Tribal Perspectives and Scenarios
- Appendix X Supplement Analysis of the *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*

S.9 GLOSSARY

accident – In the context of this environmental impact statement, a specific, identifiable, unexpected, unusual, and unintended event or sequence of events that results in undesirable consequences.

acid – A chemical compound with a pH value lower than 7.0.

activity – (1) A measure of the amount of radiation emitted from a radioactive material, expressed in either becquerels or curies. (2) An action, operation, or effort.

additive – The property whereby the total effect of multiple agents is the sum of effects of the agents acting separately under the same conditions.

administrative control – Provisions related to organization and management, procedures, record-keeping, assessment, and reporting that are necessary to ensure safe operation of a facility.

affected environment – The existing biological, physical, social, and economic conditions of an area that are subject to direct and/or indirect changes as a result of a proposed human action.

air pollutant – Generally, an airborne substance that, in sufficiently high concentrations, could harm living things or cause damage to materials. From a regulatory perspective, air pollutants are substances for which emissions or atmospheric concentrations are regulated or for which maximum guideline levels have been established to enable assessment of their potential for harmful effects on human health and welfare.

air quality – The cleanliness of the air as measured by the levels of pollutants relative to the standards or guideline levels established to protect human health and welfare.

alternative – One of two or more actions, processes, or propositions from which a decisionmaker will determine the course to be followed. The National Environmental Policy Act (NEPA) of 1969, as amended, states that in preparing an environmental impact statement (EIS), an agency “shall ... study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources” (Title 42 of the *United States Code*, Section 4322(2)(E)). Council on Environmental Quality NEPA-implementing regulations indicate that the alternatives section in an EIS is “the heart of the environmental impact statement” (Title 40 of the *Code of Federal Regulations*, Section 1502.14) and include rules for presenting the alternatives, including no action, and their estimated impacts.

ambient – Surrounding.

ambient air – The atmosphere surrounding people, plants, and structures.

ambient air quality standards – As prescribed by regulations, the level of pollutants in the air that may not be exceeded during a specified time in a defined area. Air quality standards are used to provide a measure of the health-related and visual characteristics of the air.

ancillary equipment – Structures associated with tank operations, including miscellaneous underground storage tanks; the waste transfer system (diversion boxes, valve pits, and transfer piping); tank pits; tank risers; in-tank equipment; and miscellaneous facilities used in the treatment, transfer, or storage of tank waste.

anion – A negatively charged ion.

annulus – The space between the inner and outer shells of a double-shell tank.

aquatic – Living or growing in, on, or near water.

aquatic biota – The sum total of living organisms within any designated aquatic area.

aquifer – An underground geologic formation, group of formations, or part of a formation that is capable of yielding a significant amount of water to wells or springs.

Atomic Energy Act – A law enacted in 1946 and amended in 1954 (Title 42 of the *United States Code*, Part 2011 et seq.) that placed nuclear production and control of nuclear materials under the oversight of a civilian agency, originally the Atomic Energy Commission.

backfill – Excavated earth or other material transferred into an open trench, cavity, or other opening in the earth.

background radiation – Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material); and atmospheric fallout (e.g., from the testing of nuclear explosive devices).

barrier – Any material or structure that prevents or substantially delays movement of constituents toward the accessible environment, especially an engineered structure used to isolate contaminants from the environment in accordance with appropriate regulations.

basalt – The most common volcanic rock, dark gray to black in color, high in iron and magnesium, low in silica, and typically found in lava flows.

baseline – The existing environmental conditions against which the impacts of the proposed actions and their alternatives can be compared.

becquerel – A unit of radioactivity equal to one disintegration per second. Thirty-seven billion becquerels equal 1 curie.

benchmark – Dose or concentration known or accepted to be associated with a specific level of effect. Thus, Federal drinking water standards (Title 40 of the *Code of Federal Regulations*, Parts 141 and 143) are used as benchmarks against which potential contamination can be compared. Drinking water standards for Washington State are found in *Washington Administrative Code* 246-290.

benchmark standards – The —benchmark standards” used in this environmental impact statement represent dose or concentration levels that correspond to known or established human health effects. For groundwater, the benchmark is the maximum contaminant level (MCL) if an MCL is available. For constituents with no available MCL, additional sources for benchmark standards include Washington State guidance and relevant regulatory standards, e.g., Clean Water Act, Safe Drinking Water Act. For example, the benchmark for iodine-129 is 1 picocurie per liter; for technetium-99, it is 900 picocuries per liter. These benchmark standards for groundwater impacts analysis were agreed upon by both the U.S. Department of Energy and the Washington State Department of Ecology as the basis for comparing the alternatives and representing potential groundwater impacts.

best management practices (BMPs) – Structural, nonstructural, and managerial techniques, other than techniques for effluent limitations, used to prevent or reduce pollution of surface water. They are the most effective and practical means to control pollutants that are compatible with the productive use of the resource to which they are applied. BMPs are used in both urban and agricultural areas. BMPs can include activity schedules; practice prohibitions; maintenance procedures; treatment requirements; operating procedures; and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

biota (biotic) – The plant and animal life of a region.

borrow – Excavated material that has been taken from one area to be used as raw material or fill at another location.

borrow area (pit, site) – An area designated as the excavation site for geologic resources such as rock/basalt, sand, gravel, or soil to be used elsewhere for fill.

bound – To use simplifying assumptions and analytical methods in an analysis of impacts or risks such that the result overestimates or describes an upper limit on (i.e., —bounds”) potential impacts or risks.

bulk vitrification – A supplemental thermal treatment process that converts low-activity waste into a solid glass form by drying that waste, mixing it with soil, and applying electrical current to the mix within a large steel container.

burial ground – A place for burying low-level radioactive waste and mixed low-level radioactive waste so as to prevent the escape of hazardous chemicals or radiation, and the dispersion thereof, into the environment.

byproduct material – (1) Any radioactive material (except special nuclear material [SNM]) yielded in, or any material made radioactive by exposure to radiation during, the process of producing or utilizing SNM. (2) The tailings or waste produced by the extraction or concentration of uranium or thorium from any ore that is processed primarily for its source material content.

Byproduct material is exempt from regulation under the Resource Conservation and Recovery Act (RCRA) (Title 42 of the *United States Code*, Part 6901 et seq.). However, the exemption applies only to the actual radionuclides dispersed or suspended in the waste substance. Any nonradioactive hazardous waste component of the waste is subject to regulation under RCRA.

cancer – The name given to a group of diseases characterized by uncontrolled cellular growth where the cells have invasive characteristics that enable the disease to transfer from one organ to another.

canister – A general term for a container, usually cylindrical, used in the handling, storage, transportation, or disposal of waste.

canyon – In the nuclear industry, a large, heavily shielded concrete building that contains a remotely operated nuclear materials processing facility.

capacity (electric) – An electric power plant's maximum power output.

carbonate – A salt or ester of carbonic acid.

carbon dioxide – A colorless, odorless gas that is a normal component of ambient air and a product of fossil fuel combustion, animal expiration, and the decay or combustion of animal or vegetable matter.

carbon monoxide – A colorless, odorless, poisonous gas produced by incomplete fossil fuel combustion.

carcinogen – A substance or agent that produces or incites cancerous growth.

cask – A heavily shielded container used to store or ship radioactive materials.

cast stone – A nonthermal waste stabilization process that may be performed at ambient temperatures and pressures and involves mixing the waste with grout formers (e.g., Portland cement, fly ash, slag) and conditioners to produce a solid waste form.

cation – A positively charged ion.

Central Plateau – The elevated area in the center of the Hanford Site where the 200-East and 200-West Areas are located.

characterization – See *waste characterization.*

Clean Air Act – This act (Title 42 of the *United States Code*, Part 7401 et seq.) mandates, and provides for enforcement of, regulations to control air pollution from various sources.

clean closure – The premise of clean closure is that all hazardous waste has been removed from a given Resource Conservation and Recovery Act (RCRA)-regulated unit and any releases at or from the unit have been remediated so that further regulatory control under RCRA Subtitle C is not necessary to protect human health and the environment. Under State of Washington requirements (*Washington Administrative Code* 173-303-64) for closure of a tank system, the owner or operator must remove or decontaminate all waste residues, contaminated containment system components (e.g., liners), contaminated soils, and structures and equipment contaminated with waste and must manage them as dangerous waste as required.

cleanup – Refers to the full range of projects and activities undertaken to address environmental and legacy waste issues associated with the Hanford Site.

closure – Refers to the deactivation and stabilization of a waste treatment, storage, or disposal unit (such as a waste treatment tank, waste storage building, or landfill) or hazardous materials storage unit (such as an underground storage tank). For storage units, closure typically includes removal of all residues, contaminated system components, and contaminated soil. For radioactive and hazardous waste disposal units (i.e., where waste is left in place), closure typically includes site stabilization and emplacement of surface barriers. Specific requirements for the closure process are found in the regulations applicable to many types of waste management units and hazardous material storage facilities. For the State of Washington, hazardous waste disposal unit closure regulations are found at *Washington Administrative Code* 173-303-610.

***Code of Federal Regulations* (CFR)** – The publication, in codified form, of all Federal regulations that are in effect.

collective dose – The sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation. Collective dose is expressed in units of person-rem or person-sieverts.

community – *(biotic definition)* All plants and animals occupying a specific area under relatively similar conditions.

(environmental justice definition) A group of people or a site within a spatial scope exposed to risks that potentially threaten health, ecology, or land values or exposed to industry that stimulates unwanted noise, smell, industrial traffic, particulate matter, or other nonaesthetic impacts.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 – A Federal law (also known as Superfund) enacted in 1980 and reauthorized in 1986 (Title 42 of the *United States Code*, Part 9601 et seq.) that provides the legal authority for emergency response and cleanup of hazardous substances released into the environment and for the cleanup of inactive waste sites.

conformity – Conformity is defined in the Clean Air Act (Title 42 of the *United States Code*, Part 7401 et seq.) as the action's compliance with an implementation plan's purpose of eliminating or reducing the severity and number of violations of the National Ambient Air Quality Standards and achieving expeditious attainment of such standards. Such activities will not cause or contribute to any new violation of any standard in any area; increase the frequency or severity of any existing violation of any standard in any area; or delay timely attainment of any standard, any required interim emission reduction, or other milestones in any area.

constituent of potential concern (COPC) – A chemical or radionuclide, present in a source material or environmental media, whose quantity and concentrations are significant enough to warrant analysis via one or more receptor pathways.

contact-handled waste – Radioactive waste or waste packages whose external dose rate is low enough to permit contact-handling by humans during normal waste management activities (e.g., waste with a surface dose rate not exceeding 200 millirem per hour).

container – In regard to radioactive waste, the outside envelope in the waste package that provides the primary-containment function of the waste package, which is designed to meet the containment requirements of Title 10 of the *Code of Federal Regulations*, Part 60.

contamination – The deposition of undesirable material in air, soils, water, or ecological resources or on the surfaces of structures, areas, objects, or personnel.

coolant – A substance, either gas or liquid, circulated through a nuclear reactor or processing plant to remove heat.

cooperating agency – —Any Federal agency (other than a lead agency) that has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major Federal action significantly affecting the quality of the human environment. A state or local agency of similar qualification or, when the effects are on a reservation, an Indian tribe, may, by agreement with the lead agency, become a cooperating agency" (Title 40 of the *Code of Federal Regulations*, Section 1508.5).

