



The National Environmental Policy Act (NEPA) requires Federal agencies to analyze the potential environmental impacts of their proposed actions to assist them in making informed decisions. A similar Washington State law, the State Environmental Policy Act (SEPA), requires State agencies, including the Washington State Department of Ecology (Ecology), to analyze environmental impacts before making decisions that could impact the environment. A major emphasis of both laws is to promote public awareness of these actions and provide opportunities for public involvement. Because NEPA and SEPA requirements are similar, the U.S. Department of Energy (DOE) and Ecology have agreed to co-prepare this Environmental Impact Statement (EIS) to streamline the environmental review process.

An EIS is prepared in a series of steps: compiling Federal and State agency, stakeholder, Tribal Nation, and public comments to define issues requiring analysis (a process known as scoping); preparing the Draft EIS; receiving and responding to public comments on the Draft EIS; and preparing the Final EIS.

An EIS does not make decisions; rather, it is one of several sources of information that decision makers consider in making a decision on a proposed action. The final step in the NEPA process is issuing a Record of Decision on the proposed action, which documents the decisions made by the agency.

DOE is the Federal agency responsible for waste management and environmental restoration at the Hanford Site near Richland, Washington (Figure S.1.1). The proposed Federal action analyzed in this EIS is the management and disposal of Tank Waste Remediation System (TWRS) radioactive, hazardous, and mixed waste. This waste is stored in 177 large underground storage tanks and in approximately 60 smaller active and inactive miscellaneous underground storage tanks. The proposed Federal action also includes managing and disposing of approximately 1,930 cesium and strontium capsules stored in the Waste Encapsulation and Storage Facility.



The proposed State action is the permitting of proposed waste management and disposal facilities for the tank waste and cesium and strontium capsules. The tank waste and cesium and strontium capsules currently pose a low short-term risk to human health and the environment; however, storage costs are high, and the potential for an accident resulting in large releases of radioactive and chemical contaminants will increase as the facilities age. In addition, there are regulatory requirements that require the waste to be remediated.

DOE and Ecology conducted a scoping process from January 23, 1994 to March 15, 1994 to define the issues for analysis in the EIS and prepared a Draft EIS based in part on comments from Federal and State agencies, Tribal Nations, stakeholders, and the public.



The Draft EIS was distributed for public review and comment on April 4, 1996 and the public comment period extended from April 12, 1996 to May 28, 1996. Public hearings and meetings were held at Portland, Oregon; Washington D.C.; and Pasco, Seattle, and Spokane, Washington during the comment period. Approximately 750 comments were received from 350 Federal and State agencies, Tribal Nations, stakeholders, and the public. In addition, consultation meetings were held with 19 agencies, Tribal Nations, and stakeholders.



The Draft EIS was revised in response to comments received and to incorporate emerging technical information that was not available when the Draft EIS was prepared and this Final EIS was produced. A Record of Decision will be

issued to document DOE's decisions on remediation of the tank waste and cesium and strontium capsules no sooner than 30 days after publication of this EIS in accordance with NEPA regulations.

S.2 BACKGROUND

From 1943 to 1989, the Hanford Site's principal mission was the production of weapons-grade plutonium. To produce plutonium, uranium metal was irradiated in a plutonium production reactor.

The irradiated uranium metal, also known as spent fuel, was cooled and treated in a chemical separations or reprocessing plant, where plutonium was separated from uranium and many other radioactive by-products. The plutonium then was used for nuclear weapons production. Large amounts of spent fuel were generated to produce enough plutonium to make a nuclear weapon. The chemical separations processes resulted in large volumes of radioactive waste.

The Hanford Site processed approximately 100,000 metric tons (110,000 tons) of uranium and generated several hundred thousand metric tons of waste. The waste included high-level, transuranic, low-level, hazardous, and mixed waste (waste that includes both radioactive and hazardous waste). The waste was managed in compliance with the laws and regulations applicable at the time, but major changes in laws and regulations governing waste management and disposal have mandated changes in the waste management program.

Double-Shell Tanks Under Construction in 1984



To provide better leak protection than single-shell tanks, 28 one-million-gallon double-shell tanks were constructed at the Hanford Site between 1968 and 1986.

Tank Contents Vary from Tank to Tank



These tanks contain various radionuclides and chemicals that have separated into blended layers of vapors, liquids, slurries, sludges, and saltcake,

For the high-level waste generated by the chemical reprocessing plants, waste management initially involved adding sodium hydroxide or calcium carbonate to make the acidic waste alkaline and storing the waste in large underground tanks until a long-term disposal solution could be found. In the 1940's through the early 1960's, 149 single-shell tanks with capacities of 210,000 liters (55,000 gallons) to 3.8 million liters (1 million gallons) were built to store high-level waste in a region near the center of the Hanford Site referred to as the 200 Areas.

During the 1950's, uranium was extracted from some of the single-shell tanks for reprocessing, an action that introduced new chemicals to the tanks. Also, to free up tank space for large volumes of new waste generated by fuel reprocessing, chemicals were added to the tanks to settle radionuclides from the liquid waste to the bottom of the tanks. This left the upper liquid layer less radioactive and allowed large volumes of liquid waste to be siphoned off as low-activity waste. Additionally, several single-shell tanks were built with piping connections that allowed waste to flow from one tank to another, separating or settling most of the solids from the liquid waste. The low-activity liquid waste that resulted was sent to shallow subsurface drainfields, referred to as cribs, where it percolated into the soil. This process resulted in higher concentrations of heat-generating cesium-137 and strontium-90 in the tanks, which threatened the integrity of the tanks.

B Plant - Waste Encapsulation and Storage Facility



Cesium and strontium capsules are stored in the Waste Encapsulation and Storage Facility (circled), which is attached

to B Plant, an inactive reprocessing plant.



Heat generation in the tanks was addressed in the 1960's when single-shell tank waste was recovered and sent to B Plant to remove cesium and strontium from the waste. Cesium and strontium then were converted to salts, placed in capsules, and stored in a separate facility as waste by-product. Most of these capsules currently are stored at the Hanford Site in water-filled basins at the Waste Encapsulation and Storage Facility. Some of the capsules were sent offsite to be used as heat or radiation sources. These capsules are scheduled to be returned to the Site by 1997.

The single-shell tanks had a design life of approximately 20 years. Leakage of waste from the single-shell tanks to the underlying soil was suspected in 1956 (from tank 241-U-104) and confirmed in 1961. By the late 1980's, 67 of the single-shell tanks were known or suspected leakers, and an estimated 3.8 million liters (1 million gallons) of high-level waste had been released to the soil beneath the 200 Areas. To address concerns with the design of single-shell tanks, the Hanford Site adopted a new double-shell tank design that includes an outer steel shell to contain any leaks that occur through the inner steel shell. The double-shell tank design provides for leak detection and recovery before waste can reach the surrounding soil.

Between 1968 and 1986, 28 double-shell tanks with capacities of 4.4 million liters (1.16 million gallons) to 3.8 million liters (1 million gallons) were constructed in the 200 Areas. Most of the free-standing liquid contained in the single-shell tanks has been pumped into double-shell tanks; however, the remaining solids still contain liquids within the void spaces. Newly generated waste is stored in the double-shell tanks. No leaks are known to have occurred from the double-shell tanks.

Tanks were constructed in groups called tank farms. The current tank farm system consists of 177 large underground storage tanks in 18 tank farms. These tanks include 149 single-shell tanks and 28 double-shell tanks (Figure S.2.2) that contain a total of 212 million liters (56 million gallons) of liquid, sludge, and saltcake (generally a semi-solid crusty material).

There also are approximately 60 smaller active and inactive miscellaneous underground storage tanks. Much of the waste in the inactive tanks has been removed or stabilized, and the remaining waste is similar to the waste in the double- and single-shell tanks. The active tanks primarily are used to facilitate waste transfers.

Additional waste, which is planned for storage in the double-shell tanks, includes radioactive and hazardous waste from other Hanford Site cleanup and decontamination activities.

S.3 THE HANFORD SITE ENVIRONMENT

The Hanford Site is in the semi-arid region of southeastern Washington State and occupies about 1,450 square kilometers (560 square miles) north of Richland, Washington. Population centers within 80 kilometers (50 miles) of the Hanford Site are Yakima to the west and the Tri-Cities of Richland, Kennewick, and Pasco to the southeast. Approximately 450,000 people reside within an 80-kilometer (50-mile) radius of the 200 Areas. The Hanford Site is a major contributor to the economy of the Tri-Cities, accounting for approximately 22 percent of all nonfarm jobs in 1995. Historically, changes in the Hanford Site's mission and employment levels have had large impacts on the economy of the Tri-Cities area.

The Shrub-Steppe Habitat



The Hanford Site is home to a large undisturbed shrub-steppe area, which is a valuable vegetation and wildlife habitat.

Land adjacent to the Hanford Site principally is range and agricultural land except for the area on the southeast corner of the Site where the city of Richland is located. The Columbia River flows through the northern part of the Site and forms part of the Site's eastern boundary. The stretch of the Columbia River that flows through the Site is known as the Hanford Reach, and is the last free-flowing segment of the Columbia River in the United States. The Hanford Reach has been proposed as a Recreational River under the Wild and Scenic Rivers Act. The Columbia River's many uses include irrigation water for area farms and drinking water for communities downriver of the Hanford Site. The river is approximately 11 kilometers (7 miles) from the 200 Areas.



About 6 percent of the Hanford Site has been used for defense production and waste management purposes. Because much of the Hanford Site has been undisturbed for nearly 50 years, the Site contains one of the largest remaining relatively undisturbed shrub-steppe habitat areas in Washington State.

Shrub-steppe habitat is vegetation that flourishes on arid lands in areas with extreme temperature ranges. Shrub-steppe is considered a priority habitat by Washington State because of its importance to sensitive wildlife. About one-half of the land located on the Hanford Site has been designated as an ecological study area or wildlife refuge. These areas include the Fitzner Eberhardt Arid Lands Ecology Reserve located south and west of the 200 Areas and areas north of the Columbia River.

The tank waste and the Waste Encapsulation and Storage Facility are located in the 200 Areas near the center of the Hanford Site on the Central Plateau (Figure S.3.1). Much of the defense production activity occurred in the 200 Areas, and therefore, much of the land in the 200 Areas is disturbed. The 200 Areas also are the location of large low-level waste burial grounds. The 200 Areas and the surrounding Central Plateau have been identified as potential exclusive-use waste management areas to support the Hanford Site's waste management and environmental restoration programs. Because of past disturbances in the 200 Areas, the shrub-steppe habitat, wildlife typically found in the shrub-steppe habitat, and archeological sites are limited.

Groundwater occurs beneath the 200 Areas at a depth of 70 to over 90 meters (230 to over 300 feet) below the ground surface. Past production and disposal practices resulted in extensive contamination in various concentrations in the soils beneath the 200 Areas. Contributors to the contamination were tank waste management practices that resulted in releases of liquid from the tanks as well as leaks from the tanks. Radioactive and nonradioactive contamination occurs in various concentrations in the soils beneath the 200 Areas, especially near the waste management facilities and the locations of unplanned releases. Over time, the contaminants in the soils have been carried down to the groundwater and toward the Columbia River.



At least 12 different contaminants have been identified in the groundwater beneath the 200 Areas. Contaminants include arsenic, chromium, cyanide, carbon tetrachloride, cobalt-60, strontium-90, technetium-99, iodine-129, cesium-137, tritium, and plutonium-239 and -240.

