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CHAPTER 5
Impact Analysis Methodologies

This chapter summarizes the methodologies used to evaluate the potential direct, indirect, and cumulative effects of the 36 Alternatives within the four broad categories of alternatives described in Chapter 3. Following an overview of the waste management impact analysis framework and analytical process, this chapter describes the generic methodologies and assumptions used for waste loads, waste management technologies, and waste management facilities. The chapter then describes how DOE, using generic designs of proposed waste management facilities, derived estimates of facility pollutant discharges to the environment, of resources required or consumed in the process of constructing and operating the facilities, and of costs. The methodologies and assumptions used to evaluate the environmental impacts for each resource area are also explained.

Related discussions of methodologies can be found in other chapters:

Chapter 4 describes the methodology used to characterize the affected environment.

Chapters 6 through 10 describe specific methodologies for the analysis conducted for each of the five waste types.

Chapter 11 describes in more detail the methodologies to estimate cumulative impacts.

Appendix B provides the specific methodology used for the analysis of the sensitivity of waste management (WM) alternative decision making to waste from environmental restoration.

Appendix C provides detailed descriptions of methodologies used to estimate environmental and socioeconomic impacts and cost.

Appendices D, E, and F provide detailed descriptions of methodologies used to estimate human health risks from normal operations, transportation, and facility accidents, respectively.

The technical reports listed in the chapter references provide detailed descriptions of data gathering and estimating methodologies used for each waste type to assess risk, cost, transportation, and accident impacts.

5.1 Overview of the WM PEIS Analysis Approach

5.1.1 IMPACT ANALYSIS FRAMEWORK

In order to evaluate the potential environmental impacts of the alternatives, DOE first identified the type, characteristics, quantity, and special requirements (e.g., handling requirements) of each waste type. The Department then determined the health risks, environmental impacts, and costs of waste management

treatment, transport, storage, and disposal as applicable for each waste type. Figure 5.1–1 depicts this framework. To frame the analysis within reasonable bounds and to make the analytical process more manageable, DOE developed and applied particular assumptions. This chapter describes those assumptions and explains the process DOE used to conduct the health risk, environmental impacts, and cost analyses contained in the WM PEIS.

5.1.2 WM PEIS Analytical Process

The treatment, storage, or disposal impacts of alternatives for managing the five waste types were evaluated using an analytical process consisting of three phases, as shown in Figure 5.1–2, for each of the alternatives under the four broad categories of alternatives (No Action, Decentralized, Regionalized, and Centralized).

In the **first phase**, DOE made assumptions regarding waste loads for the five waste types. These assumptions related to the volume of waste currently in inventory and anticipated from future operations of DOE facilities and to its physical (gaseous, liquid, solid), chemical, and radiological characteristics. The assumptions used for each waste type are based on DOE records (see Section 5.2.1) and are described in the waste-type chapters.

DOE also developed a generic design of the waste management processes and facilities that could produce environmental impacts. In developing the generic design, DOE considered all the types of facilities needed to process each waste type (including treatment, transportation, storage, and disposal facilities). The Department also examined the various technologies available for managing the specific waste type and selected one technology option for analysis purposes.[1] The technologies used in the WM PEIS were chosen for analytical purposes only; the Records of Decision based on the WM PEIS will not select technologies.

The generic design of the waste management facility was placed at a specific location on each DOE site—either co-located with existing waste management facilities or at the geographic center of the site—so that actual environmental data from those locations could be used in the analysis of impacts (e.g., data regarding distance to receptors and prevailing winds). It is important to note that the use of a specific location was only to facilitate the computerized analysis of impacts. Decisions regarding the actual location

[1] The facilities considered and the technology chosen for each waste type, and the rationale for that selection, are described more fully in the waste-type chapters.

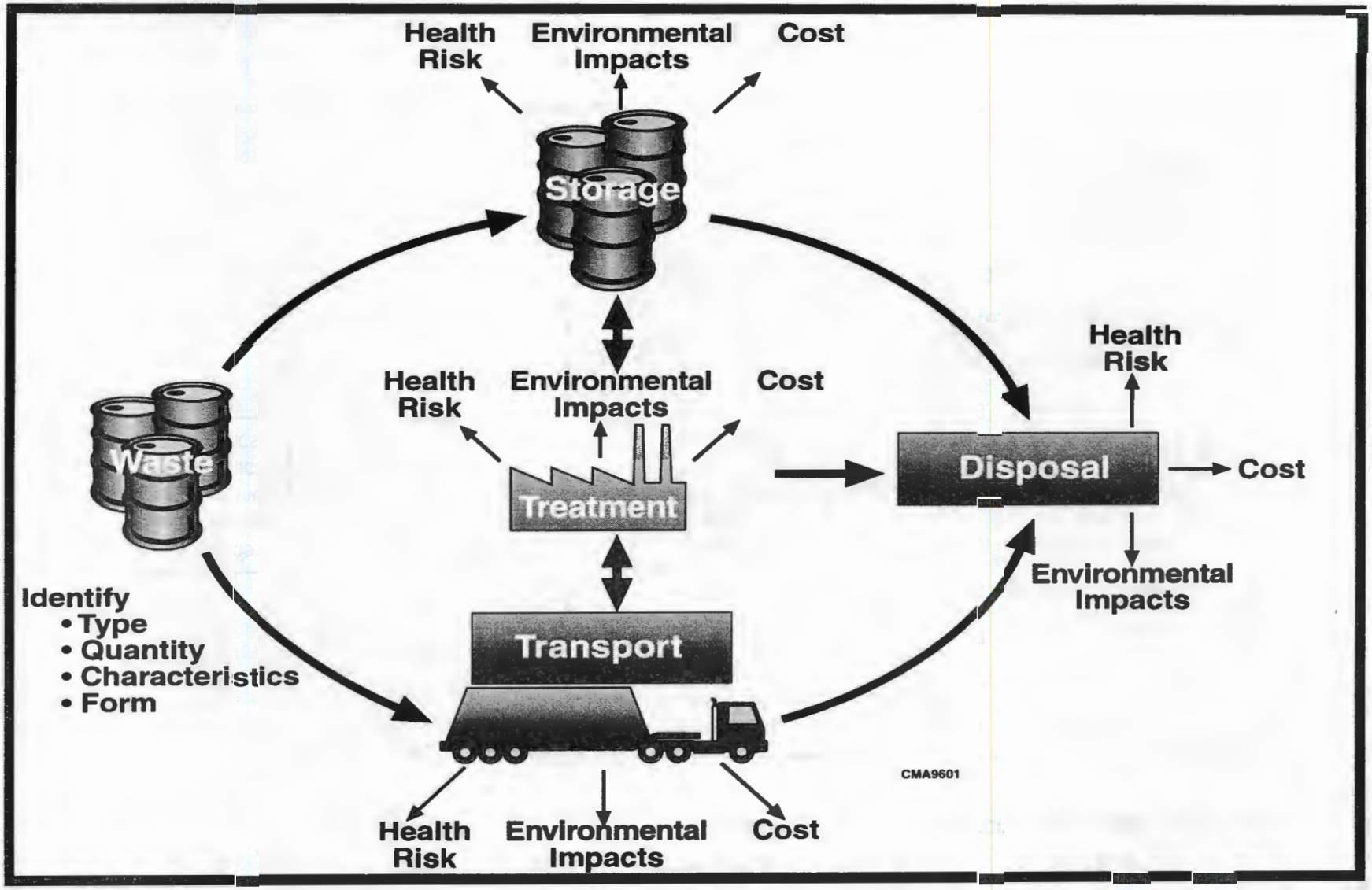

Figure 5.1–1. Waste Management Analysis Overview

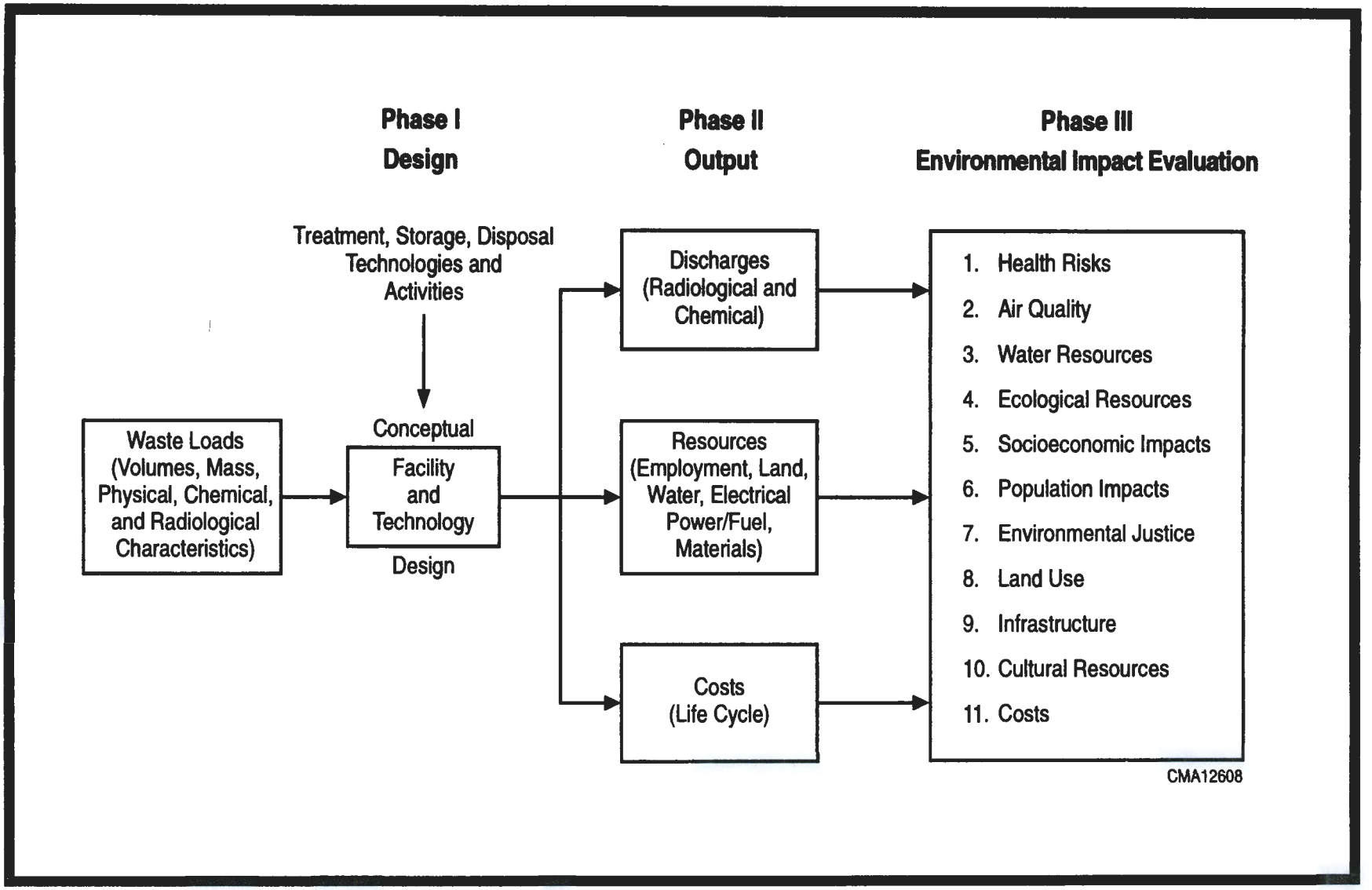

Figure 5.1–2. WM PEIS Analytical Relationships

of waste management facilities at particular DOE sites will not be made on the basis of this PEIS, but rather will be the subject of sitewide or project-specific NEPA reviews. Because locating future WM facilities at the centers of the sites could lead DOE to underestimate impacts at the large sites, where the distance from the center of the site to the site boundary is large, co-locating future WM facilities with existing WM facilities was done at the six largest DOE sites (Hanford, INEL, LANL, NTS, ORR, and SRS). Sections 6.1.3 and 7.1.3 list existing LLMW and LLW disposal facility capacities at these six sites. For the remaining 11 sites, DOE assumed that facilities would be located at the center of each site. Since these are the smaller sites, locating WM facilities at the center of a site would have less mitigative effect on offsite impacts than at the larger sites. Therefore, assuming that facilities would be located at the center of the smaller DOE sites is a reasonable assumption because it is unlikely to drastically affect impact estimates, particularly offsite human health risk.

In the **second phase** of the analytical process, waste materials (using the waste load assumptions developed in the first phase) were conceptually "processed" through the assumed facilities, and estimates of outputs were obtained for radiological and chemical discharges to the environment, the resources required or consumed, and costs. In the **third phase**, the discharges, resources, and costs became the input for evaluating environmental impacts, socioeconomic impacts, and human health risks.

For many aspects of the human health risk and environmental impacts analysis DOE relied on computer models for estimates of discharges and exposures. Table 5.1-1 lists the models used, gives the resource for which they were used, and describes how they were used.

The remainder of this chapter describes the methodologies developed for and used in the three-phase analytical process described above. Information about the generic design phase (waste loads, waste management technology, and waste management facilities) is provided in Section 5.2. Section 5.3 describes the methodology and assumptions used to determine discharges, resources required or consumed, and costs. The methodologies and assumptions used for evaluating the environmental impacts on the various resource areas are described in Section 5.4.

Table 5.1–1. Major Computer Models Used in the WM PEIS

Name	Resource	Developer	Description
MEPAS (Multimedia Environmental Pollutant Assessment System)	Unit dose, risk, and toxicity factors for contaminants related to groundwater	Battelle Pacific Northwest Laboratory	This model simulates the transport of contaminants through the vadose zone and into groundwater to give environmental concentrations of contaminants at various receptor locations.
DUST (Disposal Unit Source Term Model)	Contaminant-specific flux rates out of the disposal facility	Oak Ridge National Laboratory	This model selects unit risks and unit toxicities stored in a data base for specific contaminants in site-facility-, and waste form-specific records.
DITTY (Dose-In-Ten-Thousand-Years, Sub-model of GENII)	Exposure to radionuclides and hazardous chemicals	Battelle Pacific Northwest Laboratory	This model takes the 70-year average concentration, adjusted for humans, and multiplies it by the drinking water populations to give a total contaminant dose, which is multiplied by a slope factor or reference dose to give a unit risk or unit toxicity.
GENII (formerly Generation Model)	Radionuclide unit doses for atmospheric releases	Battelle Pacific Northwest Laboratory	This model simulates the environmental transport of radionuclides released to the environment and predicts the exposure and dose to specified receptors. The model uses an emission rate of 1 Ci/yr (curie per year) for each radionuclide, utilizing a series of Gaussian-plume models to estimate air concentrations.
RADTRAN 4	Population risk along transportation routes	Sandia National Laboratories	This model calculates population risk by scheduling packages through a route, with several input parameters quantifying the loaded vehicle, route, population centers, speed, and stop time.
RISKIND	Consequences of most severe (Category VIII) transportation-related accidents: committed dose, latent cancer fatalities	Argonne National Laboratory	This model calculates consequences for highest potential radiological risk; as identified by screening site-specific characteristics, considering physical forms of waste, and relative hazards of individual radionuclides.
ISC2 (Industrial Source Complex Model, Revision 2)	Hazardous chemical risk and toxicity factors of atmospheric releases	EPA	This model predicts the average concentration in air of chemicals released to the environment which is multiplied by appropriate slope factors and reference doses to give unit risks and unit toxicities.
HIGHWAY 3.1	Truck transportation mileage and routing	ORNL	This model simulates the U.S. highway system, using a least distance and driving time algorithm, including 1990 U.S. Census population densities of centers along routes.
INTERLINE 5.0	Rail transportation mileage and routing	ORNL	This model simulates the U.S. rail system, using a shortest route algorithm, including 1990 U.S. Census population densities of centers along routes.
ALOHA (Areal Locations of Hazardous Atmospheres)	Accidental source term releases (gases)	National Oceanic and Atmospheric Administration	This model uses a dispersion algorithm to simulate continuous and intermittent releases of passive nonbuoyant vapors and heavy gases in rural and urban atmospheres, calculating time-dependent concentrations and hazard distances for various levels of concern.
MicroShield	Unit external dose exposure rate	Grove Engineering (1992)	This model computes the exposure rate for workers within each facility module assuming that a unit concentration of each radionuclide is present.
WASTE_MGMT	Waste loads, radiological and chemical profiles, and emissions	Argonne National Laboratory (1996c)	Using reference files for waste inventory and characterization, TSD facility characterization, and alternative definition, the model quantifies and characterizes waste loads at and emissions from the facilities, and the quantities and characteristics of waste transported among the sites.

Table 5.1–1. Major Computer Models Used in the WM PEIS—Continued

Name	Resource	Developer	Description
MOBILE 5A	Vehicle emissions for criteria air pollutants CO, NO_2 and VOC.	EPA	This model calculates emissions in grams of pollutants per vehicle mile traveled.
PART 5	Vehicle emissions for criteria pollutant PM_{10}	EPA	This model calculates emissions in grams of pollutants per vehicle mile traveled.
RIMS II	Multipliers for disposable income, output and job years for economic impact analysis	U.S. Department of Commerce Bureau of Economic Analysis	This model estimates the response of regional economies to changes in expenditures.
WASTE_ACC	Accident frequencies and radiological profiles of the resulting atmosphere releases	Argonne National Laboratory (1996b)	Using reference filter for accident initiation frequencies, event conditional probabilities, and source term development parameters, the model quantifies the amount of each radioisotope in the atmospheric release and the probability of the release. Interfaced with WASTE_MGMT.

5.1.3 DOE Sites Evaluated

DOE has some waste management responsibility for 54 sites that are within the scope of this PEIS. Of the 54 sites, 17 have been designated major sites in the PEIS because they meet one or more of the following criteria: (1) they are candidates to receive wastes generated offsite, (2) they are candidates to host disposal facilities, (3) they manage HLW, or (4) they were included to be consistent with the Federal Facilities Compliance Act process. The major sites contain the bulk of the five waste types, have the capacity for the future disposal of LLMW or LLW, or have existing or planned major waste management facilities. The WM PEIS analyzes the impacts of waste management activities at these major sites. The designation of these sites as major has no relevance outside of the context of the WM PEIS analysis. Major sites have not been "preselected" for waste management activities; rather, analysis of potential waste management activities at these sites provides a range of environmental impacts that could arise from treating, storing, and disposing of DOE's waste. As a result, broad comparisons of potential impacts across sites can be made.

5.2 Phase I: Reference Design

5.2.1 Waste Loads

Waste Volumes. Waste loads reported in Tables 1.6–2 and 1.6–3 in Chapter 1, as well as in Chapters 6 through 10, represent a "snapshot in time"—accurate to the extent existing inventories and future operations were understood when the databases were developed. Accordingly, inventories and projections reported in Table 1.6–3 and Chapters 6 through 10 may not exactly match projections at the time of publication of the Final WM PEIS.

Factors affecting the degree of uncertainty in waste loads can be found in Appendix I, which provides a more recent snapshot of DOE's waste inventory and projections. At selected sites, substantial differences are apparent and represent uncertainties. It was deemed necessary to make only selected updates in the waste load information and associated analyses presented in the WM PEIS. Additionally, as Appendix I shows, consolidation of waste loads and operations across sites in Regionalized and Centralized Alternatives serves to somewhat dampen uncertainty associated with site-specific waste inventories and projections.

Considering these uncertainties, dampening effects, and the selected updates, the waste loads used for the WM PEIS analysis are sufficiently accurate for programmatic decision making. Sources of data for each of the waste types are listed below:

- **Low-level mixed waste (LLMW)**—The *Mixed Waste Inventory Report* (DOE, 1994) was used for all LLMW inventories and generation rates, except for Colonie, ETEC, and RFETS, whose generation rates and inventories come from late 1994 site estimates, and ANL-E and NTS, whose generation rates and inventories come from the updated *Mixed Waste Inventory Report* (DOE, 1995a).
- **Low-level waste (LLW)**—The *Integrated Data Base for 1992* (DOE, 1992) was used for generation rates and inventories of stored waste, except for BNL, NTS, ORR, Pantex, and WVDP, whose generation rates and inventories come from the updated *Integrated Data Base Report–1994* (DOE, 1995b). The Waste Management Information System (ORNL, 1992) was consulted for data not available in the Integrated Data Base.
- **Transuranic Waste (TRUW)**—The *Integrated Data Base for 1992* (DOE, 1992) and the *Interim Mixed Waste Inventory Report* (DOE, 1993a) were used for TRUW inventories and generation rates, except for Hanford and SRS. SRS generation rates and inventories come from the updated *Mixed Waste*

Inventory Summary Report (DOE, 1995a), while Hanford's come from the *WIPP TRUW Baseline Inventory Report (BIR-2) for 1995* (DOE, 1995c).

- **High-level Waste (HLW)**—Site-specific plans and NEPA documents for Hanford, INEL, SRS, and WVDP were used for HLW volume and canister production rates.
- **Hazardous waste (HW)**—The EPA Information System biennial and annual reports (EPA, 1991) were used for generation rates. Offsite shipments to commercial treatment were derived from DOE fiscal year 1992 HW shipping manifests.

With some exceptions, the more recent data in Appendix I include waste projections that are lower than the projections used for analysis by the WM PEIS. This is a reflection of current pollution prevention policies and the reduction in the nuclear weapons mission. The net effect is that the WM PEIS impacts are likely to be conservative, portraying greater impacts than will actually occur. DOE believes that these conservative estimates are adequate for the programmatic purposes of the WM PEIS and that the trends in the WM PEIS are not sensitive to these fluctuations in waste projections. Project-level analyses which would be used to determine actual technology designs and capacities for the waste management activities would rely on the most current data.

It is DOE policy that sites employ pollution prevention practices to reduce the amount of waste generated. The databases from which estimates of annual generation were obtained did not fully consider pollution prevention efforts. Possible impacts of pollution prevention are discussed in Appendix G.

Environmental Restoration Waste. In addition to existing wastes and wastes expected to be generated from the routine operation of DOE facilities (generally referred to as waste management wastes), environmental restoration and decontamination activities at DOE sites will also generate wastes (generally referred to as environmental restoration wastes) that must be further treated or disposed of at waste management facilities.[2] The location and timing of these future environmental restoration activities and the size and characteristics of resulting waste loads are difficult to predict. Thus, the waste loads analyzed in detail in this PEIS do not include wastes that may be generated as a result of environmental restoration activities.

[2] An unknown percentage of environmental restoration wastes will be managed at environmental restoration—not waste management—facilities (see Appendix B). The environmental impacts of managing environmental restoration waste at environmental restoration facilities will be addressed in the Remedial Investigation/Feasibility Studies that DOE conducts under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) for each environmental restoration site.

However, in each of the waste type chapters except HLW and HW, the anticipated environmental restoration waste loads are described for the DOE complex, and compared to the existing and anticipated waste management waste loads. These chapters also contain a discussion of the extent to which the environmental restoration waste loads could affect the comparison of waste management alternatives. There are no HLW loads anticipated from environmental restoration activities. Even though treatment of HLW is not analyzed in this PEIS, the removal of HLW from the tanks at the Hanford Site is considered to be a waste management activity and not a result of environmental restoration activities. DOE anticipates that volumes of HW generated during environmental restoration activities would be treated offsite at commercial facilities. Environmental-restoration HW will not be transferred to waste management facilities.

Physical Structure. While this PEIS covers five waste types, those wastes are not homogenous and are derived from thousands of different waste streams. Thus, the waste streams were combined into treatability groups for purposes of developing treatment system designs. Each treatability group is identified with one of the five waste types considered in the WM PEIS and a treatment method, where appropriate, that EPA recognizes as meeting the requirements of RCRA. For the WM PEIS analyses, the physical structure of the waste was used for the initial sort for treatability. At the most basic level of analysis, all waste can be grouped into six physical categories using common engineering criteria design parameters, which also served as the initial set of treatability categories:

- **Aqueous liquids**—Primarily water with organic content less than 1% (such as process wastewater)
- **Organic liquids**—Liquids and slurries with organic content greater than 1% (such as solvents)
- **Organic and inorganic sludge and particulates**—Solid and semisolid material other than debris (such as sludge from treatment plants, resins, and solids less than 2.5-inch diameter particle size)
- **Soils**—Contaminated soils
- **Debris**—Solid material exceeding 2.5-inch diameter particle size that is either (1) manufactured, or (2) plant or animal matter, or (3) discarded natural or geological material (such as cobblestones)
- **Other**—Special waste streams (such as batteries, laboratory packs, reactive metals, and toxic metals, which include mercury, lead, and beryllium)

Four waste types use this basic framework analysis: LLMW, LLW, TRUW, and HW. For purposes of the WM PEIS analysis, HLW, also in the above treatability categories, is assumed to have been treated (vitrified). The HLW analysis only addresses the environmental consequences of storing and transporting vitrified HLW canisters. The environmental impacts of HLW treatment are addressed in other DOE NEPA

documents identified in Section 9.1 and are included in the cumulative impacts addressed in this PEIS in Chapter 11.

Radiological and Chemical Composition. The DOE used standard radiological profiles for each site and made assumptions about the concentration of each waste type in each treatability group based on available data on the origins of the waste. Hazardous constituents were apportioned to the treatability groups on the basis of the most prevalent hazardous chemicals using average compositions for all DOE sites. The assumptions for both radioactive and hazardous elements are waste-type specific and are summarized in more detail in the waste-type chapters. Details of the radiological and chemical compositions assumed for each waste-type are found in the respective technical report published for that waste type. See the reference lists for titles.

The standard profiles supported the evaluation of risks from waste disposal to the hypothetical farm family and impacts to groundwater quality for the most prevalent radionuclides and hazardous constituents in DOE wastes. Impacts were not evaluated for many radionuclides and hazardous constituents not present in significant quantities, because the databases on which the WM PEIS is based, in most cases, do not contain sufficient information on the presence of these constituents. Adverse impacts could occur from some of these small quantity constituents. In addition, one radionuclide that is contained in the standard profile used when the actual characterization of the waste is not known, carbon-14, was not included in the evaluation of impacts from disposal of LLW or LLMW. Carbon-14 would be expected to move relatively quickly through the groundwater, and has a moderately long half-life (approximately 5,730 years). Therefore, health risk and groundwater quality could be adversely affected if significant quantities of this radionuclide were present in the waste. However, including this radionuclide without specific knowledge of its existence or concentration at a site would have biased the analysis results without scientific foundation for the assumption of its presence. Adverse impacts from the presence of specific radionuclides or hazardous constituents could be mitigated by additional treatment and/or instituting waste acceptance criteria at the disposal facility. The impacts of these trace quantity constituents could be considered in more detail in sitewide or project-specific NEPA documents, if necessary.

5.2.2 Waste Management Technologies

Various waste management technologies are used to sort and handle waste, reduce waste volume, destroy organic chemicals in waste, remove toxic metals from waste, treat hazardous characteristics to render them nonhazardous, recover and recycle materials, and stabilize and package waste for disposal. The facilities that use these technologies must be designed to accommodate the various physical and chemical forms and the radioactive and chemical characteristics discussed in previous sections. Existing, generic technologies necessary to meet the treatment, storage, and disposal requirements for each waste type were identified and sized to meet anticipated waste volume needs. Existing, rather than advanced, technologies were used because the applicability of advanced technologies is more problematic, because estimates of environmental impacts would more likely be conservative (tending to be the highest likely to occur) with the use of existing technologies, and because the type of technology would be unlikely to determine the preferred alternative. However, advanced technologies could be considered in project-specific NEPA reviews expected to tier from this programmatic review.

For analytical purposes, and to facilitate utilization in any system at any site, the waste management technologies were grouped into **common functions** (front-end support such as administrative and laboratory services; receiving, inspecting, dumping, and sorting the waste; maintenance of facilities; certification and shipping of the waste), **pretreatment** (shredding and compaction), **primary treatment** (thermal destruction, special processing, neutralization, deactivation, aqueous waste treatment, lead recovery, mercury separation and recovery), **secondary treatment and stabilization** (polymer stabilization, grout stabilization, packaging, and vitrification of secondary processing residues), **storage** (administration, receiving and inspection, contact-handled storage, and remote-handled silo storage), and **disposal** (administration, receiving and inspection, shallow land disposal, engineered vault disposal, silo disposal, and borehole disposal).

5.2.3 Waste Management Facilities

Treatment, transportation, storage, and disposal "modules" were developed to represent every component required for waste management. Each module was assumed to contain several types of equipment, each able to perform a step needed in the waste management process.

Individual modules were linked together for each treatability group and were adjusted for the chemical and physical type of waste. This method was used so that impacts could be compared among sites, with each site assumed to be using the identical array of linked modules. Any variation in impacts would then result from site-specific environmental differences. This approach also allowed an examination of the changes in impacts resulting from changes in the linked modules.

Typically the type of facility considered was a building structure, i.e., a "fixed" facility at a given site. The analysis also considered the possible use of mobile treatment facilities that could be moved from site to site for treatment of the very small amounts of waste that exist at a number of the sites considered.

The generic design of the waste management facility, consisting of these treatment, storage, transportation, and disposal modules, enabled the calculation of land utilization, worker-years, resource consumption (i.e., water and electricity), pollutant discharges, and costs for the treatment, storage, transportation, and disposal of each waste type. The engineering features of the generic facility and the waste loads "processed" through the generic facility formed the basis for the risk and environmental impacts analysis.