Core Zone – A portion of the Central Plateau within the Hanford Site, encompassing the 200-East and 200-West Areas, that lies within the Industrial-Exclusive land use designation established under the 1999 *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*.

Core Zone Boundary – The perimeter of the core zone that is used as a line of analysis for groundwater transport calculations.

crib – An underground structure designed to distribute liquid waste, usually through a perforated pipe, to the soil directly or to a connected tile field. Cribs use the filtration and ion exchange properties of the soil to contain radionuclides. A crib is operated only if radionuclide contamination observed in the groundwater beneath the crib is below a prescribed limit.

criteria pollutant – An air pollutant that is regulated by National Ambient Air Quality Standards. The U.S. Environmental Protection Agency must describe the characteristics and potential health and welfare effects that form the basis for setting or revising the standard for each regulated pollutant. Criteria pollutants include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and two size classes of particulate matter: less than or equal to 2.5 and 10 micrometers (0.0001 and 0.0004 inches) in diameter. New pollutants may be added to or removed from the list of criteria pollutants as more information becomes available.

cultural resources – Archaeological sites, historical sites, architectural features, traditional use areas, and American Indian sacred sites.

cumulative impacts – Impacts on the environment that result from incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions, regardless of the agency or person undertaking such other actions. Cumulative impacts can result from individually minor, but collectively significant, actions that take place over a period of time (Title 40 of the *Code of Federal Regulations*, Section 1508.7).

curie – (1) A unit of radioactivity equal to 37 billion disintegrations per second (i.e., 37 billion becquerels). (2) A quantity of any radionuclide or mixture of radionuclides having 1 curie of radioactivity.

dangerous waste – Solid waste designated in *Washington Administrative Code* 173-303-070 through 173-303-100 as dangerous, extremely hazardous, or mixed waste.

deactivation – Placing a facility in a stable and known condition, including removal of hazardous and radioactive materials, to ensure adequate protection of workers, public health and safety, and the environment, thereby limiting the long-term cost of surveillance and maintenance. Actions include the removal of fuel, draining and/or de-energizing of nonessential systems, removal of stored radioactive and hazardous materials, and related actions. Deactivation does not include all decontamination necessary for the dismantlement and demolition phase of decommissioning (e.g., removing contamination remaining in fixed structures and equipment after deactivation).

As applied to waste treatment, removal of the hazardous characteristics of a waste due to its ignitability, corrosivity, and/or reactivity.

decay (radioactive) – See *radioactive decay.*

decommissioning – The process of closing and securing a nuclear facility or nuclear material storage facility to provide adequate protection from radiological exposure and to isolate radioactive contamination from the human environment. It takes place after deactivation and includes surveillance, maintenance, decontamination, and/or dismantlement. These actions are taken at the end of the facility‘s life to retire it from service with adequate regard for the health and safety of workers and the public and protection of the environment. The ultimate goal of decommissioning is unrestricted release or restricted use of the site.

decontamination – The removal or reduction of residual chemical, biological, or radioactive contaminants and hazardous materials by mechanical, chemical, or other techniques to achieve a stated objective or end condition.

dewatering – The removal of water. Saturated soils are ―dewatered” to make construction of building foundations easier.

discharge – In surface-water hydrology, the amount of water issuing from a spring or in a stream that passes a specific point in a given period of time.

disposal – As generally used in this environmental impact statement, the placement of waste with no intent to retrieve. Statutory or regulatory definitions of disposal may differ.

disposal groups – Specific combinations of waste capacities allocated to the River Protection Project Disposal Facility and 200-East (or both 200-East and 200-West) Area Integrated Disposal Facility(ies) over varying operational timeframes, based on the different types and amounts of waste generated under the three sets of alternatives analyzed in this environmental impact statement.

disposition – The ultimate ―fate” or end use of a surplus U.S. Department of Energy facility following transfer of the facility to the Office of the Assistant Secretary for Environmental Management.

DOE orders – Requirements internal to the U.S. Department of Energy that establish policy and procedures, including those for compliance with applicable laws.

dose – A generic term that means absorbed dose, effective dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined in Chapter 9 of this EIS.

dose (chemical) – The amount of a substance administered to, taken up by, or assimilated by an organism. It is often expressed in terms of the amount of substance per unit mass of the organism, tissue, or organ of concern.

dose (radiation) – The accumulated radiation or hazardous substance delivered to the whole body or a specified tissue or organ within a specified time and originating from an external or internal source.

dose equivalent – A measure of radiation dose that correlates with biological effect on a common scale for all types of ionizing radiation. Defined as a quantity equal to the absorbed dose in tissue multiplied by a quality factor (the biological effectiveness of a given type of radiation) and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and the sievert.

dose rate – The radiation dose delivered per unit of time (e.g., rem per year).

double-shell tank – A large reinforced concrete underground container with two steel liners to provide containment and backup containment of liquid waste. The space between the liners has instruments that detect leaks from the inner liner.

ecology – A branch of science dealing with the interrelationships of living organisms with one another and with their nonliving environment.

ecosystem – A community of organisms and their physical environment that interact as an ecological unit.

efficacy – A measure of the probability and intensity of beneficial effects.

effluent – A waste stream flowing into the atmosphere, surface water, groundwater, or soil; frequently applied to waste discharged to surface water.

emission – A material discharged into the atmosphere from a source operation or activity.

emission standard – A requirement established by the state or the U.S. Environmental Protection Agency that limits the quantity, rate, or concentration of air pollutant emissions on a continuous basis, including any requirement relating to (1) operation or maintenance of a source to ensure continuous emission reduction and (2) any design, equipment, work practice, or operational standard.

endangered species – *Federal:* Species that are in danger of extinction throughout all or a significant portion of their ranges and that have been listed as endangered by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service following procedures outlined in the Endangered Species Act (Title 16 of the *United States Code*, Part 1531 et seq.) and its implementing regulations (Title 50 of the *Code of Federal Regulations* [CFR], Part 424). The lists of endangered species can be found in 50 CFR, Sections 17.11 (wildlife), 17.12 (plants), and 222.23(a) (marine organisms).

Washington State: Any wildlife species native to the state of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state within the foreseeable future if factors contributing to its decline continue (*Washington Administrative Code* 232-12-297; Washington State Natural Heritage Program, established by the Natural Area Preserves Act [*Revised Code of Washington*, Chapter 79.70]).

entombment – A process whereby aboveground structures are decontaminated and dismantled, belowground structures are grouted and left in place, and an infiltration barrier is placed over the contaminated material.

environmental assessment (EA) – A concise public document that a Federal agency prepares under the National Environmental Policy Act (NEPA) (Title 42 of the *United States Code*, Part 4321 et seq.) to provide sufficient evidence and analysis to determine whether a proposed agency action would require preparation of an environmental impact statement (EIS) or a Finding of No Significant Impact. A Federal agency may also prepare an EA to aid its compliance with NEPA when no EIS is necessary or to facilitate its preparation of an EIS when one is necessary.

An EA must include brief discussions of the (1) need for the proposal, (2) alternatives, (3) environmental impacts of the proposed actions and alternatives, and (4) a list of agencies and persons consulted.

environmental impact statement (EIS) – The detailed written statement that is required by Section 102(2)(C) of the National Environmental Policy Act (NEPA) (Title 42 of the *United States Code*, Part 4321 et seq.) for a proposed major Federal action that could significantly affect the quality of the human environment. A U.S. Department of Energy (DOE) EIS is prepared in accordance with applicable requirements of the Council on Environmental Quality's NEPA regulations (Title 40 of the *Code of Federal Regulations* [CFR], Parts 1500–1508) and the DOE NEPA regulations found in 10 CFR, Part 1021. The statement includes, among other information, discussions of the environmental impacts of the proposed actions and the range of reasonable alternatives; the adverse environmental effects that cannot be avoided should the proposal be implemented; the relationship between short-term use of the environment and long-term productivity; and any irreversible and irretrievable commitments of resources.

environmental justice – The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, and socioeconomic groups, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, or commercial operations or the execution of Federal, state, local, or tribal programs or policies. Executive Order 12898 directs Federal agencies to make achieving environmental justice part of their missions by identifying and addressing disproportionately high and adverse effects of agency programs, policies, and activities on low-income and minority populations.

erosion – Removal of material by water, wind, or ice.

excavation – A cavity in the earth formed by cutting, digging, or scooping using heavy construction equipment.

exposure – The condition of being subject to the effects of, or acquiring a dose of, a potential stressor such as a hazardous chemical agent or ionizing radiation; also, the process by which an organism acquires a dose of a chemical such as mercury or a physical agent such as ionizing radiation. Exposure can be quantified as the amount of the agent available at various boundaries of the organism (e.g., skin, lungs, gut) and available for absorption.

Fast Flux Test Facility (FFTF) – A liquid-metal (sodium)-cooled and -moderated nuclear test reactor at the Hanford Site. It was fueled with a mixture of plutonium-uranium dioxide and had a 400-megawatt power level. It is presently being deactivated.

Finding of No Significant Impact (FONSI) – A document by a Federal agency that briefly presents the reasons why an action will not have a significant effect on the human environment and for which an environmental impact statement therefore will not be prepared (Title 40 of the *Code of Federal Regulations*, Section 1508.13). (See *environmental impact statement*.)

fissile material – Although sometimes used as a synonym for fissionable material, this term has acquired a more restricted meaning, namely, any material fissionable by thermal (slow) neutrons. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

fission – A nuclear transformation that is typically characterized by the splitting of a heavy atomic nucleus into at least two other nuclei, the emission of one or more neutrons, and the release of a large amount of energy. Fission of heavy atomic nuclei can occur spontaneously or be induced by neutron bombardment.

fission products – Radioactive elements or compounds formed by the fission of heavy elements, plus the nuclides formed by the radioactive decay of those elements or compounds.

floodplain – The lowlands and relatively flat areas adjoining inland and coastal waters and the flood-prone areas of offshore islands. Floodplains include, at minimum, that area with at least a 1 percent chance of being inundated by a flood in any given year.