DOE has a system of monitoring wells installed in the vicinity of each waste tank. The depth of these wells vary but they do not extend to the water table. These wells were installed to allow detection of gamma radiation as a means of detecting potential tank waste leaks and movement of existing contamination in the subsurface soils from other water sources such as potable water line leaks. Until recently, the gamma emissions detected were not indicative of a specific radionuclide. These emissions have been detected in many of the wells at depths ranging from ground surface up to 38 m (125 ft) belowground surface. Recent improvements in the logging detection equipment has resulted in the identification of specific gamma-emitting radioisotopes. The most prevalent radioisotope detected was cesium-137. Other gamma-emitting radionuclides such as cobalt-60, europium-152 and -154 were generally found near the surface and are believed to be the result of spills.

The transport of cesium-137 in the subsurface soils is believed to be greatly slowed by adsorption by the subsurface soils. Cesium would not be expected to be found at depths of up to 38 m (125 ft) if it were being transported by

interstitial flow through the subsurface soils by previously anticipated mechanisms. The detection of cesium-137 at this depth raise several questions concerning the distribution of contaminants in the subsurface soils and the active transport mechanisms. These questions and other are being addressed by DOE in a recently implemented Resource Conservation and Recovery Act groundwater assessment of the S and SX Tank Farms. A panel of outside experts has been convened to assist in resolving these concerns

The Hanford Site is an attainment area for all criteria pollutants under the Clean Air Act, as amended. However, there are occasional episodes of blowing dust, which typically are the result of recently plowed farmland adjacent to the Hanford Site. Severe natural events such as flooding, earthquakes, and tornadoes are rare in the 200 Areas.

Since the Hanford Site began operations in 1943, the nearby population has been exposed to the radioactive effluents and emissions from Site activities. The measure of radiation exposure for an individual is the rem. For a population, the exposure of the individuals is summed together to give the population dose, in person-rem, which is used in analyzing potential health effects resulting from the exposure. Summing the nearby population's annual radiation exposure for over 50 years of Hanford Site operations, it is estimated that the nearby population has received a cumulative population dose of approximately 100,000 person-rem from Hanford Site activities. Most of this dose was received before 1972. The same population also received radiation exposure from natural background radiation over the same time period estimated at about 5 million person-rem. Currently, the annual incremental population dose from Hanford Site activities is very small. In the most recent year for which data are available, 1995, the nearby population dose was only 0.3 person-rem. For comparison, the annual incremental dose to the nearby population from background radiation was approximately 110,000 person-rem.

S.4 REGULATORY HISTORY AND REQUIREMENTS

Throughout much of the history of plutonium production at the Hanford Site there were few laws regulating waste management and environmental protection. Because of national security concerns, nuclear production facilities like the Hanford Site were largely exempted from external regulation. Under the provisions of the Atomic Energy Act of 1954, DOE was authorized to establish standards to protect health and minimize dangers to life or property for activities under DOE's jurisdiction. In the 1970's and 1980's, new environmental laws were enacted regulating waste management, storage and disposal, and pollution emissions to the air and water. In more recent years other agencies have become responsible for regulating many aspects of DOE's activities, particularly hazardous waste management and remediation.



In response to the continued accumulation of spent nuclear fuel, high-level radioactive waste, other hazardous wastes, and a growing public awareness and concern for public health and safety, Congress passed numerous laws including the Nuclear Waste Policy Act. The purpose of these laws was to establish a national policy and program that would provide reasonable assurance that the public and the environment would be adequately protected from the hazards posed by these wastes. The action by Congress was influenced by a national consensus that, because of potential hazards, spent nuclear fuel and high-level waste needed to be permanently isolated from the human environment with minimal reliance on institutional controls. Permanent isolation consists of placing the waste within engineered and natural barriers that are likely to contain the material for a long time. Minimal reliance on institutional controls means the isolation will not be dependent on ongoing maintenance of facilities, human attention, or commitment by governments or other institutions. The national consensus has been reflected in the Northwest by strong support from DOE, Federal and State agencies, Tribal Nations, and citizens and stakeholders to accomplish cleanup of the Hanford Site.

In 1974, Congress passed the Energy Reorganization Act, which authorized the Nuclear Regulatory Commission to regulate and license DOE facilities authorized for the express purpose of long-term storage of high-level radioactive waste that are not part of DOE's research and development program. The Nuclear Regulatory Commission established regulations for low-level radioactive waste that can be disposed of in land disposal sites (10 Code of Federal Regulations [CFR] Part 61), as well as radioactive waste requiring geologic disposal (10 CFR Part 60). The U.S. Environmental Protection Agency (EPA) was authorized to establish standards for managing and disposing of spent

nuclear fuel, high-level waste, and transuranic waste. These standards are contained in 40 CFR Part 191 and would apply if high-level waste is disposed of at the Hanford Site.

In addition to applicable laws and regulations, DOE has established a set of policies to guide DOE activities. It is DOE policy that new and readily retrievable existing high-level waste would be processed into an immobilized form for disposal in a potential geologic repository. High-level waste that is not readily retrievable shall be evaluated for in-place stabilization or disposal in a potential geologic repository. DOE's policy for low-level waste is that it be disposed of at the site where it was generated, if practicable. If onsite disposal capacity is not available, the low-level waste shall be disposed of at an offsite disposal facility.

The Clean Air Act, as amended, requires DOE to meet national air quality standards, ensure that hazardous air emissions from existing and new sources are controlled to the extent practical, and obtain an operating permit for all major emission sources. The Clean Water Act and the Safe Drinking Water Act, as amended, regulate discharges to surface water, set national drinking water standards, and regulate discharges of hazardous constituents to surface and groundwater.

With the passage of the Resource Conservation and Recovery Act of 1976, as amended by the Hazardous and Solid Waste Amendments of 1984, and the Federal Facility Compliance Act of 1992, the EPA and states were authorized to regulate hazardous and mixed waste generation, treatment, storage, and disposal. The Resource Conservation and Recovery Act does not apply to Atomic Energy Act materials (source, special nuclear, and by-product material) but in 1987 mixed waste at DOE facilities was determined to be covered by the Resource Conservation and Recovery Act regulations. The Federal Facility Compliance Act of 1992 amended the Resource Conservation and Recovery Act to define mixed waste as waste that contains both hazardous waste and source, special, and by-product nuclear material. In November 1987, Ecology, the administering agency for the State Hazardous Waste Management Act, was authorized by EPA to administer state statutes in lieu of the Resource Conservation and Recovery Act. These regulations established regulations for newly generated hazardous waste but as originally enacted did not address past waste disposal practices.



To address the clean up of past hazardous and radioactive waste disposal sites, Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended by the Superfund Amendments and Reauthorization Act of 1986. This law required Federal agencies to investigate and remediate releases of hazardous substances (including radioactive contaminants) from their facilities.

In 1986, EPA, Ecology, and DOE's Richland Operations Office began to examine how best to bring the Hanford Site into compliance with the Resource Conservation and Recovery Act and the Comprehensive Environmental Response, Compensation, and Liability Act. The regulators and DOE agreed to develop one compliance agreement that set agreed-upon milestones for cleaning up releases of hazardous substances. Negotiations concluded in late 1988, and the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) was signed by the three agencies on January 15, 1989. The existing waste, as well as new waste added to the tank farms, is regulated by the Tri-Party Agreement's Resource Conservation and Recovery Act enforcement provisions.

In 1988, after completing the Hanford Defense Waste EIS, DOE decided to proceed with preparing the double-shell tank waste for final disposal. Subsequent to this decision, the following important changes occurred in the Tank Waste Remediation System program for managing the disposal of the tank waste.

- B Plant, selected in the Hanford Defense Waste Record of Decision as the facility for pretreatment processes to comply with current environmental and safety requirements, was found not to be viable or cost effective to operate.
- The Tri-Party Agreement was signed in 1989, establishing a revised approach for achieving environmental compliance at the Hanford Site including specific milestones for the retrieval, treatment, and disposal of tank waste.

- Safety issues were identified for approximately 50 double-shell and single-shell tanks, which became classified as Watchlist tanks in response to the 1990 enactment of Public Law 101-510.
- The planned grout project for immobilizing low-activity waste was terminated, and a vitrified waste form was adopted as the proposed approach as a result of concerns with the adequacy of disposal of low-activity waste using grout to immobilize the waste. The concerns involved the ability of grout to adequately inhibit contaminants leaching from the grouted waste and the ability to safely retrieve the waste from the grout vaults in the future, if retrieval became necessary for some reason.
- The planning basis was revised to retrieve waste from all underground storage tanks, including the single-shell tanks, and treat the retrieved single-shell tank waste in combination with the double-shell tank waste.
- The construction of the Hanford Waste Vitrification Plant was terminated because of insufficient capacity to vitrify the high-level waste fraction of all double-shell and single-shell tank waste in the planned time frame.

Aerial View of 200 Areas Tank Farms



At the Hanford Site, there are 177 underground tanks clustered in 18 tank farms in the 200 Areas of the Central Plateau. The tanks are buried approximately 3 meters (10 feet) under the soil, with monitoring equipment and access ports above the ground.

These changes and further research on the tank waste and remediation technologies resulted in an extensive reevaluation of the waste treatment and disposal plan that culminated in adopting a revised strategy to manage and dispose of tank waste. In 1994, DOE, Ecology, and EPA modified the Tri-Party Agreement to incorporate the new strategy for remediating the tank waste. The revised technical strategy embodied in the Tri-Party Agreement addressed the need to manage and dispose of tank waste because the waste has an unacceptable potential for release to the environment and thereby poses a risk to human health and the environment. The risk posed by tank waste includes both urgent tank safety issues and longer-term risk.

To address the urgent safety issues, the Safe Interim Storage of Hanford Tank Wastes EIS was prepared as an interim action EIS to consider alternatives for maintaining safe storage of tank waste. The actions considered in the Safe Interim Storage of Hanford Tank Waste EIS included interim actions to mitigate the generation of high concentrations of flammable gases in tank 241 -SY-101 and interim stabilization of older single-shell tanks, many of which have leaked. The most pressing interim need identified by DOE and Ecology was for a safe, reliable, and regulatory compliant replacement cross-site transfer capability to move waste between the 200 West and 200 East Area tank farms.



On December 1, 1995, DOE published a Record of Decision in the Federal Register (60 FR 61687). The decision was to do the following.

- Construct and operate a replacement cross-site transfer pipeline system.
- Continue to operate the existing cross-site transfer pipeline system on a limited basis until the replacement system is operational.
- Continue to operate the mixer pump in tank 241-SY-101 to mitigate the unacceptable accumulation of hydrogen and other flammable gases.
- Perform activities to mitigate the loss of shrub-steppe habitat.



In 1995, the agencies began negotiating changes to the Tri-Party Agreement to allow private companies to perform remediation of the tank waste in response to a DOE initiative to encourage industry to use innovative approaches to remediate the tank waste. The goal of the privatization effort is to streamline the TWRS mission, transfer a share of the responsibility, accountability, and liability for successful performance to industry, improve performance, and reduce

cost without sacrificing worker and public safety or environmental protection. The agencies issued these changes in the Tri-Party Agreement for public comment in January 1996. These changes were approved by DOE, Ecology, and EPA in July 1996.

The alternatives evaluated in this EIS could be implemented by either a Management and Operations contractor or through DOE's privatization initiative. The environmental impacts would be the same under either contracting mechanism. The cost savings anticipated by privatizing the remediation are not included in the estimates in the EIS. DOE will independently evaluate and verify the accuracy of the environmental data and analysis and, as appropriate, would use the information to help ensure the consideration of environmental factors in the selection process in accordance with 10 CFR Part 1021.216. DOE will also require selected offers to submit further environmental information and analysis, and would use the additional information, as appropriate, to assist in the NEPA compliance process, including a determination under 10 CFR Part 1021.314 of the potential need for a future NEPA analysis.