For purposes of analysis, the following assumptions were made regarding the construction and operation of the waste management facilities:

- The facilities were assumed to be built over a 10-year period and operated over a 10-year period to process wastes generated over the 20-year construction and operation period. It was assumed that existing waste management facilities did not operate (i.e., did not process waste) during the 10-year construction period for new facilities. Exceptions to this assumption would include a full 20-year operations phase (i.e., construction phase not applicable) for the No Action Alternative, and the site-specific operational periods for HLW storage facilities, which are discussed in Chapter 9 in Volume I of the WM PEIS. The WM PEIS analysis is highly conceptual, and DOE recognizes that construction of actual facilities could occur within a much shorter time period and that waste will begin to be processed at some facilities before construction at all facilities is completed. Nevertheless, DOE believes that the WM PEIS provides a reasonable and conservative estimate of environmental impacts sufficient to support programmatic decision making.
- For new facilities, the costs of decontamination and demolition were included; for disposal facilities, the costs of custodial care after closure through a 300-year period of institutional control were included, but were not substantial.
- The facilities were assumed to operate 240 days per year with three 8-hour shifts.

Although the WM PEIS analyzes the environmental impacts from the operation of the WM facilities for only 10 years, it is possible that the facilities could operate for up to 30 years. During this additional 20-year operating period, additional WM wastes or ER wastes could be processed. DOE believes that most of the impacts of operating the WM facilities for an additional 20 years would be similar, on an annual basis, to the impacts of operating these facilities for the 10 years analyzed in the WM PEIS. DOE believes this for the following reasons:

- The 10-year period of operations analyzed in the WM PEIS includes processing any wastes in storage, wastes accumulated during 10 years of construction, and wastes generated during the 10 years of operations. Therefore, the annual feed rate into the WM facilities would be expected to be higher or comparable to the feed rate during the latter 20 years of operations.
- Many of the impacts analyzed in the WM PEIS were analyzed on a daily or annual basis. For example, infrastructure impacts were analyzed for resource use in gallons of water per day, gallons of wastewater per day, and megawatts of power per year. Resource use during operation of the facilities for an additional 20 years is unlikely to exceed these annual rates of resources use and therefore is unlikely to exceed the environmental impacts predicted in the WM PEIS.
- Some impacts in the WM PEIS, such as human health risk to the offsite population, were analyzed for the entire 10-year operations period. DOE expects that the impacts during the additional 20 years of operations would be no more that twice the impacts predicted in the WM PEIS. For example, if the WM PEIS predicted a population health risk of 1 in 1 million (see Chapters 6 through 11 for actual health risk estimates), the additional health risk of operating the facilities for 20 more years would be no more than 2 in 1 million, with total health risk for 30 years of operations of 3 in 1 million.

This analysis assumes that the characteristics of the waste processed during the additional 20-year operating period are similar to the characteristics of the wastes analyzed in the WM PEIS. If the characteristics of the wastes processed during the latter 20 years of operations are found in the future to be appreciably different from the characteristics of the waste analyzed in the WM PEIS, additional environmental documentation could be prepared to support continued operations.

5.3 Phase II: Output

5.3.1 Discharges

As noted above, using a generic design of a waste management facility (including treatment, storage, transportation, and disposal modules) and hypothetically processing wastes through that generic design, DOE derived estimates of pollutant discharges. DOE assumed the existence of discharges as a result not only of the radiological and chemical components of the waste, but also from the burning of fuel to operate the waste management facility.

5.3.2 Resources Required or Consumed

The resources required to process wastes (e.g., workers, land, water, electrical power, and raw materials) were based on estimates for the materials, labor, and other resources needed to build, operate, and maintain the waste management facilities. The resources were identified and added in the estimating process, and became input to the impacts analyses. Resource estimates were developed for the construction and operations and maintenance phases. The industrial engineering analysis established the number of workers for each type and size of facility module.

5.3.3 Costs

The costs evaluated were life-cycle costs of facilities plus transportation costs between sites. Facility costs include the costs of: planning, design, construction, operations and maintenance (O&M), and decontamination. The total costs of each alternative include the sum of the treatment, storage, disposal, and transportation costs, and, in some instances, any special costs where specialized treatment (other than treatment specified in generic design modules) is now being performed and will continue to be performed in the same manner in the future. Each alternative includes a definition of the assumed technologies for the complete treatment process. For each site and each alternative, wastes were hypothetically routed through the waste management process, and the modules were individually sized to handle the processing requirements. Since many sites have some existing treatment, storage, and disposal capabilities, the analysis

accounts for existing facilities to minimize additional construction requirements. Only the O&M and decontamination costs were estimated for those existing facilities (INEL, 1996).

The transportation methodology tables (for LLMW, LLW, TRUW, and HW) include summaries of fixed and variable costs for each intersite transportation route segment and were computed for road and rail options. Each fixed cost component equals the number of trips multiplied by a fixed cost waste-type trip price. Each variable cost component equals total mileage transported by route segment, multiplied by a waste-type cost-per-mile price. The number of trips reflects the amount of waste divided by the capacity of individual trucks or railcars. Weight and volume restrictions were considered, and the mileage for each trip was derived from current DOE guidelines. Trip prices and cost-per-mile prices were established by reviewing transportation industry tariffs and practices (INEL, 1995b). Transportation costs for HLW were computed using regression formulas developed by ANL from industry practices (ANL, 1996a).

Costs are presented in constant dollars, reflecting the total life-cycle costs by waste-type alternative. Costs were estimated using an approach that tied the cost of facilities and transportation to waste quantities. In addition, DOE used costs associated with existing technologies and historical industrial cost experience for estimating purposes.

The program life-cycle cost estimates for the various WM PEIS alternatives include the following major cost elements:

- **Preoperations costs**—technology site adaptation, including bench tests and demonstrations; statutory and regulatory permitting; plant startup costs; and related generic design, project management, and contingencies
- **Facility construction costs**—building, equipment, and related design; construction management, project management, and contingencies
- **Operations and maintenance costs**—annual operations, maintenance, utilities, contractor supervision and overhead, and related project management and contingencies
- **Decontamination and decommissioning costs**—demolition of facilities, environmental closure, postclosure, and monitoring activities
- **Transportation costs**—intersite road and rail transportation carrier costs for the transportation network established by Department of Transportation computer models (INEL, 1995b)

The cost elements also include the following subelements: direct labor, equipment, and materials; indirect technical labor and facilities; overhead and profit; government administration and management; and reserve/contingencies. The cost elements do not include site infrastructure costs, operations office oversight costs, or DOE program and policy-related costs.

The waste management process modules costs were developed for a range of facility waste processing capacity. The cost estimates for each module size (small, medium, large) were then used as data points linking waste load throughput to cost. For very small waste loads, mobile units or skid-mounted units were used. These units use existing structures and utility connections (INEL, 1995a, c-e).

Preoperations costs were estimated by including factored costs for generic design, safety assurance studies, project management and contingencies; extracting costs for bench tests, demonstrations, and permitting requirements from management analysis studies; and including the operations and maintenance costs for 1 year to allow for test production runs and operational certification; the preoperational monitoring requirements (DOE Order 5400.1, Chapter IV, Section 3) were also included.

Construction costs were estimated for each module, sized for large, medium, and small operations. This procedure involved laying out the waste management process line and contacting industrial suppliers about prices for the equipment used; determining the size and nature of the building required to house the process line; computing building costs using standard construction estimating procedures; and factoring in all other elements that constitute the remainder of the construction cost element (INEL, 1995a,c-e).

Operations and maintenance costs were estimated by extracting annual costs for operations labor, material, and utilities from management analysis studies; by considering maintenance labor and material costs from equipment purchase and site costs; and by including costs for contractor supervision and overhead, project management, and contingencies.

Decontamination costs were estimated by multiplying the area of the facility by a unit cost based on square footage established through cost studies, addressing different waste-type facilities separately (INEL, 1995a,c-e).

The cost analysis provides data that should fall within $\pm 30\%$ of actual costs using the waste loads quantified in the alternatives. This range reflects the experience of the cost estimators using similar procedures (based

on standard design costing procedures) for other generic design industrial processes and DOE projects. Changes in the characterization and quantity of the waste loads would significantly affect costs. Indirect costs and overhead burden rates used in the cost estimating methodology were based on those historically encountered at DOE's Idaho National Engineering Laboratory (INEL). They fall approximately in the middle of the range of cost factors found at several other DOE sites and were therefore considered to be representative for complexwide estimating purposes.

Facility costs were established on the basis of the costs of DOE facilities (primarily at INEL) and commercial facilities. To the extent possible, equipment costs for each facility module were compared with data from existing facilities to establish a cost confidence level with the boundaries established for programmatic life-cycle cost estimates. Both DOE and the commercial nuclear industry are now planning or operating similar facilities. These facilities were surveyed to obtain capacity and cost data, and other information needed to support the cost methodology data. Before using these costs, the data were adjusted to account for capacity differences and escalation.

Additional assessment activities included a review of existing DOE facility capital and operating costs for comparison with the cost methodology data. Existing DOE facilities that have been evaluated include the Waste Experimental Reduction Facility (incineration, shredding, and compaction) at INEL; the Controlled Air Incinerator at Los Alamos National Laboratory; the Toxic Substances Control Act (TSCA) Incinerator at the Oak Ridge Reservation; the Supercompactor and Repackaging Facility at Rocky Flats; the Radioactive Waste Management Complex (LLW disposal) at INEL; and the Transportable Waste Water Treatment Unit from the Uranium Mill Tailings Remedial Action Project. Planned DOE facility costs at INEL were also evaluated for the Radioactive Waste Storage Facility, the Waste Characterization Facility, the Idaho Waste Processing Facility, and the Mixed Low-Level Waste Treatment Facility.

Other facilities evaluated include the Illinois Compact Low-Level Engineered Disposal Facility and the Commonwealth of Massachusetts Low-Level Radioactive Waste Disposal Facility.

Cost estimates for facility components were adapted from commercial sources (INEL, 1995b-d, 1996). Commercial facilities evaluated include conceptual designs and cost estimates for the following: air- and area-monitoring units from Eberline Corporation of Santa Fe, NM; amalgam mixers from Miracle Paint Rejuvenator of St. Paul, MN; blending equipment from Velmac Associates, Inc., of Novato, CA; calciner/kiln units from ABB Raymond, Inc., of Lisle, IL; chemical oxidation units from Peroxidation

System, Inc., of Tucson, AZ; compactor units from Stock Equipment Company of Chagrin Falls, OH; concentrator units from LCI Corporation of Charlotte, NC; drum capping and washing units from Stock Equipment Company of Chagrin Falls, OH; dry offgas filters from Pall Advances Separation Systems of Cortland, NY; dry and wet offgas treatment trains from NGK-Locke, Inc., and Callidus Technologies; drying equipment from Wyssmont, Co., Inc., of Fort Lee, NJ; extruder equipment from Sterling Extruders, Davis-Standard Division of Edison, NJ; gross-organic removal units from McTighe Industries, Inc., of Mitchell, SD; incineration packages from Joy Energy Systems of Charlotte, NC, and ABB Raymond, Inc., of Lisle, IL; quencher and scrubber (wet scrubbing) units from Croll-Reynold Company of Westfield, NJ; melter units from Ajax Corporation and Retec Corporation; preparation and feed units from various vendor quotes; processing equipment from the U.S. Navy LLW processing facility of Lynchburg, VA; open dump, and sort devices, and robotic arms in consultation with personnel from DOE contractors involved with the Office of Technology Development, Robotic Technology Development Program; organic stripper units from APV Crepaco, Inc., of Tonwanda, NY; radiological and hazardous material measurement systems from conceptual designs and cost estimates provided by Lockheed Martin; segmented gamma scanning (SGS) assay systems data from Atlan-Tech Corporation, Inc., of Roswell, GA; shredder units from Komor Industries, Inc., of Groveport, OH; feeder/shredder units from System Service Solutions of Wilsonville, OH; retort units from Denver Mineral Engineers, Inc., of Littleton, CO; size reduction and baler systems from Stock Equipment Company of Chagrin Falls, OH; selected solidification units from Stock Equipment Company; solidification module assemblies from Stock Equipment Company; stack monitoring units from Eberline Corporation of Santa Fe, NM; suspended-solids filtration systems (Membralox) from U.S. Filter Corporation of Warrendale, PA; thin film evaporator units from LCI Corporation of Charlotte, NC; washing equipment from CF Systems (a subsidiary of Morrisen-Knudson); wet oxidation units from Zimpro of Rothchild, WI; and the commercial treatment and disposal processes for hazardous wastes from various vendors (INEL, 1995a-d).

5.4 Phase III: Environmental Impact Evaluation

The environmental impact assessment methodologies and assumptions described in this section address the range of natural and human resource issues pertinent to the range of alternatives under consideration in this PEIS. The following sections provide the scientific approach and analytical methods used to evaluate potential environmental consequences (including health risks), as presented in the subsequent waste-type Chapters 6 through 10.

The generic design and estimated waste loads provided the output data for the impact assessments. The estimated discharges of pollutants to air and water as a result of the treatment, transportation, storage, and disposal of the five waste types were used to calculate human health risks. Combustion by-products discharged to the air from waste treatment facilities were not considered in the health risk assessments conducted for most waste types because the potential impacts from exposure to these contaminants are expected to be minor compared with impacts from releases of radionuclides and hazardous chemicals occurring in the wastes. However, emissions of dioxin and furan from hazardous waste treatment facilities were considered in the health risk analysis conducted for LLMW and HW. The results of the health risk analysis are presented in Sections 6.4 and 10.4 of this volume. The health risk analysis also included evaluation of the potential impacts of waste transportation. Impacts from transportation included estimation of excess latent cancer fatalities resulting from exposure to diesel exhaust (see Appendix E for additional details).

The air quality analysis for O&M considered emissions of criteria pollutants from incineration and from combustion to provide heat for buildings. Emissions of these pollutants were compared with applicable air quality standards to determine compliance. The standards are set, in part, through consideration of adverse health effects. Therefore, health effects of combustion by-products were also indirectly considered in the air quality analysis in the WM PEIS.

Risks to the public and workers from facility treatment, storage, and disposal operations, for both routine and accident conditions, used information on waste characteristics and worker-years. Wastes transported to other sites for treatment or disposal were evaluated for the radiological, chemical, and physical risks they pose to the public and to workers for both routine and accident conditions (for rail and truck transport).

For comparison purposes, environmental concentrations of pollutants are presented in this PEIS with the appropriate regulatory standards or guidelines. For all resource areas, an effort was made in this PEIS to use data that were as current as possible.

All exposures to chemical and radiological discharges were estimated using computer models that simulate the fate and transport of contaminants in the environment.

Use of Percentages in Analysis and Presentation of Environmental Impacts. In summary, DOE used a three-step process to evaluate environmental impacts: (1) preparing comprehensive estimates of all

impacts, (2) screening these impacts and focusing the analysis on those with a greater potential to be significant, and (3) preparing a summary listing and description of potentially significant impacts.

First, DOE estimated environmental impacts at major DOE sites for each alternative and each waste type. The site data tables in Volume II of the WM PEIS list the results of this comprehensive analysis without any screening for significance. Because of the volume of data and because NEPA requires agencies to focus on significant impacts, DOE made the tables a separate part of the document and did not insert them in Volume I. DOE screened the table values and further evaluated those with a potential for significance in the PEIS text (Chapters 6 through 10).

Use of Percentages where Regulatory Standards Exist. In assessing impacts on resources for which regulatory standards or guidelines exist, DOE evaluated the significance of waste management facility pollutant emissions and effluents by comparing facility emission and effluent estimates or resultant concentrations to relevant Federal and state regulatory limits. DOE based its evaluation of the significance of impacts on the environmental and socioeconomic resources that have no such comparable regulatory standards, on significance criteria defined in CEQ regulations of 40 CFR 1508.26 and on the experience and judgment of the WM PEIS interdisciplinary team members in their fields of expertise.

Air Quality Impacts. The air quality impacts presentation focused on sites and alternatives where air quality standards could be exceeded (that is, where air quality impacts could be significant). Thus, all cases where emissions are 100% of a standard or greater are presented in the waste type chapters. In addition, DOE chose a 10%-of-standard threshold to highlight the sites where air pollutant emissions from proposed waste management activities do not exceed standards, but where they could substantially contribute to overall pollutant emissions from all sources in the area, which could result in cumulative air quality impacts.

Water Quality Impacts. For the groundwater quality impacts analyses for low-level mixed waste and low-level waste, estimates of pollutant concentrations in downgradient well water caused by disposal facility leachate were compared to relevant water quality comparison criteria. As was the case for air quality, all sites/alternatives where the comparison criteria are met or exceeded are presented in the waste type chapters because they represent a potential for significant impacts to persons consuming the groundwater. In addition, to account for some level of uncertainty in the modeling results for the disposal analysis, water pollutant concentrations that met or exceeded 25% of the comparison criteria are also presented in the waste

type chapters for discussion, even though they would be less likely to indicate instances where impacts would be significant.

Economic and Population Impacts. For economic and population impacts, DOE used a 1% significance screening level because regional economic or population changes of 1% or more in the communities around DOE sites are likely to be considered by those communities as substantial; that is, economic benefits are likely to be important and population growth could substantially affect social and medical services, housing, and educational systems. This is particularly true if the economic or population changes occur in localities within an affected region rather than uniformly across the region.

Ecological Resources and Land Use Impacts. For ecological resources and land use impacts, DOE used a screening level of 1%, principally to screen out sites under an alternative where DOE can reasonably conclude it is unlikely there would be significant impacts. DOE based this percentage on the fact that it has not yet proposed facility locations and detailed impact evaluation would require location-specific information and that, at sites where less than 1% of the available land would be required for waste management facility construction, DOE would have sufficient flexibility to locate the facility in a manner that would avoid significant impacts to critical habitats and site land use.

Infrastructure Impacts. The analysis of infrastructure impacts was somewhat more complex. For the impacts analysis of the onsite water, power, and wastewater treatment infrastructure, DOE discusses requirements that exceed 5% of current capacities in Chapters 6 through 10. DOE believes that, in general, infrastructure requirements below 5% could be accommodated by existing infrastructure because estimates of capacity would have some built-in margin for substantial peak loads. Corresponding capacities of onsite transportation infrastructure were not known, so DOE estimated increases in site employment as an index of the potential increased traffic load on existing site transportation infrastructure. DOE discussed site employment increases of 5% or more as instances in which transportation infrastructure impacts from those increased traffic loads could be significant. Similarly, offsite infrastructure impacts were keyed to regional population growth, with growth greater than 5% considered to have the potential to cause substantial stress to the regional transportation infrastructure.

For both the standards-based and nonstandards-based analyses, it must be emphasized that:

- All impacts were analyzed consistently; that is, the impact values were estimated for each major site using the same input data and computations for all alternatives.

- All impacts estimates are provided in the WM PEIS in the site data tables.
- Screening values were used to focus the waste-type chapter presentations on impacts with a greater potential to be significant, thereby minimizing discussion of those likely not to be significant.
- Screening values were not used and should not be interpreted as "absolute" benchmarks of the significance or nonsignificance of an impact, but only as indicators of the importance or extent of impacts resulting from particular alternatives.

Use of Percentages in Defining the Affected Environment. Other screening criteria were used to focus the impacts analysis on those components of the environment likely to experience significant impacts. For example, the region-of-influence (ROI) for socioeconomic impacts was defined as encompassing the DOE site host county and nearby counties which, in combination, were the residence counties of at least 90% of the site's current employees (DOE, 1993c). The rationale for use of this percentage is that it would identify those counties where most of the project expenditures would be made, particularly for locally available materials, such as concrete, where the major portion of the workers' salaries would most likely be spent, and where workers would be most likely to move, which in turn would affect housing, community service, and financial infrastructure.

5.4.1 Human Health Impacts

The human health risk analysis provides estimates of the adverse effects, or impacts, on human health that might occur as a result of implementation of the proposed waste management actions. Risks resulting from facility routine operations and accidents and waste transportation were estimated in the WM PEIS.

Risks to the public and workers from facility treatment, storage, and disposal operations, for both routine operation and accident conditions, were derived using information on waste loads (volumes and characteristics) and required worker-years. Wastes transported to other sites for treatment or disposal were evaluated for the radiological, chemical, and physical risks they pose to the public and crews for both incident-free and accident conditions (for both rail and truck transport).

The approach taken in the WM PEIS risk analysis was first to identify the groups potentially at risk and then to compare the risk that these groups (and individuals within them) may sustain if the different alternatives were implemented. Each phase of waste management activities—treatment, storage, and

disposal—included in an alternative was considered when identifying the persons at risk, the exposures that produce that risk, and the types of health impacts that the exposed groups might experience. As discussed in Appendix F (Section F.2.3.4), incineration was selected as the treatment technology most likely to dominate risk to site workers and to the surrounding populations, and accordingly was used as the reference technology for accident calculations.

The risk assessments conducted for the WM PEIS used assumptions and best-estimates when data were only generally known or where processes have not been demonstrated fully; therefore, uncertainties are present. Additional details about the methodologies and assumptions used to assess human health impacts can be found in Appendices D, E, and F.

5.4.1.1 Uncertainty in Risk Estimates

Human health risk assessment results are conditional estimates that are influenced to a large extent by the many assumptions that must be made in order to account for an insufficient understanding of biological processes or a lack of information on contaminant or receptor behavior. Therefore, in evaluating risk estimate results, it is important to recognize that uncertainties are involved in the analysis in order to place the risk estimates in proper perspective.

Risk estimates are composed of a number of parameters. To estimate risk, information must be available on dose/response relationships which define the biological response per unit of exposure to a contaminant. Although human epidemiological data are used for developing radiation dose-response models, dose-response data are also developed in laboratory tests using animals exposed to relatively high doses. Therefore, uncertainty in dose/response relationships includes extrapolating from effects in animals seen at high doses in order to estimate potential effects in humans that most often are exposed at lower doses.

Another important component of risk assessment is estimation of exposure concentrations. Uncertainties associated with this component of the analysis include estimating (generally through the use of mathematical models) releases of contaminants from emission sources to different environmental media, the transport and transformation of contaminants in these media, and the pathways, frequency and duration by which humans contact the contaminants. Modeling involves trying to simulate a process that is inherently complex using a fixed and relatively small number of variables. Model uncertainty may result from the general limitations of mathematical models as well as from the lack of information on model parameters. For example, the fate

and transport models used to estimate risks for the WM PEIS require large amounts of data, including meteorological measurements, hydrogeologic settings, and release parameters. Where possible, actual data are used, but generic data are often substituted where site-specific data are unavailable.

The assumptions made in performing this program-level evaluation were intended to yield reasonably conservative risk estimates (e.g., estimates that tend to overestimate rather than underestimate risk) using the best available data and state-of-the-art models. Many of the uncertainties associated with the WM PEIS risk estimates are "systemic," given the programmatic nature of the WM PEIS and the use of the unit approach to risk assessment. This means that many of the modeling and scenario assumptions (e.g., facility emission rates for particular types of waste treatment or storage, inhalation rates, etc.) were applied consistently or systematically throughout the analysis. Therefore, the *relative* differences in risk estimates among waste management alternatives should not be affected by errors associated with these systematic uncertainties.

The uncertainties associated with the WM PEIS risk estimates cannot easily be quantitatively evaluated because of the many different parameters involved in the models used in the analysis. However, risk estimate uncertainty can be qualitatively differentiated as follows. Certain risks, such as worker physical hazard injuries during construction, or transportation accident physical trauma injuries, are based on historical statistics or actuarial data (e.g., number of hours worked, or number of miles traveled). Therefore, these risks can be estimated with a relatively high degree of confidence.

On the other hand, risks associated with the release of radionuclides or chemicals to ambient environmental media during the routine operation of treatment or storage facilities are estimated using probabilistic models. The risk estimates produced by these models have a larger uncertainty than those based on actuarial data. However, it is reasonable to assume that such releases will occur on a routine basis over the operational lifetime of the facility; that is, the estimated annual frequency (or probability) of occurrence of these events is one.

A third group of risk estimates generally involve even more uncertainty than facility routine operation exposure risks. This group includes facility accident risks and the hypothetical farm family and intruder scenarios. These risk estimates also involve the use of probabilistic models. However, unlike releases from facilities during routine operations, facility accidents generally have estimated probabilities of occurrence that are much less than one. Therefore, in interpreting the potential risks from facility accidents, both the

estimated probability of occurrence as well as the estimated consequences should be considered. Certain low probability accidents (e.g., aircraft crashes) may have potentially large consequences (e.g., a large number of latent cancer fatalities), but they are not expected to occur very often (e.g., probability of less than one-in-one million on an annual basis). Other types of accidents (e.g., fires) may have a higher probability of occurrence (e.g., one-in-one hundred) but generally have smaller consequences.

The hypothetical farm family risk estimates include an additional degree of uncertainty, since they attempt to estimate risks far into the future (up to 10,000 years). Both the hypothetical farm family and intruder scenarios take place in the future and assume the loss of institutional control of disposal facilities allowing the establishment of a farming operation that uses groundwater near the disposal site and excavation directly into the disposal unit.

Finally, the maximally exposed individual (MEI) risk estimates generally involve a greater level of uncertainty than population risk estimates, given the required assumptions about continuous exposure at a specific location for a single individual.

Appendix D, Section D.4, presents an evaluation of some parameter uncertainties associated with the WM PEIS health risk estimates.

Similar to the facility risk discussed above, the determination of transportation risk is subject to numerous uncertainties. Whereas risks such as physical injuries and fatalities from transportation accidents are based on historical statistical data, radiological risks are predicted using complex mathematical models. These models attempt to describe transportation operations that take place over time and through a constantly changing landscape. Moreover, different models and assumptions are typically used to describe different shipment modes, such as truck and rail, and may result in different levels of uncertainty between modes. Additional details related to the uncertainties in transportation risk estimates, including considerations in comparing truck and rail shipment results, are provided in Appendix E.

5.4.1.2 Populations and Individuals at Risk

Several groups may be exposed to a variety of hazards during the treatment, storage, and disposal phases of waste management. In general, the WM PEIS considers:

- The offsite population—those living within a 50-mile radius of the site, as well as within 0.5 miles on each side of the transportation routes
- The onsite population—the workers on DOE sites who are not involved in actual environmental management activities (the "noninvolved" or "collocated" workers)
- The facility workers (or "waste management workers," including those operating the trucks and trains that transport the waste)

The WM PEIS health risk analysis evaluates impacts to members of the public living within a 50-mile radius of DOE sites, to waste management workers, and to onsite workers not directly involved in the proposed waste management actions. For each of these groups of receptors, the standard risk assessment assumption of 70 years is used for the length of an average lifetime.

For offsite population receptors, health risks are primarily from exposure to airborne contaminants released from waste treatment facilities. Both radionuclide and hazardous chemical contaminants are potentially released. Exposure to radionuclides and hazardous chemicals is assumed to occur over the 10-year period of facility operation. Exceptions to this assumption would include a full 20-year operations phase (i.e., construction phase not applicable) for the No Action Alternative, and the site-specific operational periods for HLW storage facilities, which are discussed in Chapter 9. Exposure to radionuclides that are inhaled or ingested is expected to continue for up to 50 years, since these contaminants, once incorporated into the body, will irradiate tissues even after the 10-year operation period has ended. This 50-year exposure period (also known as a commitment period) is assumed for radionuclide releases from both treatment facilities and from trucks or railcars following transportation accidents.

Waste management workers are also subject to physical hazard injuries and fatalities resulting from industrial accidents occurring during the assumed 10-year facility construction period and 10-year facility operation period.

Population risks are expressed as numbers of cancer incidences, cancer fatalities, or genetic effects. Individual risk was assessed by considering the hypothetical MEI within each onsite and offsite population. These persons would receive the highest total dose—estimated by summing the highest doses delivered

along all pathways over the person's lifetime. Risks for individuals are expressed in probabilities that a particular adverse effect will occur (ORNL, 1995a,b). DOE has not specifically evaluated the human health risk to subpopulations that may derive a substantial portion of their food supply from native plants and animals that live near DOE sites. This is a complex analysis that cannot be performed with confidence until locations of the facilities on the sites are known, the routes of exposure explicitly defined, and the dietary habits of the populations quantified.

5.4.1.2.1 *Intruder Scenario*

To consider the maximum potential human exposure from the disposal of waste, the WM PEIS examines scenarios of a hypothetical intruder and a hypothetical farm family.

An intruder scenario was evaluated in order to estimate the potential health risks to an individual from the disposal of LLW and LLMW in a future era when disposal facilities are no longer under institutional control. A hypothetical intrusion scenario with two different time frames (100 and 300 years after closure of the disposal facility) was developed. The scenario assumes that a single adult drills a well directly through the disposal facility to the water table. As a result of the drilling, contaminated soil from within the facility is brought to the surface, where it mixes with the top layers of the surface soil. The individual raises crops on this plot of land and consumes the resulting produce.

Exposure of the intruder to radionuclide and chemical contaminants was assumed to result from the ingestion of plants, inhalation of resuspended soil particulates, and inadvertent ingestion of soil. In addition, the intruder was assumed to be exposed to direct radiation from the soil. Health effect endpoints evaluated as a result of radionuclide and direct radiation exposure included probability of cancer fatality, cancer incidence, and genetic effects. For chemical exposure, the endpoints used were probability of cancer incidence and noncancer risks.