The *probable maximum flood* is the hypothetical flood considered to be the most severe reasonably possible flood, based on comprehensive hydrometeorological application of maximum precipitation and other hydrological factors favorable for maximum flood runoff (e.g., sequential storms, snowmelts). It is usually several times larger than the maximum recorded flood.

formation – In geology, the primary unit of formal stratigraphic mapping or description. Most formations possess certain distinctive features.

fuel rod – A nuclear reactor component that includes the fissile material.

fusion – The combining of two light atomic nuclei (such as hydrogen isotopes or lithium) to form a heavier atomic nucleus. Fusion is accompanied by the release of large amounts of energy.

generator – Within the context of this environmental impact statement, generators refer to organizations within the U.S. Department of Energy (DOE) or managed by DOE whose act or process produces low-level radioactive waste (LLW), mixed LLW, hazardous waste, or transuranic waste.

geologic repository – A place to dispose of radioactive waste deep beneath Earth‘s surface.

geology – The science concerned with the materials, processes, environments, and history of Earth, including rocks and their formation and structure.

graded approach – A process by which the level of analysis, documentation, and actions necessary to comply with a requirement are commensurate with (1) the relative importance to safety, safeguards, and security; (2) the magnitude of any hazard involved; (3) the life-cycle stage of a facility; (4) the programmatic mission of a facility; (5) the particular characteristics of a facility; and (6) any other relevant factor.

grading – Any stripping, cutting, filling, stockpiling, or combination thereof that modifies the land surface.

gravel pit No. 30 – This gravel pit, located between the 200-East and 200-West Areas, is an approximately 54-hectare (134-acre) borrow site containing a large quantity of aggregate (sand and gravel) suitable for multiple uses. Gravel pit No. 30 provides aggregate for onsite concrete batch plants in support of the construction of new facilities, including those at the Waste Treatment Plant adjacent to the 200-East Area.

greater-than-Class C (GTCC) low-level radioactive waste (LLW) – LLW generated by U.S. Nuclear Regulatory Commission (NRC) or agreement state licensees that contains radionuclide concentrations that exceed NRC limits for Class C LLW as defined in ―Licensing Requirements for Land Disposal of Radioactive Waste" (Title 10 of the *Code of Federal Regulations*, Part 61). It is the most radioactive of the categories of LLW.

groundwater – Water below the ground surface in a zone of saturation.

grout – A fluid mixture of cement-like materials and liquid waste that sets up as a solid mass and is used for waste fixation, immobilization, and stabilization.

habitat – The environment occupied by individuals of a particular species, population, or community.

half-life (radiological) – The time in which one-half of the atoms of a particular radioactive isotope disintegrate to another nuclear form. Half-lives vary from millionths of a second to billions of years.

Hanford barrier – A horizontal, multilayered, above-grade soil structure used as a representative surface barrier (cap) for closure at a Hanford Site landfill. The barrier's function is to isolate the waste site from the environment by preventing or reducing the likelihood of wind erosion; water infiltration; or plant, animal, or human intrusion.

Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) – An agreement signed in 1989 by the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology that identifies milestones for key environmental restoration and waste management actions.

hazard driver – A chemical constituent of potential concern evaluated in this environmental impact statement to be a major contributor to chemical hazard (i.e., non-cancer-associated toxic effects) during the year of peak hazard at locations of analysis during the 10,000-year period of analysis.

Hazard Quotient – The value used as an assessment of non-cancer-associated toxic effects of chemicals, e.g., kidney or liver dysfunction. It is a ratio of the estimated exposure to that level of exposure at which it is expected that adverse health effects would begin to be produced. It is independent of a cancer risk, which is calculated for only those chemicals identified as carcinogens.

hazardous air pollutants – Air pollutants that are not covered by ambient air quality standards, but may present a threat of adverse human health or environmental effects. Those specifically listed in Title 40 of the *Code of Federal Regulations*, Section 61.01, are asbestos, benzene, beryllium, coke oven emissions, inorganic arsenic, mercury, radionuclides, and vinyl chloride. More broadly, hazardous air pollutants include any of the 189 pollutants listed in or pursuant to Section 112(b) of the Clean Air Act (Title 42 of the *United States Code*, Part 7412).

hazardous chemical – Under Title 29 of the *Code of Federal Regulations*, Part 1910, Subpart Z, hazardous chemicals are defined as ―any chemical that is a physical hazard or a health hazard." Physical hazards include combustible liquids, compressed gases, explosives, flammables, organic peroxides, oxidizers, pyrophorics, and reactives. A health hazard is any chemical for which there is good evidence that acute or chronic health effects occur in exposed employees. Hazardous chemicals include carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, agents that act on the hematopoietic system, and agents that damage the lungs, skin, eyes, or mucous membranes.

hazardous material – A material, including a hazardous substance, as defined by Title 49 of the *Code of Federal Regulations*, Section 171.8, that poses a risk to health, safety, or property when transported or handled.

hazardous substance – Any substance subject to the reporting and possible response provisions of the Clean Water Act (Title 33 of the *United States Code* [U.S.C], Part 1251 et seq.) and the Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S.C., Part 9601 et seq.).

hazardous waste – A category of waste regulated under the Resource Conservation and Recovery Act (RCRA). To be considered hazardous, a waste must be a solid waste under RCRA and must exhibit at least one of four characteristics described in Title 40 of the *Code of Federal Regulations* (CFR), Sections 261.20 through 261.24 (i.e., ignitability, corrosivity, reactivity, or toxicity), or it must be specifically listed by the U.S. Environmental Protection Agency in 40 CFR, Sections 261.31 through 261.33. Hazardous waste may also include solid waste designated by Washington State in *Washington Administrative Code* 173-303-070 through 173-303-100 as dangerous or extremely hazardous waste.

high-efficiency particulate air filter – An air filter capable of removing at least 99.97 percent of particles 0.3 micrometers (about 0.00001 inches) in diameter. These filters include a pleated fibrous medium (typically fiberglass) that is capable of capturing very small particles.

high-level radioactive waste – As defined in the *Radioactive Waste Management Manual* (U.S. Department of Energy Manual 435.1-1), highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and other highly radioactive material that is determined, consistent with existing law, to require permanent isolation.

historic resources – (1) Archaeological sites, architectural structures, and objects produced after the advent of written history or dating to the time of the first European-American contact in an area.

(2) As defined by the National Historic Preservation Act of 1966, as amended (Title 16 of the *United States Code*, Part 470 et seq.), any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion on, the National Register of Historic Places, including artifacts, records, and material remains related to such a property or resource.

hydrology – The science dealing with the properties, distribution, and circulation of natural water systems.

immobilization – Placement of waste within a material such as concrete or glass to reduce (immobilize) the dispensability and leachability of the radioactive or hazardous components within the waste.

immobilized high-level radioactive waste (IHLW) – High-level radioactive waste as defined in the *Radioactive Waste Management Manual* (U.S. Department of Energy Manual 435.1-1) that has been immobilized (vitrified) by processing it through the Waste Treatment Plant.

immobilized low-activity waste (ILAW) – (1) Waste immobilized by the Waste Treatment Plant or processed by supplemental treatment (i.e., bulk vitrification, cast stone, or steam reforming). After receiving the necessary approvals, ILAW could be managed as low-level radioactive waste incidental to reprocessing, as defined in the *Radioactive Waste Management Manual* (U.S. Department of Energy Manual 435.1-1). Because it is produced from treatment of Hanford Site tank waste, it also could be managed as a mixed waste. (2) Waste that contains mostly nonradioactive chemical constituents.

infrastructure – The basic facilities, services, and utilities needed for the functioning of an industrial facility. Transportation and electrical systems are part of the infrastructure.

ingestion – The action of taking solids or liquids into the digestive system.

inhalation – The action of taking airborne material into the respiratory system.

institutional control – The period of time when a site is under active governmental controls. Institutional controls may include administrative or legal controls, physical barriers or markers, and methods to preserve information and data and to inform current and future generations of hazards and risks.

Integrated Disposal Facility – A permitted landfill on the Hanford Site with two separate, expandable cells—one for the disposal of low-level radioactive waste and another for the disposal of mixed low-level radioactive waste.

involved worker – A worker participating in a proposed action.

ion – An atom that has too many or too few electrons, causing it to be electrically charged.

ion exchange – A unit physiochemical process that removes anions and cations, including radionuclides, from liquid streams (usually water) for the purpose of purification or decontamination.

ion exchange resin – An organic polymer that functions as an acid or base. These resins are used to remove ionic material from a solution. Cation exchange resins are used to remove positively charged particles (cations); anion exchange resins, to remove negatively charged particles (anions).

ionizing radiation – Alpha particles, beta particles, gamma rays, high-speed electrons, high-speed protons, and other particles or electromagnetic radiation that can displace electrons from atoms or molecules, thereby producing ions.

irradiated – Exposed to ionizing radiation. The condition of nuclear reactor fuel elements and other materials in which atoms bombarded with nuclear particles have undergone nuclear changes.

isotope – Any of two or more variations of an element in which the nuclei have the same number of protons (i.e., the same atomic number) but different numbers of neutrons so that their atomic masses differ. Isotopes of a single element possess almost identical chemical properties, but often different physical properties (e.g., carbon-12 and -13 are stable; carbon-14 is radioactive).

landfill closure – Following tank waste retrieval, the single-shell tank system would be closed in accordance with state, Federal, and/or U.S. Department of Energy requirements for closure of a landfill. Landfill closure typically includes site stabilization and emplacement of a surface barrier, followed by a postclosure care period.

land use designations – Land use designations at the Hanford Site were established by the U.S. Department of Energy under the 1999 *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* Record of Decision, amended in September 2008. Changes to land use are subject to procedures identified in that environmental impact statement.

Industrial: An area that is suitable and desirable for activities such as reactor operations; rail and barge transport facilities; mining; manufacturing; food processing; assembly, warehouse, and distribution operations; and other industrial uses.

Industrial-Exclusive: An area that is suitable and desirable for treatment, storage, and disposal of hazardous, dangerous, radioactive, and nonradioactive wastes and related activities.