DOE has received two proposals under the privatization initiative for constructing and operating demonstration-scale facilities for separating selected portions of the tanks waste into low-activity waste and high-level waste fractions and immobilizing the separated waste. The two proposals would follow the same general approach described in the EIS for Phase 1 of the Phased Implementation alternative including; separating the waste into low-activity waste and high-level waste streams, immobilizing the high-level waste by forming a borosilicate glass, and using high-temperature processes to generate immobilized low-activity waste. Evaluation of the two proposals has shown that they would have similar overall environmental impacts and that the impacts would be less than or approximately the same as the impacts described in Phase 1 of the Phased Implementation alternative assessed in this EIS.

One proposal has the potential to substantially reduce the volume of low-activity waste requiring disposal and would result in less disposal-related land disturbance. However, the total amount of radioactivity in the low-activity waste would be approximately the same for both proposals, and the associated impacts on groundwater would be the same (i.e., small). This proposal also offers the potential for recycling a portion of the low-activity waste, and some of the raw material used in low-activity waste processing might be suitable for other beneficial uses within DOE or the nuclear industry. There is uncertainty about whether markets for these materials will be available. If such markets were not available then the potential benefits of low-activity waste volume reduction would not occur and these materials would need to be disposed of. Differences between the proposals in environmental impacts associated with the use of resources such as fuel and from air emissions such as nitrogen oxides would be small.

S.5 ALTERNATIVES CONSIDERED IN THE EIS

S.5.1 Tank Waste Alternatives

A wide variety of potential alternatives and combinations of alternatives exist for treating and disposing of the tank waste. One of the challenges for DOE and Ecology is to develop a range of reasonable alternatives for detailed analysis and presentation in the EIS. The alternatives presented in the EIS were chosen to be representative of the many possible variations of the alternatives. The EIS contains an analysis of the full range of reasonable alternatives for management and disposal of the Tank Waste Remediation System waste. The continued safe management of the tank farms is included in all of the alternatives. The tank waste alternatives can be grouped into four major categories depending on the extent of waste retrieval as shown in Figure S.5.1. These groups are as follows.

- Continued management alternatives - No retrieval would be performed. Two continued management alternatives were analyzed; one without replacing double-shell tanks and one with replacing double-shell tanks and upgrading tank farm waste transfer systems to provide long-term management of the double-shell tank liquids.
- Minimal retrieval alternatives - Liquid waste only would be removed from the double-shell tanks and concentrated in an evaporator. The concentrated waste from the evaporator would be returned to the tanks. The solid waste would be disposed of in place in the tanks; referred to as in situ disposal. Two in situ alternatives were analyzed; one without treatment and one with in-tank treatment of the waste.
- Partial retrieval alternatives - The tank waste resulting in the fewest potential environmental impacts would be disposed of in situ. The liquid waste and the portion of the solid waste that would result in the greatest potential

long-term groundwater impacts would be retrieved from the tanks. The retrieved waste then would be immobilized and disposed of outside of the tanks; referred to as ex situ disposal. The retrieved portion of the waste would be separated by physical and chemical processing into low-activity and high-level waste. The low-activity waste would be immobilized and disposed of onsite in near-surface concrete vaults and covered with a thick earthen barrier. The high-level waste would be immobilized and stored onsite for eventual shipment to and disposal at a potential geologic repository. Two partial retrieval alternatives were analyzed; one that would result in a reduced long-term human health risk of approximately 90 percent and one that would reduce the long-term human health risk by 85 percent. These alternatives provide less long-term protection of human health but would cost less to implement.

- Extensive retrieval alternatives - All of the solid and liquid waste practicable (assumed for purposes of analysis to be 99 percent) would be retrieved and separated by physical and chemical processing into low-activity waste and high-level waste. The low-activity waste would be immobilized and disposed of onsite in near-surface vaults and covered with a thick earthen barrier. The high-level waste would be immobilized and stored onsite for eventual shipment to and disposal at a geologic repository. Three extensive retrieval alternatives, with different levels of separations, were analyzed. A fourth alternative was analyzed to present the potential impacts that would occur if DOE chooses to implement an extensive retrieval alternative in phases rather than immediately implementing a full-scale program. This phased approach was analyzed because of the numerous uncertainties associated with the extensive retrieval alternatives.

[Figure S.5.1 Tank Waste Alternatives](#)

The EIS was prepared to support decisions on how to dispose of the waste in the tanks. However, closure of the tank farm system after the waste has been remediated, which is interrelated with the decisions to be made on disposition of the waste, is another action required under the Resource Conservation and Recovery Act. Closure is the final disposition of the tanks and associated equipment and the remediation of contaminated soil and groundwater associated with leaks from the tanks. Closure is not within the scope of this EIS because there is insufficient information available concerning the amount of contamination to be remediated. The amount and type of waste ultimately remaining in the tanks after remediation affects closure decisions. The Notice of Intent to prepare the Tank Waste Remediation System EIS (59 FR 4052) stated, "The impacts of closure cannot be meaningfully evaluated at this time. DOE will conduct an appropriate NEPA review, such as an EIS, to support tank closure in the future." However, some of the decisions to be made concerning how to dispose of tank waste may impact future decisions on closure, so the EIS provides information on how tank waste remediation and closure are interrelated.



A single and consistent method of closure was assumed for all alternatives to allow for a meaningful comparison of the alternatives. The closure method used for purposes of analysis was closure as a landfill, which includes placing an earthen surface barrier over the tanks after remediation is complete. Impacts that primarily are dependent on the type of closure that will be selected in the future include 1) releases to the groundwater from residual waste and the associated potential health effects; and 2) the amount and location of land and vegetation disturbances at potential earthen borrow sites. Borrow sites to be used during tank farm closure will be addressed in a future NEPA analysis.



In response to emerging technical information and the need to support DOE's integrated approach to remediating the Central Plateau and the Hanford Site as a whole, DOE will prepare a future NEPA analysis to address tank farm closure and other issues associated with TWRS remediation. The analysis will address alternatives for closing the tank farms; including disposition of the tanks and associated equipment, residual waste remaining after retrieval, and contaminated soils; resolution of emerging information concerning contamination of the vadose zone; and the integration of tank farm closure with the remediation of other Central Plateau areas.

The Nuclear Waste Policy Act, as amended, establishes the planning basis for the development of geologic repositories for disposal of high-level waste and commercial spent nuclear fuel. One of the requirements of the Nuclear Waste Policy Act is that the first geologic repository shall not accept in more than 70,000 metric tons (77,000 tons) of heavy

metal or equivalent prior to operation of a second repository. The current planning basis for the repository program allocates 10 percent, or 7,000 metric tons (7,700 tons) of heavy metal for disposal of DOE-owned spent nuclear fuel and high-level waste. Current planning also assumes that this waste would be contained in approximately 3,500 waste packages. Based on the calculated waste loading of 20 percent, some of the alternatives may produce more waste packages than the current planning basis for the Hanford Site's expected allocation at the geologic repository. Some of the waste would need to be disposed of at a second geologic repository, or changes in the repository planning basis would be required to allow for more waste packages. For purposes of analysis, a potential geologic repository candidate site at Yucca Mountain, Nevada was assumed to be the final disposal site for high-level waste sent offsite for disposal. Yucca Mountain currently is the only site being characterized as a potential geologic repository for high-level waste. If selected as the site for development, it would be ready for acceptance of high-level waste no sooner than 2015. The environmental impacts that would occur at the geologic repository from the disposal of high-level waste from the Tank Waste Remediation System are not addressed in this EIS. Potential impacts at the repository are being addressed in a separate EIS, which DOE will prepare to analyze the site-specific environmental impacts from construction, operation, and eventual closure of a potential geologic repository for spent nuclear fuel and high-level waste at Yucca Mountain. The tank waste alternatives developed for analysis in the EIS are summarized in Table S.5.1

[Table S.5.1 Summary of Tank Waste Alternatives](#)

All of the TWRS EIS alternatives include the continuation of on-going activities to safely manage the tank waste, including removing liquid waste and operating the existing 242-A Evaporator to concentrate waste and provide additional tank storage capacity and waste management flexibility; additional characterization of the waste; maintaining tank safety activities, such as operating waste mixer pumps and transferring waste between the tanks; and other associated monitoring, maintenance, security, and regulatory compliance activities.

All of the alternatives except the No Action alternative include upgrades to the tank farm waste transfer system, which involve the construction of buried waste transfer pipelines and replacement of transfer lines that are not regulatorily compliant. Also under all of the alternatives DOE would continue its policy of continually evaluating the issues associated with the Tank Waste Remediation System and its path forward as additional tank characterization data and process knowledge are obtained.

S.5.2 Cesium and Strontium Capsule Alternatives

The cesium and strontium waste is classified as waste by-product and currently is stored in the Waste Encapsulation and Storage Facility. The alternatives addressed in the EIS for disposal of the cesium and strontium capsules include 1) no action; 2) onsite disposal in newly constructed shallow wells; 3) offsite disposal at a geologic repository by overpacking the capsules and shipping them to a repository; or 4) physically mixing the capsule contents with the high-level tank waste, which would be vitrified and disposed of at a potential geologic repository. All of the alternatives (Figure S.5.2) include continued monitoring and maintaining the integrity of the capsule and support facilities. These alternatives are described in Table S.5.2.

[Table S.5.2 Summary of Capsule Alternatives](#)

S.6 ENVIRONMENTAL IMPACTS

The tank waste currently is stored in 177 underground tanks and 60 smaller miscellaneous underground storage tanks. The cesium and strontium capsules are stored in the Waste Encapsulation and Storage Facility. The cost of continuing to store the tank waste and cesium and strontium capsules is high, and the storage facilities are becoming less reliable with age. Some of the single-shell tanks have leaked contaminants into the surrounding soil and, based on historical data, one additional tank begins to leak each year. In response to these conditions and the requirements of applicable regulations, DOE, Ecology, and EPA have entered into the Tri-Party Agreement, an enforceable strategy to dispose of the tank waste. DOE, Ecology, and EPA have developed an overall plan for remediation, which is identified in the Tri-Party Agreement. This plan and the full range of reasonable alternatives are analyzed in the EIS.



Each of the alternatives described in Section S.5 involves some trade-off among the 1) risk of failure of a component of the alternative to function adequately due to technical uncertainties; 2) short-term human health and environmental impacts during remediation activities ; 3) long-term human health and environmental impacts after remediation activities ; and 4) compliance with laws, regulations, and policies (Figure S.6.1). An understanding of these factors is important to an understanding of the comparison of alternatives presented in Section S.7.

Figure S.6.1 Factors Influencing Evaluation of Alternatives

S.6.1 Uncertainty

Uncertainties associated with the characteristics of the tank waste and technologies involved in some alternatives add a degree of complexity to the calculation of environmental impacts.

The tank waste contains a complex mix of chemical and radiological constituents that is constantly changing as chemical reactions and radioactive decay occur. The contents of each tank are not fully characterized ; however, there is a better understanding of the contents of the tank system as a whole. Considerable historical data on the tank contents are available and have been used to estimate the contents. These historical data provide a basis for an overall tank waste inventory and are compiled from invoices of chemical purchases and records of waste transfers and processing. Historical tank content estimates have been completed for the double-shell tanks and solid waste in the single-shell tanks.



There is an ongoing waste characterization program to better determine the contents of each tank through analyses of samples to help resolve safety issues and support design decisions for remediation. However, this program will not be complete for many years. The lack of detailed characterization information on a tank-by-tank basis adds a level of uncertainty to certain aspects of the tank waste remediation project.

In addition, certain technologies that may be used to remediate the waste have not been performed, have not been applied at the scale necessary for this project, or have not been previously applied to this type of waste. For example, there are uncertainties with the application of in situ vitrification on a scale necessary to remediate the tank waste and the effectiveness of certain high-level and low-activity waste separations processes. The level of uncertainty involved with each alternative is described in Section S.7.0. Extensive research and some testing have been performed in recent years to reduce the level of uncertainty, but a level of uncertainty will remain until additional performance data are available.