5.4.1.2.2 *Hypothetical Farm Family*

The hypothetical farm family is assumed to establish a water supply well 300 meters downgradient from the center of an underground disposal facility. This distance is roughly equivalent to the 100-meter distance

from the edge of the disposal unit used in the performance assessment analyses required under DOE Order 5820.2A. Concentrations of groundwater contaminants at this location are assumed to be higher than those that could be expected at greater distances from the unit due to dispersion of contaminants. Construction of multiple units is expected to be required at certain sites, particularly under the Regionalized and Centralized Alternatives in order to process the projected waste volumes. Since the analysis looks only at a single receptor located 300 meters from the center of each unit, DOE assumes that each of these close-in receptors will be affected primarily by the contaminant plume from the disposal unit closest to them. DOE recognizes that commingling of contaminant plumes from multiple disposal units may occur as distance from the units increases, but anticipates that, at 300 meters, the highest concentration of contaminants is likely to result from the single closest plume. At greater distances from the disposal units, where overlap of the plumes is more likely, the concentrations in any given plume should be lower than those estimated at the 300 meters well as a result of dispersion and dilution. The WM PEIS did not address groundwater contaminant concentrations at distances greater than 300 meters from disposal units. More detailed analyses, such as the performance assessments required under DOE Order 5820.2A, will address the issues of existing groundwater contamination and multiple disposal units. For example, in April 1996 DOE issued guidance for the conduct of composite analyses in addition to performance assessments to help ensure that continuing disposal of low-level waste will not compromise the future radiological protection of the public. The composite analysis will estimate the potential cumulative impacts to a hypothetical future member of the public from an active or planned LLW disposal facility and other sources of radioactive material in the ground that might interact with the LLW disposal facility.

The hypothetical farm family scenario assumes that a series of families lives downgradient of the disposal unit for a period of 10,000 years. Each family's lifetime is assumed to be of 70 years' duration; therefore, 143 lifetimes were evaluated. The exposure to this hypothetical farm family was assumed to occur at a time when there has been a breach of the disposal facility and when institutional controls (fences, warning signs, land records, etc.) no longer exist. The family engages in farming activities, such as growing and consuming their own crops and livestock, and uses nearby water for drinking, bathing, and recreation as well as for watering their crops and livestock. This hypothetical farm family is assumed to be located so that they received the highest possible exposure to contaminants in groundwater by all possible routes. The 10,000-year period was selected for the analysis to maintain consistency with the "Guidelines for Radiological Performance Assessment of DOE Low-Level Radioactive Waste Disposal Sites" that existed at the time the WM PEIS analysis was initiated. The guidance for performance assessments has since been

changed; current guidance suggests that a 1,000-year time period should be used in the performance assessments for waste disposal conducted to satisfy the requirements of DOE Order 5820.2A.

The hypothetical farm family scenario attempts to estimate potential risk resulting from the future contamination of groundwater following disposal of LLW and LLMW. Humans are assumed to be exposed through use of the groundwater as a source of drinking water and irrigation water. Several aspects of the scenario should be noted. The analysis addresses only new disposal units and does not account for existing disposal inventory or existing groundwater contamination at a site. Also, this analysis does not attempt to suggest that farming is a reasonable or preferred future use of the land at DOE sites upon the loss of institutional control. Farming was selected only in order to maximize the potential exposure and risk from contaminated groundwater through its use both as drinking water and in crop irrigation at arid sites.

5.4.1.2.3 *Collective Offsite Population*

The population risk vulnerability analysis was developed to compare LLMW and LLW disposal alternatives using measures that characterize their relative potential to cause disposal risks to offsite populations.

Rationale for Not Quantifying Offsite Population Risks From Disposal. The hypothetical farm family scenario does not attempt to quantitatively estimate the potential risks to current offsite populations living near DOE sites (collective risks) from the disposal of LLMW and LLW. Certain considerations led DOE to conclude that an alternative to collective risk estimation was needed for the WM PEIS comparison of disposal alternatives. First, other DOE efforts to address disposal risk do not generally estimate population risk. DOE has been addressing the issue of protecting the public from the effects of exposures to radioactive and mixed waste constituents released from disposal facilities. Ongoing Department efforts include performance assessments conducted for LLW disposal facilities in compliance with the requirements of DOE Order 5820.2A and performance evaluations conducted for candidate LLMW disposal sites by the FFCAct Disposal Workgroup. Although these efforts currently address risks to single individuals at specified compliance points, none attempts to predict collective risks to current or future populations.

Second, DOE determined that estimation of offsite population risk from exposure to disposal facility contaminants in the WM PEIS would require too many speculative assumptions and would not provide a credible basis for comparison of LLMW or LLW disposal alternatives. The concentrations of contaminants

in the groundwater and the number of people potentially exposed will be determined in large part by the locations of the disposal units and the receptor wells. Estimation of the number of adverse health effects in current offsite populations would require information about the exact locations of the disposal facilities on sites. Since the WM PEIS does not attempt to make such siting decisions, offsite population doses (i.e., person-rem) and risks (e.g., number of latent cancer fatalities) from disposal were not estimated. Analysis of future offsite population risks requires similar siting information and involves additional uncertainty with respect to the sizes of future populations. Therefore, the WM PEIS could not credibly estimate adverse health impacts from disposal for future offsite populations.

Given this uncertainty about quantifying potential collective risks to offsite populations from waste disposal, DOE determined that some relative indicator of the potential for offsite risks would be an appropriate approach. Therefore, DOE has supplemented the quantitative estimates of farm family MEI risk presented in Sections 6.4 and 7.4 of Chapters 6 and 7 with statistical analyses of site environmental data. These analyses evaluate site parameters that influence groundwater contamination or that are expected to be associated with the sizes of the populations potentially at risk. The results of the analyses are indicative of the relative potential for offsite population risk from disposal. This procedure is a screening- level analysis that does not take into account any measures that would limit migration of disposed wastes into the groundwater, such as engineered disposal units or changes in waste acceptance criteria. The objective of the analysis is not to rule out any sites for disposal—a number of sites are currently disposing LLW—but to indicate where disposal mitigation measures are more likely to be necessary and where the costs of disposal would likely increase as a result of such measures.

Population Risk Vulnerability Analysis Approach. In the population risk vulnerability analysis, DOE selected environmental variables expected to determine or be associated with the level of offsite population risk, performed statistical factor and cluster analyses to determine how to group the sites in terms of vulnerability, then tabulated the individual site and overall alternative vulnerability classification of the LLMW and LLW disposal alternatives.

Selection of Important Explanatory Variables. The variables chosen to be used in the factor and cluster analyses of the 16 candidate disposal sites were six site characteristics that would likely cause or be associated with future levels of offsite population risk from radioactive or mixed waste disposal—annual rainfall, annual groundwater recharge, aquifer depth, travel time of water from the time it infiltrates the ground surface to the time it reaches the aquifer and appears in a downgradient well, current human

populations within 50 miles of the site, and site acreage (see Table 5.4–1). The first three variables, which characterize the surface and groundwater hydrology of the sites, are measures known to influence the speed, duration, and extent of dispersal of contaminants from disposal facilities, and the level of resulting downgradient concentrations in groundwater. The travel time estimates are based on the physical properties of the soils, the aquifer depth, and the groundwater velocity at each site. Current population levels are considered the most appropriate measure of the potential size of the population at risk, at least on a relative basis from site to site. It should be noted that the parameter "current population level within 50 miles" serves only as a general index of potential populations at risk from contaminated groundwater, not as a specific estimate of future populations at risk. The 50-mile radius populations may include large, relatively distant population centers (such as Buffalo in the case of WVDP) that would not likely draw groundwater from downgradient wells or, on the other hand, may exclude large population centers just outside the 50-mile radius (such as Las Vegas in the case of NTS) that may use downgradient wells in the future. Site acreage provides an indirect measure of two associated characteristics—the size of the potential populations at risk and the likelihood that contaminants in downgradient groundwater would appear in a publicly accessible wellwater source, the former because the larger sites exclude population growth on extensive areas, the latter because of the relationship between the proximity of offsite population centers to locations on the sites where disposal facilities likely would be constructed.

These site characteristics are generally strongly correlated with each other—for example, the smaller sites tend to be situated in regions of denser population with higher rainfall. Therefore, DOE transformed the 96 data points comprising the six variable measures on the 16 sites mathematically, using a statistical technique called factor analysis, into principal factor variables that are composite measures of the important variations in these site characteristics. Factor analysis reconstitutes the data into a smaller derivative set of "explanatory variables" as linear combinations of the original variable set (Norusis/SPSS Inc., 1993). Appendix C, Section C.4.1 provides the details of the factor analysis methodology. In this analysis, 80% of information in the data set is represented after the factor transformations by two principal factors. The first factor, which accounts for approximately 64% of the variability in the site environmental data, is primarily a positive measure of the site rainfall and recharge characteristics and a negative measure of groundwater travel time. The second factor, accounting for an additional 15% of the data variability, is primarily a measure of the sites' size and population characteristics. The sites are arrayed according to their scores on the first two principal factors of the site environmental data in Figure 5.4–1. Sites to the right in the diagram have higher scores on the first factor, indicating they have groundwater hydrologic conditions

Table 5.4–1 Environmental and Population Data Used to Categorize Disposal Sites in Terms of Population Risk Vulnerability

Site	Population Within 50 Miles	Acreage	Annual Rainfall (cm)	Aquifer Depth (ft)	Annual Aquifer Recharge (ft/yr)	Time of Travel (yr)
ANL-E	7,939,785	1,025	80	90	0.33	246
BNL	5,738,554	5,263	107	200	0.50	59
FEMP	2,764,589	1,050	104	59	0.50	18
Hanford	377,645	370,656	16	236	0.16	191
INEL	153,061	572,160	23	600	0.23	298
LLNL	6,324,234	6,900	36	98	0.08	70
LANL	159,152	28,000	47	749	0.05	411
NTS	14,266	864,000	19	787	<0.001	1,352
ORR	895,379	34,560	139	26	0.60	11
PGDP	500,502	3,425	120	49	0.43	17
Pantex	265,185	16,000	51	320	0.02	175
PORTS	639,062	4,032	101	24	0.39	24
RFETS	2,171,877	6,550	38	18	0.16	25
SNL	610,714	2,791	20	94	0.06	132
SRS	620,618	192,700	122	110	1.30	23
WVDP	1,698,391	220	104	10	0.23	226

that would tend to move contaminants more quickly downgradient from disposal units and possibly to drinking-water wells that might be used by the public. Sites to the left in the diagram are those where site characteristics would tend to limit migration of contaminants and increase the time over which any movement might result in wellwater contamination. In terms of scores on the second factor, sites plotted in the upper portion of the diagram are those that are smaller in size with higher surrounding populations. Those plotted lower are the larger sites with lower surrounding populations. Land uses on and near the sites, the site size itself, and the size of the surrounding populations are more likely to change substantially during the time contaminants may be leaching from disposal units than the physical characteristics of the site. Therefore, DOE considers the first factor scores more important than the second factor scores in characterizing the sites' relative potentials for offsite population risk.

Derivation of Population Risk Potential Groups. The factor analysis gives a general indication of the relative population risk vulnerability of the 16 proposed disposal sites. The factor scores of the 16 sites show relationships among the sites in hydrologic and population characteristics that would be reasonable

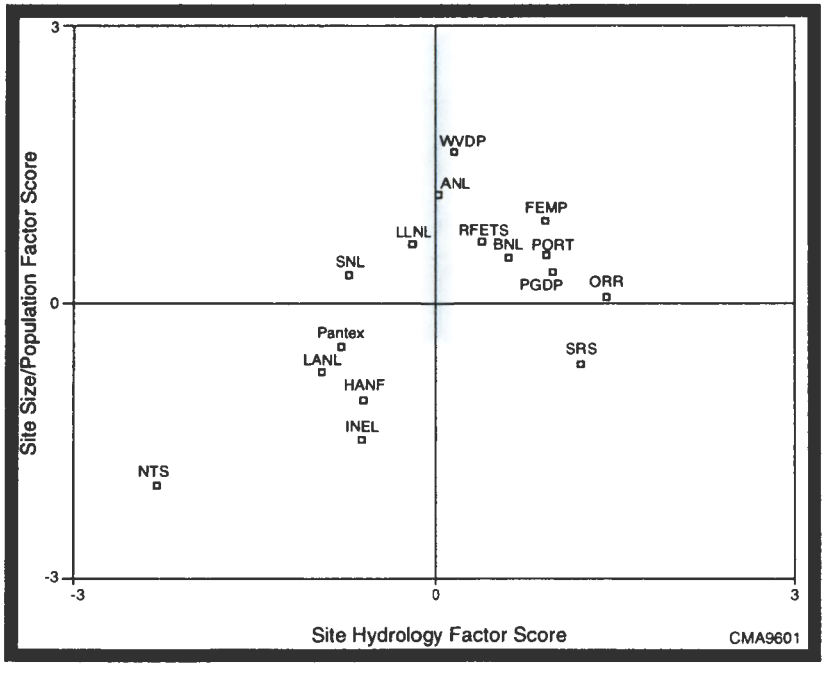

Figure 5.4–1. Sites Arrayed According to Their Scores on the First Two Principal Factors of Environmental Data

to conclude would be directly related to the levels of population doses and risk. DOE proceeded further to identify distinct groups of sites representing similar levels of potential for population risk from waste disposal using a cluster analysis of the same six site characteristics.

In the cluster analysis, DOE used the site environmental data on the six variables to calculate measures of overall difference among the 16 sites. These difference measures were used to combine sites into clusters. The difference measures are greater between clusters than they are for sites within a cluster. By labeling the factor plots with the cluster membership of each site, distinct risk vulnerability groupings were identified. Details of the cluster analysis for the 16 proposed disposal sites are presented in Appendix C.

The cluster analysis was used to identify three general site groups according to their expected relative population risk vulnerability (PRV). The group number of each site is plotted against the two principal factors of the site data in Figure 5.4–2. The groups are listed with the basis of their relative population risk vulnerability ratings in Table 5.4–2.

Population risk vulnerability was judged to increase from left to right in the factor diagram (Figure 5.4–2). Group 3 sites were judged to have a relatively higher offsite population risk vulnerability for waste disposal (Table 5.4–2) because these sites scored highest on the first environmental factor—and those scores are expected to be directly related to the level of eventual leaching of contaminants from the LLMW or LLW disposal facilities and the rate of transport of contaminants through the groundwater. Group 1 sites were considered to have a relatively lower population risk vulnerability because their scores on both factors are lower than the other site clusters. Group 2 sites generally scored high on the population/site size factor but lower than Group 3 sites on the groundwater hydrology factor. Because the first factor is considered a more important determinant, they are considered intermediate in terms of population risk vulnerability.

5.4.1.2.4 *Comparison of Alternatives for Population Risk Potential*

LLMW and LLW disposal alternatives were arrayed in terms of greater or lesser potential for population risk based on the final PRV group designation of the sites proposed for disposal under each alternative and the waste volume, total radioactivity, and number of disposal units proposed under each alternative at each of the sites. LLMW and LLW alternatives were then summarized in terms of the total waste volume, total

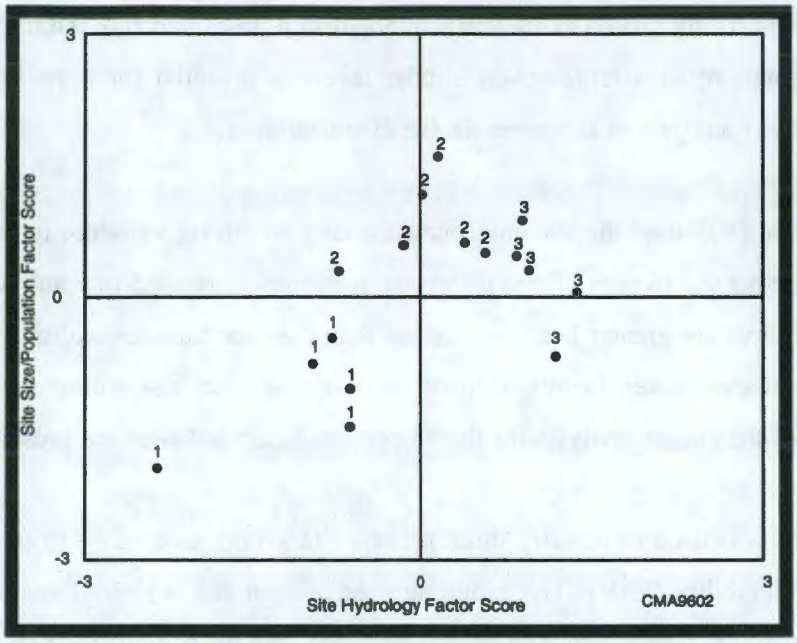

Figure 5.4–2. Sites Labeled by Population Risk Vulnerability Group Number Arrayed According to First Two Principal Factors of Environmental Data

Table 5.4–2. Population Risk Vulnerability Groups of the 16 Proposed Disposal Sites

Population Risk Vulnerability Group	Relative Offsite Population Risk Level	Sites in Population Risk Vulnerability Group	Relative Score on Groundwater Hydrology Factor	Relative Score on Site Size/Population Factor
3	Higher Relative Risk	FEMP, PGDP, PORTS, ORR, SRS	High	Intermediate to High
2	Intermediate Risk	ANL, BNL, LLNL, RFETS, SNL, WVDP	Intermediate	Intermediate to High
1	Lower Relative Risk	HANF, INEL, LANL, NTS, Pantex	Very Low to Low	Very Low to Intermediate

radioactivity, and number of disposal units required at all sites within each population risk vulnerability group. Those alternatives with greater volume, total radioactivity, and number of disposal units at PRV Group 3 sites could generally be considered to represent a relatively greater risk to populations than alternatives that concentrate disposed wastes at PRV Group 1 and 2 sites. From a population risk perspective, alternatives that concentrate disposed wastes at PRV Group 1 sites would represent the lowest potential risk.

5.4.1.3 Exposure Pathways

Different groups were assumed to be exposed through different pathways during each waste management phase. The exposure pathways and potentially affected populations and individuals are summarized in Table 5.4–3. The exposure pathways considered for the different receptor groups are shown in Figures 5.4–3 through 5.4–6. The exposure pathway for storage was assumed to be direct radiation from the storage containers.

The potential exists for human exposure to radiological and chemical contaminants in surface water. Receptors can be exposed through the use of contaminated surface water for drinking water, bathing, swimming, or irrigation. In addition, ingestion of fish or shellfish taken from contaminated surface waters may be another source of exposure through bioaccumulation of the contaminants in the tissues of these organisms. Potential pathways for surface water contamination from waste management practices include deposition of contaminants released to the atmosphere to surface water bodies, overland runoff to surface waters, releases of contaminants in aqueous effluents from treatment and storage facilities, and recharge of surface waters by groundwaters potentially contaminated through waste disposal.

A limited analysis was performed to show the potential health effects from the deposition of airborne contaminants on surface water bodies. Preliminary estimates described in Appendix D for the Columbia and Clinch Rivers indicated that the potential dose received from ingestion of surface water contaminated by deposition of airborne contaminants was a thousand to millions of times lower than that received from inhalation in a gaseous plume of hazardous or radioactive material. Other potential pathways of surface water contamination can be controlled or are more affected by the technical design and relative location of the waste management facilities with respect to the location of surface water bodies. Releases of contaminants in aqueous effluents from treatment and storage facilities are expected to be small because

Table 5.4–3. Exposure Pathways for Treatment, Storage, Transportation, and Disposal Activities

Waste Processing Phase	Pathway	Potentially Exposed Populations and Individuals
Treatment • Routine emissions • Accidents	Atmospheric • Inhalation • Ingestion of crops and animals[a] Direct radiation	• Public within 50-mile radius • Onsite employees, evenly distributed within site borders (atmospheric only) • Onsite MEI (atmospheric only) • Offsite MEI (atmospheric only) • Waste management worker (inhalation and direct radiation only)
Storage • Routine emissions • Accidents	Atmospheric • Inhalation • Ingestion of crops and animals Direct radiation	• Public within 50-mile radius • Onsite employees, evenly distributed within site borders (atmospheric only) • Onsite MEI (atmospheric only) • Offsite MEI (atmospheric only) • Waste management worker (inhalation and direct radiation only)
Disposal • Routine emissions	Atmospheric • Inhalation Groundwater • Ingestion of drinking water • Irrigation of crops • Watering of livestock • Bathing Direct radiation	• Waste management worker (atmospheric and direct radiation during disposal operations only) • Hypothetical farm family (ingestion of groundwater and food) • Hypothetical intruder (ingestion of crops and soil, inhalation of soil particulates, direct radiation)
Transportation • Routine emissions • Direct radiation • Accidents	Atmospheric (accident only) • Inhalation • Ingestion of crops and animals[a] Direct radiation	• Population living and traveling along the route and present at rest stops • Workers

Note: MEI = maximally exposed individual.
[a] Radiological only.

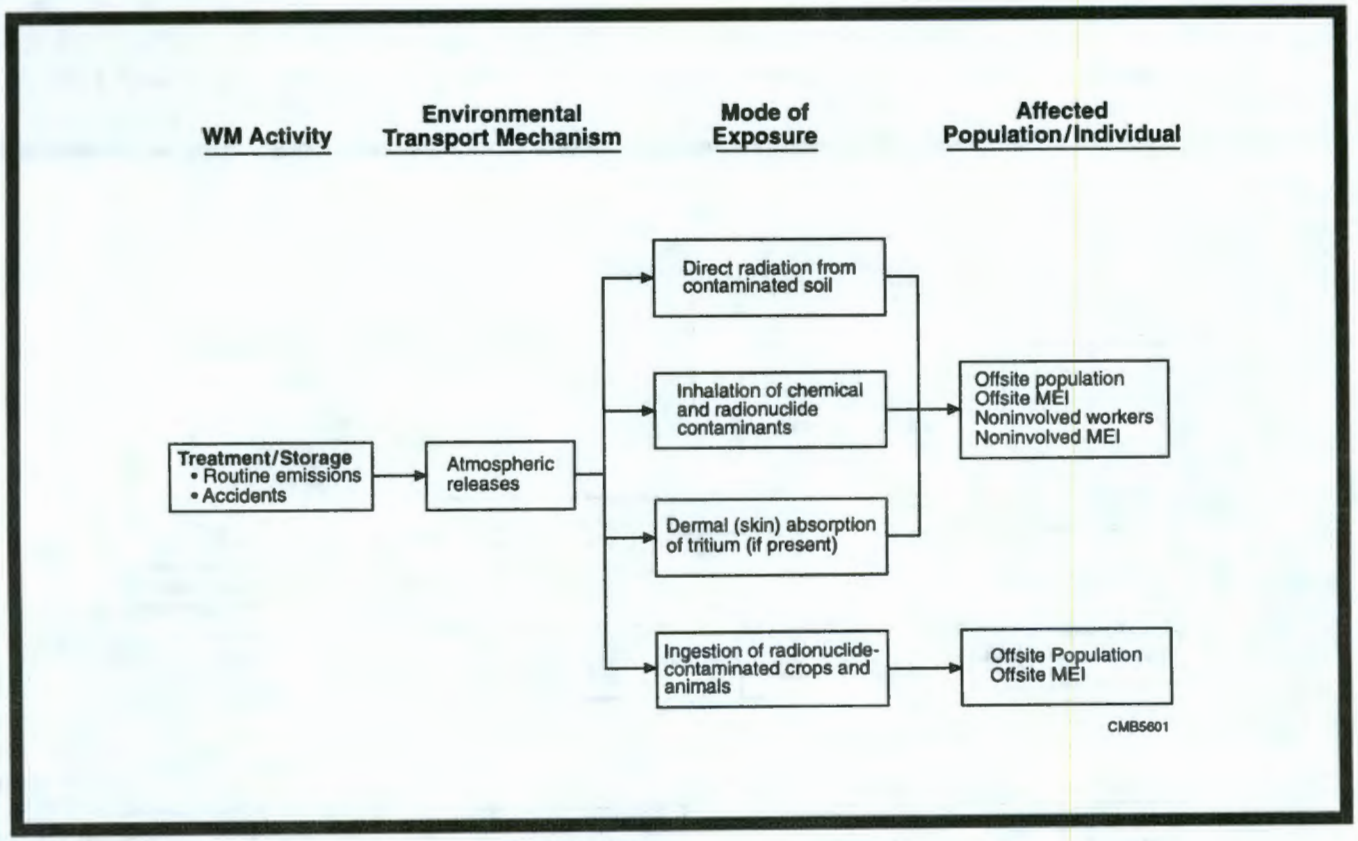

Figure 5.4–3. Exposure Pathways for the Offsite and Noninvolved Worker Populations for Treatment and Storage Activities

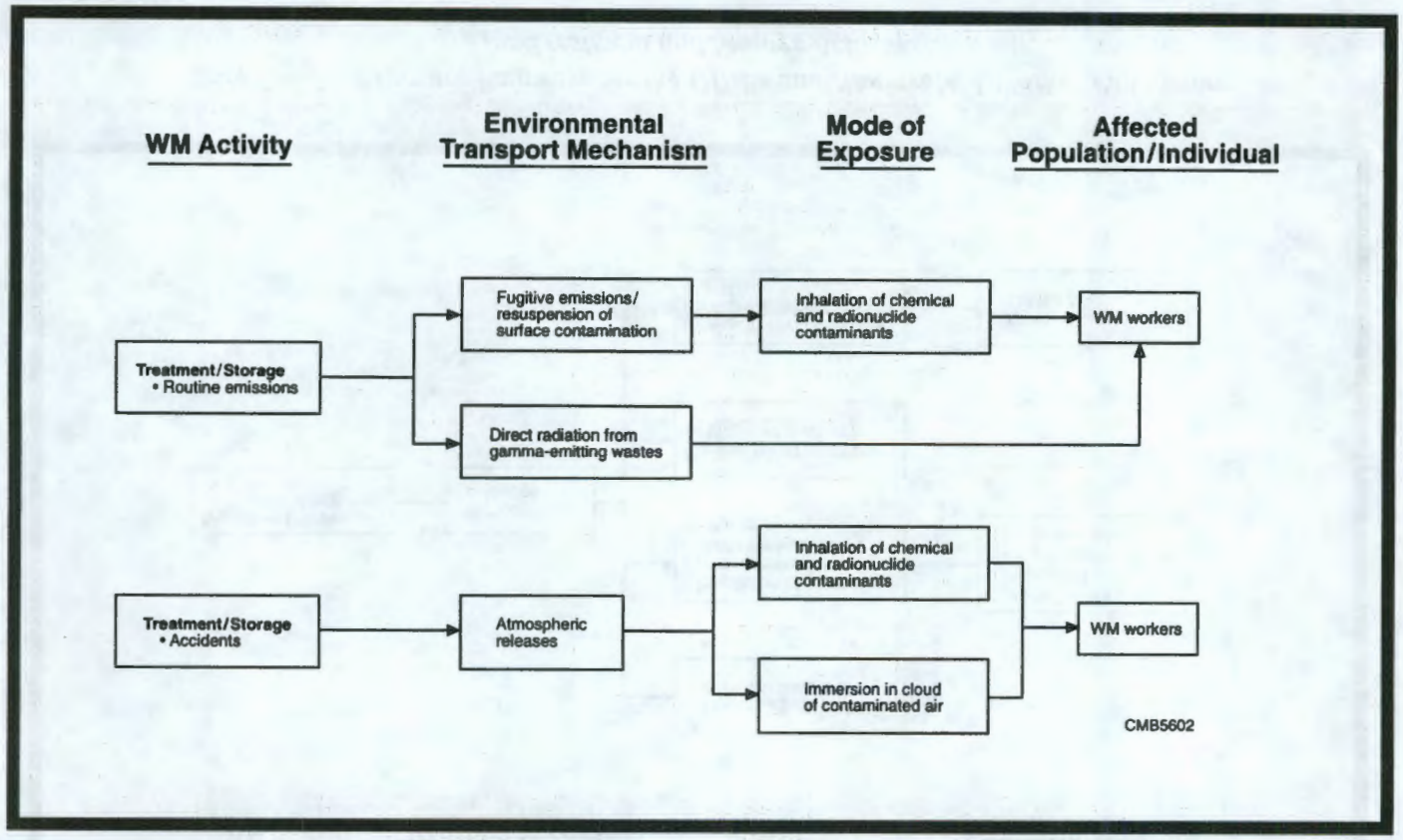

Figure 5.4–4. Exposure Pathways for Waste Management Workers for Routine Operations and Accidents During Waste Treatment and Storage