Conservation (Mining): An area reserved for management and protection of archaeological, cultural, ecological, and natural resources. Limited and managed mining (e.g., quarrying for sand, gravel, basalt, and topsoil for governmental purposes only) could occur as a special use within appropriate areas (a permit would be required). Limited public access would be consistent with resource conservation. This designation includes related activities.

latent cancer fatality – Death from cancer occurring sometime after, and postulated to be due to, exposure to ionizing radiation or other carcinogens.

leachate – As applied to mixed low-level radioactive waste trenches, any liquid, including any suspended components in the liquid, that has percolated through, or drained from, hazardous waste.

lobe – A lobe is a section of a barrier that covers a tank farm or an area of contiguous tank farms. Three barrier lobes are anticipated in the 200-West Area, and two much larger lobes are anticipated in the 200-East Area.

lost workdays – The total number of workdays (consecutive or not) during which employees were away from work or limited to restricted work activity because of an occupational injury or illness.

low-activity waste (LAW) – Waste that remains after as much radioactivity as technically and economically practical has been separated from high-level radioactive waste that, when solidified, may be disposed of as low-level radioactive waste in a near-surface facility. In its final form, such solid LAW would not exceed Title 10 of the *Code of Federal Regulations* (CFR), Section 61.55, Class C radioisotope limits and would meet performance objectives comparable to those in 10 CFR, Part 61, Subpart C.

low-income population – Low-income populations, as defined in terms of U.S. Census Bureau annual statistical poverty levels (Current Population Reports, Series P60 on Consumer Income), may consist of groups or individuals who either live in geographic proximity to one another or are geographically dispersed or transient (such as migrant workers or American Indians), where either type of group experiences common conditions of environmental exposure or effect.

low-level radioactive waste – Radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in Section 11e(2) of the Atomic Energy Act of 1954, as amended [Title 42 of the *United States Code*, Part 2014]), or naturally occurring radioactive material.

maximally exposed individual (MEI) – A hypothetical individual whose location and habits result in the highest total radiological or chemical exposure (and thus dose) from a particular source for all exposure routes (e.g., inhalation, ingestion, direct exposure). As used in this environmental impact statement, the MEI refers to an individual located off site, unless characterized otherwise in terms of time or location.

maximum contaminant level (MCL) – The U.S. Environmental Protection Agency (EPA) standards for drinking water quality under the Safe Drinking Water Act (Title 42 of the *United States Code*, Section 300(f) et seq.). The MCL for a given substance is the maximum permissible concentration of that substance in water delivered by a public water system, i.e., the ―drinking water standard.” The primary MCLs (Title 40 of the *Code of Federal Regulations* [CFR], Part 141) are intended to protect public health and are federally enforceable. They are based on health factors, but are also required by law to reflect the technological and economic feasibility of removing the contaminant from the water supply. Secondary MCLs (40 CFR, Part 143) are set by EPA to protect the public welfare. These secondary drinking water regulations control substances in drinking water that primarily affect aesthetic qualities (such as taste, odor, and color), which are related to public acceptance of water. These secondary regulations are not federally enforceable, but are intended as guidelines for the states.

megawatt – A unit of power equal to 1 million watts. *Megawatt-thermal* is commonly used to describe heat produced, while *megawatt-electric* describes electricity produced.

melter – A term for the type of joule-heated melters used in the Waste Treatment Plant (WTP) to treat tank waste. Joule heating involves placing electrodes into a material (a slurry of tank waste mixed with glass-forming materials) and applying electrical potential. This results in an electrical current and resistance heating. WTP melters include (1) high-level radioactive waste (HLW) melters used to treat the HLW stream, and producing a theoretical maximum capacity (TMC) of 3 metric tons of glass (MTG) per day, and (2) low-activity waste (LAW) melters used to treat the LAW stream, and producing a TMC of 15 MTG per day.

migration – (1) The natural movement of a material through the air, soil, or groundwater. (2) Seasonal movement of animals from one area to another.

millirem – One-thousandth of 1 rem.

minority – Individuals who are members of the following population groups: American Indian or Alaska Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic.

minority population – Minority populations exist where either (1) the minority population of the affected area exceeds 50 percent or (2) the minority population percentage of the affected area is meaningfully greater than that in the general population or in some other appropriate unit of geographic analysis (such as a governing body‘s jurisdiction, a neighborhood, census tract, or other similar unit). ―Minority populations" include either a single minority group or the total of all minority persons in the affected area. They may consist of groups of individuals living in geographic proximity to one another or a geographically dispersed/transient set of individuals (such as migrant workers or American Indians), where either type of group experiences common conditions of environmental exposure or effect.

miscellaneous underground storage tanks – These tanks were used for waste storage in the past, and some are currently being used for a variety of purposes. The tanks vary in capacity from 3,407 to 189,270 liters (900 to 50,000 gallons) and are considered part of the Hanford Site tank waste system.

mitigation – Mitigation includes (1) avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of an action; or (5) compensating for an impact by replacing or providing substitute resources or environments.

mixed low-level radioactive waste – Low-level radioactive waste determined to contain source, special nuclear, or byproduct material that is subject to the Atomic Energy Act of 1954, as amended (Title 42 of the *United States Code* [U.S.C.], Part 2011 et seq.), as well as a hazardous component subject to the Resource Conservation and Recovery Act, as amended (42 U.S.C., Part 6901 et seq.), or *Washington Administrative Code* 173-303-140.

mixed waste – Waste that contains source, special nuclear, or byproduct material that is subject to the Atomic Energy Act of 1954, as amended (Title 42 of the *United States Code* [U.S.C.], Part 2011 et seq.), as well as a hazardous component subject to the Resource Conservation and Recovery Act (42 U.S.C., Part 6901 et. seq.).

modified RCRA Subtitle C barrier – Landfill cover described by Resource Conservation and Recovery Act (Title 42 of the *United States Code*, Part 6901 et seq.) regulations that also accounts for the unique climatic conditions at the Hanford Site. The design includes layers for foundation and slope, gas collection, and drainage, as well as a low-permeability barrier and cover soil.

National Ambient Air Quality Standards – Standards defining the highest allowable levels of certain pollutants in the ambient air (outdoor air to which the public has access). Because the U.S. Environmental Protection Agency must establish the criteria for setting these standards, the regulated pollutants are called criteria pollutants. Criteria pollutants include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and two size classes of particulate matter: less than or equal to 2.5 and 10 micrometers (0.0001 and 0.0004 inches, respectively) in diameter. Primary standards are established to protect public health; secondary standards are established to protect public welfare (e.g., visibility, crops, animals, buildings).

National Emission Standards for Hazardous Air Pollutants (NESHAPs) – Emission standards set by the U.S. Environmental Protection Agency for air pollutants that are not covered by National Ambient Air Quality Standards and may, at sufficiently high levels, cause increased fatalities, irreversible health effects, or incapacitating illness. These standards are given in Title 40 of the *Code of Federal*

Regulations, Parts 61 and 63. NESHAPs are given for many specific categories of sources (e.g., equipment leaks, industrial process cooling towers, drycleaning facilities, petroleum refineries).

National Environmental Policy Act of 1969 (NEPA) – This act (Title 42 of the *United States Code*, Part 4321 et seq.) is the basic national charter for protection of the environment. It establishes policy, sets goals (Section 101), and provides means for carrying out policy (Section 102). Section 102(2) contains ―action-forcing" provisions to ensure that Federal agencies follow the letter and spirit of the act. For major Federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of NEPA requires Federal agencies to prepare a detailed statement that analyzes the environmental impacts of the proposed actions and other specified information.

National Pollutant Discharge Elimination System (NPDES) – A provision of the Clean Water Act (Title 33 of the *United States Code*, Part 1251 et seq.) that prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the U.S. Environmental Protection Agency; a state; or, where delegated, a tribal government on an American Indian reservation. The NPDES permit lists either permissible discharges, the level of cleanup technology required for wastewater, or both.

National Register of Historic Places – The official list of the Nation‘s historic resources that are worthy of preservation. The National Park Service maintains the list under direction of the Secretary of the Interior. Buildings, structures, objects, sites, and districts are included in the National Register for their importance in American history, architecture, archaeology, culture, or engineering. Properties included in the National Register range from large-scale, monumentally proportioned buildings to smaller-scale, regionally distinctive buildings. Listed properties are not just of nationwide importance; most are primarily significant at the state or local level. Procedures for listing properties in the National Register are found in Title 36 of the *Code of Federal Regulations*, Part 60.

neutralization – Changing the pH of a solution to near 7 by adding an acidic or basic material.

neutron – An uncharged elementary particle with a mass slightly greater than that of the proton. Neutrons are found in the nucleus of every atom heavier than hydrogen-1.

nitrate – A compound containing nitrogen, typically seen as a negative anion composed of one nitrogen and three oxygen atoms.

nitrogen – A natural element with the atomic number 7. It is a diatomic, colorless, odorless gas that constitutes about four-fifths of the volume of the atmosphere.

nitrogen oxides – The oxides of nitrogen, primarily nitrogen oxide and nitrogen dioxide. These are produced by the combustion of fossil fuels and can constitute an air pollution problem. Nitrogen dioxide emissions contribute to acid deposition and formation of atmospheric ozone.

noise – Any sound that is undesirable because it interferes with speech and hearing, is intense enough to damage hearing, or is otherwise annoying or undesirable.

noninvolved worker – A worker on the site of an action, but not participating in the action.

normal operations – All normal (incident-free) conditions, as well as those abnormal conditions that frequency estimation techniques indicate typically occur with a frequency greater than 0.1 events per year. As used in this environmental impact statement, normal operations refers to routine waste management activities (excluding accident conditions, except for minor process upsets), e.g., waste treatment activities (including processing), packaging and repackaging, storage, final disposal of waste.

Notice of Intent – An announcement of the initiation of an environmental impact scoping process. The Notice of Intent is usually published in both the *Federal Register* and a local newspaper. The scoping process includes holding at least one public meeting and requesting written comments on issues and environmental concerns that an environmental impact statement should address.

nuclear reactor – A device that sustains a controlled nuclear-fission chain reaction that releases energy in the form of heat.

offsite/off site – Outside the site boundary.

onsite/on site – Within the site boundary.

operable unit – A term for each of a number of separate activities undertaken as part of a Superfund site cleanup. A typical operable unit would be removal of drums and tanks from the surface of a site.

order of magnitude – As used in this environmental impact statement, an order of magnitude is taken as a power (or factor) of 10.

oxide – A compound of oxygen and another element.

ozone – The triatomic form of oxygen. In the stratosphere, ozone protects Earth from the Sun's ultraviolet rays, but in lower levels of the atmosphere, ozone is considered an air pollutant.

parameter – A term in a model or equation representing a measurable property or quantity of fixed or variable value.

particulate matter (PM) – Any finely divided solid or liquid material other than uncombined (i.e., pure) water. A subscript denotes the upper limit of the diameter of the particles included. Thus, $PM_{2.5}$ includes only particulate matter with an aerodynamic diameter less than or equal to 2.5 micrometers (0.0001 inches); PM_{10}, less than or equal to 10 micrometers (0.0004 inches).

past-practice unit – The Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) defines past-practice unit as a waste management unit where wastes or substances have been disposed of (intentionally or unintentionally) that is not subject to regulation as a treatment, storage, or disposal unit. Due to the relatively large number of past-practice units at the Hanford Site, these units have been organized into groups called operable units for investigation and response action to prioritize the cleanup work to be done at the site.

pathways (exposure) – The means by which a substance moves from an environmental source to an organism.

person-rem – A unit of collective radiation dose applied to populations or groups of individuals; that is, a unit for expressing the dose when summed across all persons in a specified population or group. One person-rem equals 0.01 person-sieverts.

picocurie – One trillionth (10^{-12}) of a curie.

plume – The elongated volume of contaminated water or air originating at a pollutant source such as an outlet pipe or a smokestack. A plume eventually diffuses into a larger volume of less-contaminated material as it is transported away from the source.

plutonium – A heavy, radioactive metallic element with the atomic number 94. It is produced artificially by neutron bombardment of uranium. Plutonium has 15 isotopes with atomic masses ranging from 232 to 246 and half-lives ranging from 20 minutes to 76 million years.