To account for these uncertainties, the analyses in the EIS are based on waste characterization, retrieval, and processing data and calculations that provide a conservative analysis of the impacts likely to occur and thus bound the impacts of the alternatives.

S.6.2 Short-Term Impacts

The primary short-term impacts are potential health effects, disturbance of shrub-steppe habitat, and socioeconomic impacts during remediation activities .



Short-Term Potential Health Effects

Potential health effects would result from 1) occupational accidents; 2) occupational radiological exposure during operations; 3) radiological and chemical accidents; 4) nonradiological transportation accidents from deliveries of materials and supplies to the Site; and 5) radiological exposures and accidents during offsite shipments of high-level

waste.

Occupational accidents are injuries and fatalities to project workers, such as falls from ladders or twisted ankles, that occur at predictable rates. The number and severity of accidents are dependent on the type of activity and the number of labor hours spent performing the activities. Construction activities have the highest accident rates. Therefore, alternatives that would involve extensive construction labor hours would tend to have the highest number of occupational injuries and fatalities.

The alternatives would begin in 1997 and end in approximately 2100, including the administrative control period. All alternatives except the No Action alternative would involve extensive activities only during their construction and operations periods, which would be completed no later than 2040. Each of the alternatives would result in an estimated one to four occupational fatalities during remediation.

Occupational radiological exposures are the routine exposures received from working in proximity to radioactive sources. They would occur while managing the tank farms and performing remedial activities. Exposures are closely monitored, and the radiation dose a worker may receive is limited by law and Hanford Site administrative controls. Extensive historical data are available to calculate the doses radiological workers would receive, and there are standard methods for calculating the statistical probability of a person contracting cancer from a dose. Workers are informed of the potential risk before performing work and routinely informed of the doses they receive. The alternatives with the largest workforce of radiological workers, such as the extensive retrieval alternatives, would tend to have the highest risk of latent cancer fatalities. Each of the alternatives except the No Action, Long-Term Management, and In Situ Fill and Cap alternatives may result in one to three latent cancer fatalities from occupational exposures.

Radiological and chemical accidents are unexpected events that result in the release of radiological and chemical contaminants that may result in exposure to project workers, other nearby nonproject workers, or to the public if the release was large enough. The potential for radiological and chemical accidents would be analyzed extensively for each component of the design during the final design phase of the project and engineering or administrative controls would be incorporated into the design and operating procedures to reduce the probability of serious accidents to an acceptable level. Even with these controls in place, accidents could occur, although the probability of occurrence would be low. Radiological and chemical accidents and their potential consequences are specific to the types of activities being performed. They include accidents such as potential spray releases during the transfer of waste in the cross-site transfer line and breakdown in the air filtration system s .

Because of the uncertainties involved with the tank waste characterization data and the conceptual nature of the designs, a bounding approach to estimating accident consequences was taken in the EIS. Conservative estimates were made for the type and amount of contaminants that would be released and how they could be transported in the atmosphere to expose workers and the public.

Potential health risks were calculated for the maximally-exposed individual and the population as a whole for both the workforce and the offsite public. The probability that the accident would result in a latent cancer fatality due to radiological or chemical exposure was calculated, as well as potential health effects from exposure to chemicals. The potential health effects are multiplied by the calculated probability that the accident would occur (the point estimate) to present a measure of the health risk to the project workers, nearby Site workers, and the public.

The accident with the most severe potential health impacts for each of the alternatives is an energetic hydrogen gas fire in a tank. At least 25 tanks currently are estimated to be generating hydrogen gas in sufficient quantities to cause an energetic fire if ignited. DOE is carefully managing these tanks through extensive monitoring and by ventilating the tanks to allow the hydrogen to escape and thereby prevent the build up of hydrogen to concentrations that can ignite. DOE also has installed a mixer pump in the tank generating the most hydrogen to further facilitate the gradual release of hydrogen. However, there is a possibility that an energetic hydrogen gas fire could occur.

If the energetic hydrogen gas fire accident were to occur, there is the potential for up to 22 latent cancer fatalities including 20 Site workers and 2 offsite members of the general public from direct radiation and inhalation of radioactive contaminants. This is a conservative estimate based on bounding tank inventory and meteorological conditions and does not account for evacuation of the potentially affected people, which would greatly reduce the

potential health effects.

The longer the waste remains in the tanks, the higher the probability that an energetic hydrogen gas fire would occur. Because the No Action and Long-Term Management alternatives would leave the waste in the tanks for at least 100 years, the probability of an energetic hydrogen gas fire would be greatest for these two alternatives. The probability of occurrence for these two alternatives over a 100-year period would be a relatively high 0.72. When this number is multiplied by the number of latent cancer fatalities (22 fatalities) that would occur, the point estimate would be 16 latent cancer fatalities. Using this same method of deriving point estimates results in a total number of latent cancer fatalities for the other alternatives of between two and five. These lower numbers result from the fewer number of years before the tanks would be remediated. Calculations were also performed using a less conservative tank inventory (average tank inventory), referred to as the nominal case. These results showed approximately 100 times fewer health effects for the nominal case for each of the alternatives.

Nonradiological transportation accidents are the injuries and fatalities resulting from both rail and truck accidents. The transportation scenarios analyzed include transportation of building and operating materials. The incidence rates for injuries and fatalities were based on U.S. Department of Transportation statistics, Washington State highway accident reports, and Hanford Site statistics. The total number of transportation fatalities would be none to two fatalities for all of the alternatives.

High-Level Waste Transportation Impacts

The partial retrieval and extensive retrieval alternatives would involve the shipments of treated high-level waste offsite for disposal at a national geologic repository. These shipments would be by dedicated trains, and the high-level waste would be packaged in transportation casks that would provide shielding from the radiation being emitted from the high-level waste. Routine exposures from the shipment of high-level waste would not result in any latent cancer fatalities under any of the alternatives. Calculations show that no latent cancer fatalities would occur from an accident involving shipments of high-level waste.

Shrub-Steppe Habitat Disturbance

The extent of disturbance of shrub-steppe habitat is dependent on the size of surface disturbance for construction of facilities. In the 200 Areas, where most of the remediation activities addressed in this EIS would occur, most of the land has been disturbed previously by the construction of roads, processing facilities, pipelines, and other facilities associated with the production of plutonium and waste management. However, all of the alternatives except the No Action alternative would result in the disturbance of some shrub-steppe habitat. The amount of habitat lost would range from 44 hectares (57 acres) for the In Situ Fill and Cap alternative, to 70 to 140 hectares (170 to 340 acres) for the extensive retrieval alternatives. The sensitive wildlife species that inhabit this area also would be displaced. For all alternatives, the total disturbance of shrub-steppe habitat would be less than 1 percent of the shrub-steppe habitat on the Central Plateau. DOE would implement a mitigation plan to replace the loss of critical habitat to partially offset these impacts.



Socioeconomic Impacts

The socioeconomic impacts would be an indirect result of changes in the Hanford Site employment due to remediation, which is dependent on the size and complexity of the facilities constructed and the length of time the facilities are operated. The workforce required to implement each alternative at the Hanford Site would generate indirect impacts such as new jobs, population growth, and demands for public facilities and services (e.g., schools) in the Tri-Cities as well as traffic congestion and accidents, including fatalities. These impacts are dependent on the level of employment estimated for each alternative. Therefore, the alternatives that involve larger workforces, such as the extensive retrieval alternatives, would have the greatest level of socioeconomic impact. All of the alternatives except the No Action alternative would create new jobs at the Hanford Site. Peak employment typically would occur during the construction phase for each alternative except No Action. The extensive retrieval alternatives would involve the highest levels of

peak employment, ranging from 4,000 to 6,700 jobs.

New jobs created under each alternative would have impacts on the Tri-Cities economy. A large number of jobs would be created over a short period of time under the extensive retrieval alternatives, which would result in a boom-bust cycle that could adversely impact the Tri-Cities economy.

S.6.3 Long-Term Impacts

Potential long-term impacts are addressed from 100 years in the future to 10,000 years into the future. The primary long-term impacts would be groundwater contamination and the potential health effects associated with consumption of the groundwater, potential health effects resulting from post-remediation intruders and accidents, and restrictions on land use.

Groundwater

Groundwater is the principal pathway for humans to be exposed to contaminants from the waste after remediation. Contaminants could reach the groundwater from releases during retrieval of the tank waste, releases from residual materials left in the tanks after remediation, and releases from immobilized waste in the onsite low-activity waste vaults (Figure S.6.2).

Liquids have leaked from some of the single-shell tanks because the tanks have corroded. The amount of liquids within the single-shell tanks currently are being reduced through pumping much of the liquids out of the tanks and transferring the liquids to the double-shell tanks, a process called saltwell pumping.

Liquids are expected to be released from the single-shell tanks during the implementation of any alternative that includes removing the waste from the tanks. These releases could occur because the principal retrieval method involves using large quantities of liquids to dissolve and suspend the solids in the tanks so they could be pumped to the surface for treatment, a process called sluicing. Measures would be incorporated to control the sluicing liquid as much as possible. No leaks would be expected during retrieval from the double-shell tanks because they have a second shell to contain any leaks.



Another method of retrieval involves the use of an articulated arm to reach into the tanks and recover waste. This process, which would be used to retrieve the waste that is the most difficult to recover, involves spraying liquid at high pressures in a localized area using less water and providing better liquid control than sluicing. This technology would reduce the amount of leakage. Other measures could be implemented to minimize or contain retrieval leaks through the use of subsurface barriers and leak collection systems.

[Figure S.6.2 Groundwater Pathways by Alternative](#)

Releases of contaminants also would occur after remediation as water from precipitation slowly moves through the earthen surface barriers placed over the tanks, dissolves contaminants from the residual waste left in the tanks, and slowly carries the contaminants through the soil and into the groundwater, which occurs at 70 to 90 meters (230 to 300 feet) below the tanks.

This is a long-term process, and hundreds to thousands of years may be required to leach the contaminants into the groundwater depending on which alternative is selected. Some contaminants, such as technetium, would be leached more easily than others and would enter the groundwater more quickly than slower-moving contaminants. The amount and rate at which contaminants would enter the groundwater is dependent on how much waste is left in the tanks and whether the contaminants had been processed into a more stable waste form, referred to as immobilization, and whether an earthen surface barrier had been placed over the waste. An immobilized waste form, such as a vitrified waste (waste turned into glass) would release contaminants at a very slow rate over a long period of time. An earthen surface barrier also would limit infiltration of precipitation into the waste, which would reduce the rate at which

contaminants would reach groundwater.

All of the alternatives except the No Action and Long-Term Management alternatives would include an earthen surface barrier to limit infiltration of precipitation into the residual that would remain in the tanks. All alternatives except the No Action, Long-Term Management, In Situ Fill and Cap, and the Ex Situ/In Situ Combination 1 and 2 alternatives would involve immobilizing all of the waste that would remain onsite except the residual waste that could not be recovered from the tanks.

Contaminants also would be leached from the near-surface low-activity waste disposal vaults by the same process described for the tank residuals. However, because many of the radionuclides would be removed from the waste during the separations process and because the waste would be in an immobilized form, the rate of leaching of contaminants would be very slow, and therefore the amount of contaminants that would reach the groundwater would be small. Also, the greater the level of separations performed and the greater the effectiveness of the immobilization process, the lower the level of contamination in the groundwater. The vaults also would be covered with an earthen surface barrier to inhibit infiltration of precipitation. In general, for the alternatives that would involve the use of low-activity waste disposal vaults, the amount of contamination in the groundwater from the immobilized waste in the near-surface low-activity waste disposal vaults would be up to 100 times less than the contamination that would result from leaks during retrieval and leaching of the residuals in the tanks.