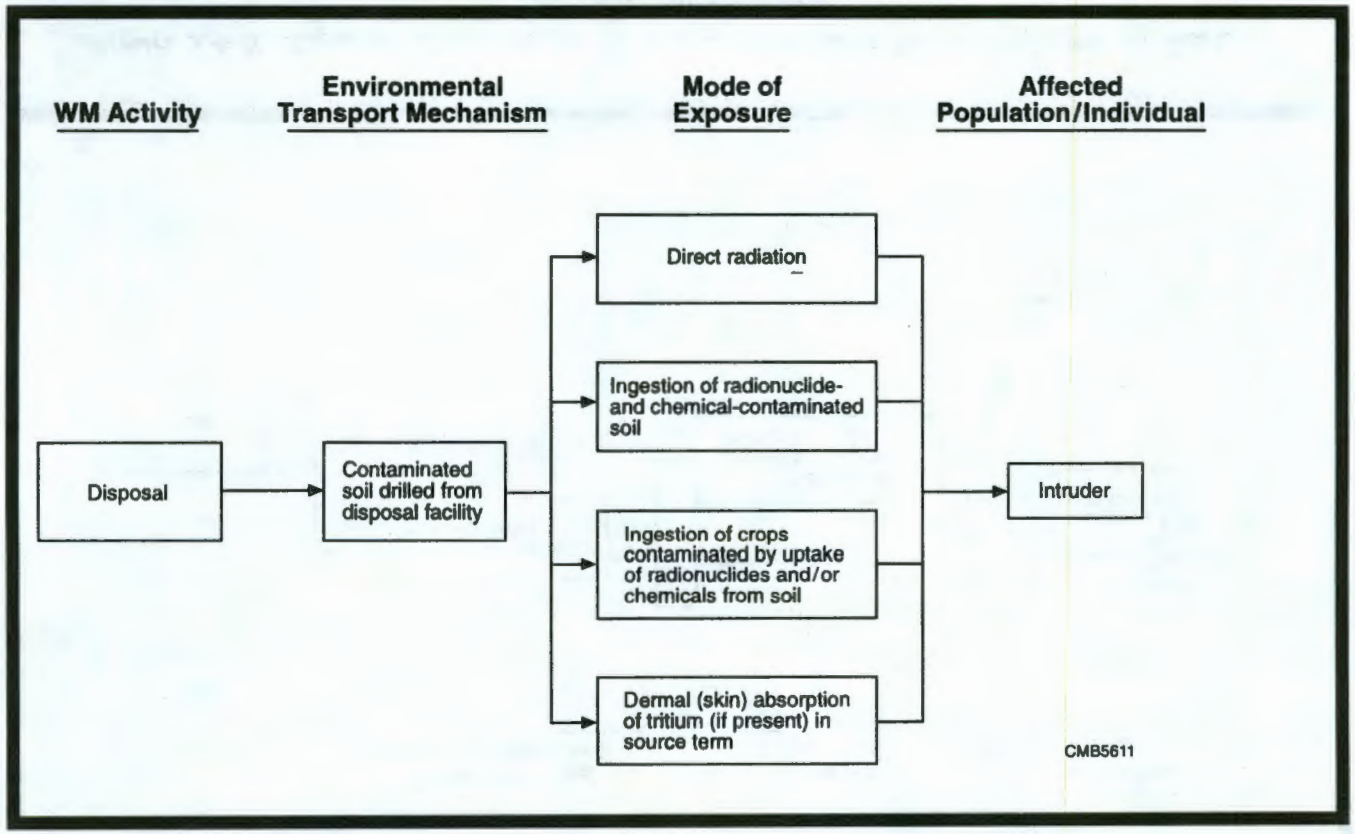

Figure 5.4–5. Exposure Pathways for the Intruder for Disposal Activities

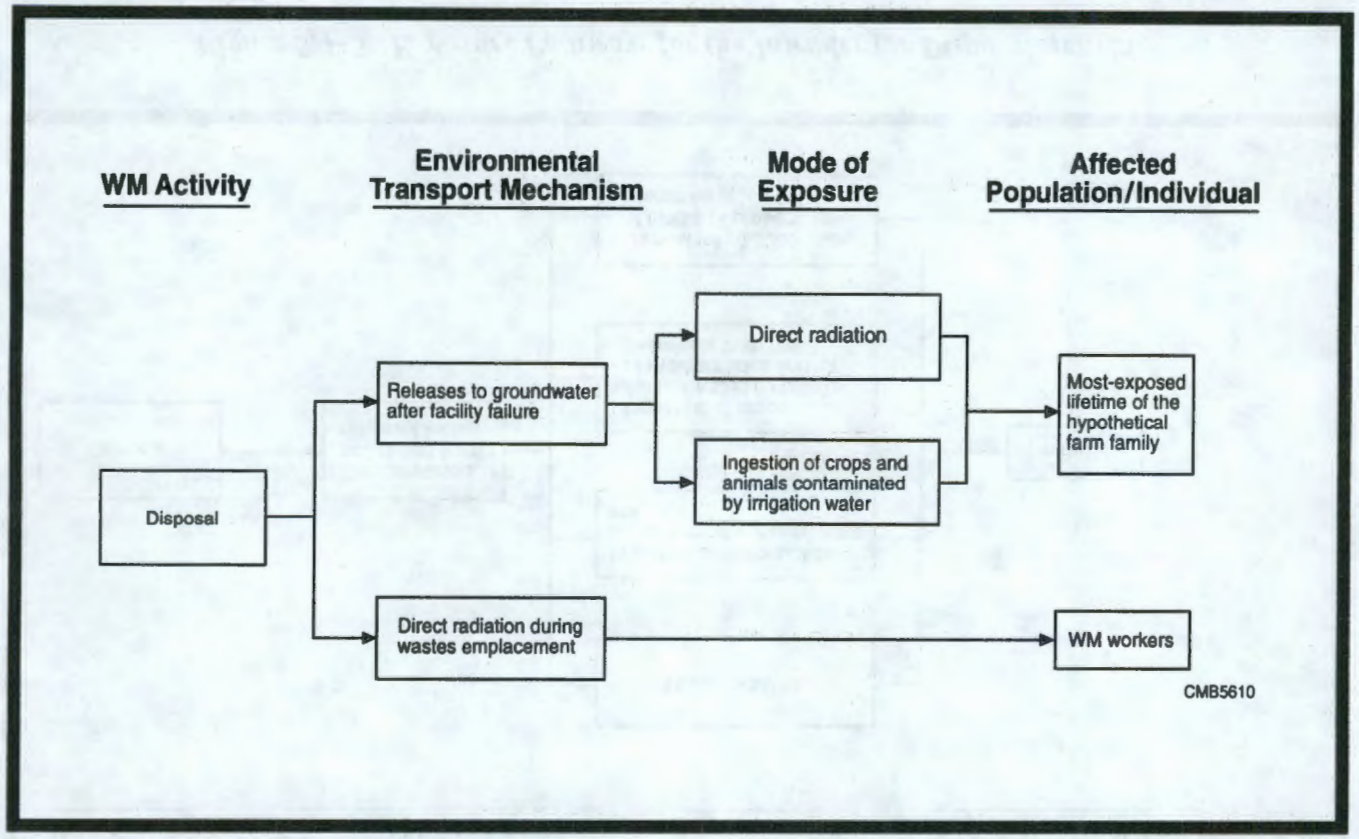

Figure 5.4–6. Exposure Pathways for the Farm Family and Waste Management Workers for Disposal Activities

process wastewaters from these facilities would be discharged to aqueous waste treatment facilities. After treatment, wastewaters would be recycled or discharged from these plants. All wastewaters, including storm waters, would be discharged in compliance with site-specific DOE, National Pollutant Discharge Elimination System (NPDES), or industrial wastewater discharge limits, which are established based upon consideration of the potential health and environmental effects of contamination of the receiving body. Disposal facilities may eventually degrade and release contaminants to the groundwater. Resultant contamination of surface water from the groundwater is dependent on the specific location of the disposal facility with respect to the surface water; however, dilution of the contaminants in "clean" surface waters is likely to result in surface water concentrations that are much lower than the concentrations in the groundwater.

Since the WM PEIS does not attempt to make waste management facility technology or siting decisions, there would be a high degree of uncertainty associated with any quantitative surface water pathway exposure estimates. Consequently, the WM PEIS did not conduct a detailed evaluation of this pathway. Surface water pathway analyses are appropriate for sitewide or project-level NEPA reviews where potential impacts may appear important to decision making.

Radioactive decay and the ingrowth of daughter products are taken into account in the estimation of radiological dose from direct radiation, ingestion of contaminated groundwater, and inhalation of contaminated air. Since treatment and storage periods are assumed to be 10 years in duration, radioactive decay and ingrowth are estimated for external radiation for an average of five years in order to capture the doses of photon-emitting daughters. For the groundwater pathway, radioactive decay is considered at several points in the exposure assessment. The first point is prior to the breach of the disposal facility, where decay is evaluated and the contaminant inventory is modified accordingly. Decay then occurs after the breach of the disposal facility and during transport to the vadose zone is accounted for prior to the transfer of flux rates to the MEPAS model. The MEPAS model then accounts for radioactive decay and ingrowth involved in transport through the vadose and saturated zones. All doses from daughter products are attributed to the parent radionuclide. The GENII model used in estimating exposure from inhalation of airborne radionuclides also accounts for radioactive decay and ingrowth, and assumes, as in the groundwater pathway, that all doses from daughter products are attributed to the parent radionuclides.

Offsite population and noninvolved onsite workers were assumed to be exposed to radionuclides through inhalation of airborne vapor and dust. This aspect of exposure lasts throughout waste treatment, storage,

and disposal operations. Onsite and waste management workers, during nonworking hours, are counted among the individuals living near the site (offsite population).

Onsite workers were assumed to experience chemical and radiological exposure from treatment, storage, and disposal facilities. The exposure pathways for these workers were assumed to be inhalation of vapor and dust, and direct external radiation. These workers are also subject to a variety of construction- or operation-related accidents. Workers were assumed to be wearing the proper industrial safety and health equipment for the task being performed (construction in a nonradioactive environment, operations in a radioactive environment).

The population living and traveling along the transportation routes are assumed to be exposed to radionuclides by way of direct radiation under routine conditions and both direct radiation and inhalation of airborne vapor and dust under accident conditions (SNL, 1993). Onsite industrial and transportation accidents were evaluated using the RISKIND model (ANL, 1993). Exposure to hazardous chemicals under accident conditions is assumed to occur only by inhalation of vapors and dust. Direct exposure by other pathways such as dermal (skin) absorption, is possible, but these routes are expected to result in much lower exposure than the inhalation pathway doses. The public is assumed to be exposed to vehicle exhaust fumes. The exposure pathways for transportation workers are assumed to be the same as those for the general population.

5.4.1.4 Health Impacts

Health impacts, which may range from bodily injury or illness to death, can result from exposure to radionuclides; exposure to chemicals or exhaust fumes; or physical trauma (crushing, burning, electrocuting). The effects on people of radiation that is emitted during disintegration (decay) of a radioactive substance depends on the kind of radiation (alpha and beta particles and gamma and x-rays) and the total amount of radiation energy absorbed by the body. The total energy absorbed per unit quantity of tissue is referred to as the absorbed dose. The absorbed dose, when multiplied by certain quality factors and factors that take into account different sensitivities of various tissues, is referred to as the effective dose equivalent, or where the context is clear, simply dose. The common unit of effective dose equivalent is the rem or millirem (1 rem equals 1,000 millirem).

An individual may be exposed to ionizing radiation externally, from a radioactive source outside the body, and/or internally, from ingesting or inhaling radioactive material. The external dose is different from the internal dose. An external dose is delivered only during the actual time of exposure to the external radiation source. An internal dose, however, continues to be delivered as long as the radioactive material remains in the body, although both radioactive decay and elimination of the radionuclide by ordinary metabolic processes decrease the dose rate with the passage of time. Health impacts from radiation exposure, whether from sources external or internal to the body, generally are identified as "somatic" (affecting the individual exposed) or "genetic" (affecting descendants of the exposed individual).

Adverse health impacts associated with chemical exposure include cancer and a range of noncancer toxicity effects, including organ system toxicity (e.g., liver, respiratory, cardiovascular), neurotoxicity, immunotoxicity and developmental and reproductive toxicity. The risk of cancer incidence from exposure to hazardous chemicals is not directly comparable to the risk of cancer incidence from exposure to radionuclides. Section D.2.6.3 of Volume III provides additional information about comparing the potential health impacts of radionuclide versus hazardous chemical exposures.

The details of the methodologies used to estimate cancer fatalities, cancer incidence, adverse genetic effects, and noncancer toxic effects are discussed in Appendix D, Section D.2. An overview of uncertainties in health impacts is given in Appendix D, Section D.2.15.

Cancers and some birth defects are believed to result from certain genetic changes in specific individuals in a given generation; however, not all genetic effects result in disease. Genetic effects include gene mutations (alterations in the elementary units of heredity—the genes) and gross chromosomal aberrations (alterations in the structure or number of chromosomes). For the purposes of this PEIS, risks for genetic effects were calculated only for radionuclides; genetic toxicity from chemicals is more difficult to assess because of its diverse nature.

Cancer Fatalities. Cancer fatalities are the excess deaths (deaths that would not otherwise have occurred) resulting from all types of cancer over the lifetime of an individual measured as a frequency (or incidence) in a population, or a probability for individuals. Cancer fatalities resulting from airborne exposures to radionuclides are calculated over an assumed 70-year lifetime. Cancer fatalities resulting from groundwater exposures to radionuclides are calculated over a period of up to 10,000 years after the disposal facility has been breached.

Because of the nature of the biological processes by which chemicals or radiation are currently understood to induce cancer, the conservative approach used in this PEIS assumed that there is no threshold below which there is no risk for cancer, and that the risk of cancer from multiple exposures to different sources is additive. As described in Section D.2.8.2 of Volume III, cancer risks from radiological exposure were estimated using the radiological risk factors developed by the International Commission on Radiological Protection (ICRP). A certain percentage of radiologically-induced cancers were assumed to be fatal (ICRP, 1990). Similar assumptions regarding fatalities from chemically induced cancers are not possible because of the diverse nature of chemically induced cancer.

Cancer fatalities are used in the WM PEIS as a representative health risk endpoint because the occurrence of the other health impacts evaluated (except noncancer toxicity) generally follows the same pattern as radionuclide-induced cancer fatalities. Cancer fatalities in the offsite population were calculated for radionuclides released during routine operations of treatment or storage facilities, during facility accidents, and in the public along transportation routes.

Cancer Incidence. Not all cancers are fatal. The total cancer incidence encompasses all cancers, not just cancers that result in death. The concepts discussed above with regard to cancer fatalities also apply to the consideration of total cancer incidence. For the purposes of this PEIS, radiation cancer incidence and chemical cancer incidence are separately evaluated and reported.

With respect to radiation-induced cancers, the number of nonfatal cancers can be derived from the cancer incidence values by subtracting the estimated number of fatal cancer cases. Note that both the total cancer incidence and the nonfatal cancer incidence values are overestimated by a factor of about two. The ICRP dose conversion factors used in the WM PEIS to convert radiation exposure to estimates of total cancer incidences contain a relatively large component of skin cancers. Such cancers generally result from external exposures to radiation. However, the exposure pathways evaluated in the WM PEIS (e.g., inhalation or ingestion of radionuclides) are largely internal pathways. These internal exposures to radionuclides are not likely to induce large numbers of skin cancers.

Noncancer Toxic Effects. Although carcinogens (cancer-causing agents) are emphasized because they are believed to have no threshold, most mechanisms of noncancer toxic effects do have thresholds below which no toxic effects are observed. For noncarcinogens, a procedure for comparing hazards has been developed by comparing the exposure concentration or dose to the concentration or dose believed to have no

appreciable adverse effects. For members of the offsite population (including sensitive subgroups of the offsite population) assumed to be continually exposed to a chemical throughout their lifetime, or portions of their lifetime, this comparison standard is the reference dose or reference concentration. The quantitative ratio of the exposure concentration (or dose) to the reference concentration (or reference dose) is called the "Hazard Quotient." The sum of all chemical-specific Hazard Quotients is the Hazard Index, which is used by EPA (and in the WM PEIS) to measure the risk of noncancer health effects.

Offsite Population. Health impacts to the offsite population resulting from releases of chemical and radiological contaminants from treatment and storage facilities were evaluated as potential latent cancer fatalities, cancer incidences, genetic effects, and noncancer toxic effects (for chemical contaminants). Offsite population sizes were based upon 1990 U.S. Census data (DOC, 1992a).

Health Impacts to Workers. In addition to potential impacts from airborne exposures estimated for the offsite population, onsite workers will be at risk for health effects resulting from construction and operation injuries. This category includes all significant physical injuries sustained by workers in various job classifications. Injuries are considered together regardless of their nature and are measured as a statistical frequency per labor hour. Some percentage of construction and operation injuries were assumed to result in death. The percentages of construction and operational injuries resulting in death were obtained from the Bureau of Labor Statistics records concerning the Sanitary Services occupational group, which includes plant operations (BLS, 1992, 1993).

For noncarcinogenic risks for waste management workers, estimated exposures were compared to the established chemical-specific occupational exposure limit values. This ratio is referred to in the WM PEIS as the "Exposure Quotient" and it is analogous to the "Hazard Quotient" used to estimate noncancer effects in the offsite population. Unlike carcinogenic risk, the hazard/exposure quotient is not directly related to frequency of disease, but provides a standard way to compare different exposures to noncarcinogens. The sum of all Exposure Quotients is the Exposure Index. Exposure Quotients and Exposure Indices were calculated only for chemical contaminants.

Note that WM worker population radiation exposures are presented as "person-rem" estimates in Volume I and as "FTE-rem" estimates in Appendix D of Volume III. In Appendix D, to make it possible to compare estimated worker exposures to regulatory criteria, staffing was expressed as the number of "full-time equivalents" (FTEs). An FTE was assumed to be commensurate to one individual working full-time in a

waste management facility. In reality, one FTE could represent several individuals who are not exposed full-time to waste management activities, but whose *cumulative* work time totals one FTE. Because the risk of exposure could be shared by more than one worker working less than full-time in a waste management facility, risks to actual individual workers might be overestimated. Therefore, when interpreting the Volume I risk analysis results for WM workers readers may find it useful to interpret person-rem as FTE-rem.

Health Impacts to Workers and Offsite Population From Transportation. The same exposure-related health impacts discussed above for treatment and storage facilities can result from transportation of waste. Transportation risks were estimated for workers and the public for routine operations and accidents. These risks were based on State data on the frequency of accidents for trucks and trains per mile traveled. The number of shipments by truck or train were calculated for the WM PEIS based on waste load, whereas mileage was dependent on the sites proposed for the waste management facilities. Calculation of truck mileage was done using the HIGHWAY 3.1 model, and calculation of rail mileage was done using the INTERLINE 5.0 model. These models are the standard means of DOE estimation of truck and rail shipping distances.

National average rural, suburban, and urban population densities were used in the WM PEIS transportation risk analysis for all transportation routes, consistent with DOE practice. This approach was considered appropriate because of the programmatic nature of the WM PEIS. In general, these averages tend to be conservative (i.e., overestimate) compared with route-specific values. Therefore, the estimated risks in the WM PEIS are somewhat higher than if route-specific population densities were used. For complexwide programmatic purposes, the WM PEIS used an external dose rate of 1 mrem/hour at 1 meter from the surface of the shipment for all DOE LLW shipments. This dose rate is based on historical shipment data. The shipment external dose rates for LLMW, TRUW, and HLW are identified in Section E.6.2 of Volume IV.

Interpreting Risk Results. The goal of the WM PEIS risk analyses is to provide estimates of health risk to aid in determining the advantages and disadvantages of implementation of the various waste management alternatives. The risk results are best interpreted as *relative* differences among alternatives rather than as absolute point estimates of risk.

For example, consider a decentralization alternative (Decentralized Alternative 1) that affects the populations at 12 sites and a centralization alternative (Centralized Alternative 1) that affects the population at only one site. If the number of cancer fatalities in the offsite populations of all sites in Decentralized Alternative 1 is *numerically* higher than the number of cancer fatalities in the offsite population of the one site in Centralized Alternative 1, Decentralized Alternative 1 is the highest risk case, for the offsite population cancer fatality endpoint, at the *program level*. Note that each health risk endpoint should be considered independently; values for different endpoints should *not* be added to obtain overall estimates for a given group of receptors. That is, radiation exposure cancer fatalities for waste management workers should *not* be added to physical hazard fatalities to obtain an estimate of the total number of fatalities for this receptor group.

The WM PEIS risk analyses also provide estimates of *site-level* risks. For example, suppose the overall programwide risk of latent cancer incidence from radionuclide exposure under Decentralized Alternative 1 is 0.8 (or 8E–01), and this total risk is distributed across 23 million people, the sum of the offsite populations at all 12 sites involved in that alternative. If this programwide risk (8E–01) is divided by the total affected population (23 million), the resulting number, 0.000000035 (or 3.5E–08), might be considered the "average" risk to an individual member of the programwide offsite population. Note that this number is *not* the risk to the MEI and will in all cases be less than the risk to the MEI. This is because on the average, members of the general population receive less exposure, by definition, than the MEI. Although this "average" individual risk is *not* a formal construct in risk analysis, it may be helpful to the reader for comparing the risk estimates among alternatives or sites. Common activities that produce a comparable risk of death per year are found in Table 5.4–4.

For air emissions a comparison benchmark is the National Emission Standards for Hazardous Air Pollutants (NESHAP) for radionuclides (40 CFR 61), which has a goal of individual lifetime risk no greater than 1 in 10,000, which is approximately equivalent to the standard of 10 mrem/year. All measures of risk, including population risk, should be examined to determine if the MEI risk should be allowed to exceed this value or be constrained to a lesser value.

Another relevant benchmark is the disposal standard for spent nuclear fuel, HLW, and TRUW (40 CFR 191), which states that disposal of these materials in compliance with the containment requirements should not result in MEI exposures of greater than 15 millirem/year. Other standards include drinking water standards, with individual risk goals of 1 in 10,000 or lower for carcinogens, worker radiation protection

Table 5.4–4. Risks Estimated to Increase Chance of Death in Any Year by One in a Million

Activity	Cause of Death
Smoking 1.4 cigarettes	Cancer; heart disease
Traveling 16 km (10 mi) by bicycle	Accident
Flying 1,600 km (1,000 mi) by jet	Accident; cancer caused by cosmic radiation
Existence of potassium-40 in a human body	Cancer caused by naturally occurring radiation
Drinking 30 12-oz cans of diet soda	Cancer caused by saccharin

Sources: Slovic (1986) and Eisenbud (1987).

standard (5 rem per year), and the maximum annual allowable radiation dose to the members of the public from DOE-operated nuclear facilities (100 mrem per year) (DOE, 1990).

Finally, exposure to direct radiation and radionuclides should be considered in the context of background radiation. The average individual in the United States is estimated to receive a dose of about 360 mrem (0.3 rem) per year from all sources combined, including medical sources of radiation (such as x-rays — e.g., chest x-ray dose is about 8 mrem, diagnostic hip x-ray dose is about 83 mrem), and natural background radiation (such as radon gas). This dose results in a calculated individual lifetime risk of fatal cancer of about 1 in 100 (40 CFR 61).

With respect to accident scenarios, where individuals such as waste management workers may receive high short-term (or acute) doses, a person must receive a dose approaching the LD50 dose level before there is a high probability of near-term death (NAS, 1983).

5.4.2 Air Quality Impacts

Air quality impacts were assessed for the construction of new treatment, storage, and disposal facilities; for the operation and maintenance (O&M) of the facilities; and for shipment of wastes between sites. The air quality impacts analysis estimated the air emissions effects for criteria air pollutants, hazardous air pollutants

(HAPs, including radionuclides), and toxic air pollutants (TAPs). Descriptions and assessment criteria for these classes of pollutants are presented below. The potential impacts of emissions of ozone-depleting substances (e.g., chlorofluorocarbons (CFCs) and halons) were also evaluated. Air quality impacts were analyzed only for those pollutants where emissions estimates were provided. A summary of the air quality impacts analyzed in the WM PEIS is presented in Table 5.4–5.

Criteria Air Pollutants. In compliance with the Clean Air Act (CAA) (42 USC 7401), EPA has promulgated National Ambient Air Quality Standards (NAAQS) for six criteria air pollutants (40 CFR 50): carbon monoxide (CO), sulfur dioxide (SO_2), particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM_{10}), ozone (O_3), nitrogen dioxide (NO_2), and lead (Pb). These pollutants are

Table 5.4–5. Air Quality Impacts Analysis: Summary of Emissions Evaluated

		DOE Site-Level Analysis			National Analysis	
			O&M Emissions			
Pollutant Class	**Relevant Waste Types**	**Construction Emissions**	**Local Stationary Source Emissions**	**Local Transportation Source Emissions**	**Transportation Corridor Emissions**	**Total National Emissions**
Criteria Air Pollutants	All Five Waste Types	Local Construction Equipment Emissions and Worker Vehicle Emissions (Tons/Yr)	Local Stationary Source Emissions from Proposed Waste Management Facilities (Ambient Concentrations and Tons/Year)	Offsite Emissions from Worker Vehicles and Waste Transport Within 50 Miles (Tons/Year)	Total Emissions From Waste Transport outside 50-Mile Radius of Sites (Tons/Year)	Sum of Onsite, Offsite, and Transportation Corridor Emissions (Tons/Year)
Radio-nuclides	TRUW, LLW, & LLMW[a]	No Emissions During Construction	Local Stationary Source Emissions From Proposed Waste Management Facilities (Total Airborne Radionuclides Based on Radiation Dose From All Exposure Pathways)	Not Calculated for Worker Vehicles. Assumed to Be Negligible From Routine Waste Transport	Assumed to Be Negligible From Routine Waste Transport	Assumed to Be Negligible
Other Hazardous and Toxic Air Pollutants	TRUW, HW, & LLMW[a]	Assumed to Be Negligible	Local Stationary Source Emissions From Proposed Waste Management Facilities (Pollutant-Specific Ambient Concentrations)	Not Calculated for Worker Vehicles. Assumed to Be Negligible From Routine Waste Transport	Assumed to Be Negligible From Routine Waste Transport	Assumed to Be Negligible

[a] Emissions of radionuclides and other hazardous constituents from the storage of vitrified HLW are assumed to be negligible due to the physical form of the HLW. Once HLW is vitrified, the glass matrix binds the radionuclides and hazardous chemicals, such that releases to the atmosphere are negligible.

regulated both in terms of annual production in tons per year and in terms of ambient concentrations emanating from point and mobile sources. Unlike the other five criteria air pollutants, ozone is not a direct emission but is formed in the atmosphere through a complex reaction of ozone precursor pollutants, sunlight, and temperature. Ozone precursor pollutants include nitrogen oxides (NO_x) and nonmethane hydrocarbons (NMHCs), which include the class of compounds known as volatile organic compounds (VOCs). The analysis of ozone impacts was performed by evaluating NO_x and VOCs emissions.

Hazardous Air Pollutants. Section 112 of the CAA requires EPA to establish technology-based standards for sources of 189 pollutants listed in the statute, and to specify categories of sources subject to the emission standards. The NESHAP are promulgated in 40 CFR 61. HAPs include cancer-causing agents, such as arsenic, benzene, carbon tetrachloride, formaldehyde, and radionuclides, as well as materials with noncancer health hazards, such as fluoride, ammonia, and hydrochloric and sulfuric acids. EPA regulates radionuclides as a total annual dose limit under the NESHAP. Radionuclides are also regulated by the Department of Energy (DOE Order 5400.5 [DOE, 1990] and proposed 10 CFR 834 [DOE, 1993b]) as a total dose limit.

Toxic Air Pollutants. Toxic air pollutants include cancer-causing agents and compounds with noncancer health hazards. These substances are regulated by the EPA and on a state or local basis, through allowable ambient standards or guidelines.

Ozone-Depleting Substances. Ozone-depleting substances are regulated through the CAA and by the Montreal Protocol on Substances that Deplete the Ozone Layer. The CAA includes requirements for controlling ozone depleting substances that are generally consistent with, but in some cases more stringent than those in the Montreal Protocol. Title VI of the CAA calls for a phaseout of CFCs by January 1, 2000. In addition to the phaseout of ozone-depleting substances (ODSs), Title VI includes a variety of other provisions intended to reduce emissions of ODSs and promote the recycling of these substances.

Air Quality Impacts Analysis. The air quality impacts analysis estimated annual criteria pollutant emissions in tons per year (tpy) for construction and O&M activities. HAPs/TAPs concentration impacts were not estimated for construction activities but were estimated for the treatment of waste by thermal destruction during O&M.

Annual criteria air pollutant emissions in tons per year from construction activities were estimated based on emission rate data for construction equipment and worker vehicles traveling to and from the work site on a daily basis. Annual criteria pollutant emissions in tons per year from waste management activities were estimated based on standard EPA emission rate factors for O&M facilities (see EPA, 1995), thermal destruction of waste, worker vehicles, and transportation of waste.

Criteria air pollutant ambient concentration impacts were estimated based on thermal destruction emission rate factors and concentration impact estimates obtained from computer dispersion modeling. The HAPs and TAPs concentration analysis assumed that the most conservative estimate of impact would be from concentrations that the offsite MEI would be subject to in the human health risk assessment. Therefore, the HAPs and TAPs air quality impacts analysis for thermal destruction emissions used data on emissions, airborne concentrations, and MEI doses assembled for the human health risk assessment. The estimated concentrations of criteria air pollutants were compared to the NAAQS, while HAPs and TAPs concentrations were compared to applicable EPA or State ambient concentration guidelines.

The air quality analysis assumed that transportation sources may be an important source of criteria pollutant emissions in addition to those from the facilities. Transportation sources were not assumed to contribute significantly to hazardous or radioactive airborne contaminants in routine operations. Therefore, for criteria air pollutants only, in addition to estimating ambient concentrations from facility sources, the analysis estimated local transportation source annual tonnage of criteria air pollutants, intersite transport annual tonnage of criteria air pollutants, and a national annual tonnage of criteria air pollutants from all activities proposed for each waste type under each alternative.