$PM_{2.5}$ and **PM_{10}** – See *particulate matter.*

pollution prevention – The use of materials, processes, and practices that reduce or eliminate the generation and release of pollutants, contaminants, hazardous substances, and waste into land, water, and air. For the U.S. Department of Energy, this includes recycling activities.

population dose – See *collective dose*.

postclosure care – The period following closure of a hazardous waste disposal system (e.g., a landfill) during which monitoring and maintenance activities must be conducted to preserve the integrity of the disposal system and continue preventing or controlling releases from the disposal unit.

priority habitat – A habitat type with unique or significant value to many species that may be described by a (1) unique vegetation type or dominant plant species of primary importance to fish and wildlife (e.g., oak woodlands, eelgrass meadows) or (2) successional stage (e.g., old growth, mature forests). Alternatively, a priority habitat may consist of a specific habitat element (e.g., consolidated marine/estuarine shorelines, talus slopes, caves, snags) of key value to fish and wildlife.

process – Any method or technique designed to change the physical or chemical character of a product.

processing – As used in this environmental impact statement, any activity necessary to prepare waste for disposal. Processing waste may consist of repackaging, removal, or stabilization of nonconforming waste or treatment of physically or chemically hazardous constituents in compliance with state or Federal regulations.

radiation (ionizing) – See *ionizing radiation*.

radioactive decay – The decrease in the amount of any radioactive material with the passage of time due to spontaneous nuclear disintegration (i.e., emission from atomic nuclei of charged particles, photons, or both).

radioactive waste – In general, waste that is managed for its radioactive content. Waste material that contains source, special nuclear, or byproduct material is subject to regulation as radioactive waste under the Atomic Energy Act (Title 42 of the *United States Code*, Part 2011 et seq.). Also, waste material that contains accelerator-produced radioactive material or a high concentration of naturally occurring radioactive material may be considered radioactive waste.

radioactivity – *(process definition)* The spontaneous transformation of unstable atomic nuclei, usually accompanied by the emission of ionizing radiation.

(property definition) The property of unstable nuclei in certain atoms to spontaneously emit ionizing radiation during nuclear transformations.

radioisotope or radionuclide – An unstable isotope that undergoes spontaneous transformation, emitting radiation.

radiological risk – In general, a measure of potential harm to populations or individuals due to the presence or occurrence of an environmental or manmade radiological hazard. In terms of human health, risk comprises three components: a sequence of events leading to an adverse impact, the probability of occurrence of that sequence of events, and the severity of the impact. For the release of radionuclides affecting a population, the impact is occurrence of a fatal cancer; risk is expressed as the expected number of latent cancer fatalities (i.e., the product of probability of occurrence and the magnitude of impact). For the release of radionuclides affecting individuals, the impact is incidence of cancer; risk is expressed as the probability over a lifetime of developing cancer.

radon – A gaseous, radioactive element with the atomic number 86 resulting from the radioactive decay of radium. Radon occurs naturally in the environment and can collect in unventilated enclosed areas, such as basements. Large concentrations of radon can cause lung cancer in humans.

reactivity – The rate of nuclear disintegration in a nuclear reactor.

reactor containment – A steel-reinforced concrete dome built over a nuclear reactor to trap radioactive vapors that may otherwise be released into the environment during a nuclear accident.

reactor coolant system – The system used to transfer energy from the reactor core either directly or indirectly to the heat rejection system.

receptor – An organism that is exposed to chemicals or radionuclides in the environment.

Record of Decision (ROD) – *(National Environmental Policy Act [NEPA] definition)* A concise public document that records a Federal agency‘s decision(s) concerning proposed actions for which the agency has prepared an environmental impact statement. The ROD is prepared in accordance with Council on Environmental Quality NEPA regulations (Title 40 of the *Code of Federal Regulations*, Section 1505.2). A ROD identifies the alternatives considered in reaching the decision, the environmentally preferred alternative(s), the factors balanced by the agency in making the decision, and whether all practicable means to avoid or minimize environmental harm were adopted, and if not, why they were not.

(Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] definition) A document that records the selection of remedial actions, facts, analyses, public participation, and site-specific policy determinations considered in the course of carrying out CERCLA cleanup activities.

refractory block – A solid object composed of a nonmetallic material that maintains its strength and integrity when exposed to extreme heat. Refractory blocks are used in the construction of structures or system components that are exposed to extremely high temperatures.

region of influence – A site-specific geographic area in which the principal direct and indirect effects of actions are likely to occur and are expected to be of consequence for local jurisdictions.

release – Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a material into the environment. Statutory or regulatory definitions of release may differ.

rem – See *roentgen equivalent man*.

remediation – The process, or a phase in the process, of rendering radioactive, hazardous, or mixed waste environmentally safe, whether through entombment, processing, or other methods.

remote-handled waste – In general, radioactive waste that must be handled at a distance (remotely) to protect workers from unnecessary exposure (e.g., waste with a dose rate of 200 millirem per hour or more at the surface of the waste package).

resin – See *ion exchange resin*.

resource – Valued attribute of a system.

Resource Conservation and Recovery Act (RCRA), as amended – This law (Title 42 of the *United States Code*, Part 6901 et seq.) gives the U.S. Environmental Protection Agency the authority to control hazardous waste from ―cradle to grave" (i.e., from the point of generation to the point of ultimate disposal), including its minimization, generation, transportation, treatment, storage, and disposal. RCRA also sets forth a framework for management of nonhazardous solid waste.

Revised Code of Washington **(RCW)** – The compilation of all permanent laws now in force. It is a collection of Session Laws (enacted by the Legislature and signed by the Governor, or enacted via the initiative process), arranged by topic, with amendments added and repealed laws removed. It does not include temporary laws such as appropriation acts.

risk – In general, a measure of potential harm to populations or individuals due to the presence or occurrence of an environmental or manmade hazard. Risk is calculated as the product of the probability of an occurrence of an impact and the magnitude of the impact. The probability can be interpreted as a relative frequency of occurrence, a quantity with no assigned units.

In terms of human health, risk comprises three components: a sequence of events leading to an adverse impact, the probability of occurrence of that sequence of events, and the severity of the impact. For the release of radionuclides affecting a population, the impact is occurrence of a fatal cancer; risk is expressed as the expected number of latent cancer fatalities (i.e., the product of probability of occurrence and the magnitude of impact). For the release of radionuclides affecting individuals, the impact is incidence of cancer; risk is expressed as the probability over a lifetime of developing cancer.

River Protection Project (RPP) – The Hanford Site‘s U.S. Department of Energy RPP mission is to retrieve and treat the site‘s tank waste and to close the tank farms to protect the Columbia River.

roentgen equivalent man (rem) – A unit of dose equivalent. The dose equivalent in rem equals the absorbed dose in rad in tissue multiplied by the appropriate quality factor and possibly other modifying factors. Rem refers to the dosage of ionizing radiation that will cause the same biological effect as 1 roentgen of x-ray or gamma-ray exposure. One rem equals 0.01 sieverts.

runoff – The portion of rainfall, melted snow, or irrigation water that flows across the ground surface and eventually enters streams.

Safe Drinking Water Act – This act (Title 42 of the *United States Code*, Section 300(f) et seq.) protects the quality of public water supplies, water supply and distribution systems, and all sources of drinking water.

sand – Loose grains of rock or mineral sediment formed by weathering that range in size from 0.0625 to 2.0 millimeters (0.0025 to 0.08 inches) in diameter and often consist of quartz particles.

sanitary waste – Liquid or solid waste generated by normal housekeeping activities (includes sludge) that is not hazardous or radioactive.

scope – The range of actions, alternatives, and impacts to be considered in a document prepared pursuant to the National Environmental Policy Act of 1969 (Title 42 of the *United States Code*, Part 4321 et seq.).

scoping – An early and open process for determining the scope of issues to be addressed in an environmental impact statement (EIS) and for identifying significant issues related to proposed actions. The scoping period begins upon publication in the *Federal Register* of a Notice of Intent to prepare an EIS. The public scoping process is that portion of the process where the public is invited to participate. The U.S. Department of Energy (DOE) also conducts an early internal scoping process for environmental assessments and EISs. For EISs, this internal scoping process precedes the public scoping process. DOE‘s scoping procedures are found in Title 10 of the *Code of Federal Regulations*, Section 1021.311.

secondary waste – Waste generated as a result of other activities, e.g., waste retrieval or waste treatment, that is not further treated by the Waste Treatment Plant or supplemental treatment facilities and includes liquid and solid wastes. Liquid-waste sources could include process condensates, scrubber wastes, spent reagents from resins, offgas and vessel vent wastes, vessel washes, floor drain and sump wastes, and decontamination solutions. Solid-waste sources could include worn filter membranes, spent ion exchange resins, failed or worn equipment, debris, analytical laboratory waste, high-efficiency particulate air filters, spent carbon adsorbent, and other process-related wastes. Secondary waste can be characterized as low-level radioactive waste, mixed low-level radioactive waste, transuranic waste, or hazardous waste.

security – An integrated system of activities, systems, programs, facilities, and policies for the protection of restricted data and other classified information or matter; nuclear materials, weapons, and components; and/or U.S. Department of Energy contractor facilities, property, and equipment.

sediment – Soil, sand, and minerals washed from land into water and deposited on the bottom of a water body.

seismic – Pertaining to any Earth vibration, especially an earthquake.

selective clean closure – This hybrid closure approach would implement clean closure of a representative tank farm in each of the 200-East and 200-West Areas (i.e., the BX and SX tank farms), while implementing landfill closure for the balance of the single-shell tank system.