Once contaminants reached the groundwater they would move relatively quickly, and in approximately 25 to 50 years, they would discharge into the Columbia River where they would be rapidly dispersed. The EIS analyzes all of these potential mechanisms for each alternative, analyzes potential exceedances of groundwater standards, and presents the potential human health impacts associated with consumption of the groundwater.

Recent improvements in monitoring well logging techniques have resulted in the identification of cesium-137 and other contaminants at depths greater than previously anticipated, as discussed in Section S.3. This means that some of the contaminants that were expected to move very slowly downward towards the groundwater have moved more quickly than previously anticipated. The mechanisms for how these contaminants moved more quickly than anticipated are not fully understood. The mechanisms for transport through the soil and rock beneath the tanks could have occurred by one or more physical or chemical processes. The physical processes include flow down preferential flow paths such as sand lenses, unsealed monitoring wells, or leaks of large volumes of liquids that could drive the contaminants downward. The chemical processes that could enhance the mobility of contaminants include various chemical reactions that may affect the chemical nature of the contaminants, allowing them to be more readily released from the waste or inhibit the ability of the soils to retard the downward movement of the contaminants.

Groundwater assessments for the Resource Conservation and Recovery Act have been implemented at the following five tank farms: B, BY, BX, S, and SX. The most recent tank farms to under go the Resource Conservation and Recovery Act groundwater assessment are the S and SX Tank Farms. These assessments will provide more information on the extent of contaminants in the subsurface soils. DOE also has implemented a program and convened a panel of experts to determine the mechanism(s) for this transport. Depending on a determination of which mechanisms are responsible for the transport, additional measures may need to be taken during closure of the tank farms to reduce the releases of contaminants from the residual waste. DOE is also considering measures to reduce water infiltration around the tanks to reduce the potential for the contaminants to be transported downward in the near future.

There is a substantial amount of uncertainty in estimating the levels of contaminants in the groundwater over the 10,000-year period of analysis. Changes in climate and land uses as well as the performance of the earthen surface barriers and the immobilization technologies could all affect the calculated levels of contamination and their distribution. Also, additional remediation could be determined to be necessary during closure, which would reduce the releases of contaminants into the groundwater. The groundwater impacts described below should also be considered in the context of groundwater contamination from other Hanford Site activities, as discussed in Section S.3.

The No Action and Long-Term Management alternatives would result in by far the highest and fastest contamination of the groundwater because the waste would not be retrieved or immobilized, and an earthen barrier would not be

placed over the tanks (Figure S.6.2). The fastest moving contaminants would reach the groundwater in approximately 130 years. Maximum concentrations would be reached in approximately 210 years and then gradually decrease over several thousands of years.

The In Situ Fill and Cap and Ex Situ/In Situ Combination 1 and 2 alternatives would result in the next highest levels of groundwater contamination because the solid waste would remain in some or all of the tanks, and the waste would not be immobilized. The contaminants would not reach the groundwater for approximately 2,300 years for the In Situ Fill and Cap alternative and approximately 1,100 years for the Ex Situ/In Situ Combination 1 and 2 alternatives. The earlier arrival of contaminants for the Ex Situ/In Situ Combination 1 and 2 alternatives is due to the releases calculated to occur during retrieval. Contaminants resulting from each of the alternatives would reach maximum concentrations in approximately 5,000 years and then decrease slowly over many thousands of years. All of the extensive retrieval alternatives would have approximately the same maximum concentrations of contaminants because most of the contamination would come from releases during retrieval or from the tank residuals, which would be the same for all alternatives. This maximum concentration would be lower than any of the other alternatives except the In Situ Vitrification alternative. The contaminants would not reach the groundwater for approximately 1,000 years, would reach a maximum concentration in approximately 5,000 years, and would then decrease slowly over many thousands of years.



The In Situ Vitrification alternative would result in the lowest levels of contamination if the in situ vitrification technology functioned effectively. The contaminants would not reach the groundwater for approximately 2,400 years and would remain relatively constant for many thousands of years.

Potential Health Effects

The long-term health effects are dependent on the rate of release to the environment of any contaminants that would remain onsite, how the contaminants would be transported through the environment, and how humans and ecological resources would be exposed to the contaminants. The only anticipated post-remediation pathway would be through consumption of contaminants that may enter the groundwater as previously described.

Because the groundwater discharges to the Columbia River within the Hanford Site, a person would need to be on the Site and consume groundwater or plants irrigated with groundwater, or be exposed to contaminants from the groundwater that would seep into the Columbia River along its banks within the Site boundary. Contaminants reaching the Columbia River would quickly disperse to extremely low levels as they entered the river and would present an extremely low potential health risk. Releases to the groundwater would occur over many thousands of years, so the potential human health risk also would occur over many thousands of years. The EIS presents the risk to several different potential users of the land at various points in time to 10,000 years from the present and the total number of fatalities that could result over the 10,000-year period of analysis from the implementation of each alternative under one potential future use scenario.

The potential post-remediation site users addressed in the EIS are the residential farmer, industrial worker, recreational user of the Columbia River, Native American user, and downstream users of the Columbia River.

All of these exposure scenarios, except the Native American scenario, are derived from the Hanford Site Risk Assessment Methodology, which is the DOE, Ecology, and U.S. Environmental Protection Agency accepted method for calculation of health risks. DOE also has included a Native American exposure scenario in an analysis of potential long-term health effects. This scenario was developed from the Columbia River Comprehensive Impact Assessment, which was modified at the request of and in consultation with the potentially affected Tribes. This scenario is in its initial stages of development and has not received a complete review by the scientific community, nor has it been approved by the potentially affected Tribes. Therefore, this scenario should be considered preliminary and may have more uncertainty associated with it than the other scenarios. However, the scenario does provide a bounding assessment of the potential health effects to a Native American who might inhabit the Site in the future and engage in both subsistence lifestyle activities (e.g., hunting, fishing, and using sweat lodges) and contemporary lifestyle activities

(e.g., irrigated farming).

The long-term risk of contracting cancer for the potential onsite farmer, industrial worker, recreational user, and Native American user would be high for the No Action and Long-Term Management alternatives: up to a 1 in 2 chance for the onsite farmer, up to a 1 in 10 chance for the industrial worker, up to 1 in 100 chance for the recreational user, and up to 1 in 1 chance for the Native American user. The risk would be less but still relatively high for the In Situ Fill and Cap and Ex Situ/In Situ Combination 1 and 2 alternatives: up to a 4 in 1,000 chance for the onsite farmer, up to a 1 in 1,000 chance for the industrial worker, up to a 1 in 10,000 chance for the recreational user, and up to a 5 in 100 chance for the Native American user. The risk for the extensive retrieval alternatives and the In Situ Vitrification alternative would be relatively low compared to the other alternatives: up to a 3 in 10,000 chance for the onsite farmer, up to a 1 in 10,000 chance for the industrial worker, up to 1 in 100,000 chance for the recreational user, and up to a 4 in 1,000 chance for the Native American user.

An assessment was prepared of the total latent cancer fatalities that could occur over 10,000 years for each of the exposure scenarios. These calculations are based on assumptions and represent one of many possible scenarios representing long-term risk. The uncertainties associated with these calculations are high and the National Council on Radiation Protection cautions that the application of low risks to large populations over long periods of time has large inherent uncertainties and is a poor indication of true risk. Therefore, the 10,000-year population exposure scenarios presented in this EIS should be used to assess the relative relationship between alternatives and not considered a measure of absolute risks. If farming on the Hanford Site were to occur, the No Action and Long-Term Management alternatives may result in 600 fatalities to onsite farmers over 10,000 years. The In Situ Fill and Cap and Ex Situ/In Situ Combination 1 and 2 alternatives may result in 300 and 60 fatalities, respectively, to onsite farmers over 10,000 years. The other alternatives may result in 1 to 10 fatalities to onsite farmers over 10,000 years. The industrial worker and recreational user scenarios would result in much fewer fatalities, and the Native American user scenario would result in 2 to 4 times more fatalities than the onsite farmer scenario.

The potential health risks to the users of the Columbia River also were calculated. The total number of fatalities over 10,000 years was calculated for an estimated population. Uses of the Columbia River that were analyzed included fishing, boating, swimming, irrigating crops, and drinking water. The total number of fatalities calculated for the 10,000-year period ranges from 0 to 30 to downstream users of the Columbia River. The In Situ Fill and Cap alternative is calculated to have the highest number of health effects because the leaching of contaminants occurs later when the downstream population is projected to be much greater.



These risks should be considered in the context of contamination from other Hanford Site activities. As discussed in Section S.3, the groundwater currently contains high levels of numerous contaminants, and there are additional contaminants within soil that would be transported slowly to the groundwater. The potential impacts from the Tank Waste Remediation System alternatives must be evaluated within the context of the current contamination and plans for remediation and long-term use of the Site. Also, additional measures could be taken to reduce the impacts to groundwater during closure of the tank farms, which will be addressed in a future NEPA analysis.

Land Use

The contaminants in the tanks and groundwater would persist for many thousands of years, and the ability to ensure that administrative controls would be maintained over this length of time is not certain. Under all of the alternatives, some waste would be left onsite, which would preclude using a portion of the 200 Areas for any purpose except waste management and disposal for thousands of years. Permanent markers (stone monuments) would be placed around any waste left onsite to warn people of the hazards associated with disturbing the site. The 200 Areas of the Hanford Site have been identified as potential exclusive use areas for waste management activities, and DOE will maintain administrative controls of these areas for the foreseeable future.

The groundwater contamination that would result from each of the alternatives would occur under much of the Hanford Site north and southeast of the 200 Areas for many thousands of years. Use of the land surface over these areas would

not present a human health risk from the Tank Waste Remediation System waste, but use of the groundwater from this area or use of the Columbia River shoreline would result in varying degrees of human health risk depending on which alternative is implemented.

It is not certain that restrictions on groundwater use could be maintained over thousands of years, and it is assumed that people eventually would move onto the Hanford Site and use the contaminated groundwater for residential, industrial, and agricultural purposes. Therefore, the risk from consuming groundwater within the Site boundary would be expected to exist over a long period of time.

Generally, a health risk greater than 1 chance in 10,000 of contracting cancer is considered high, and restrictions may be necessary on areas that exceed this level. Based on this criteria, use of portions of the Hanford Site for farming and industrial purposes would need to be restricted for the No Action, Long-Term Management, In Situ Fill and Cap, and Ex Situ/In Situ Combination alternatives. Traditional Native American uses of the land could occur but use of the groundwater would need to be restricted. Use of the Site for farming or industrial purposes would result in a risk near the 1 chance in 10,000 criteria for all other alternatives except for the In Situ Vitrification alternative, which would result in a risk of up to 6 chances in 100,000.

Use of the southern shoreline of the Columbia River would exceed the criteria of the 1 chance in 10,000 of contracting cancer for the No Action and Long-Term Management alternatives. The risk to the recreational user would be near the 1 chance in 10,000 criteria for the In Situ Fill and Cap alternative. None of the other alternatives would exceed this criteria for using the Columbia River shoreline. The maximum risk levels would occur within approximately 300 years for the No Action and Long-Term Management alternatives, but would not occur for approximately 5,000 years for the other alternatives.

Post-Remediation Intruders and Accidents

There are two ways that humans could be exposed to contaminants after the administrative control period other than consuming contaminants in the groundwater or being exposed to contaminants along the Columbia River shoreline. They include intruders into waste that remains onsite and accidents that could occur from natural causes if the waste was not disposed of securely and permanently.

Intruders are persons who ignore warning signs and permanent markers and go to great effort to gain access to the waste. The EIS analyzes the impacts that would occur from the most likely intruder scenario. This scenario is someone who drills a well into the waste remaining onsite after remediation and spreads the contaminants encountered during drilling on the ground surface. Potential health impacts were analyzed for the driller and a person who might use the contaminated Site as a residence after drilling the well.