The focus of the air quality analysis for proposed onsite waste management activities was on estimating potential emissions of criteria air pollutants, HAPs (including radionuclides), and TAPs from operating treatment facilities, where the treatment facility is a stationary source of those emissions. Because ozone is formed photochemically, at a substantial distance downwind from an ozone precursor emission source, the analysis of ozone effects from these operations was done separately and used a different estimation technique.

Airborne concentrations of criteria air pollutants and HAPs from proposed thermal destruction operations were estimated by calculating the highest concentration of each substance likely to be emitted at each site using the "ISC2" computer dispersion model used in the human health risk assessment. The model estimates

downwind concentrations of contaminants as they originate from a known source and disperse with the wind. The model requires input of appropriate local weather data and important facility data, including stack heights, diameters, and discharge rates.

Emission rate data for waste management facility fuel use were obtained from the most recent version of EPA's *Compilation of Air Pollutant Emission Factors, Volume I: Stationary, Point, and Area Sources* (EPA, 1985). Fuel use emission estimates were based on emissions for an industrial boiler using either gaseous or liquid fuels. Criteria air pollutant emission rate data for thermal destruction were obtained from a review of EPA literature.

Rather than estimating individual radionuclide concentrations downwind from proposed treatment facilities, a screening analysis was used to determine whether radionuclides as a group would exceed the overall NESHAP dose standard of 10 millirem (mrem) per year. Annual doses to the offsite MEI were obtained from the GENII model for each site and waste management alternative. The dose values were compared to the NESHAP annual dose standard and discussed if they exceeded 10% of the standard. Comparison to the standard is not intended to demonstrate compliance for permitting purposes.

The potential impacts of transportation on air quality were estimated. Specifically, the analysis examined:

- Exhaust emissions from on-road vehicle and railroad diesel engines during transport of wastes between sites
- Increased vehicle traffic at each site based on the total shipments reaching a site and on the privately owned vehicles used by workers going to and from the waste management facilities

Local impacts for truck or rail shipments were based on emissions estimates for that segment of each waste shipment within a 50-mile radius of the site. Shipment emission estimates outside the 50-mile radius were added to national transportation source emission estimates for each waste management alternative. Worker vehicle trips were based on a daily round-trip distance of 40 miles for a work period of 240 days per year. A quantitative analysis of the contribution of vehicle exhaust was performed for the exhaust compounds CO, NO_2 (as NO_x), PM_{10}, and VOC (EPA no longer considers airborne lead to be a problem because unleaded fuels are now the norm). NO_x and VOC are ozone precursor pollutants and are of particular concern in ozone nonattainment areas. Emission factors for the quantitative analyses were estimated using the most recent version of the EPA-approved vehicle emissions model, Mobile5a.

Criteria air pollutant effects were assessed for each of the six criteria air pollutants based on the air quality attainment status of each site's air quality control region. In general, a sites applicable air quality control region is in attainment for a particular criteria air pollutant if monitored ambient concentration levels are below the NAAQS for that pollutant. The site's applicable air quality control region is in a nonattainment area for a particular criteria air pollutant if ambient concentration levels are equal to or exceed the NAAQS for that pollutant.

Any predicted increases to ambient concentration levels in areas designated as "in attainment" by EPA were compared to the NAAQS. If the increased estimated ambient concentrations equaled or exceeded the NAAQS, then that alternative and the affected area were identified in the WM PEIS. The annual criteria emissions, in tons per year, were compared to the allowable increase levels specified in 40 CFR 52.21, "Regulations for the Prevention of Significant Deterioration (PSD) of Ambient Air Quality." PSD regulations are applicable to attainment areas for each of the criteria air pollutants. These allowable increases are referred to as PSD increments and PSD significant emission levels (SELs). PSD increases account for all stationary source emissions that can be reasonably attributed to the action but do not account for emissions from mobile sources. If the estimated annual emissions for an alternative are equal to or exceed the allowable PSD SELs increments, then that alternative and the affected area were identified in the WM PEIS text. Sites that exceed the allowable PSD increments may require additional control measures to reduce criteria pollutant emissions to acceptable levels.

New major stationary sources or major modifications of existing sources located in attainment and nonattainment areas for any criteria air pollutant must conform to New Source Performance Standards (40 CFR 60). In addition, Federal actions that are located in nonattainment areas are required to follow the guidelines of EPA's General Conformity Rule (GCR) (40 CFR 93) (EPA, 1993). The conformity rule establishes specified minimal levels for criteria air pollutant emissions, in tons per year, based on the air quality control region's nonattainment designation. Actions producing emissions that are below the minimal levels are considered to conform, while those at or above the limits are required to perform a conformity determination as outlined in the conformity rule. The conformity rule accounts for all stationary and mobile sources of emissions that can reasonably be attributed to the action.

Ozone pollution can be caused by reactions between VOC and NO_x in the presence of sunlight, and it generally reaches its maximum concentration many miles downwind of the sources of these substances. The impacts of the alternatives on ambient ozone levels were assessed by assuming that if emissions and

concentrations of VOC and NO_x associated with each alternative are within applicable PSD, GCR, or NAAQS, ozone production would be minimal.

Impacts to the stratospheric ozone layer due to emissions from waste management activities were estimated. The analysis was performed at all treatment sites in an alternative since emissions of ozone depleting substances is a global rather than a site issue. The analysis was performed for waste types where treatment of waste containing hazardous constituents occurs (e.g., LLMW, TRUW and HW). The compounds analyzed include the ozone depleting substances identified by EPA in 40 CFR 82. Emissions of ozone depleting substances from thermal treatment were tallied from information supplied by the health risk assessment. The total emissions from each alternative were found to be exceedingly small for all waste types, and in fact were less than 0.1 pound per year for all LLMW alternatives (DOE, 1996a). These minor emissions would not be expected to have any measurable affect on upper atmosphere ozone levels. Emissions of ozone depleting substances from other treatment, storage and disposal operations were assumed to be small due to the nature of these activities, and the mandated phase-out of the use of ozone depleting substances.

Construction activities could affect air quality by causing fugitive dust emissions and contributing vehicle, heavy equipment, and mobile power generator exhaust emissions. Estimates of fugitive dust and exhaust emissions were made for each site under each alternative. The estimates were based on the extent of land clearing required to build the proposed facility, the size of the construction workforce, and the requirements for trucks, heavy equipment, and mobile generators.

5.4.3 Water Resources Impacts

The analysis evaluated water resource effects based on engineering estimates of expected water use and liquid discharges from the waste management activities under each waste type. The analysis quantified water quality effects for those waste types for which disposal is proposed at DOE sites under the assumption that the disposal facilities would deteriorate after closure and that such disposed wastes might contaminate groundwater. Other potential water resources impacts are discussed qualitatively.

At certain DOE sites, impacts from normal operations to surface water or groundwater or both can be ruled out, given the source of water or the receiving body for effluents, as follows:

- Municipal water is used as the source of water for RFETS, SNL-NM, and WIPP; therefore onsite surface and groundwater resources would not be affected by water withdrawals.
- Groundwater is used as the source of water for the water supply at ANL-E, BNL, FEMP, INEL, LANL, LLNL-Site 300, NTS, the Pantex Plant, PORTS, and SRS; therefore, impacts to surface water resources are likely to be small as a result of groundwater withdrawals.
- Surface water is used as the source of water at the Hanford Site, ORR, Paducah, and WVDP; therefore, impacts to groundwater resources are likely to be small as a result of surface water withdrawals at these sites.
- Wastewater is discharged to municipal wastewater treatment systems at SNL-NM; therefore, onsite surface water resources would not be affected by effluent discharges.
- Wastewater is not discharged to natural flowing surface water bodies at the Hanford Site, INEL, LANL, LLNL-Site 300, NTS, the Pantex Plant and WIPP; therefore, impacts to surface water resources are likely to be small as a result of effluent discharges at these sites.

5.4.3.1 Water Availability

Impacts on water availability were analyzed by comparing the rates of water use and wastewater discharge estimated for each site during construction and operation of proposed waste management facilities to volumes or use rates for current water sources. For sites that obtain water from surface water sources, a comparison was performed for both current use and stream flow.

For each waste type, water use rates for construction and operation activities at each site under each alternative were taken from technical reports prepared for specified alternatives or interpolated from the technical reports for the remaining alternatives. Total water use at a site was computed as the sum of water use for waste treatment, storage, or disposal operations.

The analysis assumed that water for the proposed waste management activities would be withdrawn from the current water source at each site. The surface, groundwater, or municipal water source at each site is part of the water resources affected environment data in Chapter 4. Where surface water is the current source, surface flow rate data were also assembled.

5.4.3.2 Water Quality Impacts From Disposal of LLMW and LLW

Groundwater quality may be affected in the future assuming there is a loss of institutional control at disposal sites and subsequent deterioration of disposal facility integrity. Disposed waste contaminants could then leach into groundwater and subsequently appear downgradient in well water. Analysis of this possible effect used the modeling for the human health risk assessment. The transport and fate of disposed radionuclides, and hazardous constituents were estimated using the Disposal Unit Source Term (DUST) and Multimedia Environment Pollutant Assessment System (MEPAS) models that tracked the contaminants as they moved from the disposal location to the point of exposure for a hypothetical farm family living 300 meters downgradient of the disposal facility.

Input data for the water quality analyses were assembled for LLMW and LLW, the only two waste types that will be disposed of at DOE sites under this PEIS. These data were taken from two sources:

- DUST/MEPAS modeling that estimated human health risks from use of contaminated groundwater for drinking and for crop irrigation
- Estimated quantities of radionuclides and hazardous chemicals in the waste

The water quality impacts analysis applied the radionuclide and hazardous constituent inventory data to the health risk modeling results in order to calculate contaminant concentrations in a hypothetical well located 300 meters downgradient from each disposal unit. The analysis accounted for the degradation of the wastes during the time period between disposing of the wastes and loss of containment (ranging from 0 to 700 years depending on the technology), and for creation of radioactive daughter products from the decay of disposed radionuclides (ORNL, 1995b). Disposal of 36 radionuclides was evaluated for LLMW and LLW; disposal of 15 hazardous constituents was evaluated for LLMW. The constituents analyzed in the WM PEIS are listed in Section C.4.3.5 of Volume III.

Estimated radionuclide and hazardous constituent concentrations in the hypothetical downgradient well were compared to drinking water standards promulgated by EPA in the Primary Drinking Water Regulations (40 CFR 141) and in DOE Order 5400.5 (DOE, 1990). These drinking water standards are listed in Section C.4.3.5 of Volume III. Drinking water standards promulgated under the Safe Drinking Water Act are applicable to treated drinking water at the tap, and therefore are not directly applicable to groundwater quality. Since there are no Federal standards for groundwater quality protection, predicted concentrations of contaminants in the groundwater are compared with drinking water standards to provide an indication of the level at which adverse impacts to water quality may occur. These criteria are commonly used as

Applicable or Relevant and Appropriate Requirements (ARARs) to determine appropriate levels for groundwater cleanup under RCRA and CERCLA cleanup actions. Since drinking water standards adequately protect human health, groundwater contamination at or below these levels is considered to result in low risk to human health. Federal water quality standards, rather than state standards, were used to provide a consistent means of comparing among sites.

DOE will evaluate the performance of disposal facilities at each site in detail in the DOE's Performance Assessment process. If significant groundwater contamination were predicted by the Performance Assessment process, changes in the waste acceptance criteria would be made to limit disposal of the waste causing the significant groundwater contamination. The waste would require further treatment prior to disposal, would be disposed of at another DOE site where the waste meets the waste acceptance criteria, or would be stored until a method was found to treat or dispose of the waste. In no case would DOE knowingly dispose of waste in violation of legal requirements.

5.4.3.3 Other Water Resources Impacts

Some impacts on water resources were assumed to be minimal at all sites or at particular sites regardless of which waste type and alternative are being considered. In order to focus the analysis on significant environmental impacts that could influence the choice of alternatives, these potential minimal effects are discussed here and therefore not addressed in the waste type impacts analyses in Chapters 6–10. Further evaluations of these potential effects could be conducted as part of sitewide or project-specific NEPA reviews.

The impacts of waste management activities on floodplains cannot be estimated at this time because the specific locations of the waste management facilities at the DOE sites are not analyzed in the WM PEIS. If possible, no new waste management facilities would be located in floodplain areas. As a minimum, facilities managing LLMW or HW would be required to meet additional design criteria and/or siting requirements to obtain a RCRA permit. Compliance with floodplain and wetland review requirements, including Executive Order 11988 (Floodplain Management) and 10 CFR 1022 (Compliance with Floodplain/Wetland Environmental Review Requirements), would be examined in detail when specific locations are proposed in sitewide or project-specific NEPA reviews.

During the construction period, impacts to surface water resources could occur from runoff and sedimentation as a result of site clearing. During operations, impacts to water resources could occur through increased runoff from buildings, parking lots, and cleared areas. The impacts would generally be proportional to the amount of land disturbed during construction and occupied during operations. In all cases the impacts would be minimized by implementation of best management practices for stormwater runoff and erosion control. These practices include the use of silt fences, run-on and runoff diversion ditches, and stormwater retention and sedimentation ponds. Therefore, impacts from these activities are not expected to be major, and should not influence the choice of alternatives. If necessary, these impacts would be considered in sitewide or project-specific NEPA reviews.

During waste management operations, stormwater runoff may be contaminated with materials deposited from airborne emissions. Most of the potentially contaminated stormwater runoff would be contained within onsite stormwater collection ponds. The stormwater runoff would evaporate or infiltrate into the ground, although the ponds may discharge to surface water bodies during high flow conditions. Stormwater runoff would be routinely monitored and any discharges would be in compliance with site-specific permit limits. Stormwater runoff that is not contained within the stormwater management system may contaminate surface waters. This runoff may contain small amounts of contaminants. Controls would be implemented at each site to minimize the potential for contaminated stormwater runoff. Impacts from stormwater runoff are expected to be minor, but are highly site-specific and would depend on the design of the stormwater management system, meteorologic conditions, topography, soil type, and the affected surface water body at the site. These impacts should not influence the choice of alternatives but would be considered in sitewide or project-specific NEPA reviews, if necessary.

During normal waste management operations, no untreated sanitary or process wastewater would be discharged to surface or groundwater. Wastewater would be treated and recycled to the extent possible and then discharged to existing sanitary or process treatment plants, as appropriate. After additional treatment, wastewaters would be discharged from these plants in compliance with all NPDES and industrial wastewater discharge permits. Onsite surface water resources would not be affected by effluent discharges at SNL-NM, because wastewaters are discharged to municipal wastewater treatment systems. Surface water resources have a low potential to be affected by effluent discharges at the Hanford Site, INEL, LANL, LLNL–Site 300, NTS, the Pantex Plant, or WIPP, because generally, wastewaters are discharged to dry stream beds or man-made ponds, and not natural flowing surface water bodies. Even at sites such as ORR and SRS where surface waters could be affected by effluent discharge, it is not always possible to determine

which water course(s) would be affected, since the locations of the waste management facilities have not been selected. If necessary, these impacts would be considered in sitewide or project-specific NEPA reviews.

The majority of new aqueous waste would be sanitary waste generated by the employees needed to operate the facilities associated with each alternative. Sanitary wastes by definition are nonhazardous and would be discharged to existing sanitary wastewater treatment facilities. After treatment, sanitary wastewaters would be recycled or discharged from these plants in compliance with site-specific NPDES or industrial wastewater discharge permit limits. The impacts on existing sanitary wastewater treatment facilities are discussed in the infrastructure section of this chapter (Section 5.4.9).

Although the volume of sanitary wastewater may vary between alternatives, it would remain similar in quality. Therefore, current conditions would not change appreciably unless the discharge volume was a large percentage of the flow in the receiving water body. The impacts of combined sanitary and process wastewater discharges on surface water volume were evaluated in the WM PEIS and show only minor (less than 1%) changes in flow. Since the quality of effluent discharges from sanitary wastewater treatment facilities would not change, and the flow would not be a significant fraction of the average flow in the major receiving water body, current monitoring captures most of the water quality effects of sanitary wastewater treatment plant discharges for the alternatives. Therefore, impacts from these activities are not expected to be major and should not influence the choice of alternatives. If necessary, these impacts would be considered in sitewide or project-specific NEPA reviews.

Process wastewater is wastewater potentially contaminated by hazardous or radioactive constituents during treatment, storage or disposal activities. In the WM PEIS, it was assumed that easy-to-treat and hard-to-ship wastes, such as aqueous wastes and slurries (process wastewater), would be treated at the generating site and would not be shipped offsite for treatment. After treatment, wastewaters would be recycled or discharged in compliance with site-specific DOE, NPDES, or industrial wastewater discharge limits. Because process wastewater treatment would continue at the sites where it presently occurs, and the volumes of process wastewater treated at each site would vary only slightly between alternatives, the effects of process wastewater treatment on surface and groundwater quality are largely accounted for in the existing conditions information reported in the affected environment section. Therefore, the impacts from these activities should be similar for all alternatives and should not influence the choice of alternatives. If necessary, these impacts would be evaluated in sitewide or project-level NEPA documents.

Wastewater released by sanitary wastewater treatment plants may enter small onsite water courses before entering the major surface water body near the site. Additional effluents in these small streams may cause erosion and/or sedimentation in the stream channel. Water quality may also be affected since the facility effluents may form a large fraction of the natural stream flow. The effects of effluent discharge on natural surface water bodies would be minimized during the site selection and permitting process. Impacts on small onsite water bodies could be considered in sitewide or project-specific NEPA reviews.

During normal operations of waste storage facilities, no water (including surface water and groundwater) would be allowed to come into contact with the waste. Therefore, surface water or groundwater quality would not be affected because there would be no contaminated runoff. During normal operations of waste treatment facilities, there would be no releases to groundwater. Therefore, groundwater quality would not be affected.

Withdrawals of groundwater to supply water for waste management facilities could cause detrimental movement of existing groundwater contamination plumes. This could occur where water levels are lowered by water withdrawals. Since existing wells will be used to the extent possible, and new wells would be located to minimize their impact on contaminant plume migration, impacts of this sort are unlikely. Potential impacts on existing areas of contamination could be considered in sitewide or project-specific NEPA reviews.

Seepage of contaminated groundwater from disposal facilities could contaminate surface water. This would be expected to occur at sites with shallow groundwater, and surface water bodies that are fed by groundwater discharge (springs). Some sites (INEL, NTS, and Pantex) are located above deep groundwater such that surface water would not be expected to become contaminated. Other sites (LANL, LLNL, SNL-NM, and WIPP) have a low potential for surface water contamination due to the intermittent nature of most of the site streams. Where contaminated groundwater discharges to the surface, dilution in "clean" surface waters would cause concentrations of contaminants in surface water to be lower than concentrations in groundwater. Therefore, the groundwater pathway was assumed to be the major pathway for movement of contaminants beyond the disposal facility boundary, and was the pathway that was examined in detail.

Routine transportation would involve the intersite movement of waste by truck or rail, and the travel of workers to and from work. Waste materials would not be released during routine transport of wastes; therefore, impacts from transportation would be limited to the deposition and runoff of vehicle emissions

to surface waters, and the infiltration of materials deposited on the surface to groundwater. The vehicle emissions at any one place from transportation of waste are assumed to be minimal. Therefore, potential impacts to surface water and groundwater from routine transportation would be minimal.

Because the waste would be shipped in NRC or DOT approved containers, impacts to water resources would be unlikely unless a ruptured container fell directly into a surface water body. In the unlikely event that waste was released from a shipping container, cleanup response to the accident would be swift, and the release would be contained and cleaned up as quickly as possible. The spill response and cleanup, and any subsequent remediation, would be conducted in accordance with CERCLA (42 USC 9601 *et seq.*), the National Oil and Hazardous Substances Pollution Contingency Plan, and DOE emergency response requirements. Because cleanup would be swift, no long-term impacts to water quality would be expected. For waste transported in Type B NRC certified containers, the probability of container leakage would be very low during an accident. In addition, it is unlikely that there would be any significant release of radionuclides or hazardous constituents from vitrified waste during an accident. Therefore, it is unlikely that transportation accidents involving Type B containers or vitrified wastes would result in impacts to surface water or groundwater resources.

The primary water-related impacts from WM activities are likely to be through groundwater. Nevertheless, there may be sites at which WM activities could cause surface water impacts. The vulnerability of a site to surface water impacts was estimated by comparing selected environmental data at the site. These data include: (1) precipitation, (2) the characteristics of major surface water bodies near the site such as distance to the site and flow rate, (3) the presence of groundwater discharge to surface water bodies near the site, and (4) the presence of nearby surface water supply intakes downstream from the site.

Several of the sites are located in arid climates with limited rainfall and have no discharges to major surface water bodies (i.e., INEL, NTS, Pantex, and WIPP). Site wastewater discharges and stormwater runoff are unlikely to reach major surface water bodies, and little or no groundwater discharges into streambeds. These characteristics make it unlikely that WM activities would produce major surface water impacts near these sites.

At three other arid sites (LANL, LLNL, and SNL-NM), discharges offsite occur only rarely and are made up of stormwater runoff or snowmelt. At these sites, groundwater can seep into the streambeds of the

intermittent streams at times during the year. These characteristics also make it unlikely that major surface water impacts would occur near these sites.

At RFETS, annual average precipitation is also low, but groundwater discharges into the nearby creeks. Parts of the site originally drained via small creeks to two reservoirs that are used for drinking water supplies by the Towns of Broomfield and Westminster. Since 1989, all discharges from RFETS are contained in onsite manmade ponds and diverted to the Broomfield Diversion Ditch, which bypasses the reservoirs and discharges to Walnut Creek downstream from the reservoirs. Although past activities at RFETS have impacted surface water resources, it is unlikely that major impacts to surface waters would occur from the incremental addition of WM activities.

ANL-E, FEMP, Hanford, ORR, PGDP, PORTS, and SRS are located near major water bodies that have large to very large average flows. Groundwater at these sites recharges into the nearby streams and rivers. These characteristics indicate that although some impacts to surface water are likely to occur near these sites, it is unlikely that major surface water impacts would occur.

BNL and WVDP are located near water bodies with small to medium average flows. During wet periods, groundwater discharges to onsite streams. Although these sites are more vulnerable to surface water contamination than the sites discussed in the previous paragraphs, in the near term, surface water impacts from the incremental addition of WM activities are not expected to be major. As described in the Draft WVDP closure EIS (DOE, 1996b), significant impacts to surface water could occur in the future if erosion breaches the waste disposal facilities.

Nearby water supply intakes are not present downstream from most of the sites, although there are nearby water supply intakes downstream from Hanford, ORR, and RFETS. At RFETS, site discharges are routed around the water supply reservoirs. At Hanford and ORR, the large surface water bodies provide a great deal of dilution for any contaminants released from the sites. Therefore, major impacts to downstream drinking water supplies from WM activities are unlikely.

Impacts on surface water resources and drinking water supplies would be considered after the WM facility locations on the sites are selected in sitewide or project-specific NEPA reviews.

5.4.4 ECOLOGICAL RESOURCES IMPACTS

Waste treatment, storage, disposal, and transportation activities may affect communities of plants and animals on and near DOE sites and in the transportation corridors. Three types of impacts were quantitatively evaluated: (1) loss or degradation of terrestrial habitats; (2) toxicity resulting from exposure to radioactive and hazardous contaminants released from waste treatment facilities; and (3) toxicity resulting from spills of radioactive contaminants following transportation accidents.

5.4.4.1 Habitat Impacts

The WM PEIS evaluated the potential for waste management actions to eliminate or disturb portions of existing nonsensitive terrestrial habitat as a result of the site clearing and excavation activities required to build waste treatment, storage, and disposal facilities. Because the specific location of any proposed facility at a given site is not addressed in this PEIS, site-specific impacts on nonsensitive terrestrial habitats at individual sites are difficult to predict or evaluate. However, the WM PEIS analysis assumed that the severity of these impacts would generally be related to the amount of land disturbed in building waste management facilities compared to the overall extent of the range of the plant and animal species that constitute these habitats. Site disturbance is expected to be on the order of acres or tens of acres; plant and animal ranges are on the order of hundreds or thousands of square miles. These comparisons are made in each waste-type impacts chapter.

The potential for site clearing and excavation to affect nearby sensitive habitats, including wetlands and designated critical habitats of Federally- and State-listed endangered and threatened species, was evaluated based on the assumption that the potential for such effects would be proportional to waste management acreage requirements compared to the acreage of nonsensitive land on site. The premise was that the smaller the fraction of available nonsensitive lands that waste management construction required, the greater DOE's flexibility in siting the facility to avoid placement that might affect nearby sensitive habitats. The analysis therefore compared total waste facility acreage requirements at each site having sensitive habitats with the amount of available, nonsensitive land area at each site for each waste type under each alternative. The available land area was determined from site development plans and site environmental reports as either land specifically designated for waste management facility development or as the amount of land remaining after subtracting from the site's total acreage the acreages of wetlands, wildlife management areas, topographic features, existing roads and structures, cultural properties, and other areas and features that

would make development unfeasible. The analysis in each waste-type chapter presents percentage figures for those sites and alternatives under which land requirements equal or exceed 1% of the available land. These are noted as those situations that pose the greatest likelihood of effects to nearby sensitive habitats. Site-specific analyses, tiered from this PEIS, would be conducted to evaluate the extent and severity of these potential impacts.

5.4.4.2 Toxicity From Exposure to Contaminants

The impacts of airborne releases of radionuclides to terrestrial animals living in the vicinity of waste treatment facilities was estimated using atmospheric emission/deposition modeling using the GENII model. This modeling, which used the same atmospheric emissions estimates as used in the human health risk assessment, provided estimates of doses of radioisotopes deposited downwind on soils close to the source and soils distant from the source over the 10-year period of operations. The model also estimated uptake from the soils and transfer in a terrestrial food chain leading to exposure of a small mammal used as a model terrestrial receptor (ORNL, 1995d).

All nonvolatile hazardous chemicals expected to be released from waste treatment facilities were included in the analysis; volatile chemicals are not expected to be significantly redeposited to surface soils. Radionuclides that contributed up to 80% of the total released activity were included in the analysis. The remaining activity was contributed by smaller emissions of a large number of radionuclides. Not including these minor radionuclides may be compensated for by the conservative assumptions used to characterize the scenario (e.g., accumulation of contaminants in surface soils for 10-year period of operation with no loss due to decay or transport).

Total internal and external doses for the model receptors were compared to a benchmark value of 100 millirads per day established by the International Atomic Energy Agency (IAEA, 1992). (A millirad—one thousandth of a rad—is a unit of measure for small amounts of energy absorbed by a material.) No-observed-effect levels (NOELs) were used as benchmarks for exposures to chemicals. The resulting ratio of chemical doses to NOELs, the Hazard Index (HI), is used to identify alternatives that may be of concern for potential ecotoxicity. When the dose exceeds the benchmark, that is, when the HI is greater than 1 (HI > 1), there is a potential concern for the development of adverse effects in terrestrial receptor populations as a result of the exposure.

5.4.4.3 Effects on Sensitive Species

The ecological impacts analysis in this PEIS does not determine the likelihood and severity of habitat impact effects on sensitive species, including Federally and State-listed endangered and threatened species, because the specific waste management facility locations at the various sites are not yet proposed. These evaluations would be included in sitewide or project-level NEPA analyses. However, the WM PEIS analysis does provide information to the decisionmaker concerning the sensitive species that may be affected by the proposed waste management facilities at each site. Chapter 4 describes the sensitive species at each site and provides a summary table of the Federally- and State-listed species known to occur, or with the potential to occur, at the 17 major sites. The waste-type impacts chapters list in tabular form the numbers of Federally- and State-listed endangered and threatened species that might be affected at each site under each alternative where DOE is proposing to build waste management facilities.

In addition to impacts through disturbance of habitat, sensitive species may be affected by exposure to contaminants released from waste treatment and storage facilities. These impacts are expected to be similar to those estimated for nonsensitive species, as described previously in this section (see discussion under the heading "Toxicity From Exposure to Contaminants"). However, unlike for nonsensitive species, estimated adverse impacts to a single organism may have a significance for the entire population. Therefore, careful consideration of potential actions to mitigate toxic effects to sensitive species is required. Potential toxicity effects on sensitive species can be better addressed in sitewide or project-specific NEPA analyses tiered from the WM PEIS.

5.4.4.4 Toxicity From Transportation Spills

The ecological impacts of waste transportation accidents were evaluated as consequence assessments that estimated the potential impacts of releases of radionuclides or hazardous wastes under certain spill scenarios but did not include estimates of the probability of these events occurring.

The postulated transportation accident scenario involves a rail shipment spill of waste directly into surface waters of different classes. Assessments were performed for stream-size classes ranging from a small second order stream (e.g., flow rate of a few meters per second) to a tenth order major continental river (e.g., the Mississippi River). For aquatic biota exposed to contaminants released as a result of waste transportation accidents, short-term, acute toxic effects are assumed to occur if the estimated doses exceeded the maximum

safe dose of 1 rad per day (rad/day) recommended by the National Council on Radiation Protection and Measurements (NCRP, 1991). Spills of hazardous chemicals were not assessed quantitatively due to the extreme variability in the types and amounts of chemicals that would be shipped. Although it is unlikely that an accident involving wastes with hazardous constituents (LLMW, TRUW, HLW and HW) would involve releases into a surface water body or wetland area, this type of accident could cause adverse impacts to aquatic organisms. The severity of the impact would depend largely on the type of waste involved, the amount of waste released, and the characteristics of the surface water body affected.