severe accident – An accident with a frequency rate of less than 10^{-6} per year that would have more-severe consequences than a design-basis accident in terms of damage to the facility, offsite consequences, or both. Also referred to as ―beyond-design-basis reactor accidents" in this environmental impact statement.

shielding – In regard to radiation, any material of obstruction (bulkheads, walls, or other construction) that absorbs radiation to protect personnel or equipment.

shutdown – Facility condition wherein operations and/or construction activities have ceased.

silt – Loose particles of rock or mineral sediment ranging in size from about 0.002 to 0.0625 millimeters (0.00008 to 0.0025 inches) in diameter. Silt is finer than sand, but coarser than clay.

single-shell tank (SST) – Underground reinforced-concrete containers with one carbon steel liner that are covered with 2 to 3 meters (6.6 to 9.8 feet) of earth. Capacity ranges from 208,175 to 3.79 million liters (55,000 to 1 million gallons). SSTs have been used to store radioactive and mixed waste.

single-shell tank (SST) system – An area of the Hanford Site high-level radioactive waste tank farm system that includes 149 SSTs, ancillary equipment, and soils (from surface soils to the interface with groundwater) within SST farms and/or waste management area boundaries used to support Hanford Site waste retrieval and storage activities.

site – A geographic entity comprising leased or owned land, buildings, and other structures required to perform program activities.

soils – All unconsolidated materials above bedrock; natural earthy materials on Earth‘s surface, in places modified or even made by human activity, that contain living matter and either support or are capable of supporting plants out of doors.

solid waste – In general, nonliquid, nonsoluble discarded materials, ranging from municipal garbage to industrial waste, that contain complex and sometimes hazardous substances, including sewage sludge, agricultural refuse, demolition waste, and mining residues. For purposes of regulation under the Resource Conservation and Recovery Act, solid waste is —any garbage; refuse; sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility; and other discarded material (Title 42 of the *United States Code* [U.S.C.], Part 6903)." Solid waste includes solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities. Solid waste does not include solid or dissolved material in domestic sewage or irrigation return flows or industrial discharges, which are point sources subject to permits under Section 402 of the Clean Water Act (33 U.S.C., Part 1342). Finally, solid waste does not include source, special nuclear, or byproduct material as defined by the Atomic Energy Act (42 U.S.C., Part 2011 et seq.). A more detailed regulatory definition of solid waste can be found in Title 40 of the *Code of Federal Regulations*, Section 261.2.

source term – The amount of a specific pollutant (e.g., chemical, radionuclide) emitted or discharged to a particular environmental medium (e.g., air, water) from a source or group of sources. It is usually expressed as a rate (i.e., amount per unit time).

spent nuclear fuel – Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated.

stabilization – Mixing of an agent such as Portland cement with waste to increase the mechanical strength of the resulting waste form and decrease its leachability.

State Environmental Policy Act (SEPA) – The State of Washington‘s environmental law enacted in 1971 as Chapter 43.21C of the *Revised Code of Washington*. The purposes of this law are to (1) declare a state policy that will encourage productive and enjoyable harmony between man and his environment, (2) promote efforts that will prevent or eliminate damage to the environment and biosphere, (3) stimulate the health and welfare of man, and (4) enrich the understanding of the ecological systems and natural resources important to the state and Nation.

steam reforming – A thermal process that immobilizes waste by converting (1) low-activity waste solutions (tank waste) to granular minerals and volatilizing water and (2) the decomposing organic compounds, nitrate, and nitrite present in the tank waste to carbon dioxide, water, and nitrogen.

storage – Holding waste for a temporary period, at the end of which the waste is treated, disposed of, or stored elsewhere.

sulfate removal – Sulfate, a significant component in the supernatant fractions of tank waste at the Hanford Site, poses serious economic impacts (creating more glass) and risks for the low-activity waste (LAW) vitrification process. Sulfate tends to phase-separate in the melter, forming a corrosive molten sulfate salt layer on top of the glass melt that will damage the melter if allowed to accumulate. Removal of the sulfate from the LAW before vitrifying can mitigate these problems. The sulfate removal approach comprises sulfate precipitation using strontium nitrate addition, filtration, and solidification with grout-forming additives for immobilized waste.

sulfur oxides – Common air pollutants, primarily sulfur dioxide, a heavy, pungent, colorless gas formed in the combustion of fossil fuels and considered a major air pollutant, and sulfur trioxide. Sulfur dioxide is involved in the formation of acid rain. It can also irritate the upper respiratory tract and cause lung damage.

supplemental treatment – As used in this environmental impact statement, a waste treatment process used to solidify or immobilize the low-activity waste fraction of tank waste in addition to the Waste Treatment Plant vitrification process.

surface water – All bodies of water on the surface of Earth that are open to the atmosphere, such as rivers, lakes, reservoirs, ponds, seas, and estuaries.

tank systems – *Single-shell tank (SST) system:* All 149 SSTs, ancillary equipment (e.g., pipes, pits), and soils (from the surface to the interface with groundwater) within SST farms and/or waste management area boundaries.

Double-shell tank (DST) system: Existing and new DSTs, as well as the ancillary equipment and soils within the DST farms.

target – A tube, rod, or other form containing material that, on being irradiated in a nuclear reactor or an accelerator, would produce a desired end product.

10,000-year period of analysis – The period of analysis used in this environmental impact statement for the long-term impacts analysis for groundwater, human health, and ecological risks.

terrestrial – Of or pertaining to life on land.

thermal treatment – Treatment of waste in a device that uses elevated temperature to change the chemical, physical, or biological character of the waste. Examples include, but are not limited to, vitrification, pyrolysis, steam reforming, and calcination.

threatened species – *Federal:* Species that are likely to become endangered species within the foreseeable future throughout all or a significant portion of their ranges and have been listed as threatened by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service following the procedures set out in the Endangered Species Act (Title 16 of the *United States Code*, Part 1531 et seq.) and its implementing regulations (Title 50 of the *Code of Federal Regulations* [CFR], Part 424).

The lists of threatened species can be found at 50 CFR, Sections 17.11 (wildlife), 17.12 (plants), and 227.4 (marine organisms).

Idaho State: Any wildlife species native to the state that is likely to become an endangered species within the foreseeable future throughout a significant portion of its range within the state if factors contributing to its decline continue.

Washington State: Any wildlife species native to the state that is likely to become an endangered species within the foreseeable future throughout a significant portion of its range within the state if factors contributing to its decline continue (*Washington Administrative Code* 232-12-297; Washington State Natural Heritage Program, established by the Natural Area Preserves Act [*Revised Code of Washington*, Chapter 79.70]).

total recordable cases – The total number of cases recorded of work-related (1) deaths or (2) illnesses or injuries resulting in loss of consciousness, restriction of work or motion, transfer to another job, or required medical treatment beyond first aid.

total uranium – As used in this environmental impact statement, the total concentration of all of the 14 isotopes of uranium used for calculating *nonradiological* human health and ecological risk.

transuranic – Refers to any element with an atomic number higher than uranium (atomic number 92), including neptunium, plutonium, americium, and curium. All transuranic elements are produced artificially and are radioactive.

transuranic isotope – Isotopes of any element having an atomic number greater than 92 (the atomic number of uranium).

transuranic (TRU) waste – Radioactive waste containing more than 100 nanocuries (3,700 becquerels) of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years, except for: (1) high-level radioactive waste; (2) waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the U.S. Environmental Protection Agency, does not need the degree of isolation required by Title 40 of the *Code of Federal Regulations* (CFR), Part 191, disposal regulations; or (3) waste that the U.S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR, Part 61.

treatment – The physical, chemical, or biological processing of dangerous waste to make such waste nondangerous or less dangerous, safer for transport, amenable for energy or material resource recovery, amenable for storage, or lower in volume, with the exception of compacting, repackaging, and sorting, as allowed under *Washington Administrative Code* 173-303-400(b) and 173-303-600. For radioactive waste, treatment is any method, technique, or process designed to change the physical or chemical character of waste to render it less hazardous; safer to transport, store, or dispose of; or lower in volume.

trench (ditch) – A depression dug in the ground, open to the atmosphere, and designed for disposal of low-level or intermediate-level radioactive waste. It uses the moisture retention capability of the relatively dry soils above the groundwater.

Tri-Party Agreement (TPA) – See *Hanford Federal Facility Agreement and Consent Order*.

uranium – A radioactive, metallic element with the atomic number 92; one of the heaviest naturally occurring elements. Uranium has 14 known isotopes, of which uranium-238 is the most abundant in nature. Uranium-235 is commonly used as a fuel for nuclear fission.

uranium-238 – As used in this environmental impact statement, the total concentration of all of the 14 isotopes of uranium used for calculating *radiological* human health and ecological risk.

U.S. Nuclear Regulatory Commission (NRC) – The Federal agency that regulates the civilian nuclear power industry in the United States.

vadose zone – The region of soil and rock between the ground surface and the top of the water table in which pore spaces are only partially filled with water. Over time, contaminants in the vadose zone often migrate downward to the underlying aquifer.

viewshed – The extent of an area that may be viewed from a particular location. Viewsheds are generally bounded by topographic features such as hills or mountains.

vitrification – A method used to immobilize waste (radioactive, hazardous, and mixed). This involves adding glass formers and waste to a vessel and melting the mixture into a glass. The purpose of this process is to permanently immobilize the waste and isolate it from the environment.

***Washington Administrative Code* (WAC)** – Regulations of the Executive branch agencies in the State of Washington as issued by the authority of statutes. In the WAC, the regulations of the State of Washington are codified and arranged by subject or responsible agency. The WAC, which is a source of primary law, also states how agencies shall organize and adopt rules and regulations.

waste acceptance criteria – The technical and administrative requirements that a waste must meet for it to be accepted at a treatment, storage, and disposal facility.

waste characterization – Identification of waste composition and properties to determine appropriate storage, treatment, handling, transportation, and disposal requirements by (1) review of process knowledge, (2) nondestructive examination, (3) nondestructive assay, or (4) sampling and analysis.

waste classification – Wastes are classified according to the *Radioactive Waste Management Manual* (U.S. Department of Energy Manual 435.1-1) and include high-level radioactive, transuranic, and low-level radioactive wastes.

waste container – Any portable device in which waste material is stored, transported, treated, disposed of, or otherwise handled (*Washington Administrative Code* 173-303-400). A waste container may include any liner or shielding material that is intended to accompany the waste in disposal. At the Hanford Site, waste containers typically consist of 208- or 320-liter (55- or 85-gallon) drums and standard waste boxes. Other sizes and styles of containers may also be employed, depending on the physical, radiological, and chemical characteristics of the waste.

waste disposal – See *disposal*.