The severity of the potential health impacts depends on the amount of waste brought to the surface and whether the waste has been immobilized. The potential risk for an intruder would be high for all of the alternatives with a range of 5 chances in 100 to 5 chances in 10,000 of contracting cancer. The risk is highest (5 chances in 100) for the alternatives that involve leaving the waste in the tanks without immobilizing the waste : the No Action, Long-Term Management, and In Situ Fill and Cap alternatives.

Potential post-remediation accidents could occur from earthquakes or other natural events if sufficient measures are not taken to ensure the waste that remains onsite is permanently isolated and disposed of securely. The only natural event with a credible probability of impacting remediated waste within 10,000 years would be an earthquake. Seismic activity in the Hanford Site area is low compared to other regions of the Pacific Northwest, and there are few active faults on or near the Site. Regional seismic stresses are low and are estimated to result in a maximum of 0.06 millimeters/year (0.002 inches/year) structural displacement over the entire Columbia Plateau. Although rare and low in magnitude, earthquakes in the area will occur.



For the No Action and Long-Term Management alternatives, the potential effects of an earthquake could be severe. The tank waste would not be stabilized under these alternatives, and the tank domes would lose their structural

integrity over time and become less stable. At some point, which cannot be accurately calculated, the tank domes would collapse into the tanks. The initiating event could be an earthquake. If this were to occur, there would be an immediate release of relatively high levels of contaminants and continued releases at much lower levels until the waste was covered with earth by natural forces. The releases could be transported through the atmosphere, and the potential health effects to persons onsite and offsite could be catastrophic, with up to 200 fatalities from chemical or radiological exposures.

Another way that natural events could impact the waste after remediation would be from an explosion in the tanks. The tank waste currently generates flammable gases such as hydrogen. Although much of the gas is generated from a small number of tanks, nearly all of the tanks generate some flammable gas. Any waste left onsite that is not adequately immobilized would continue to release flammable gases after remediation. If these gases accumulate in sufficient quantities and in the necessary concentrations, they could be ignited by a natural event such as an earthquake. This could result in a fire or perhaps detonation within the tanks. The tanks would be covered with a minimum of 6.4 meters (21 feet) of earth (existing soil and the Hanford Barrier), so the most likely result would be a disruption or cracking of the Hanford Barrier, which potentially would increase the infiltration of precipitation and leaching of contaminants into the groundwater. The rate at which these gases are generated is decreasing and will continue to decrease over time, so the probability of this accident will decrease with time.

This potential post-remediation accident is more likely for the In Situ Fill and Cap alternative and the fill and cap portion of the Ex Situ/In Situ Combination 1 and 2 alternatives because large amounts of waste would be left in the tanks. This potential accident could be mitigated effectively by providing a mechanism for the gases to vent into the atmosphere. This is not a credible accident for the extensive retrieval or the In Situ Vitrification alternatives .

S.6.4 Regulatory Compliance

Section S.4 summarizes the laws, regulations, and policies applicable to remediating the tank waste and cesium and strontium capsules. NEPA requires that EISs address the full range of reasonable alternatives, including alternatives that would not be in compliance with laws and regulations. A number of the alternatives addressed in the EIS would not be in compliance with the agreements contained in the Tri-Party Agreement, would not meet the land disposal restrictions under the Resource Conservation and Recovery Act and may not meet DOE policy for disposal of high-level waste. If an alternative was selected that did not meet certain regulatory requirements, changes in policy, waivers of requirements from regulatory agencies, or changes in laws by Washington State or Congress would be necessary before that alternative could be implemented.

Environmental Justice

An environmental justice analysis was performed to assess whether the TWRS alternatives could cause disproportionately high and adverse human health or environmental impacts on minority, Native American, or low-income populations. The analysis involved 1) a demographic analysis of the area potentially impacted by TWRS actions within an 80-kilometer (50-mile) radius of the Hanford Site; 2) a review of the impacts for each area of analysis presented in the EIS to determine if any adverse impacts on minority, Native American, or low-income populations would occur, and 3) a determination, if an adverse impact were identified, as to whether the impact would be disproportionately high.

Two areas of potentially disproportionate and adverse impacts were identified. These impacts include 1) potential increases in housing prices under some alternatives, which could adversely impact access to affordable housing by low-income populations; and 2) continued restrictions on access to portions of the 200 Areas while impacting all individuals, could have a higher adverse effect on the Tribal Nations that have expressed an interest in access to, and unrestricted use, of the Hanford Site.

The EIS analyzes potential post-remediation human health risks under various land-use scenarios. This assessment of risk indicates that under the closure scenario analyzed in the EIS for the purpose of comparing alternatives, post-remediation risks would be highest under the preliminary Native American scenario. The method used to develop this alternative is discussed in the previous section. Implementation of the No Action and Long-Term Management

alternatives and all of the in situ alternatives would preclude clean closure or modified clean closure of some or all of the tanks. For all these alternatives except In Situ Vitrification, post-remediation health risks under the Native American scenario would be disproportionately high and adverse for Native American users of the Site compared to other future Site users. For the alternatives involving extensive retrieval of waste from all of the tanks, closure options that would reduce risks beyond those presented in the EIS would not be precluded. Therefore, future NEPA analysis would address risks associated with various closure alternatives to determine if any particular closure alternative would result in potential disproportionately high and adverse impacts to minority Native American, Tribal Nation, and low-income populations. If restrictions were placed on future use of the groundwater there would be no disproportionately high and adverse impacts on any minority, Native American, or low-income populations under any of the alternatives.

S.7 COMPARISON OF ALTERNATIVES

This section provides a comparison of the primary human health and environmental impacts associated with each of the alternatives.

S.7.1 Tank Waste Alternatives

All of the alternatives would have similar short-term potential health effects including a calculated one to four occupational fatalities; none to two fatalities from transportation of materials and supplies to the project; no latent cancer fatalities from accidents involving transportation of high-level waste to a potential geologic repository; none to three latent cancer fatalities from routine radiation exposures to workers during operations; and no latent cancer fatalities from routine exposures during shipments of high-level waste to a potential geologic repository. The only major difference in short-term health impacts between the alternatives is that the No Action and Long-Term Management alternatives would have a higher potential for a hydrogen gas fire because the waste would not be remediated. Overall, the minimal retrieval alternatives would result in slightly fewer health impacts during remediation than the extensive retrieval alternatives. The continued management alternatives would have the highest groundwater quality impacts of any of the alternatives after the assumed loss of institutional control. Tables S.7.1 through S.7.6 provide an overall comparison of the tank waste alternatives.

[Table S.7.1 Potential Short-Term Health Effects](#)

[Table S.7.2 Potential Short-Term Environmental Effects](#)

[Table S.7.3 Potential Long-Term Health Effects](#)

[Table S.7.4 Intruder and Post-Remediation Accident Health Effects](#)

[Table S.7.5 Potential Long-Term Environmental Effects](#)

[Table S.7.6 Regulatory Compliance, Technical Uncertainties, and Cost](#)

Continued Management Alternatives

These alternatives would involve the continued management of tank waste and would not include remediation (Figure S.7.1). For the purpose of analysis, a 100-year period of continued management was assumed after which the tanks would be abandoned.

The current tank waste storage practices do not meet hazardous waste storage regulations, and continued storage would not comply with these regulations. Leaks from the tanks are occurring and would continue to occur. The estimated short-term cost would be low compared to all other alternatives, up to \$230 million per year on an annualized average basis.



Continued management would allow time for development of additional waste treatment technology, if determined to be needed. After the 100-year duration of these alternatives, DOE still would need to determine how to remediate the waste, and the environmental impacts and cost associated with future remediation would be incurred at a later time.

If DOE did not remediate the tank waste, the long-term impacts would involve the addition of contamination to the groundwater in concentrations that would greatly exceed drinking water standards within 300 years, resulting in high potential health effects (latent cancer fatalities) to future users of the Site. Eventually, the tank domes would collapse causing high levels of contaminant releases and severe potential health impacts.

The No Action alternative would result in high long-term risks to potential future users of the Site. The maximum risk of contracting cancer would be 1 in 2 for an onsite farmer, 1 in 10 for an industrial worker, 1 in 100 for a recreational user of the Columbia River and 1 in 1 for the Native American user. These high risk levels would occur within 300 years and decrease slowly over many thousands of years. The tank domes would lose their structural integrity and eventually fail. If they all were to fail at the same time in response to a natural event such as an earthquake, up to 200 fatalities could occur from radiological and chemical exposures.

Implementation of this alternative would not enable DOE to comply with the waste management and land disposal restrictions of the State Dangerous Waste Regulations (including the Resource Conservation and Recovery Act requirements), and DOE's policy for disposal of readily retrievable high-level waste, and would be inconsistent with the planned disposal of other high-level waste in a geologic repository. Implementation of this alternative also may require changes in the requirements for the disposal of high-level radioactive waste. This alternative would cost an estimated \$13 to 16 billion over a period of 100 years.

Long-Term Management Alternative

This alternative is identical to the No Action alternative, except that two activities would be performed to improve the regulatory compliance status of the waste storage; upgrading the intra- and inter-tank farm waste transfer system, and replacing double-shell tanks twice during the assumed 100-year duration of the administrative control period to prevent the release of large volumes of liquid to the environment from the double-shell tanks. No waste remediation would be performed under this alternative. Similar to the No Action alternative, this alternative would result in severe long-term impacts on public health and the environment. The Long-Term Management alternative would result in high long-term risk to potential future users of the Site. The maximum risk of contracting cancer would be 1 in 3 for an onsite farmer, 1 in 10 for an industrial worker, 1 in 100 for a recreational user of the Columbia River, and 1 in 1 for the Native American user. These high risk levels would occur within 300 years and decrease slowly over many thousands of years. The impacts on groundwater and associated potential health effects would be nearly identical to the No Action alternative. The tank domes eventually would fail, and up to 200 fatalities would occur from radiological and chemical exposures.

This alternative would result in improved compliance with the near-term waste management requirements of the State Dangerous Waste Act (including the Resource Conservation and Recovery Act requirements) but, in the long term, implementation of this alternative would not enable DOE to comply with the land disposal restrictions of the State Dangerous Waste Regulations (including the Resource Conservation and Recovery Act requirements) and DOE's policy for disposal of readily retrievable high-level waste, and would be inconsistent with the planned disposal of other high-level waste in a geologic repository. Implementation of this alternative also may require changes in the requirements for the land disposal of high-level radioactive waste. This alternative would cost an estimated \$19 to 23 billion over a period of 100 years.

Minimal Retrieval Alternatives

Under the minimal retrieval alternatives, only liquid waste would be retrieved from the tanks (Figure S.7.2). The liquid waste would be concentrated in an evaporator and the solids would be returned to double-shell tanks. All solid waste and liquid waste that could not be readily retrieved would be disposed of in situ in the tanks. The issues associated with the minimal retrieval alternatives are 1) their ability to adequately protect the groundwater; 2) their ability to comply with Federal and State laws and regulations concerning the disposal of high-level waste and hazardous waste;

and 3) uncertainties regarding the effectiveness of the technologies.

In general, the short-term and long-term impacts of the minimal retrieval alternatives would fall between those of the continued management alternatives and the extensive retrieval alternatives. The primary exception is the impact on groundwater, which differs greatly between the two minimal retrieval alternatives. Based on the generic closure method assumed (placement of earthen surface barriers), the analysis indicates that the groundwater would become more contaminated for the In Situ Fill and Cap alternative than for the In Situ Vitrification alternative. Final closure actions to be addressed in a future closure plan could result in additional actions to protect the groundwater.