Accidents involving wastes contaminated by metals would be unlikely to cause major impacts due to their generally low acute toxicity, and low solubility of most metals in natural surface waters. Clean-up efforts mandated by EPA and DOE regulations would reduce the possibility of any long-term effects. Accidents involving wastes contaminated by low concentrations of organic chemicals would be unlikely to cause major impacts due to the small amount of contaminants present, and the volatile nature of many of these compounds. Accidents involving large releases of liquid organic compounds (e.g., spent solvents) are likely to cause significant mortality of aquatic organisms due to acute effects. Chronic effects are less likely due to mandated clean-up efforts. These impacts would also vary with the amount of dilution provided by the surface water body; large rivers would provide more dilution than small streams or stagnant marshlands.

5.4.4.5 Toxicity From Facility Accidents

Toxicity impacts due to facility accidents on terrestrial and aquatic ecosystems on and near the sites were not specifically evaluated. DOE assumes that facility accidents would affect all or portions of these ecosystems, potentially causing acute and chronic effects to exposed communities. The human health risk assessment of facility accidents provides information on the predicted frequency of occurrence and severity of these accidents. That analysis indicated that for the more severe, lower frequency accidents, human health effects, including acute and chronic illnesses and death would result. Effects on ecosystems exposed during these accidents would likely be of the same severity, at least on a local basis. Emergency response procedures should limit the areal extent of severe effects, especially chronic effects.

5.4.5 Economic Impacts

The economic impacts analysis used changes in disposable income, output (monetary value of industry sales), job-years, and employment. In addition, baseline data were available for disposable income and employment, so percent changes in the baseline income and employment were analyzed at both the regional and national levels.

Economic Impacts in the Host Communities. Expenditures for labor and materials to build and operate waste management facilities were evaluated for effects in terms of job creation, changes in personal income, and changes in economic output in the regional economy at each of the 17 major sites. For these sites, the region of influence (ROI) for economic effects was determined based on the residence patterns of the site employees. In addition to the host county, counties were included in the ROI if they contained 5% or more of the current site workforce. If the total represented by these counties did not represent at least 90% of the total site workforce, counties with progressively lower percentages of site workforce were included until the 90% threshold was met. Contiguous counties were included by exception (DOE, 1993c).

To determine the total regionally based economic effects across all the waste management sites, a parallel analysis was conducted for the minor sites, although these sites are not addressed individually in the impacts chapters. To minimize data and analysis requirements, the ROI for the minor sites consisted of the host and contiguous counties.

DOE recognizes the potential for negative public perceptions associated with its waste management program; for example, real estate property values in the vicinity of a radioactive waste disposal facility may decline, or the region may experience some effect on its ability to attract a diversified business base. However, the extent of such impacts is not amenable to analysis at the programmatic level without specific information on the location of any proposed facility and, thus, has not been included in this PEIS.

Impacts in the National Economy. Changes in National employment, personal income, and economic output were calculated based on complexwide expenditures for labor and materials required to construct and operate all waste management facilities for each waste type under each alternative. National level economic impacts were also estimated on the basis of total expenditures for intersite transportation and (where applicable) commercial treatment and disposal of waste.

Economic Impacts Evaluation. The economic impact analysis assumed that direct expenditures on labor and materials for constructing and operating waste management facilities would lead to subsequent cycles of spending. An initial expenditure by DOE becomes income to the recipient, who in turn spends a portion of the money, thereby increasing income in the economy for the second time. This process of multiple rounds of spending continues until all the money is used for savings, taxes, or the purchase of imported goods.

The first step in the analysis was to estimate general regional economic multipliers, which quantify how responsive the various regional economies and national economy were to changes in the level of expenditures. These economic multipliers quantify the change in employment, personal income, or industry output per unit input of money. Each site ROI and each industry within an ROI had a unique degree of responsiveness to changes in the level of expenditures. General multipliers for employment, personal income, and economic output were developed for 80 industries for the site ROIs and the national economy (DOC, 1992c). A simplifying assumption was made that the average (mean) multiplier was an unbiased and efficient estimator of the 80 separate industry multipliers.

A set of behavioral assumptions was applied in the calculation of multipliers. A national savings rate of 5% of personal income was deducted from the first cycle expenditures. An additional 32.1% was deducted for taxes and benefits. The full economic consequences of waste management activities (construction phase and operations phase) were assumed to continue for an additional 5-year period beyond the end of each phase (Cuthbertson and Nitzsche, 1994).

Economic Impacts Data. The baseline data come from the U.S. Department of Commerce, Bureau of Economic Analysis. The Bureau's "Regional Economic Information System" provides historical data on employment and personal income (DOC, 1992b).

5.4.6 Population Impacts

The population impacts analysis evaluated effects associated with any large-scale industrial or public works project, such as the introduction of new workers to the surrounding region or increased demand on services.

5.4.6.1 Population Impacts Evaluation

The ROI for population impacts was the same as the ROI defined for the economic impacts analysis.

Estimates of worker in-migration were derived from predicted labor requirements for the treatment, storage, or disposal facilities proposed under each alternative for each site. Total in-migration to the region surrounding each site was calculated based on the average household size of worker families; calculations for both construction and operations phases were made. The potential for impact on community characteristics and on the provision of social services was derived by comparing the size of potential in-migrating populations with the current regional population (Canter, 1977; Halstead et al., 1984).

Sites experiencing an estimated in-migration greater than 1% of the total 1990 ROI population were considered to have a significant potential for creating change to the social environment. This criterion is based on the assumption of a minimum 1% surplus capacity in public service delivery systems, infrastructure, and other health and welfare services. An increase of less than 1% would also not normally be expected to change the general distribution of demographic characteristics within the population as a whole (e.g., change the character of the population by changing the percentage of the population in a given category such as gender, marital status, etc.). These sites were identified for the analysis of each alternative under each waste type. Additionally, sites with estimated population increases over 0.5% were assumed to have a potential for minor impact to social characteristics and social services and are noted in the waste-type impacts discussions where appropriate. Where labor requirements during construction and operations were insufficient to stimulate a large in-migration to the ROI (less than 0.5%), associated impacts were considered to be unlikely to affect the local social environment.

The analysis assumes that the in-migrating workforce will be distributed throughout the ROI in the same proportions and densities as the current ROI population, since the precise location of any new facilities on a given site and the likely residence location preferences of the new workers are not available at this time. Although this analysis used the 1% population increase as a general guideline in estimating the potential effect of population change on the region as a whole, noticeable effects may occur at much lower levels if new in-migrants would be concentrated in one or two communities, rather than distributed throughout the ROI.

The potential for a rapid or sudden increase in population migration to the region of influence resulting from the cumulative effect of this action when overlapped with other planned or foreseeable projects at the site is a serious consideration for the analysis of site-level impacts associated with this analysis. Population impacts are therefore conservatively assessed to highlight those actions and alternatives that can cause rapid change. This is especially important during the construction phase, when peak periods for multiple projects may cause a sudden sharp increase in temporary employment at the site. Since the actual timing of peak employment periods is not available for this analysis, only a very general discussion is possible at the programmatic level. However, peak period employment is provided in *Waste Management Environmental and Socioeconomic Impacts Methods and Results* as a guide to later site-specific analysis and for local planners in the affected regions (DOE, 1996a).

5.4.6.2 Population Impacts Analysis Data

Statistical descriptions of population and demographic characteristics for the ROI were developed from 1990 U.S. Census data (DOC, 1992a). New workforce estimates were based on the full-time equivalent (FTE) labor requirements developed from the engineering analysis of waste management facilities and waste management activities required at each site for each alternative. Estimates of worker family size were based on 1990 census data for the national average population per household for 1991, or 2.63 persons (DOC, 1992a). The estimate of in-migration was developed by calculating the total number of potential new workers (direct, indirect, and induced) from the engineering analysis estimates, and adjusting it for the estimated percentage of the workforce that might be drawn from the ROI itself (see Appendix C for a discussion of the analytical approach to influences on worker in-migration). Potential in-migration was then estimated on the basis of the remaining percentage of the total workforce anticipated to come from outside the ROI multiplied by average household size.

5.4.7 Environmental Justice

In February 1994, Executive Order 12898, entitled *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (FR 1994), was issued. This order directs Federal agencies to achieve environmental justice as part of their missions. As such, Federal agencies are specifically directed to identify, and address as appropriate, disproportionately high and adverse human

health or environmental effects of their programs, policies, and activities on minority populations and low-income populations.

5.4.7.1 Status of Guidance on Environmental Justice

In addition to describing environmental justice goals, Executive Order 12898 directs the Administrator of the EPA to convene an interagency Federal Working Group on Environmental Justice (referred to as the Working Group). The Working Group is directed to provide guidance to Federal agencies on criteria for identifying disproportionately high and adverse human health or environmental effects on minority populations and low-income populations. The Working Group is also directed to coordinate with each Federal agency to develop an environmental justice strategy, if a strategy is required by the proposed activities. Although the Working Group has not issued final guidance on the approach to be used in analyzing environmental justice, it has issued draft definitions of terms in the *Draft Guidance for Federal Agencies on Key Terms in Executive Order 12898*, dated November 28, 1994. These definitions, with slight modifications, were used in the WM PEIS environmental justice analysis. Further, in coordination with the Working Group, DOE has issued draft internal guidance for the implementation of the Executive Order. Because both DOE and the Working Group are still in the process of developing final guidance, the approach used in this analysis might depart somewhat from whatever guidance is eventually issued.

For the environmental justice assessment, the following Working Group definitions were used:

- **Disproportionately high and adverse human health effects**—Any human health effect from exposure to environmental hazards that exceeds generally accepted levels of risk and affects minority or low-income populations at a rate that appreciably exceeds the rate for the general population. Adverse health effects are measured in risks and rates that could result in latent cancer fatalities and other fatal or nonfatal adverse impacts to human health.
- **Disproportionately high and adverse environmental impacts**—A deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an environmental hazard with a risk or rate of exposure for a low-income or minority population that appreciably exceeds the risk or rate of exposure for the general population.

5.4.7.2 WM PEIS Analysis of Environmental Justice Impacts

In order to determine potential environmental justice impacts for this assessment, DOE first identified and mapped the distribution of minority and low-income populations. DOE examined the composition of the population residing within 50 miles of the 17 major sites and then reviewed the human health effects and environmental impacts on the general public associated with alternatives for the five waste types. The review included potential impacts under each of the major disciplines evaluated for the waste-type alternatives, including health risk, air quality, water resources, ecology, economics, population impacts, land use, and infrastructure impacts, which are the sciences pertinent to the identification of the waste-type alternative environmental impacts. Regarding health effects, normal facility operations were examined and evaluated in terms of the risk to the public. The examination of transportation included both normal and potential accident conditions for both truck and rail transportation of the waste types. As described more fully below, these impacts were then examined to determine whether they were expected to be high and adverse. Except as noted below, because the risks to the general population resulting in the 50-mile zone of impact at each site are not expected to be high, DOE would not expect minorities or low-income populations to experience disproportionately high and adverse health effects from the alternatives considered in the WM PEIS.

5.4.7.2.1 *Identification and Mapping of Minority and Low-Income Populations*

For each of the 17 major waste management sites, demographic maps (see Appendix C) were generated through a geographic information system that used 1990 census data available from the U.S. Bureau of the Census. Data were resolved to the census tract group level. A census tract is an area defined for the purpose of monitoring census data that is usually composed of between 2,500 and 8,000 persons. Figures C.4–7 through C.4–40 illustrate census tract distributions for both minority and low-income populations residing within 50 miles of the 17 DOE sites being considered for the management of the five waste types. Native American Tribal lands within 50 miles of each site were also identified and mapped and are included in Appendix C, where applicable, with the minority distribution maps C.4–7 through C.4–23. These maps are based on an analysis of 1990 United States Bureau of the Census Tiger Line files, which contain political boundaries and geographical features, and Summary Tape Files 1 and 3, which contain demographic information (DOC, 1992d,e). (Data from the 1990 Bureau of the Census files are the latest

data available on a national level.) Appendix C provides the data definitions and methods used to develop the maps.

A ***minority population*** is a group of people and/or community experiencing common conditions of exposure or impact that consists of persons classified by the U.S. Bureau of the Census as Negro/Black/African-American, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, or other nonwhite, based on self-classification by the people according to the race with which they most closely identify. For purposes of this analysis, a minority population consists of any census tract within the 50-mile zone of impact with a minority population proportion greater than the national average of 24.4%. A ***low-income population*** refers to the U.S. Census Bureau data definitions of individuals living below the poverty line. The poverty line is defined by a statistical threshold that considers family size and income (see Appendix C). For purposes of this analysis, low-income population consists of any census tract within the 50-mile zone of impact with a low-income population proportion greater than the national average of 13.1%.

Native Americans. While recognizing the unique Tribal Nation Status, DOE has also included Native Americans as part of the overall regional minority populations when analyzing for disproportionately high or adverse impacts to minorities. Since the interests of Native American groups are unique to each site, the analysis of impacts to these groups and resources is more appropriate to a site-level assessment. This PEIS identifies those sites where recognized Native American groups are present in the region. Where Native Americans do not comprise a recognized group, they are still considered as a part of the site minority population. Known Native American traditional and historic properties are also identified in Chapter 4, The Affected Environment.

5.4.7.2.2 *Review of High and Adverse Health Risks and Environmental Impacts*

The environmental justice analysis presented in each waste type chapter reviewed the findings of the risk assessment for public health effects from proposed waste management activities at each site. Screening criteria (see Appendix C) based on WM PEIS population risk modeling were applied at each site to determine potential high and adverse health effects. Because the WM PEIS human health risk assessment findings indicated that risks to the general population residing in the 50-mile zone of impact at each site

would be low, it was reasonable to conclude that no segment of the population, including any minority or low-income populations, would experience disproportionately high and adverse health risks.

5.4.7.2.3 *Subsistence Consumption*

With regard to the impacts analyzed in this PEIS, and in the absence of subsistence consumption data by population subgroups, DOE prepared Table 5.4–5 using the following criteria and assumptions, listed in order of importance, to identify groups of sites that may be near minority and low-income populations potentially engaging in subsistence consumption:

- Proximity of Tribal Lands to DOE sites (the presence of Native Americans near DOE sites is assumed to create a greater possibility of subsistence consumption)
- Distance of the DOE site to major surface water bodies (populations nearer water are assumed to have a greater possibility of subsistence consumption of fish)
- Population density in the 50-mile region of influence around the site (rural residents are assumed to have a greater possibility of engaging in subsistence hunting and fishing)
- Proximity and concentration of minority and low-income populations to DOE sites (higher concentrations of minority and low-income populations are assumed to have a greater potential for subsistence consumption)

The 17 major DOE sites appear in the table in three groups: those with the highest possibility for subsistence consumption, those with intermediate possibilities for subsistence consumption, and those with the lowest possibilities for subsistence consumption. As Table 5.4–6 shows, more rural sites with recognized Native American groups are assumed more likely to engage in subsistence hunting and fishing. These include Hanford, INEL, LANL, RFETS, SNL, SRS, WIPP, and WVDP. Sites of intermediate concern include NTS, ORR, PGDP, and PORTS because of the respective site's rural surroundings, the presence of Native American populations, the presence of minority or low-income populations, or the presence of surface water on site. While sites like ANL and LLNL have a large percentage of minorities, both sites are in urban areas with populations of 8 and 6.3 million, respectively. Because of these factors, ANL and LLNL are listed along with BNL, FEMP, and Pantex as having a lower possibility of populations who principally rely on fish and/or wildlife for subsistence. Subsistence consumption analyses performed for other DOE EISs generally show no high and adverse impacts or are inconclusive. The notable exception

Table 5.4–6. Factors Contributing to the Possibility of Subsistence Consumption of Fish and Wildlife

Site	Federally Recognized Native American Groups[a]	Distance to Major Surface Water Bodies	Population in the 50-Mile Region of Influence (in millions)	Percent Minority (within a 50-mile radius)	Percent of Low-Income Populations
Sites With Higher Possibility of Subsistence Consumption					
Hanford	Yes	On site	0.35	25.8	18.8
INEL	Yes	NA[b]	0.11	10.2	12.5
LANL	Yes	At site boundary	0.27	48.1	13
RFETS	Yes	On site	1.98	19.7	9.8
SNL	Yes	6 miles	0.61	45.1	14.8
SRS	Yes	At site boundary	0.59	37.8	18
WIPP	Yes	NA	0.10	36.9	21.6
WVDP	Yes	On site	1.54	11.6	12.2
Sites With Intermediate Possibility of Subsistence Consumption					
NTS	Yes	NA	0.01	12.8	12.6
ORR	None	At site boundary	0.88	6.1	16.2
PGDP	None	<2 miles	0.50	9.1	19.1
PORTS	None	<1 mile	0.61	3.2	20.8
Sites With Lower Possibility of Subsistence Consumption					
ANL	None	<1 mile	8.03	33.5	11.4
BNL	None	On site	5.26	21.4	5.4
FEMP	None	<1 mile	2.64	13.2	11.8
LLNL	None	NA	6.31	40.9	9.5
Pantex	None	NA	0.27	19.8	15.2

[a] The presence of a Federally recognized Native American group was assumed to be the most important indicator of potential substance fishing and hunting. The remaining factors are listed in descending importance from left to right.
[b] No major surface water bodies within the Region of Influence.

is the Hanford Tank Waste Remediation System EIS, which identified potential disproportionate impacts to Native Americans. These are discussed in Appendix C, Section C.4.7.2.4.

5.4.8 LAND USE

The land resources analysis evaluated the potential for waste management alternatives for the five waste types to adversely affect land use at the sites. The evaluation was made by comparing the amount of land required for proposed waste treatment, storage, or disposal facilities with the amount of land designated for future waste management operations in the site development plans for the 17 major sites. If these sites did not have a portion of the site specifically designated for waste operations, the land required for a waste management facility was compared with an estimated amount of land considered suitable for waste management facility development. This estimate was made by subtracting from the total site acreage the known or estimated acreage of land in existing structures, sensitive habitats including wetlands, topographic and surface water features, and other features such as wildlife management areas and cultural resources.

At sites where the land requirement estimated for the proposed waste management facilities constituted 1% or more of designated or suitable land, a potential for impacts was noted in the waste type impacts discussion, and the percent required was listed in a summary table for the site/alternative. The 1% threshold was used as a general impact screening level. DOE assumed that, below the 1% level, significant impacts were unlikely and thus did not analyze these sites further. For sites above the 1% threshold, DOE assumed that there may be a potential for significant impacts. Additional analysis for sites above the 1% threshold includes the severity of impacts depending on the percentage required of the available land and an indication of the likelihood of conflicts with land uses adjacent to the site. If the land requirement for proposed facilities exceeded the amount of land designated or suitable, significant land use impacts were considered likely. The analysis also indicated whether the description of future uses given in a site's current development plans would potentially conflict with the uses proposed under the waste type alternatives.

The analysis also assumes that, regardless of the site, waste-type, or alternative, waste management facilities would not be located in the 100-year floodplain. If it is determined in sitewide or project-level NEPA analyses that the facilities are "critical actions" under the DOE floodplain regulations, they would not be located in the 500-year floodplain. Compliance with the requirements of Executive Order 11988, Floodplain Management (Executive Order 11988, 1977) and 10 CFR 1022, Compliance with Floodplain/Wetlands

Environmental Review Requirements, would be examined in detail in these sitewide or project-level NEPA reviews.

5.4.9 INFRASTRUCTURE IMPACTS

The infrastructure impacts analysis evaluated the impacts of the alternatives on onsite and offsite infrastructure by comparing the resource requirements of building and operating proposed waste treatment, storage, and disposal facilities to existing capacities of onsite infrastructure systems and to current offsite demand. The infrastructure resources considered in this evaluation include: (1) water supply (potable and process), (2) wastewater treatment facilities (sanitary and process), (3) electrical power supply, and (4) onsite transportation infrastructure. The impacts assessment evaluated the separate effects of the construction phase and the operations phase of each alternative for each of the waste types.

5.4.9.1 Onsite Impacts

The effects of the alternatives on each site's onsite infrastructure systems (except transportation) were assessed quantitatively by comparing the new demand under each alternative to the existing maximum capacity of the site's infrastructure. Where onsite maximum capacity information was unavailable, the proposed requirement was evaluated as a percentage of current demand for each resource category.

DOE assumed that new resource requirements less than 5% of current capacity would have minor or negligible impacts. Increases in requirements of 5% or greater were assumed to have the potential to cause moderate or major impacts, and were further evaluated on a site-by-site basis. An increase of 5% or greater that, when added to current use, caused total demand to exceed 90% of maximum available capacity was assumed to have a major impact. These percentages were selected as a conservative approach to alert decisionmakers to the potential for significant impacts.

Onsite transportation impacts were evaluated by comparing new onsite employment to existing site employment. New employment totals of less than 5% of current totals were assumed to have negligible or minor impacts. Increases in employment of 5% or greater were assumed to have the potential to cause moderate impacts, and increases of 15% or greater were assumed to have potentially major impacts. As

with the new project demands, these percentages were selected in order to identify the potential for significant impacts.

5.4.9.2 Offsite Impacts

New resource requirement demands on offsite infrastructure for each alternative were compared with estimated current demand. New offsite demands under the alternatives was based on population increases from the social impacts analysis. Similarly, the estimated current demand was based on 1990 regional population data from the social impacts analysis. Evaluation of the transportation effects on infrastructure resources was based on forecasted increased traffic from employees directly or indirectly associated with the alternatives, based on population changes developed by the social impacts analysis.

New offsite demands of less than 5% of current demand were assumed to be negligible or to result in minor impacts. Increases in demand of 5% or greater were assumed to have the potential to cause moderate impacts, and increases of 15% or greater were assumed to have potentially major impacts. These conservative assumptions allow DOE to identify the potential for significant impacts.

The following assumptions were made in the evaluation of infrastructure impacts:

- Wastewater treatment demand was assumed to be equal to water use. Sanitary sewage and industrial wastes are derived principally from the water supply (McGhee, 1991), and the amount of water used by a city is a good indicator of the amount of sewage that will be generated (Viessman and Hammer, 1985). Where actual data on municipal rates of wastewater were unavailable, water supply records were used to estimate wastewater flow (Metcalf & Eddy, 1991).
- Existing capacity indicates either the capacity of the onsite infrastructure or the allocation to the site by an offsite infrastructure system. Where maximum capacity information was not available, it was assumed that a comparison of new demand to existing demand is an acceptable indicator of potential impacts.
- Offsite impacts to infrastructure were assumed to be limited in aerial extent to the ROI used in the socioeconomic analyses.

5.4.10 CULTURAL RESOURCES

The cultural resources addressed in the WM PEIS analysis include prehistoric and historic resources, and Native American resources. Paleontological resources, though not cultural in origin, are also included because of their recognized value and similar need for protection.

Prehistoric and Historic Properties. A "historic property" is an archeological site, standing structure, or traditional cultural property that is listed or is potentially eligible for listing on the National Register of Historic Places. Requirements for the assessment of historic properties are met through compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 USC 470 *et seq.*), and with implementing regulations contained in 36 CFR 800.

Federal agencies are required to determine the effect that proposed actions may have on significant historic properties within the defined area of potential effects. The "area of potential effects" usually comprises the physical limits of disturbance or alteration that will result from implementing the proposed actions, such as construction or operation of a waste management facility. The presence or absence of historic properties within the area of potential effects (36 CFR 800.4) is then determined.

An adverse effect is assumed whenever the integrity of the cultural resources' property location, design, setting, materials, workmanship, feeling, or association may be diminished. Adverse effects on historic properties include, but are not limited to: (1) physical destruction, damage, or alteration; (2) isolation of the property or alteration of the character of its setting; (3) introduction of visual, audible, or atmospheric elements that are out of character; (4) neglect resulting in deterioration or destruction; and (5) transfer, lease, or sale of the property (36 CFR 800.9.b.1–5). If no cultural resources are identified that are eligible or potentially eligible for the National Register of Historic Places, then, in consultation with the State Historic Preservation Office and in the absence of any other significant cultural or Native American resources, it can be assumed that the project will have no effect on historic properties and the action may proceed.

Native American Resources. Native American resources refer to structures, regional locations, natural features, native plants, objects, and other materials considered to be of value to contemporary Native American groups for traditional, religious, or ceremonial purposes. Resources involve geographic locations and their settings such as: burial grounds; sacred sites or areas; materials for producing sacred objects and

traditional implements; botanical, biological, and geological resources of ritual importance; and natural elements. Impacts to these areas include both direct physical impacts (e.g., destruction, damage, or reduced access to sacred sites preserved in their natural settings) and indirect social and economic effects (e.g., disruption or intrusion on religious beliefs and cultural practices of tribal peoples closely connected to the earth and its resources). Several laws and Executive Orders are specifically applicable to the protection of Native American resources, including the American Indian Religious Freedom Act of 1978 (42 USC 1996 *et seq.*), the Native American Graves Protection and Repatriation Act of 1990 (25 USC 3001 *et seq.*), and Executive Order 13007 regarding sacred sites. Implementation of these statutes as well as 36 CFR Part 800 depends on establishing government-to-government consultation with American Indian tribes that have treaty and traditional interests in DOE lands.

Paleontological Resources. Paleontological materials and features are the physical remains of life forms (fossils) from a former geologic age. These include the remains of animals, plants, or trace fossils, such as impressions, burrows or tracks. Although paleontological resources are not treated with the same level of specificity as archeological or historic properties, they are addressed in several Federal statutes, such as the Federal Land Management Policy Act of 1976 (43 USC 1701 *et seq.*).

Cultural Resources Approach. Cultural resources are not uniformly distributed across the landscape but are located with reference to physical and human geography. Therefore, the actual physical location selected for the construction of a facility is the most important factor in determining the nature and extent of any potential impact. Because the specific locations of proposed waste treatment, storage, or disposal facilities at any of the DOE sites are not being selected in the WM PEIS, potential impacts to cultural resources cannot be thoroughly analyzed in this programmatic document. DOE will evaluate the potential impacts to cultural resources, including Native American resources, in sitewide or project-specific NEPA reviews prepared to evaluate alternative locations on a particular site where a waste management facility should be constructed.

Table 4.3–8 lists the known archaeological resources for each site. Only ANL-E, RFETS, and SNL-NM have been completely surveyed. With one exception (SNL-NM), wherever surveys have been conducted archaeological sites have been found. At all but two DOE sites (RFETS and WVDP) where archaeological sites have been found, at least some of the archaeological sites have been found to be eligible for the National Register of Historic Places. Even where surface surveys have been completed, however, the possibility of significant archaeological remains that have left no surface indicators cannot be excluded. The

extent to which these archaeological resources may be affected by a given alternative can be assessed only when specific construction locations have been determined. Once identified and evaluated, a plan for the management of affected cultural resources must be developed in consultation with the relevant SHPO and any Native American group whose traditional resources may be affected. Management plans include provisions for protection, mitigation (often excavation), and access to cultural resources, as appropriate.

5.4.11 GEOLOGY AND SOILS

As indicated in Chapter 4, Affected Environment, DOE's review of the geology and soils at the 17 major sites indicated that it is unlikely that impacts to these resources would affect the selection of alternatives for any waste type. For this reason, the impacts analysis in the waste-type chapters do not address geology and soils.

While geology and soil characteristics are important determinants of where on a particular site a facility could be located, such determinations are not being made at this time. The exact location of waste management facilities at selected sites will be the subject of sitewide or project-level NEPA reviews. For the DOE sites that are candidates to host waste management facilities, the land use impacts analysis determined whether there is sufficient acreage available to allow a choice among several locations.

Most of the DOE sites are in stable geologic areas. However, seismic characteristics of the sites being considered for waste management facilities were taken into account in the health risk assessment by evaluating potential accident scenarios in which exposure to chemical or radiological constituents of the waste might occur.

An analysis of soil erosion is necessarily site-specific and can be mitigated by site-specific selection processes. Similarly, the assessment of the potential to deny access to mineral resources will be deferred until sitewide or project-level NEPA documents are prepared.

5.4.12 NOISE

Noise impacts to workers were not examined in the WM PEIS, because hearing protection would be provided to all WM workers as required by OSHA regulations, and noise impacts are especially dependent

on the WM technologies employed. In addition, noise from the construction and operation of waste management facilities, and increased vehicle traffic may cause adverse impacts to the offsite public and wildlife. Because waste management facilities will be placed on industrial type sites and added traffic will be largely on high-volume corridors, these activities should not substantially increase the general ambient noise levels. In certain cases, however, sensitive receptors may be affected. These localized effects were not evaluated in this PEIS because the specific locations of any new activities relative to the locations of sensitive noise receptors at the sites cannot be accurately predicted. Since the WM PEIS will not be selecting the locations of the WM facilities, nor the technologies to be employed, noise impacts cannot be evaluated at this time, but will be considered in future sitewide or project-specific NEPA reviews.

5.4.13 CUMULATIVE IMPACTS

In addition to the environmental impacts associated with each alternative under each waste type, this document analyzes the cumulative impacts of siting one or more waste management facilities for one or more waste types at specific sites. These cumulative impacts include not only the impacts of potentially managing more than one waste type at a site, but also the "past, present, and reasonably foreseeable future actions" at that site (40 CFR 1508.7).