Waste Isolation Pilot Plant (WIPP) – A U.S. Department of Energy facility designed and authorized to permanently dispose of transuranic radioactive waste in a mined underground facility in deep geologic salt beds. WIPP is located in southeastern New Mexico, 42 kilometers (26 miles) east of the city of Carlsbad.

waste management – The planning, coordination, and direction of those functions related to the generation, handling, treatment, storage, transportation, and disposal of waste, as well as associated surveillance and maintenance activities.

waste minimization and pollution prevention – An action that economically avoids or reduces the production of waste and pollution by reducing waste generation at the source, reducing the toxicity of hazardous waste and pollution, improving the efficiency of energy usage, or recycling. These actions will be consistent with the general goal of minimizing present and future threats to human health, safety, and the environment.

waste stream – A waste or group of wastes from a process or a facility with similar physical, chemical, or radiological properties. In the context of this environmental impact statement, a waste stream is defined as a collection of wastes with physical and chemical characteristics that will generally require the same management approach (i.e., use of the same treatment, storage, and disposal capabilities).

waste treatment facilities – Existing and new facilities that are required to complete waste treatment.

Waste Treatment Plant (WTP) – The facility that is being designed and built to thermally treat and immobilize tank waste at the U.S. Department of Energy‘s Hanford Site.

water table – The boundary between the unsaturated zone and the deeper, saturated zone. The upper surface of an unconfined aquifer.

wetlands – Those areas that are inundated by surface water or groundwater with a frequency that is sufficient to support, and under normal circumstances do or would support, a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas (e.g., sloughs, potholes, wet meadows, river overflow areas, mudflats, natural ponds).

Jurisdictional wetlands are those wetlands protected by the Clean Water Act (Title 33 of the *United States Code*, Part 1251 et seq.). They must have a minimum of one positive wetland indicator from each parameter (i.e., vegetation, soil, and hydrology). The U.S. Army Corps of Engineers requires a permit to fill or dredge jurisdictional wetlands.

S.10 REFERENCES

BRC (Blue Ribbon Commission on America's Nuclear Future), 2012, *Blue Ribbon Commission on America's Nuclear Future: Report to the Secretary of Energy*, Washington, D.C., January.

CDIAC (Carbon Dioxide Information Analysis Center), 2011a, *Global CO_2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751–2008*, accessed through http://cdiac.ornl.gov/ftp/ndp030/global.1751_2008.ems, June 10.

CDIAC (Carbon Dioxide Information Analysis Center), 2011b, *Record High 2010 Global Carbon Dioxide Emissions from Fossil-Fuel Combustion and Cement Manufacture Posted on CDIAC Site*, accessed through http://cdiac.ornl.gov/trends/emis/perlim_2009_2010_estimates.html.

DOE (U.S. Department of Energy), 1995a, *Environmental Assessment, Shutdown of the Fast Flux Test Facility, Hanford Site, Richland, Washington*, DOE/EA-0993, Richland Operations Office, Richland, Washington, May.

DOE (U.S. Department of Energy), 1995b, *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement*, DOE/EIS-0203-F, Office of Environmental Management, Idaho Operations Office, Idaho Falls, Idaho, April.

DOE (U.S. Department of Energy), 1997a, *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*, DOE/EIS-0200-F, Office of Environmental Management, Washington, D.C., May.

DOE (U.S. Department of Energy), 1997b, *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*, DOE/EIS-0026-S-2, Carlsbad Area Office, Carlsbad, New Mexico, September.

DOE (U.S. Department of Energy), 1997c, *Supplement Analysis for the Proposed Upgrades to the Tank Farm Ventilation, Instrumentation, and Electrical Systems Under Project W-314 in Support of Tank Farm Restoration and Safe Operations*, DOE/EIS-0189-SA1, Richland Operations Office, Richland, Washington, May.

DOE (U.S. Department of Energy), 1997d, *Environmental Assessment, Management of Hanford Site Non-defense Production Reactor Spent Nuclear Fuel, Hanford Site, Richland, Washington*, DOE/EA-1185, Richland Operations Office, Richland, Washington, March.

DOE (U.S. Department of Energy), 1998, *Supplement Analysis for the Tank Waste Remediation System*, DOE/EIS-0189-SA2, Richland Operations Office, Richland, Washington, May.

DOE (U.S. Department of Energy), 1999a, *Surplus Plutonium Disposition Final Environmental Impact Statement*, DOE/EIS-0283, Office of Fissile Materials Disposition, Washington, D.C., November.

DOE (U.S. Department of Energy), 1999b, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, DOE/EIS-0222-F, Richland Operations Office, Richland, Washington, September.

DOE (U.S. Department of Energy), 2000a, *Final Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility*, DOE/EIS-0310, Office of Nuclear Energy, Science and Technology, Washington, D.C., December.

DOE (U.S. Department of Energy), 2000b, *Final Environmental Impact Statement for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel*, DOE/EIS-0306, Office of Nuclear Energy, Science and Technology, Washington, D.C., July.

DOE (U.S. Department of Energy), 2001, *Supplement Analysis for the Tank Waste Remediation System*, DOE/EIS-0189-SA3, Office of River Protection, Richland, Washington, March.

DOE (U.S. Department of Energy), 2002, *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, DOE/EIS-0250, Office of Civilian Radioactive Waste Management, Yucca Mountain Site Characterization Office, North Las Vegas, Nevada, February.

DOE (U.S. Department of Energy), 2003a, *Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland, WA: Waste Retrieval and Storage Data Package*, DOE/ORP-2003-06, Rev. 0, Office of River Protection, Richland, Washington, April 17.

DOE (U.S. Department of Energy), 2003b, *Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland WA: Inventory and Source Term Data Package*, DOE/ORP-2003-02, Rev. 0, Office of River Protection, Richland, Washington, April 17.

DOE (U.S. Department of Energy), 2004, *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington*, DOE/EIS-0286F, Richland Operations Office, Richland, Washington, January.

DOE (U.S. Department of Energy), 2005, *Technical Guidance Document for Tank Closure Environmental Impact Statement Vadose Zone and Groundwater Revised Analyses,* Final Rev. 0, Office of River Protection, Richland, Washington, March 25.

DOE (U.S. Department of Energy), 2006a, *Environmental Assessment, Sodium Residuals Reaction/Removal and Other Deactivation Work Activities, Fast Flux Test Facility (FFTF) Project, Hanford Site, Richland, Washington*, DOE/EA-1547F, Richland Operations Office, Richland, Washington, March.

DOE (U.S. Department of Energy), 2006b, *Report of the Review of the ―Hanford Solid Waste Environmental Impact Statement (EIS)" Data Quality, Control and Management Issues*, Office of Environmental Management, Washington, D.C., January.

DOE (U.S. Department of Energy), 2007, *Civilian Radioactive Waste Management System Waste Acceptance System Requirements Document*, DOE/RW-0351, Rev. 5, Office of Civilian Radioactive Waste Management, North Las Vegas, Nevada, May 31.

DOE (U.S. Department of Energy), 2008a, *Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, DOE/EIS-0250F-S1, Office of Civilian Radioactive Waste Management, Las Vegas, Nevada, June.

DOE (U.S. Department of Energy), 2008b, *Draft Global Nuclear Energy Partnership Programmatic Environmental Impact Statement*, DOE/EIS-0396, Office of Nuclear Energy, Washington, D.C., October.

DOE (U.S. Department of Energy), 2008c, *Supplement Analysis, Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, DOE/EIS-0222-SA-01, Richland Operations Office, Richland, Washington, June.

DOE (U.S. Department of Energy), 2009a, *Finding of No Significant Impact for the "Environmental Assessment for the Proposed Remote-Handled Waste Disposition Project*," Idaho Operations Office, Idaho Falls, Idaho, February 18.

DOE (U.S. Department of Energy), 2009b, *Cost Report for "Tank Closure and Waste Management Environmental Impact Statement" Alternatives*, DOE/ORP-2003-14, Rev. 6, Vol. 1 and 2, Office of River Protection, Richland, Washington, July.

DOE (U.S. Department of Energy), 2010, *Long-Range Deep Vadose Zone Program Plan*, DOE/RL-2010-89, Rev. 0, Richland Operations Office, Richland, Washington, October.

DOE (U.S. Department of Energy), 2011, *Draft Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste,* DOE/EIS-0375-D, Office of Environmental Management, Washington, D.C., February.

DOE (U.S. Department of Energy), 2012, *Supplement Analysis of the "Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington,"* DOE/EIS-0391D-SA-01, Office of River Protection, Richland, Washington, February.

DOE and Ecology (U.S. Department of Energy, Richland Operations Office, Richland, Washington, and Washington State Department of Ecology, Olympia, Washington), 1996, *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement*, DOE/EIS-0189, August.

DOE and Ecology (U.S. Department of Energy and Washington State Department of Ecology), 2006, Memorandum of Understanding Between the United States Department of Energy and the Washington State Department of Ecology for Development of the *Hanford Site Tank Closure and Waste Management EIS* ("*TC & WM EIS*"), January 6.

DOE and EPA (U.S. Department of Energy and U.S. Environmental Protection Agency), 2011, Memorandum of Understanding Between the U.S. Department of Energy, as Lead Agency, and the U.S. Environmental Protection Agency, as a Cooperating Agency, for the *Final Tank Closure and Waste Management EIS for the Hanford Site, Richland, Washington* ("*TC & WM EIS*"), April 22.

Ecology, EPA, and DOE (Washington State Department of Ecology, Olympia, Washington; U.S. Environmental Protection Agency, Washington, D.C.; and U.S. Department of Energy, Richland, Washington), 1989, Hanford Federal Facility Agreement and Consent Order, 89-10, as amended, accessed through http://www.hanford.gov/tpa/tpahome.htm, May 15.

Ecology, EPA, and DOE (Washington State Department of Ecology, Olympia, Washington; U.S. Environmental Protection Agency, Washington, D.C.; and U.S. Department of Energy, Richland, Washington), 1995, Establish Milestones and Target Dates for the Fast Flux Test Facility (FFTF) Transition, Milestone Series M-81, Hanford Federal Facility Agreement and Consent Order Change Control Form, M-81-94-01, January 13.

Ecology, EPA, and DOE (Washington State Department of Ecology, Olympia, Washington; U.S. Environmental Protection Agency, Washington, D.C.; and U.S. Department of Energy, Richland, Washington), 1999, Agreements in Regard to DOE's Fast Flux Test Facility (FFTF) for Standby and Transition Activities, Placement of Agreement FFTF Transition Milestones and Targets in Abeyance (M-81-00 Series), Modification of Agreement Milestone M-20-29A, Hanford Federal Facility Agreement and Consent Order Change Control Form, M-81-98-01, August 4.