In Situ Fill and Cap Alternative

This alternative includes removing the readily retrievable liquids from the tanks, filling the tanks with gravel, and placing an earthen barrier over the tanks. This alternative would involve few short-term impacts other than the relatively low level of fatalities from accidents and routine radiological exposures described previously. The long-term release of contaminants to the groundwater would be substantially lower than the continued management alternatives but relatively high compared to the other alternatives.

Contaminants would not reach the groundwater for approximately 2,300 years and would increase in concentration until approximately 5,000 years in the future, after which time they would slowly decrease. The In Situ Fill and Cap alternative would result in relatively high long-term risk to potential future users of the Site. The maximum risk of contracting cancer would be 1 in 100 for an onsite farmer, 3 in 1,000 for an industrial worker, 2 in 10,000 for a recreational user of the Columbia River, and 1 in 10 for the Native American user. These relatively high risks would not occur until approximately 5,000 years in the future and would decrease slowly over many thousands of years.

Implementation of this alternative would not enable DOE to comply with land disposal restrictions of the State Dangerous Waste Regulations (including the requirements of the Resource Conservation and Recovery Act requirements) and DOE's policy for disposal of readily retrievable high-level waste, and would be inconsistent with the planned disposal of other high-level waste in a geologic repository. Implementation of this alternative also may require changes in the requirements for licensing for the land disposal of high-level radioactive waste.

This alternative involves the application of common technology, which has a high probability of working effectively for most tanks. This alternative may not be appropriate for those tanks that generate high levels of flammable gases because of the potential for sparks causing a fire in the tanks while filling with gravel. This uncertainty may apply to 25 tanks or more. It is uncertain whether mitigation measures could be developed to prevent these fires. This alternative would involve the least estimated cost of any alternative, \$7 to 9 billion.

In Situ Vitrification Alternative

This alternative involves removing the readily retrievable liquids from the tanks and vitrifying (melting and forming a glass) the waste in-place in the tanks. The In Situ Vitrification alternative would involve few short-term impacts other than the disturbance of 44 hectares (110 acres) of shrub-steppe habitat and the relatively low level of fatalities from accidents and routine radiological exposures described previously.

[Table S.7.7 Impacts of Offsite Shipping of High-Level Waste to a Geologic Repository](#)

Contaminants would not reach the groundwater for approximately 2,300 years, and the concentrations would be low. The In Situ Vitrification alternative would result in relatively low long-term risk to potential future users of the Site. The maximum risk of contracting cancer would be 6 in 100,000 for an onsite farmer, 9 in 1 million for an industrial worker, 1 in 1 million for a recreational user of the Columbia River, and 4 in 10,000 for a Native American user.

A major issue associated with this alternative is the effectiveness of the in situ vitrification process. In situ vitrification has been performed on contaminated soil to a maximum depth of 9 meters (30 feet), but has not been used on the tank

waste or at the scale needed to vitrify the large (up to 18-meter [60-foot]-deep) tanks. In addition, it would be difficult to verify the effectiveness of this process because the waste least likely to achieve the necessary glass composition would be at the bottom of the tanks.

Implementation of this alternative would not enable DOE to comply with DOE's policy for disposal of readily retrievable high-level waste and would be inconsistent with the planned disposal of other high-level waste in a geologic repository. Implementation of this alternative would also require changes in the requirements for licensing for the disposal of high-level radioactive waste. This alternative would cost an estimated \$16 to 27 billion.

Partial Retrieval Alternatives

Ex Situ/In Situ Combination 1 and 2 Alternatives

The partial retrieval alternatives, Ex Situ/In Situ Combination 1 and 2, were developed to assess the impacts that would result if a combination of two or more of the tank waste alternatives were selected for implementation (Figure S.7.3).

Because the contents of each tank differ greatly in physical, chemical, and radiological characteristics, it may be appropriate to implement different alternatives for different tanks. There is a wide variety of potential combinations of alternatives that could be developed and a number of criteria that could be used to select a combination of alternatives for implementation.

Table S.7.8 Repository Costs and Total Alternative Costs

The Ex Situ/In Situ Combination 1 alternative was developed to bound the impacts that could result from a combination of alternatives, and it is intended to represent a variety of potential alternative combinations that could be developed to remediate the tank waste. This alternative is a hybrid alternative that combines some of the advantages of the In Situ Fill and Cap and Ex Situ Intermediate Separations alternatives into one alternative. Approximately half of the tank waste by volume (107 tanks) would be remediated in the same manner as in the In Situ Fill and Cap alternative, and the other half of the tank waste (that which contains the greatest amount of the contaminants that are readily transported in the groundwater and present the greatest long-term human health risk) would be remediated in the same manner as in the Ex Situ Intermediate Separations alternative.



The Ex Situ/In Situ Combination 2 alternative is similar to the Ex Situ/In Situ Combination 1 alternative except that waste from 25 tanks (30 percent of the waste by volume) would be retrieved and processed in the same manner as the Ex Situ Intermediate Separations alternative. The remaining 152 tanks (70 percent of the waste) would be remediated in the same manner as the In Situ Fill and Cap alternative.

The Ex Situ/In Situ Combination 1 alternative would result in relatively high long-term risk to potential future users of the Site. The maximum risk of contracting cancer would be 3 in 1,000 for an onsite farmer, 1 in 1,000 for an industrial worker, 1 in 10,000 for a recreational user of the Columbia River, and 4 in 100 for the Native American user. These relatively high risks would not occur for approximately 5,000 years from the present and then would decrease slowly over many thousands of years.

The Ex Situ/In Situ Combination 2 alternative would have long-term health effects that are up to 25 percent higher than the Ex Situ/In Situ Combination 1 alternative.

Implementation of these alternatives would not enable DOE to comply with the land disposal restrictions of the State Dangerous Waste Regulations (including the Resource Conservation and Recovery Act) and DOE's policy for disposal of readily retrievable high-level waste in a geologic repository, and would be inconsistent with the planned disposal of other high-level waste in a geologic repository. These alternatives also would be inconsistent with the national policy to dispose of high-level waste in a geologic repository. Implementation of this alternative also would require

changes in the requirements for licensing for the disposal of high-level radioactive waste.

There are no major technical uncertainties with the fill and cap portion of these alternatives, but the same technical uncertainties exist for the ex situ portion of the alternative as exist for the Ex Situ Intermediate Separations alternative. The Ex Situ/In Situ Combination 1 and 2 alternatives would cost an estimated \$22 to 27 billion and \$17 to 20 billion, respectively. This cost is substantially less than for the extensive retrieval alternatives.

Extensive Retrieval Alternatives

Overall, the extensive retrieval alternatives would result in higher short-term impacts than the other alternatives but would provide substantially greater protection of the groundwater and therefore, substantially fewer health risks to potential future users of the Site (Figure S.7.4). The extensive retrieval alternatives would involve 86 to 140 hectares (210 to 340 acres) of disturbance of shrub-steppe habitat, although this impact would be mitigated partially by a habitat replacement program. The extensive retrieval alternatives would involve the greatest levels of new employment (4,000 to 6,700 employees) during construction of facilities. These numbers of employees would cause indirect impacts such as a boom-bust cycle in the Tri-Cities, increased traffic congestion and traffic accidents, as well as strain on some social services (e.g., school and fire services).

The extensive retrieval alternatives would involve relatively low long-term risks to potential future users of the Site. The maximum risk of contracting cancer would be up to a 3 in 10,000 chance for an onsite farmer, a 1 in 10,000 chance for an industrial user, 1 in 100,000 chance for a recreational user of the Columbia River, and 4 in 1,000 for the Native American user.



The ex situ alternatives would result in the disposal of two types of waste on the Hanford Site : low-activity waste in disposal vaults and residuals in the tanks. The low-activity waste from processing the high-level waste would be disposed of in vaults and would meet all groundwater protection requirements. The residual waste remaining in the tanks is part of closure of the tank farms , which will be addressed when sufficient information is available to assess the environment impacts. However, for purposes of comparing alternatives, it was assumed that the tank residual waste would be disposed of in the tanks with a generic closure scenario; closure as a landfill. Using this closure scenario, the calculations show exceedances of the water quality protection requirements for the tank residuals. The specific closure plan for the tanks would be developed in the future following consultation with the regulators. Therefore, the ability to finally close the tanks in compliance with water quality protection requirements is dependent on the final closure plan to be developed.

The Nuclear Waste Policy Act, as amended, establishes the planning basis for the development of geologic repositories for disposal of high-level waste and commercial spent nuclear fuel. One of the requirements of the Nuclear Waste Policy Act is that the first geologic repository shall not accept in excess of 70,000 metric tons (77,000 tons) uranium or equivalent in the first repository prior to operation of a second repository. Within this capacity, 10 percent, or 7,000 metric tons (7,700 tons) heavy metal, has been set aside for disposal of DOE-owned spent nuclear fuel and high-level waste.

Based on the calculated waste loading of 20 percent, the Ex Situ Intermediate Separations and Phased Implementation alternatives may produce more high-level waste packages than the current planning basis for the Hanford Site's expected allocation at the geologic repository. The total number of waste packages could be accommodated at the first repository if the actual waste loading achieved is higher, the size of the repository is increased, or the defense waste portion of the repository is increased. The number of waste packages that would be produced under the Ex Situ No Separations alternative would greatly exceed the volume currently allocated to DOE in the first repository.

All of the extensive retrieval alternatives except for the Phased Implementation and Ex Situ Extensive Separations alternatives involve a moderate level of technical uncertainty. The Phased Implementation alternative has a lower level of technical uncertainty, and the Ex Situ Extensive Separations alternative has a moderate to high level of uncertainty due to the extensive number of separations processes, some of which have not been previously performed.

The uncertainties for the ex situ alternatives include 1) the effectiveness of the waste retrieval system and how much liquid may leak from the tanks during retrieval; 2) how effectively waste from multiple tanks can be blended to meet final waste specifications; and 3) the effectiveness of the processes for separating the waste into low-activity waste and high-level waste.

All of the extensive retrieval alternatives could be implemented with no changes to existing laws, regulations, and policies except for the calcination option of the Ex Situ No Separations alternative, which would not comply with the treatment requirements of the State Dangerous Waste Regulations (including the Resource Conservation and Recovery Act).

Ex Situ No Separations Alternative

This alternative would include vitrifying (melting the waste to form glass) or calcining (heating to temperatures below the melting point to form powder) all of the waste and shipping it to a potential geologic repository for disposal. This alternative would meet all regulatory requirements and would result in disposal of up to 99 percent of the waste offsite at a potential geologic repository. However, neither the vitrified waste form (soda-lime glass) nor the calcined waste form (compacted powder) would meet the current waste acceptance criteria for a geologic repository because the current waste acceptance criteria requires borosilicate glass, a more stable waste form than soda-lime glass or compacted powder. In addition, whether the waste is calcined or vitrified, the amount of waste generated would exceed the planned capacity allocated in the first potential geologic repository.

As previously discussed, there are technical uncertainties associated with the extensive retrieval alternatives; however, because this alternative does not involve separations, the technical uncertainties are fewer than those associated with the other extensive retrieval alternatives.

This alternative would cost an estimated \$ 59 to 75 billion. The Ex Situ No Separations (Vitrification) alternative has the largest estimated cost range due to the operating and disposal cost dependence on the number of high-level waste packages produced.

Ex Situ Intermediate Separations Alternative

This alternative would include performing the extent of separations necessary to produce a small volume of concentrated HLW for disposal at a potential geologic repository and a large volume of low-activity waste that would meet criteria for onsite disposal .

This alternative would meet all regulatory requirements and involve a moderate level of technical uncertainty as discussed under the extensive retrieval alternatives, with an added degree of uncertainty due to the unproven nature of the separations process. The separations process would be far less complicated than for the Ex Situ Extensive Separations alternative. This alternative would cost an estimated \$29 to 35 billion.