Considering five waste types, the four alternative categories comprising 36 Alternatives, and 17 potential sites, numerous combinations of possible alternatives cumulative impacts could be analyzed. Performing all possible cumulative impact analyses and including those analyses in the WM PEIS is neither warranted nor desirable.

In order to accomplish a reasonable analysis framework, DOE displays "minimum" and "maximum" impact alternatives for each DOE site. The WM PEIS indicates which combination of alternatives would impose the least cumulative impacts on that site and which would impose the most cumulative impacts. All other combinations of alternatives applicable to that site would fall somewhere between the minimum and maximum impacts. Impacts not addressed in the WM PEIS that have occurred, are occurring, or will occur at the sites are also included in the cumulative impact analyses (these non-WM PEIS activities are assumed to be constant for all the combinations applicable to a specific site).

In addition, quantitative information regarding the impacts from each alternative for each waste type at a particular site is available from tables included in Volume II of the WM PEIS. From those tables, it is possible to quantitatively estimate the cumulative impacts of any particular combination of alternatives. Guidance for performing that calculation is provided in Chapter 11.

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CHAPTER 6
Impacts of the Management of Low-Level Mixed Waste

Chapter 6 describes the environmental consequences associated with the No Action, Decentralized, Regionalized, and Centralized Alternatives for low-level mixed waste (LLMW). This chapter provides information on existing and anticipated LLMW volumes, and existing and planned facilities available at DOE sites. This is followed by an overview of the analysis and assumptions relating to LLMW characteristics, the treatment and disposal technologies considered, and the rationale for selecting the specific sites analyzed under each alternative. The chapter discusses the health risk, environmental impacts, and costs of the alternatives, and provides a comparison of the alternatives.

The methods used to evaluate impacts are outlined in Chapter 5. Impacts tables for each major DOE site are contained in Volume II. Details of the LLMW analysis are contained in the Technical Report entitled "Low-Level Mixed Waste Inventory, Characteristics, Generation, and Facility Assessment for Treatment, Storage, and Disposal Alternatives Considered in the U.S. Department of Energy Waste Management Programmatic Environmental Impact Statement" (ANL, 1996). Additional information can be found in the complete list of appendices and technical reports provided in Chapter 15.

6.1 Background

6.1.1 DEFINITION AND ORIGIN OF LLMW

- *LLMW contains both radioactive and hazardous components.*
- *LLMW is generated, projected to be generated, or stored at 37 DOE sites as a result of research, development, and production and dismantlement of nuclear weapons.*
- *Waste management activities will require management of an estimated 219,000 cubic meters of LLMW over the next 20 years.*
- *DOE must select treatment and disposal sites for LLMW.*

Low-level mixed waste contains Resource Conservation and Recovery Act (42 USC 6901 *et seq.*) (RCRA)-controlled substances and is radioactive. It is managed according to RCRA requirements because of its RCRA hazardous waste characteristics and according to the Atomic Energy Act (AEA) (42 USC 2011 *et seq.*) because of its radioactive components. The hazardous component of this LLMW is subject to either (1) EPA regulations promulgated under RCRA, (2) EPA regulations for polychlorinated biphenyls (PCBs) promulgated under the Toxic Substance Control Act (TSCA), or (3) State hazardous waste regulations promulgated under RCRA. LLMW has been generated by DOE as a result of research, development, and production of nuclear weapons; however, LLMW generation from nuclear weapons production and nuclear research is declining.

6.1.2 VOLUMES AND LOCATIONS

LLMW is generated, projected to be generated, or stored at 37 DOE sites. According to DOE estimates, waste management activities will require management of approximately 219,000 cubic meters of LLMW over the next 20 years. The total volume of wastes after treatment requiring disposal will be about 72,000 cubic meters. Additional LLMW generated by environmental restoration activities is discussed in Section 6.15.

Table 6.1–1 presents the estimated total volume of LLMW from waste management activities at each of the 37 LLMW sites. (Details of the amounts and characteristics of LLMW are provided in ANL [1996].) Both inventory wastes and 20-year projected wastes (1994–2013) are provided. The *Mixed Waste Inventory Report* (DOE, 1994) was used for all LLMW inventories and generation rates, except for Colonie, ETEC, and RFETS, which use late 1994 site estimates, and ANL-E and NTS, which use the *Mixed Waste Inventory Report* (DOE, 1995c). Where MWIR totals were provided for only 5 years, waste volumes were extrapolated to provide waste totals for the 20-year analysis period. PCB wastes have been included both in the data presented in Table 6.1–1 for each of the sites and in the analysis of impacts presented later in this chapter. Information on waste volumes updated from the Draft WM PEIS was used for ANL-E and NTS (DOE, 1995c). The analysis presented in the WM PEIS is based on this newer information for those two sites. A more complete discussion on data used in the WM PEIS analysis is presented in Appendix I.

This WM PEIS analyzed the impacts of managing LLMW at 16 major sites (WIPP, another major site, will not have LLMW). In general, the remaining 21 LLMW sites have very small existing and projected volumes and therefore were not considered major sites. Figure 6.1–1 presents the total LLMW volumes at the 16 major sites considered under the LLMW alternatives.

Owing primarily to improvements in waste characterization, projected waste volumes and inventories of LLMW have changed since the analysis of these wastes was carried out for the WM PEIS. A discussion of these changes in the waste volume estimates at each site, including updates taken from newer databases, is found in Appendix I. This appendix also identifies criteria for reanalyzing sites using the more recent data and describes DOE's conclusions about the need to analyze the more recent data for specific sites.

Table 6.1–1. Low-Level Mixed Waste Volumes (cubic meters)

Site	Inventory	20-Year Projected Generation	Estimated Inventory Plus 20 Years Generation
1. Ames Laboratory (Ames)	0.3	0.1	0.4
2. Argonne National Laboratory-East (ANL-E)[a]	34	125	159
3. Battelle Columbus Laboratories (BCL)	0	0.1	0.1
4. Bettis Atomic Power Laboratory (Bettis)	32	16	48
5. Brookhaven National Laboratory (BNL)	85	110	190
6. Charleston Naval Shipyard (Charleston)	0.3	3	3
7. Energy Technology Engineering Center (ETEC)[a]	3.7	13	17
8. Fernald Environmental Management Project (FEMP)	2,600	48	2,600
9. General Atomics (GA)	43	0.4	43
10. Grand Junction Project Office (GJPO)	0.6	0.9	1.5
11. Hanford[b]	3,100	33,000	36,000
12. Idaho National Engineering Laboratory (INEL)	25,000	9,600	35,000
13. Kansas City Plant (KCP)	0.8	0	0.8
14. Knolls Atomic Power Laboratory (KAPL)	3.1	220	220
15. Laboratory for Energy-Related Health Research (LEHR)	4	3	7
16. Lawrence Berkeley Laboratory (LBL)	6	270	280
17. Lawrence Livermore National Laboratory (LLNL)	230	4,100	4,300
18. Los Alamos National Laboratory (LANL)	670	2,100	2,800
19. Mare Island Naval Shipyard (Mare Is)	10	42	52
20. Mound Plant (Mound)	76	4	80
21. Nevada Test Site (NTS)[a]	300	2,700	3,000
22. Norfolk Naval Shipyard (Norfolk)	0	6	6
23. Oak Ridge Reservation[c] (ORR)	26,000	33,000	59,000
24. Paducah Gaseous Diffusion Plant (PGDP)	600	0	600
25. Pantex	130	560	690
26. Pearl Harbor Naval Shipyard (Pearl H)	2	4	6
27. Pinellas	0.01	0.01	0.02
28. Portsmouth Gaseous Diffusion Plant (PORTS)	7,500	25,000	33,000

Table 6.1–1. Low-Level Mixed Waste Volumes (cubic meters)—Continued

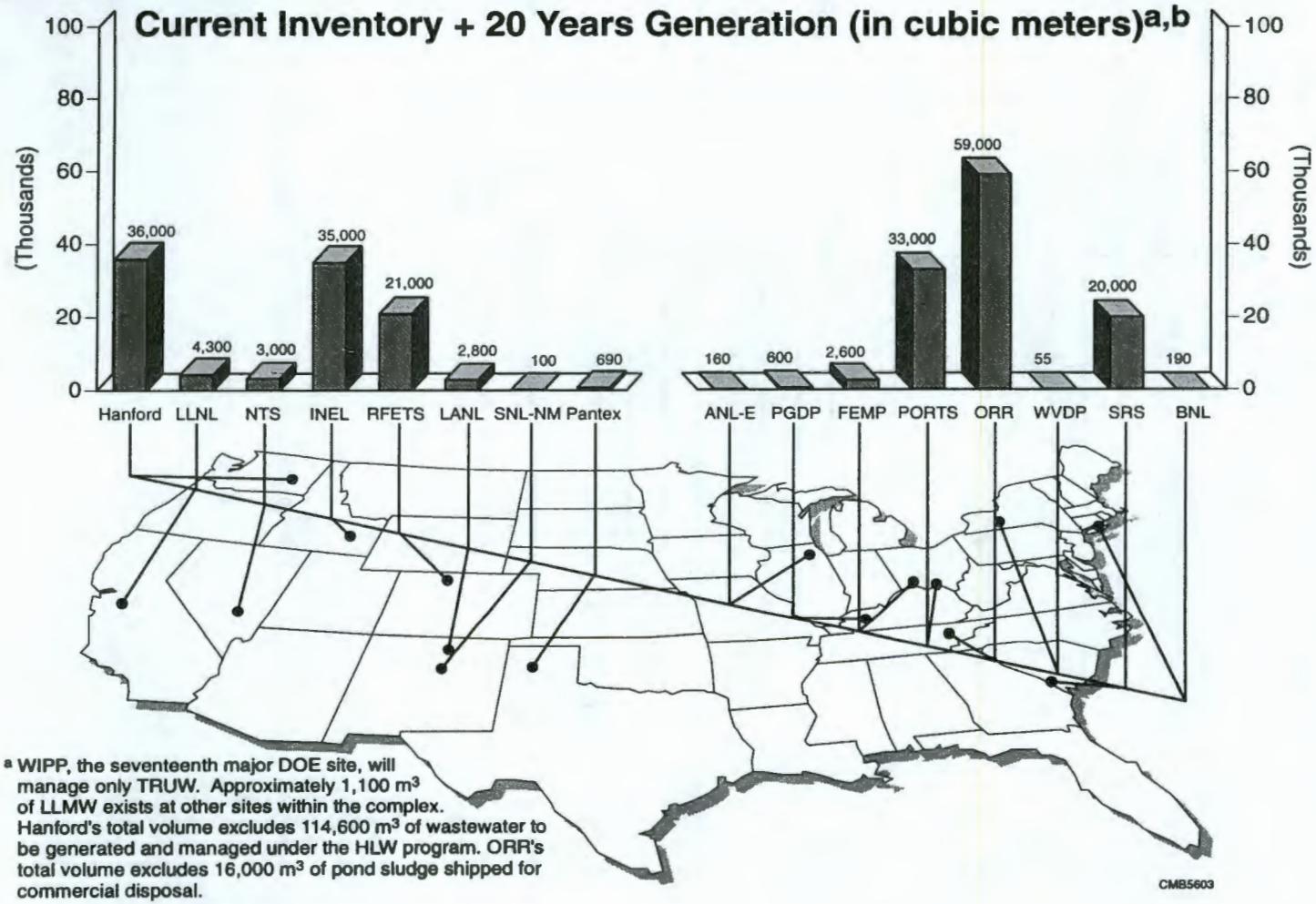
Site	Inventory	20-Year Projected Generation	Estimated Inventory Plus 20 Years Generation
29. Portsmouth Naval Shipyard (Ports Nav)	0.4	0.8	1
30. Princeton Plasma Physics Laboratory (PPPL)	0	0.02	0.02
31. Puget Sound Naval Shipyard (Puget So)	62	170	230
32. RMI Titanium Company (RMI)	22	7	29
33. Rocky Flats Environmental Technology Site (RFETS)[a]	8,300	13,000	21,000
34. Sandia National Laboratories-New Mexico (SNL-NM)	69	33	100
35. Savannah River Site (SRS)	6,600	13,000	20,000
36. University of Missouri (UofMO)	0.4	1.7	2
37. West Valley Demonstration Project (WVDP)	23	32	55
Total Complex	**82,000**	**137,000**	**219,000**

Note: Volume data are rounded from field estimates and columns do not add. Waste projections above, used for the WM PEIS analysis, are based on 1994 and 1995 data and may vary from latest site estimates. Updated inventories and waste generation rates are summarized in Appendix I. Variances include reduced LLMW projected at BNL (10 m^3 inventory and 30 m^3 projected generation versus the 85 m^3 and 110 m^3 shown above). Wastes transferred to WM from Environmental Restoration (ER) are not included in this table. A discussion of these wastes is included in Section 6.15 and Appendix B.
[a] Updated information on waste volume was used for ANL-E and NTS (DOE, 1995c). Other shaded cells indicate editing for round-off adjustments and other minor inaccuracies.
[b] Total volume excludes 114,600 m^3 of wastewater to be generated and managed under the high-level waste (HLW) program.
[c] Total volume excludes 16,000 m^3 of grouted pond sludge that is being shipped to commercial disposal.
Source: DOE (1994 and 1995c).

6.1.3 Existing and Planned Facilities Available at DOE Sites

DOE identified existing and planned LLMW facilities to establish the baseline capacities for LLMW treatment and disposal at major sites, and to determine the need for new or expanded facilities. Some facilities that are not currently operating were considered to be in existence for the analysis, based on the assumption that they could become operational if required. Planned facilities include only those facilities for which a Title II design has been initiated.

Analysis in the WM PEIS assumes use of existing and planned facilities until their capacities are met. If additional capacity is needed, use of new conceptual facilities is assumed. These conceptual facilities provide the difference in treatment, storage, and disposal capacity between the baseline reported in Table 6.1–2 and what is necessary to manage the source term which a given site would receive under any



[a] WIPP, the seventeenth major DOE site, will manage only TRUW. Approximately 1,100 m^3 of LLMW exists at other sites within the complex. Hanford's total volume excludes 114,600 m^3 of wastewater to be generated and managed under the HLW program. ORR's total volume excludes 16,000 m^3 of pond sludge shipped for commercial disposal.

[b] Updated inventories and waste generation rates are summarized in Appendix I.

Source: DOE (1994).

Figure 6.1–1. Low-Level Mixed Waste at the 17 Major Sites

Table 6.1–2. Capacities of Existing and Planned LLMW Facilities at Major LLMW Sites[a]

Site	Treatment (m^3/yr)			Storage (total m^3)	Disposal (m^3/yr)	
	Aqueous Treatment	Grout Solidification	Incineration	LLMW Container Storage	Engineered Disposal	Shallow Land
ANL-E[b]	47			101		
BNL				335		
FEMP	24,627					
Hanford[c]	120 100,000*	15,360		24,837		1,000[d]
INEL	47,472 3,921*	2,765	2,300	226,240		
LANL				28,541		
LLNL	6,822 147,000*			2,555		
NTS	3,000			3,000		12,648*
ORR	202,808		13,500	42,890		
Pantex		70		1,270**		
PGDP	156			2,719		
PORTS	84,528*			7,370		
RFETS	82,785	27,178		17,695		
SNL-NM		1		4,101		
SRS	501,500	40,000 208*	8,200*	13,760	6,800	

Notes: * = planned capacity; ** = permitted capacity. A blank indicates that a site does not perform the specified treatment or disposal operation. No onsite wastewater or wastewater treatment capacity at BNL and SNL-NM sites.
[a] The capacities of these existing and planned units may be divided among several waste types in accordance with site plans.
[b] Onsite reactive metals recovery capacity is 40 m^3/yr.
[c] Onsite reactive metals recovery capacity is 690 m^3/yr.
[d] Original disposal rate was estimated by dividing the planned total capacity of 10,000 cubic meters by 10 years of treatment operations. Trenches 31 and 34 have been constructed with an estimated total capacity of 42,000 cubic meters.

Source: INEL (1995b).

given alternative. Conceptual facilities are based on generic designs with set impacts (e.g., cost, performance/efficiency). Where necessary for analysis, an assumption was made that the impact of existing facilities essentially reflects the impact of conceptual facilities. Table 6.1–2 lists the LLMW existing and planned facility capacities at major sites considered in the WM PEIS analysis (INEL, 1995b). Wastewater treatment is the most prevalent treatment capability for LLMW; however, some capabilities for grout solidification, thermal treatment, mercury separation, lead recovery, and reactive metals recovery exist at a limited number of sites. As the table illustrates, two principal methods of disposal are shallow land burial and disposal in engineered facilities, such as concrete vaults.

Both types of LLMW disposal facilities assumed in the WM PEIS were designed to meet all applicable RCRA disposal requirements.

6.2 Analytical Methods and Assumptions

Reported LLMW volumes and facilities were used to analyze the human health risk, environmental and socioeconomic impacts, and costs associated with each of the LLMW alternatives. In addition to examining the total waste volumes and existing LLMW capabilities, DOE identified the chemical and radiological characteristics of LLMW to define treatment and disposal requirements. The LLMW characteristics were used in determining the LLMW alternatives, including location and treatment methods, and in forming the basis for the risk and impacts analyses. The specific LLMW assumptions relating to facilities, treatment and disposal technologies, and transportation are discussed below.

6.2.1 CHARACTERISTICS

6.2.1.1 Physical/Chemical

The challenge in managing LLMW arises from its dual nature: it contains RCRA-classified hazardous components (or characteristics) and it is radioactive. The various physical states (e.g., solids, liquids) of the waste and the presence of friable asbestos fibers and polychlorinated biphenyls (PCBs) pose additional challenges. The MWIR categorized more than 2,000 individual DOE LLMW streams. To define required treatment and disposal technologies, DOE categorized the waste streams into treatment groups, and further

condensed those groups based on common physical/chemical characteristics. These characteristics dictate what types of treatment are necessary at each site. Further, emissions from selected treatment technologies are a function of input wastes and their quantities and characteristics, as well as the selected technologies. The waste treatment groups were further subdivided into 23 treatment categories.

Thus, for purposes of analysis, DOE examined five LLMW treatment groups: wastewater, organic liquids, solid process residues, soils, and debris wastes. Figure 6.2–1 illustrates the general treatment flow for each physical waste form (ANL, 1996). Additionally, DOE assigned consistent chemical profiles to identify the composition and concentration of 16 RCRA-hazardous chemical constituents expected to be present in each waste type. The RCRA hazardous constituents included are arsenic, barium, cadmium, chromium, lead, mercury, silver, selenium, cyanides, methylene chloride, soluble hydrocarbons (e.g., ketones), insoluble hydrocarbons (e.g., toluene), chlorofluorocarbons, and 2-, 3-, and 4-chlorinated organic solvents. One additional waste treatment group, special wastes, is not included in this analysis because these wastes each require specialized treatment technologies outside of the scope of the treatments identified in the WM PEIS. The special wastes represent a minor component, less than 2% of the LLMW volume.

6.2.1.2 Radiological Profiles

Because LLMW is both hazardous and radioactive, DOE also identified the radiological characteristics that impose special treatment and handling requirements and, ultimately, help determine emissions, risks, and impacts. Although the MWIR did not provide detailed data on radiological concentrations within the LLMW streams, radiological profiles were assigned based on waste origin. After categorizing the waste into the physical/chemical treatability groups, a site radiological profile was determined and assigned to each treatability group at the site, using an appropriate mix of radionuclides from six distinct radiological categories. The six radiological categories are presented in Table 6.2–1 (ANL, 1996; DOE, 1992).

DOE used the radiological categories to identify the radionuclides at each site that might present a risk to human health or the environment. For example, waste classified as a fission product would contain radionuclides such as cesium-137 or strontium-90, whereas cobalt-60 is commonly associated with waste generated from induced activity (from a reactor) and would most likely occur only at sites handling induced activity wastes, such as nuclear reactor components. Additionally, each radionuclide has a different decay

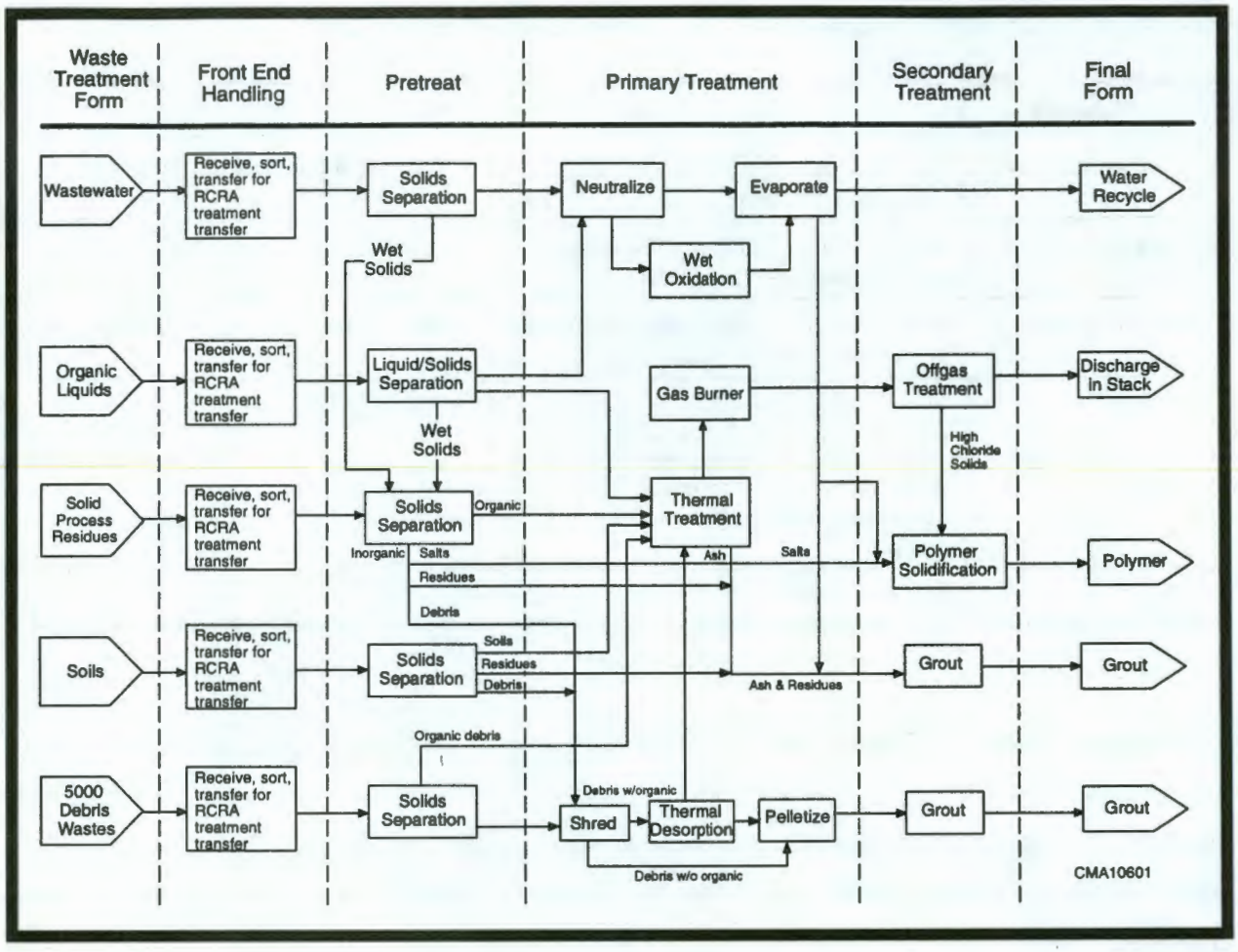


Figure 6.2–1. WM PEIS LLMW Flow Diagram

rate (or half-life) that dictates the persistence of the radioactivity for a specific waste stream at a given site. Over time, radioactive decay reduces the level of radioactivity of a material. For the WM PEIS analysis, decay rates were considered and levels of activity were adjusted to reflect more accurately the expected radiological profiles and doses at the time of treatment.

After the radiological categories of the waste streams were identified, LLMW had to be categorized as either contact-handled (CH) or remote-handled (RH), based on the level and type of radioactivity emitted. These handling categories determine the required level of protective shielding necessary to store and process the waste safely. CH waste containers can be handled directly by humans, whereas RH waste requires extra shielding and sometimes the use of robotics. DOE analyzed CH and RH LLMW separately in the WM PEIS to account for their different treatment and disposal requirements.

Table 6.2–1. Six LLMW Radiological Profiles

Category	Description
Uranium/thorium	Waste material primarily containing the naturally occurring radioactive elements of uranium or thorium
Fission products	Waste containing radioactive isotopes (e.g., cesium-137 and strontium-90) that result when a heavy nucleus is split
Induced activity	Waste that contains elements that were initially not radioactive, but became radioactive as a result of absorbing neutrons (e.g., cobalt-60)
Tritium	Waste material containing trace amounts of tritium (a synthetically produced radioactive isotope of hydrogen)
Alpha	Waste materials contaminated with alpha-emitting (helium nuclei) radionuclides not listed under uranium/thorium or low levels (less than 100 nCi/g) of transuranic isotopes
Other	Waste material that is combined or undefined

DOE further categorized LLMW by the type of radiation it emits. Radioactive materials emit alpha, beta, and gamma radiation. The LLMW analysis separately analyzed alpha-emitting waste, which contains significant quantities of plutonium and other elements whose atomic weights exceed that of uranium. These wastes require special containment and management because of the health threat posed by alpha particles if inhaled.

6.2.2 Technologies and Treatment Processes

DOE designed LLMW treatment systems based on the physical, chemical, and radiological characteristics of each treatment group. An approved treatment method recognized by the U.S. Environmental Protection Agency (EPA) was selected to process each treatability group. Most treatment facilities were assumed to be fixed facilities for LLMW. However, DOE also considered the use of mobile treatment facilities that could be moved from site to site to treat the small amounts of waste that exist at most of the 37 LLMW sites.

LLMW is treated by one or more treatment processes (or "modules"). Individual modules were linked together to form a complete treatment flow process for each treatability group and adjusted for the chemical and physical type of waste. The emissions and impacts were calculated from each module and then added

to help determine the overall impacts from each treatment process at a site. In general, each waste stream receives some front-end handling (e.g., sorting), pretreatment (e.g., separation), primary treatment (e.g., organic destruction and wastewater treatment), and secondary treatment, which transforms the waste into a final form suitable for disposal. Identical treatment flowsheets were used for each site to compare impacts, varying only the waste composition, throughput (based on volume), and site-specific environment.

DOE considered a variety of treatment methods and processes for LLMW consistent with the LDRs given in 40 CFR Part 268. For the difficult-to-treat LLMW containing organic material, two thermal treatment methods were analyzed: incineration, which EPA considers the best demonstrated available technology for organic waste; and thermal desorption, which bakes the wastes at temperatures lower than those used in incineration. An alternate treatment process that replaces thermal treatment (incineration and thermal desorption) with washing technologies was also analyzed and is available in a separate technical report (DOE, 1996). Table 6.2–2 presents the standard treatment steps assumed for both LLMW thermal and alternative organic treatment technologies (ANL, 1996a). The waste volumes in Table 6.1–1 contain small amounts of LLMW that require special treatment not covered by the treatment trains represented in Figure 6.2–1. Such LLMW is not analyzed in the WM PEIS.

The WM PEIS treatment steps may not reflect the treatment flow for specific waste streams at individual sites. Rather, DOE used generic treatment processes that have broad applicability to the LLMW sites, could provide consistent analysis among the sites, and could bound the impacts resulting from activities proposed in site-specific reports or in the site treatment plans (STPs) (and the equivalent *Report on the Hanford Site Land Disposal Restrictions for Mixed Waste* [Black, 1992–1995]) developed under the Federal Facility Compliance Act (FFCAct).

For both technologies, two types of disposal were considered: engineered disposal and shallow land burial. Engineered disposal facilities for LLMW are concrete structures with collection systems to prevent leaks into the environment. They are usually located above the natural grade of the land. Shallow land burial facilities are generally shallow earthen ditches.

With regard to privatization of DOE treatment, storage, and disposal (Sections 6.4 to 6.14), it is assumed that the environmental impacts will be essentially the same for the private versus the DOE approach, providing the facilities are located near or in similar locations to those analyzed within this document.