Ecology, EPA, and DOE (Washington State Department of Ecology, Olympia, Washington; U.S. Environmental Protection Agency, Washington, D.C.; and U.S. Department of Energy, Richland, Washington), 2002, Reestablish Milestones and Target Dates for the Shutdown (Transition; Pursuant to Tri-Party Agreement Section 8) of the Fast Flux Test Facility (FFTF) (M-81-00 Series and M-20-29A), Hanford Federal Facility Agreement and Consent Order Change Control Form, M-81-02-01, July 31.

EPA (U.S. Environmental Protection Agency), 1999, *Consideration of Cumulative Impacts in EPA Review of NEPA Documents*, EPA 315-R-99-002, Office of Federal Activities, Washington, D.C., May.

Hanlon, B.M., 2003, *Waste Tank Summary Report for Month Ending August 31, 2003*, HNF-EP-0182, Rev. 185, CH2M HILL Hanford Group Inc., Richland, Washington, October.

Hedges, J.A., 2008, Washington State Department of Ecology, Richland, Washington, personal communication (letter) to S.J. Olinger, U.S. Department of Energy, Office of River Protection, Richland, Washington, D.A. Brockman, U.S. Department of Energy, Richland Operations Office, Richland, Washington, and W.S. Elkins, Bechtel National, Inc., Richland, Washington, ―Draft Waste Treatment and Immobilization Plant (WTP) Dangerous Waste Permit," October 15.

IPCC (Intergovernmental Panel on Climate Change), 2007, *A Report of Working Group I of the Intergovernmental Panel on Climate Change, Summary for Policymakers.*

National Research Council, 1996, *The Hanford Tanks: Environmental Impacts and Policy Choices*, Committee on Remediation of Buried and Tank Wastes, Board on Radioactive Waste Management, Commission on Geosciences, Environment, and Resources, National Academy Press, Washington, D.C.

NCRP (National Council on Radiation Protection and Measurements), 2009, *Ionizing Radiation Exposure of the Population of the United States*, NCRP Report No. 160, Bethesda, Maryland, March 3.

PNNL (Pacific Northwest National Laboratory), 2009, *Hanford Site Secondary Waste Roadmap*, PNNL-18196, Richland, Washington, January.

SAIC (Science Applications International Corporation), 2006, *Area C Borrow Pit Operations*, 6734-Area-C-001, Rev. 1, Germantown, Maryland, September 29.

SAIC (Science Applications International Corporation), 2011, *Cumulative Impacts Analysis, Inventory Development*, Rev. 6, Germantown, Maryland, June 27.

Sutley, N.H., 2011, Memorandum for Heads of Federal Departments and Agencies, ―Appropriate Use of Mitigation and Monitoring and Clarifying the Appropriate Use of Mitigated Findings of No Significant Impact," Council on Environmental Quality, Washington, D.C., January 14.

Uecker, J.E., 2007, U.S. Department of Energy, Richland Operations Office, Site Utilities Office, Richland, Washington, personal communication (email) to C. Henderson, Columbia Energy & Environmental Services, Inc., Richland, Washington, ―Substation Capacities," June 20.

Code of Federal Regulations

10 CFR 61, U.S. Nuclear Regulatory Commission, —Licensing Requirements for Land Disposal of Radioactive Waste."

10 CFR 61.40–44, U.S. Nuclear Regulatory Commission, —Licensing Requirements for Land Disposal of Radioactive Waste," Subpart C, —Performance Objectives."

10 CFR 61.55, U.S. Nuclear Regulatory Commission, —Licensing Requirements for Land Disposal of Radioactive Waste: Waste Classification."

10 CFR 1021, U.S. Department of Energy, —National Environmental Policy Act Implementing Procedures."

10 CFR 1021.314(c), U.S. Department of Energy, —National Environmental Policy Act Implementing Procedures: Supplemental Environmental Impact Statements."

10 CFR 1021.331, U.S. Department of Energy, —National Environmental Policy Act Implementing Procedures: Mitigation Action Plans."

40 CFR 61.90–97, U.S. Environmental Protection Agency, —National Emission Standards for Hazardous Air Pollutants," Subpart H, —National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities."

40 CFR 141, U.S. Environmental Protection Agency, —National Primary Drinking Water Regulations."

40 CFR 143, U.S. Environmental Protection Agency, —National Secondary Drinking Water Regulations."

40 CFR 191, U.S. Environmental Protection Agency, —Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes."

40 CFR 261.20–24, U.S. Environmental Protection Agency, —Identification and Listing of Hazardous Waste," Subpart C, —Characteristics of Hazardous Waste."

40 CFR 261.31–33, U.S. Environmental Protection Agency, —Identification and Listing of Hazardous Waste: Hazardous Wastes from Non-specific Sources; Hazardous Wastes from Specific Sources; Discarded Commercial Chemical Products, Off-Specification Species, Container Residues, and Spill Residues Thereof."

40 CFR 1500–1508, Council on Environmental Quality, —Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act."

40 CFR 1502.1, Council on Environmental Quality, —Environmental Impact Statement: Purpose."

40 CFR 1502.9(c), Council on Environmental Quality, —Environmental Impact Statement: Draft, Final, and Supplemental Statements."

40 CFR 1502.14(d), Council on Environmental Quality, —Environmental Impact Statement: Alternatives Including the Proposed Action."

40 CFR 1502.22, Council on Environmental Quality, —Environmental Impact Statement: Incomplete or Unavailable Information."

40 CFR 1508.7, Council on Environmental Quality, —Terminology and Index: Cumulative Impact."

40 CFR 1508.20, Council on Environmental Quality, ―Terminology and Index: Mitigation."

Federal Register

46 FR 18026, Council on Environmental Quality, 1981, ―Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," March 23.

62 FR 8693, U.S. Department of Energy, 1997, ―Record of Decision for the Tank Waste Remediation System, Hanford Site, Richland, WA," February 26.

63 FR 3629, U.S. Department of Energy, 1998, ―Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste," January 23.

64 FR 61615, U.S. Department of Energy, 1999, ―Record of Decision: *Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)*," November 12.

65 FR 10061, U.S. Department of Energy, 2000, ―Record of Decision for the Department of Energy's Waste Management Program: Treatment and Disposal of Low-Level Waste and Mixed Low-Level Waste; Amendment of the Record of Decision for the Nevada Test Site," February 25.

66 FR 7877, U.S. Department of Energy, 2001, ―Record of Decision for the *Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility*," January 26.

68 FR 1052, U.S. Department of Energy, 2003, ―Notice of Intent to Prepare an Environmental Impact Statement for Retrieval, Treatment, and Disposal of Tank Waste and Closure of Single-Shell Tanks at the Hanford Site, Richland, WA," January 8.

69 FR 39449, U.S. Department of Energy, 2004, ―Record of Decision for the Solid Waste Program, Hanford Site, Richland, WA: Storage and Treatment of Low-Level Waste and Mixed Low-Level Waste; Disposal of Low-Level Waste and Mixed Low-Level Waste, and Storage, Processing, and Certification of Transuranic Waste for Shipment to the Waste Isolation Pilot Plant," June 30.

69 FR 50176, U.S. Department of Energy, 2004, ―Notice of Intent to Prepare an Environmental Impact Statement for the Decommissioning of the Fast Flux Test Facility at the Hanford Site, Richland, WA," August 13.

71 FR 5655, U.S. Department of Energy, 2006, ―Notice of Intent to Prepare the Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, WA," February 2.

71 FR 8569, U.S. Department of Energy, 2006, ―Extension of Scoping Period and Rescheduled Scoping Meetings for the Notice of Intent to Prepare the Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, WA," February 17.

72 FR 40135, U.S. Department of Energy, 2007, ―Notice of Intent to Prepare an Environmental Impact Statement for the Disposal of Greater-Than-Class C Low-Level Radioactive Waste," July 23.

73 FR 55824, U.S. Department of Energy, 2008, ―Amended Record of Decision for the *Hanford Comprehensive Land-Use Plan Environmental Impact Statement*," September 26.

74 FR 31017, U.S. Department of Energy, 2009, ―Notice of Cancellation of the *Global Nuclear Energy Partnership (GNEP) Programmatic Environmental Impact Statement (PEIS)*," Office of Nuclear Energy, June 29.

74 FR 56194, U.S. Environmental Protection Agency, 2009, ―Environmental Impact Statements; Notice of Availability," October 30.

74 FR 67189, U.S. Department of Energy, 2009, ―Notice of Modifications to the Preferred Alternatives for Tank Waste Treatment and Disposal of Off Site Waste in the *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, WA*," December 18.

75 FR 13268, U.S. Department of Energy, 2010, ―Extension of the Public Comment Period for the *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, WA*," March 19.

United States Code

42 U.S.C. 2011 et seq., Atomic Energy Act of 1954.

42 U.S.C. 4321 et seq., National Environmental Policy Act of 1969.

42 U.S.C. 6901 et seq., Resource Conservation and Recovery Act of 1976.

42 U.S.C. 9601 et seq., Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980.

U.S. Public Law

P.L. 105-261, Strom Thurmond National Defense Authorization Act for Fiscal Year 1999.

Washington State Codes

Revised Code of Washington

RCW 43.21C, State Environmental Policy Act.

Washington Administrative Code

WAC 173-303, Washington State Department of Ecology, ―Dangerous Waste Regulations," Olympia, Washington.

WAC 173-460, Washington State Department of Ecology, ―Controls for New Sources of Toxic Air Pollutants," Olympia, Washington.

WAC 173-480-040, Washington State Department of Ecology, ―Ambient Air Quality Standards and Emission Limits for Radionuclides: Ambient Standard," Olympia, Washington.

WAC 246-290, Washington State Department of Health, ―Group A Public Water Supplies," Olympia, Washington.

U.S. Department of Energy Guides, Manuals, and Orders

DOE Order 151.1C, *Comprehensive Emergency Management System*, November 2, 2005.

DOE Guide 435.1-1, *Implementation Guide for Use with DOE M 435.1-1*, July 9, 1999.

DOE Manual 435.1-1, *Radioactive Waste Management Manual*, Change 2, June 8, 2011.

DOE Order 451.1B, *National Environmental Policy Act Compliance Program*, Change 3, January 19, 2012.

DOE Order 458.1, *Radiation Protection of the Public and the Environment*, Change 2, June 6, 2011.

DOE Manual 460.2-1A, *Radioactive Material Transportation Practices Manual for Use with DOE O 460.2A*, June 4, 2008.