Ex Situ Extensive Separations Alternative

This alternative would include performing extensive physical and chemical separations to create the smallest volume and highest concentration of waste for offsite disposal at a potential geologic repository and the lowest concentration of low-activity waste for onsite disposal. This would require many different waste separations processes to achieve a high degree of separations. This alternative would meet all regulatory requirements.

This alternative would involve all of the technical uncertainties presented previously, and the additional uncertainties involved with the numerous and complex separations processes. This alternative would cost an estimated \$27 to 3 8 billion.

Phased Implementation Alternative (Preferred Alternative)

This alternative is similar to the Ex Situ Intermediate Separations alternative, except that a greater extent of separations

would be performed, and the alternative would be implemented in two distinct phases. The additional separations would include removal of technetium, strontium, and transuranic elements to reduce potential releases to the groundwater from the low-activity waste vaults and thereby enhance ground water protection . This alternative would meet all regulatory requirements.

A key aspect of this alternative is that it would be implemented in two phases, starting with a demonstration-scale facility, to reduce the financial risk associated with the technical uncertainties of the ex situ technologies. This phased approach also would allow DOE to use the lessons learned from the demonstration phase to improve the design, construction, and operations of the full-scale facilities constructed during Phase 2. This phased approach would reduce the financial risk of building large facilities before the processes are proven to be effective and could lead to more efficient and effective operations during Phase 2. This alternative would cost an estimated \$ 30 to 38 billion.

Basis for Identification of the Preferred Alternative

DOE and Ecology have identified the Phased Implementation alternative as the preferred alternative for the tank waste because it would provide a balance among key factors that influence the evaluation of the alternative; short-term impacts to human health and the environment, long-term impacts to human health and the environment, managing the uncertainties associated with the waste characteristics and treatment technologies, and compliance with laws, regulations, and policies.

The Phased Implementation alternative would permanently isolate the waste from humans and the environment to the greatest extent practicable and provide for protection of public health and the environment. A high percentage of the long-lived radionuclides would be disposed of offsite in a geologic repository. Releases of contaminants to the groundwater at the Hanford Site would be reduced to the greatest extent practicable. The waste disposed of onsite would be isolated from humans and the environment by immobilizing the low-activity waste and placing it in concrete disposal vaults covered with an earthen surface barrier to inhibit contaminants from reaching the groundwater, intrusion from plants and animals, and inadvertent intrusion by humans. Residuals left in the tanks would be reduced to the maximum extent practicable.

The Phased Implementation alternative also would allow DOE to obtain information concerning the uncertainties associated with waste characteristics and the effectiveness of the retrieval, separations, and vitrification technologies prior to constructing and operating full-scale facilities. This phased approach provides for the construction and operation of demonstration-scale facilities to obtain the needed process information before committing large capital expenditures for the full-scale facilities. Lessons learned from the demonstration phase would be applied to the full-scale phase, which may substantially improve the efficiency of operations of the second phase and reduce construction and operating costs.

As under all other alternatives, DOE would continue its policy of continually evaluating the issues associated with the Tank Waste Remediation System and its path forward as additional tank characterization data and process knowledge are obtained.

S.7.2 Cesium and Strontium Capsule Alternatives

None of the cesium and strontium capsule alternatives would result in substantial short- or long-term impacts to human health and the environment under nonaccident conditions. None of the alternatives would result in occupational fatalities or increased incidences of cancer or fatal chemical exposures. There would be low or no adverse impacts on surface water or groundwater, soil, air quality, transportation networks, noise levels, visual resources, biological resources, socioeconomic conditions, resource availability, or land use. There would be slight impacts on shrub-steppe habitat resulting in the loss of up to 1.8 hectares (4.5 acres) of habitat or less.

The only substantive environmental impacts associated with the cesium and strontium capsule alternatives would result from a major accident. If an earthquake were to occur with sufficient magnitude to collapse the aging Waste Encapsulation and Storage Facility, a calculated 10 worker fatalities may occur from falling debris and/or radiation exposure. An earthquake of this magnitude is calculated to occur approximately once every 4,000 years. Cleanup of

the resulting contamination would be costly and hazardous to workers.

Accelerating the schedule for the alternatives would result in substantial cost savings because approximately one-half of the cost incurred for each alternative (except the No Action alternative) is continued storage.

No Action Alternative (Preferred Alternative)

The No Action alternative would maintain the availability of the capsules for future commercial or medical productive uses, if such uses can be developed. This alternative would not result in disposal of the capsules, so the cost and impacts of disposal would be delayed until some time in the future, if appropriate uses for the capsules are not developed. This alternative would have the least estimated cost of the alternatives (\$112 million) during the assumed 10-year duration of continued storage.

Onsite Disposal Alternative

Because a potential geologic repository for high level-waste may not be available until after the year 2015, onsite disposal is the only alternative that would allow near-term disposal of the cesium and strontium capsules. This disposal would be in onsite shallow subsurface drywells, which would not meet the requirements of the Resource Conservation and Recovery Act for hazardous waste or DOE policy for disposal of readily retrievable high-level waste. Nearly all of the cesium and strontium would decay to nonradioactive chemicals and would result in essentially no impacts on groundwater. This alternative would have the highest estimated cost (\$697 million) of all capsule alternatives.

Overpack and Ship Alternative

The capsules would be disposed of offsite at a potential geologic repository in compliance with all regulatory requirements. The capsule containers would be designed to last at least 500 years, during which time the cesium and strontium would decay to nonradioactive elements. This alternative would cost an estimated \$ 587 million.

Vitrify with Tank Waste Alternative

This alternative would meet all regulatory requirements and the current requirements for accepting waste at a potential geologic repository. Implementing this alternative is dependent on selection of one of the tank waste alternatives that includes a high-level waste vitrification facility. All cesium and strontium would be disposed of offsite at a potential geologic repository as part of the vitrified high-level waste. This alternative would cost an estimated \$ 511 million.

Basis for Identification of the Preferred Alternative

Because the encapsulated cesium and strontium capsules have potential value as commercial and medical irradiation or heat sources and implementing disposal alternatives would foreclose options for these applications, DOE and Ecology have decided that their preferred alternative for the cesium and strontium capsules is the No Action alternative. DOE is evaluating the potential for commercial and medical uses for the cesium and strontium and will reevaluate the preferred alternative after a determination is made on the potential for future use of cesium and strontium. The cesium and strontium management plan will address alternatives for interim storage and beneficial uses of the capsules prior to final disposition.

S.8 PUBLIC INFORMATION AND INVOLVEMENT

The Tank Waste Remediation System EIS is available for review in DOE Public Reading Rooms and Information Repositories, as presented in Table S.8.1. For a copy of the EIS, call or write the DOE or Ecology official listed in the following section. The EIS is contained in this Summary and six volumes, which include the text of the EIS (Volume One) and 12 appendices (Volumes Two through Six) (Figure S.8.1). The appendices contain the detailed technical materials and data prepared to support the analyses summarized in the text of the EIS.

[Table S.8.1 DOE Reading Rooms and Information Repositories](#)

[Figure S.8.1 Guide to the Contents of the TWRS EIS](#)

S.8.1 DOE and Ecology Contacts

For further information on this EIS, call or write:

Carolyn C. Haass
DOE NEPA Document Manager
U.S. Department of Energy
P.O. Box 1249
Richland, Washington 99352
Voice 1-509-372-2731
Facsimile 1-509-736-7504

Geoff Tallent
Tank Waste Remediation System EIS
Project Lead
Washington State Department of Ecology
P.O. Box 47600
Olympia, Washington 98504-7600
Voice 1-360-407-7112
Facsimile 1-360-407-7151

A message may be left for Ms. Haass or Mr. Tallent by calling the toll-free Hanford Hotline at 1-800-321-2008.

S.8.2 Comments and DOE and Ecology Responses

The Draft EIS was distributed for public review on April 4, 1996, and a public comment period extended from April 12, 1996 to May 28, 1996. Public hearings and meetings were held at Pasco, Spokane, and Seattle, Washington; Portland, Oregon; and Washington, D.C. during the comment period. Approximately 750 comments were received from 350 agencies, Tribal Nations, and stakeholders. In addition, meetings were held with 19 agencies, Tribal Nations, and stakeholders.

Comments were received on a wide variety of issues, including:

- General and specific preferences for one or more of the alternatives;
- Cost estimates presented in the Draft EIS;
- Characterization and modeling of vadose zone and groundwater contamination;
- How repository fees were calculated and the basis for the assumption that high-level waste would be disposed of at an offsite repository;
- Sufficiency of characterization data to support retrieval and treatment of the waste;
- Calculation of post-remediation risk to a Native American Site user;
- Calculation of potential accident risks;
- The extent of waste retrieval from the tanks;
- Consideration of closure in the scope of the EIS;
- Consideration of impacts to cultural and natural resources; and
- Consideration of alternatives that would not comply with Federal and State laws and regulations.

In response to these and other comments and emerging technical information that was not available when the Draft EIS was published, a number of changes have been incorporated into the Final EIS. Based on review of comments and consultations held with commenting agencies and State and Tribal governments, primary EIS enhancements include the following.

- Disposal of high-level waste at the potential national geologic repository was clarified by separating the

discussion and analysis from other components of the alternatives, and current data and formulas for calculating costs were added to Volumes One and Two, as appropriate.

- The option of longer interim onsite storage of immobilized high-level waste pending availability of an offsite geologic repository was included.
- A risk analysis was performed for a Native American user exposure scenario. This preliminary exposure scenario was developed at the request of and in consultation with the Yakama Indian Nation, Nez Perce Tribe, and Confederated Tribes of the Umatilla Indian Reservation.
- Additional consultation with the affected Tribal Nations is reflected in the environmental justice analysis and throughout the EIS, as appropriate.

As committed to in the Draft EIS and in response to comments on the Draft EIS, a discussion of emerging data regarding vadose zone contamination beneath the tanks resulting from past leaks and analysis of potential cumulative impacts of past leaks and the TWRS alternatives has been added to the Final EIS in Volume One, Sections 4.2 and 5.13, Appendix F, and Appendix K. The data were unavailable for inclusion at the time the Draft EIS was published. Other enhancements to the EIS included modifying the Phased Implementation alternative to include two full-scale facilities during Phase 2. The Draft EIS had included one full-scale separations and immobilization facility during Phase 2 (full-scale production). Accident discussions and analysis were reviewed and emerging data were added.

Additional analysis was performed for the ex situ alternatives to provide an improved planning basis for the volume of high-level waste that would require interim onsite storage and offsite disposal at a geologic repository. Also, the Draft EIS contained an analysis of uncertainties for each relevant component of the environment in the applicable section of the EIS. For the Final EIS, the evaluation and discussion of uncertainties was expanded and presented together in Volume Six, Appendix K.

DOE expanded the EIS analysis of a variation to the Ex Situ/In Situ Combination alternative (known as Ex Situ/In Situ Combination 1 alternative in the Final EIS) presented in the Draft EIS. This alternative was described in the Draft EIS in the cover letter and preface to Volume One and is called the Ex Situ/In Situ Combination 2 alternative in the Final EIS. The alternative was included in the EIS to provide for the ex situ treatment of the largest contributors to long-term risk while reducing the volume of waste requiring treatment and thereby reducing occupational risks and cost. The discussion and analysis for this alternative are presented throughout the EIS.

Finally, Appendix L was added to the EIS. Appendix L contains the comments received on the Draft EIS and DOE and Ecology's responses to those comments. DOE and Ecology assessed and considered public comments both individually and collectively.

DOE also requested that the National Academy of Science review the Draft EIS to determine its adequacy to support decision making for the TWRS program. DOE has consulted with the National Academy of Science review committee since the publication of the Draft EIS and responded to initial comments and questions during preparation of the Final EIS. DOE intends to consider final comments by the National Academy of Science in the Record of Decision for the TWRS program.