Table 6.2–2. Treatment Steps for LLMW Thermal and Alternative Organic Treatment Technologies

Treatment Steps	Base Technology Option (Thermal)	Alternative Organic Technology Option (Washing)
FRONT-END ↓	Receive, sort, & transfer	Receive, sort, & transfer
PRETREATMENT PROCESS ↓	Separate solids from liquids	Separate solids from liquids
PRIMARY TREATMENT PROCESS ↓	Neutralize and evaporate aqueous liquids, with wet oxidation of solids; thermally treat combustible liquids, solids, & off-gases; noncombustible solids, including ash, and solids from soils and debris are solidified; special treatments for recovery of mercury and lead, and for inherently hazardous materials	Neutralize and evaporate aqueous liquids, with wet oxidation of solids; organic destruction process for organic liquids; separate wash modules for sludges, soil, and debris; special treatments for recovery of mercury and lead, and for inherently hazardous materials
SECONDARY TREATMENT ↓	Recycle water from evaporation; treat off-gases before discharge; oxides from special treatment solidified	Recycle water from evaporation; treat off-gases before discharge; recycle solvents, including water, from washing of solids
STABILIZATION OF SOLIDS ↓	Grout solids from treatment; stabilize in polymer salts not suitable for grouting	Grout solids from treatment; stabilize in polymer salts not suitable for grouting
BACK-END HANDLING ↓ TO DISPOSAL	Prepare stabilized solid waste for shipment for storage and/or disposal; hold recovered metal and mercury for reuse	Prepare stabilized solid waste for shipment for storage and/or disposal; hold recovered mercury for reuse

6.2.3 WM PEIS Assumptions: Facilities, Treatment, Disposal, and Indefinite Storage

Although DOE used LLMW volumes and existing facilities from well-documented data sources, the analysis of the alternatives required DOE to make additional assumptions. In addition to the estimating and extrapolating techniques used to identify the radiological and chemical characteristics of LLMW, the following general assumptions relating to LLMW facilities, treatment, disposal, and indefinite storage under the No Action Alternative, helped further define specific actions and operating parameters under each alternative.

Facilities

- All LLMW facilities are designed to treat waste to meet RCRA requirements.
- New facilities will be fully operational after a 10-year period of construction.
- LLMW currently in inventory (sometimes referred to as "legacy waste") plus annually generated waste during the period of construction will be treated during the 10-year period after construction (called a "work-off" period). After the designated work-off period, LLMW is assumed to be treated as it is generated on an annual basis; however, this was not analyzed in the WM PEIS.
- In the LLMW analysis, each site is assumed to build and operate facilities with capacities sufficient to handle only LLMW. This avoids linking the results of one waste type to decisions not yet made in another and results in conservative estimates of risk, cost, and impacts. However, the alternatives were structured to accommodate locating LLMW and LLW facilities at the same site to more accurately reflect the reality of coordinated treatment and disposal. Chapter 11 discusses the cumulative effects for sites hosting more than one waste type facility.

Treatment

- Wastewater treatment activities continue at every site for every alternative, since wastewater is difficult to transport but not to treat. However, residues resulting from wastewater treatment were assumed to be shipped for final treatment under all alternatives, except No Action. (Under the No Action Alternative, the residues are placed in storage for the 20-year analysis period. Sites with no LLMW wastewater treatment facilities, such as the Pantex Plant and LANL, are assumed to grout the aqueous waste and place it in onsite storage for the remainder of the analysis period).
- Under all alternatives, facilities are assumed to be designed to treat LLMW to meet land disposal restrictions (LDRs) using similar treatment modules at all sites. In addition, DOE scaled the treatment

facilities to the smallest size appropriate for treating all LLMW within the 10-year work-off period. Mobile treatment units are used for small waste streams under certain volume levels.

Disposal

- Two types of disposal were analyzed in the WM PEIS: engineered disposal and shallow land burial. However, when disposing of smaller quantities of waste (i.e., less than 700 cubic meters per year), aboveground silos were assumed. Both types of LLMW disposal facilities assumed in the WM PEIS were designed to meet all applicable RCRA disposal requirements.
- To conduct the risk analysis, DOE chose either an existing facility location when one was identified or a central location at the site. DOE used actual environmental settings for the analysis at each candidate site.
- No waste acceptance criteria limitations are imposed at disposal sites. That is, it is assumed that disposal sites can accommodate all waste targeted to them. In siting a disposal facility location on a site, a performance assessment analysis will be conducted to select a site location and define waste acceptance criteria.

Indefinite Storage Under the No Action Alternative

- The No Action Alternative continues current management practices. There would be full treatment to meet land disposal restrictions at only three sites and storage at all sites. Although such storage would be for an indefinite period, the analyses for storage used the same 20-year forecast for waste generation and evaluated impacts for the 20-year period in the same way as was done for 10 years of operation for the action alternatives. This was for consistency, to provide a baseline against which all other alternatives could be compared.
- The analyses assumed that all LLMW would be newly packaged. Existing storage was utilized for non-alpha waste when available; however, new storage facilities would be constructed for alpha LLMW and for any waste that exceeded the available storage capacity already on site.
- Risks, other environmental impacts, and costs were calculated for storage facilities using similar assumptions as for treatment and disposal facilities. The evaluation of human health risks includes worker risks from direct radiation and inhalation during operations and physical trauma during construction and operations. Waste containers in storage were assumed not to deteriorate, with very low emissions assumed to be released through the ventilation system from the waste containers. Potential accidents during storage are considered in the discussion of accidents in Section 6.4.

- After the initial packaging and construction of new storage facilities, no repackaging or replacement of storage was considered necessary for the remainder of the 20-year period of analysis. A longer period of storage (30–50 years) could require repackaging and facility replacement due to degradation, with corresponding impacts and costs.
- The results of the analysis of impacts in the following sections of Chapter 6 only consider the impacts for storage over the first 20 years of an indefinite period. Unlike the action alternatives, risks and other impacts that potentially exceed those predicted for the first 20 years could occur in the period beyond 20 years. The option of indefinite storage does not avoid impacts but rather causes impacts to occur every year for an indefinite period of time. A discussion of the longer term impacts for indefinite storage is presented in Section 6.16.

6.2.4 Transportation Analysis and Assumptions

DOE analyzed transportation impacts associated with each LLMW alternative. Both truck and rail transportation were analyzed using computerized routing models following the general principle of minimizing distance and transportation time. The routes were selected to be consistent with existing routing practices and all applicable routing regulations and guidelines. However, these are conceptual routes determined for the purpose of risk assessments. They do not necessarily represent the actual routes that would be used to transport waste. Actual routes will be determined during the transportation planning process described in Section 4.3.10.

In general, the risk to populations or individuals from transportation of radioactive materials is directly proportional to the external dose rate, which is a measure of the external radiation (principally gamma radiation) emitted from the shipment. For analytical purposes, DOE assumed that the average dose rate of each shipment would not exceed 1 millirem per hour at 1 meter from the shipping container (consistent with DOE's historical practices), although DOT regulations allow a higher dose rate of 10 millirem per hour at 2 meters from the container (49 CFR 173).

The shipment of the hazardous components of LLMW is regulated by the DOT as a means to protect the public from harm in the event of a potential release. All DOE shipments of LLMW would meet the numerous packaging and containment regulatory standards based on the hazardous components and characteristics of the waste.

Transportation of hazardous and radioactive materials, substances, and wastes is governed by U.S. Department of Transportation, NRC, and EPA regulations, and the Hazardous Materials Transportation Act. These regulations may be found in 49 CFR Parts 171-178, 49 CFR Parts 383-397, 10 CFR Part 71, and 40 CFR Parts 262 and 265, respectively.

6.3 Low-Level Mixed Waste Alternatives

DOE analyzed seven alternatives for CH, nonalpha LLMW within the four broad categories of alternatives: No Action, Decentralized, Regionalized, and Centralized. Treatment and disposal activities vary by alternative and by site. The foldout table at the end of this chapter shows the sites at which LLMW would be treated and disposed of under each alternative. This table is designed to be used as a quick reference when reading the LLMW impact sections.

The LLMW analysis considered treatment and disposal separately, first focusing on treatment and then using treatment residues as inputs for the disposal analysis. Each alternative was developed in order to assess environmental impacts, human health risks, and costs associated with the range of LLMW treatment and disposal options, and to provide input for programmatic decisions about where to locate LLMW treatment and disposal facilities.

Remote-handled waste requires special handling facilities for treatment and disposal. Under all alternatives, RH waste is treated and disposed of at the same four sites which house the majority of RH waste: the Hanford Site, INEL, ORR, and SRS.

Alpha LLMW requires special handling and treatment because of the adverse health effects that can occur as a result of inhalation or ingestion of alpha particles. Alpha LLMW exists at 10 sites. Sites where alpha wastes are treated or disposed of are indicated in each of the alternative tables by the alpha symbol ($\propto$).

Tables 6.3–1 to 6.3–7 show, for each alternative, the percentage of waste received from offsite for each treatment or disposal site. The percentages are derived from the waste volumes presented in this chapter and include updated LLMW volumes for these two sites: ANL-E and NTS.

6.3.1 No Action Alternative

The No Action Alternative provides a baseline for the analysis by considering treatment of LLMW at facilities that are currently capable of treating to meet LDRs, and indefinite storage of the waste onsite at all LLMW sites. INEL, ORR, SRS, and other sites to a lesser extent, are capable of some treatment to meet LDRs. Other sites may experience impacts from the construction of expanded storage, onsite shipping, or certification facilities (where the waste would be examined, characterized, and certified for shipment). These storage impacts are included in the WM PEIS in totals listed under treatment for the No Action Alternative. Under this alternative, no new treatment facilities would be built. Figure 6.3–1 and Table 6.3–1 illustrate the No Action Alternative. Because the No Action Alternative involves less treatment than other alternatives and no disposal, it will generally have smaller impacts than the other alternatives for the 20-year period of analysis. Impacts and costs would be expected beyond 20 years, however, and are discussed in Section 6.16. The No Action Alternative would not comply with RCRA because all the waste would not be treated to meet LDRs and would be placed in indefinite storage rather than in disposal facilities.

6.3.2 Decentralized Alternative

The Decentralized Alternative considers treatment of waste to meet RCRA requirements at all 37 LLMW sites. No untreated waste will be shipped offsite to any of the 37 treatment sites. Treated wastes from the smaller sites will be shipped to the larger sites for disposal. For purposes of analysis, DOE examined the impacts from treatment at the 16 major sites. Two of the 16 sites (BNL and SNL-NM) have relatively small amounts of LLMW (less then 200 cubic meters). DOE assumed that the impacts at these sites could be used to estimate the health and environmental impacts at the other 21 sites, most of which likewise have less than 200 cubic meters of LLMW. However, costs were calculated using data from all 37 sites. Figure 6.3–2 and Table 6.3–2 illustrate the Decentralized Alternative.

6.3.3 Regionalized Alternatives

The Regionalized Alternatives consider the consolidation of waste for treatment and disposal. Four LLMW Regionalized Alternatives were analyzed. The Regionalized Alternatives were developed to bound a reasonable range of intermediate variations for treatment and disposal.

LLMW No Action Alternative—(Treatment at 3 Sites; Storage at 37)

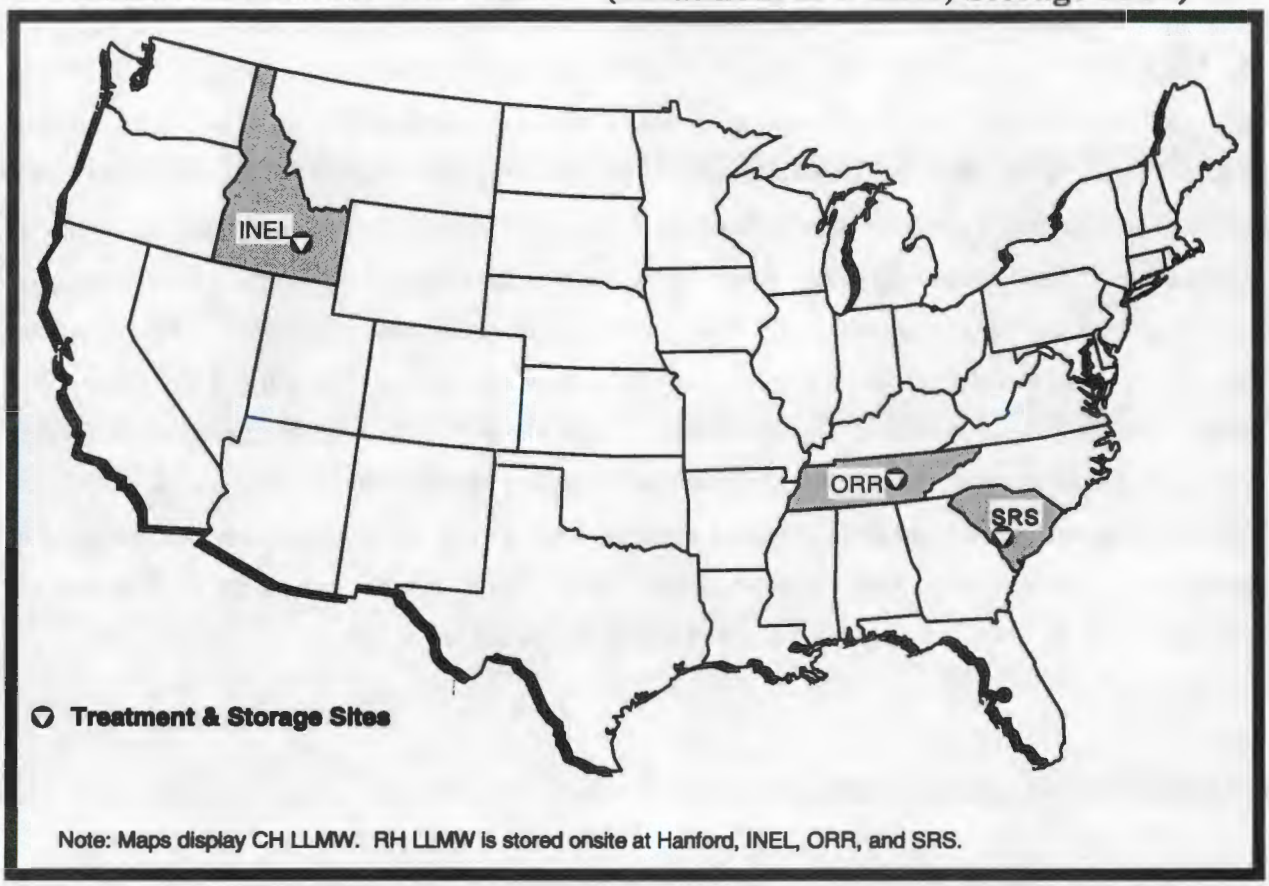


Figure 6.3–1. LLMW No Action Alternative

	Generating Sites			
	INEL	ORR	SRS	ANL-E, Ames, BCL, Bettis, BNL, Charleston, ETEC, FEMP, GA, GJPO, Hanford, KAPL, KCP, LANL, LBL, LEHR, LLNL, Mare Is, Mound, Norfolk, NTS, Pantex, Pearl H, PGDP, Pinellas, Ports Nav, PORTS, PPPL, Puget So, RFETS, RMI, SNL-NM, UofMO, WVDP
Treat (% Rec'd From Offsite)	INEL (0)	ORR (0)	SRS (0)	Onsite wastewater treatment only, as required
Store (% Rec'd From Offsite)	INEL (0)	ORR (0)	SRS (0)	Onsite

Note: Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 6.3–1. LLMW No Action Alternative

LLMW Decentralized Alternative—(Treatment at 37 Sites; Disposal at 16)

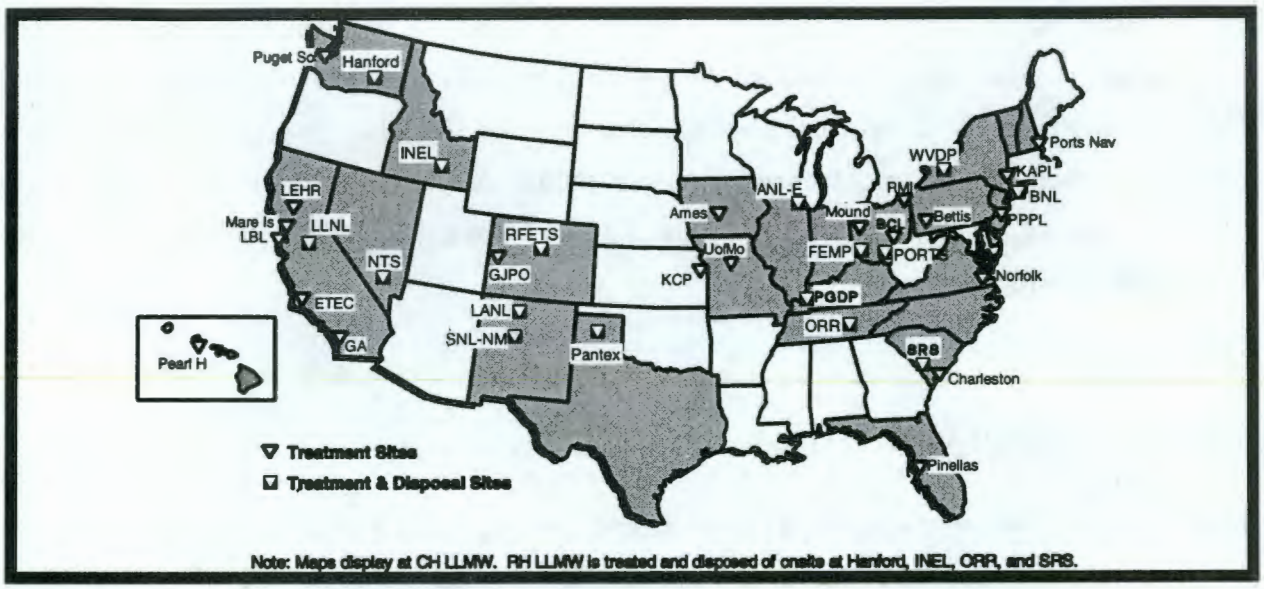


Figure 6.3–2. LLMW Decentralized Alternative

	Generating Sites								
	ANL-E Ames	BCL Bettis KAPL Mound Ports Nav PORTS PPPL RMI	BNL	Bettis∝ Charleston Mound∝ Norfolk Pinellas SRS, SRS∝ UofMO∝ WVDP∝	ETEC GA LBL LEHR LLNL Mare Is	GJPO RFETS RFETS∝	FEMP	Hanford, Pearl H Puget So	INEL INEL∝
Treat (% Rec'd From Offsite)	ONSITE TREATMENT AT GENERATING SITES								
Dispose (% Rec'd From Offsite)	ANL-E (<1)	PORTS (1)	BNL (0)	SRS (1)	LLNL (11)	RFETS (<1)	FEMP (0)	Hanford (<1)	INEL (0)

	Generating Sites							
	SNL-NM	KCP PGDP UofMO	LANL LANL∝ SNL-NM∝	ORR	Pantex	WVDP	NTS	LLNL∝ LBL∝
Treat (% Rec'd From Offsite)	ONSITE TREATMENT AT GENERATING SITES							LLNL
Dispose (% Rec'd From Offsite)	SNL-NM (0)	PGDP (<1)	LANL (0)	ORR (0)	Pantex (0)	WVDP (0)	NTS (1)	

Notes: ∝ = contact-handled alpha LLMW. Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 6.3–2. LLMW Decentralized Alternatives

Regionalized Alternative 1 considers treatment at 11 sites and disposal at 12 (those same 11 sites plus NTS). Regionalized Alternative 2 analyzes the impacts of treatment at seven sites with disposal at six sites. Under this alternative, two of the treatment sites (RFETS and PORTS) are not considered for disposal, but NTS is added for disposal only. Regionalized Alternative 3 analyzes the same seven treatment sites as Regionalized Alternative 2, but considers disposal at only one site, NTS. Regionalized Alternative 4 considers treatment and disposal at four sites—Hanford, INEL, ORR, and SRS, and disposal at six sites (the four treatment sites, plus LANL and NTS). Figures 6.3–3 to 6.3–6 and Tables 6.3–3 to 6.3–6 illustrate the Regionalized Alternatives.

6.3.4 CENTRALIZED ALTERNATIVE

The Centralized Alternative considers LLMW treatment and disposal at a single site within the complex, the Hanford Site. Regionalized Alternative 3 also considers disposal at a single site, NTS, to provide an alternative to Centralized disposal at the Hanford Site. Other sites may experience impacts from the construction of facilities where the waste would be examined, characterized, certified, and prepared for shipment. The other sites in the Centralized Alternative may also experience impacts from the treatment of wastewater that is not shipped offsite. Figure 6.3–7 and Table 6.3–7 illustrate the Centralized Alternative.

6.3.5 RATIONALE FOR SELECTING TREATMENT AND DISPOSAL SITES

How were the treatment sites selected?

The seven LLMW treatment alternatives were developed to cover the range of reasonable alternatives. One to 37 sites are available for treatment (the Centralized and Decentralized Alternatives, respectively). DOE selected four intermediate alternatives treating LLMW at 4 to 11 sites (the Regionalized Alternatives). To select the variations of the Regionalized Alternative, DOE focused on the sites where the largest volumes of LLMW are located and transportation would be minimized. Alpha and RH LLMW would be sent to the closest facility capable of treating those wastes. For all alternatives, DOE assumed that some treatment would be practical at every site. This practical treatment would include initial treatment of aqueous liquids at the site of generation using techniques such as evaporation, neutralization, precipitation, filtration, coagulation, or limited solidification.

LLMW Regionalized Alternative 1—(Treatment at 11 Sites; Disposal at 12)

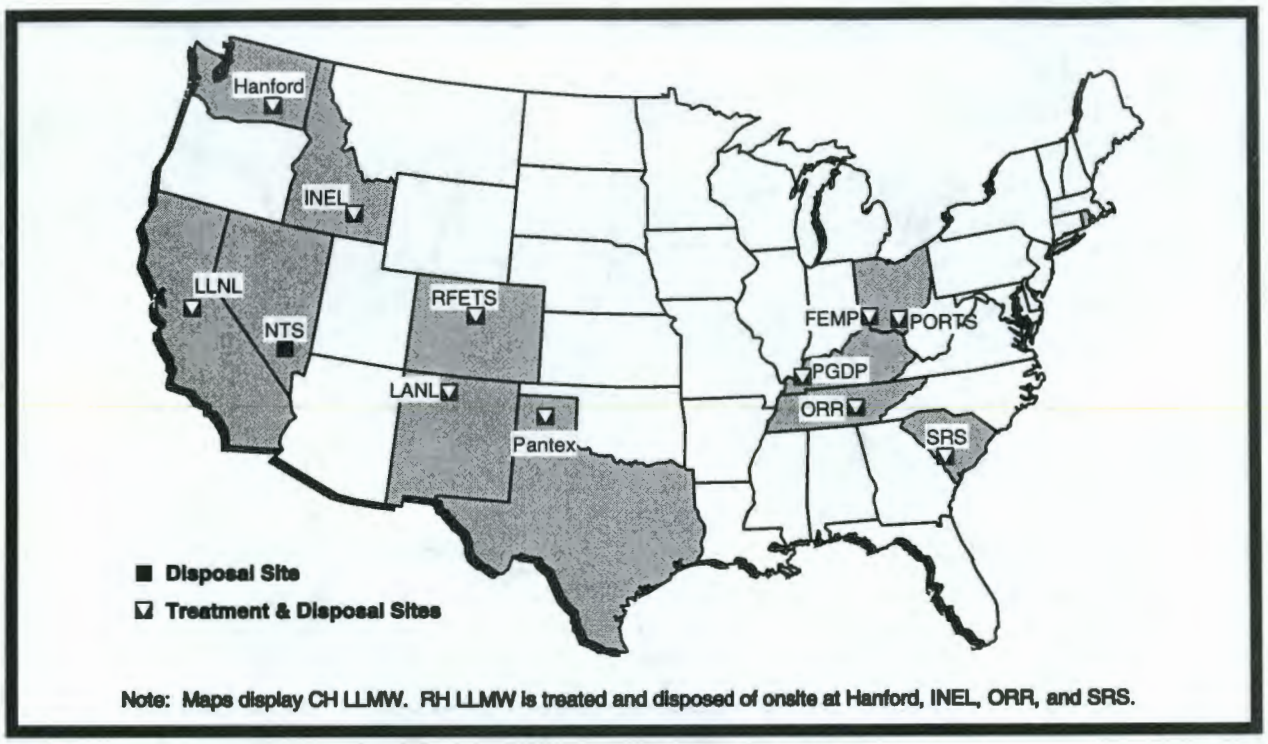


Figure 6.3–3. LLMW Regionalized Alternative 1

	Generating Sites												
	BCL BNL Bettis KAPL Ports Nav PORTS PPPL RMI WVDP	ANL-E Ames Mound	FEMP	Bettis∝ Charleston Mound∝ Norfolk Pinellas SRS SRS∝ UofMO∝ WVDP∝	ETEC GA LBL LEHR LLNL Mare Is	LBL∝ LLNL∝	GJPO RFETS RFETS∝	Hanford Pearl H Puget So	INEL INEL∝ NTS	KCP PGDP UofMO	LANL LANL∝ SNL-NM SNL-NM∝	ORR	Pantex
Treat (% Rec'd From Offsite)	PORTS (14)	FEMP (9)		SRS (1)	LLNL (1)		RFETS (<1)	Hanford (<1)	INEL (10)	PGDP (<1)	LANL (4)	ORR (0)	Pantex (0)
Dispose (% Rec'd From Offsite)	PORTS (46)		FEMP (0)	SRS (1)	LLNL (11)	NTS (100)	RFETS (<1)	Hanford (<1)	INEL (10)	PGDP (<1)	LANL (2)	ORR (0)	Pantex (0)

Notes: ∝ = contact-handled alpha LLMW. Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 6.3–3. LLMW Regionalized Alternative 1

LLMW Regionalized Alternative 2—(Treatment at 7 Sites; Disposal at 6)

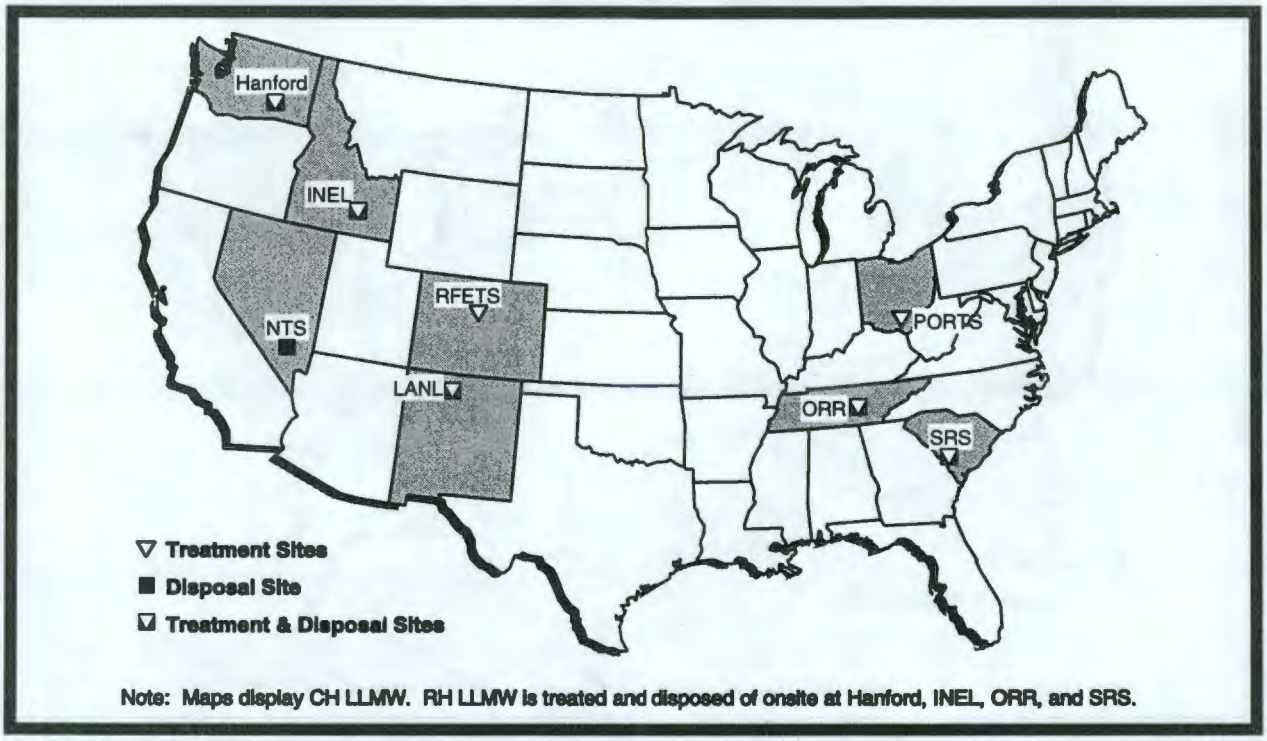


Figure 6.3–4. LLMW Regionalized Alternative 2

	Generating Sites							
	ANL-E Ames BCL BNL Bettis FEMP KAPL Mound Ports Nav PORTS PPPL RMI WVDP	ORR PGDP UofMO	Bettis∝ Charleston Mound∝ Norfolk Pinellas SRS SRS∝ UofMO∝ WVDP∝	ETEC GA INEL INEL∝ LBL∝ LLNL∝ NTS	GJPO KCP RFETS RFETS∝	LANL LANL∝ Pantex SNL-NM SNL-NM∝	Hanford LBL LEHR LLNL Mare Is Pearl H Puget So	
Treat (% Rec'd From Offsite)	PORTS (9)	ORR (1)	SRS (1)	INEL (6)	RFETS (<1)	LANL (22)	Hanford (7)	
Dispose (% Rec'd From Offsite)	ORR (35)		SRS (1)	INEL (9)	LANL (97)		Hanford (7)	NTS[a] (0)

Notes: ∝ = contact-handled alpha LLMW. Percentage of waste a site would receive from offsite is indicated in parentheses.
[a] This site disposes residues obtained from onsite wastewater treatment.

Table 6.3–4. LLMW Regionalized Alternative 2

LLMW Regionalized Alternative 3—(Treatment at 7 Sites; Disposal at 1)

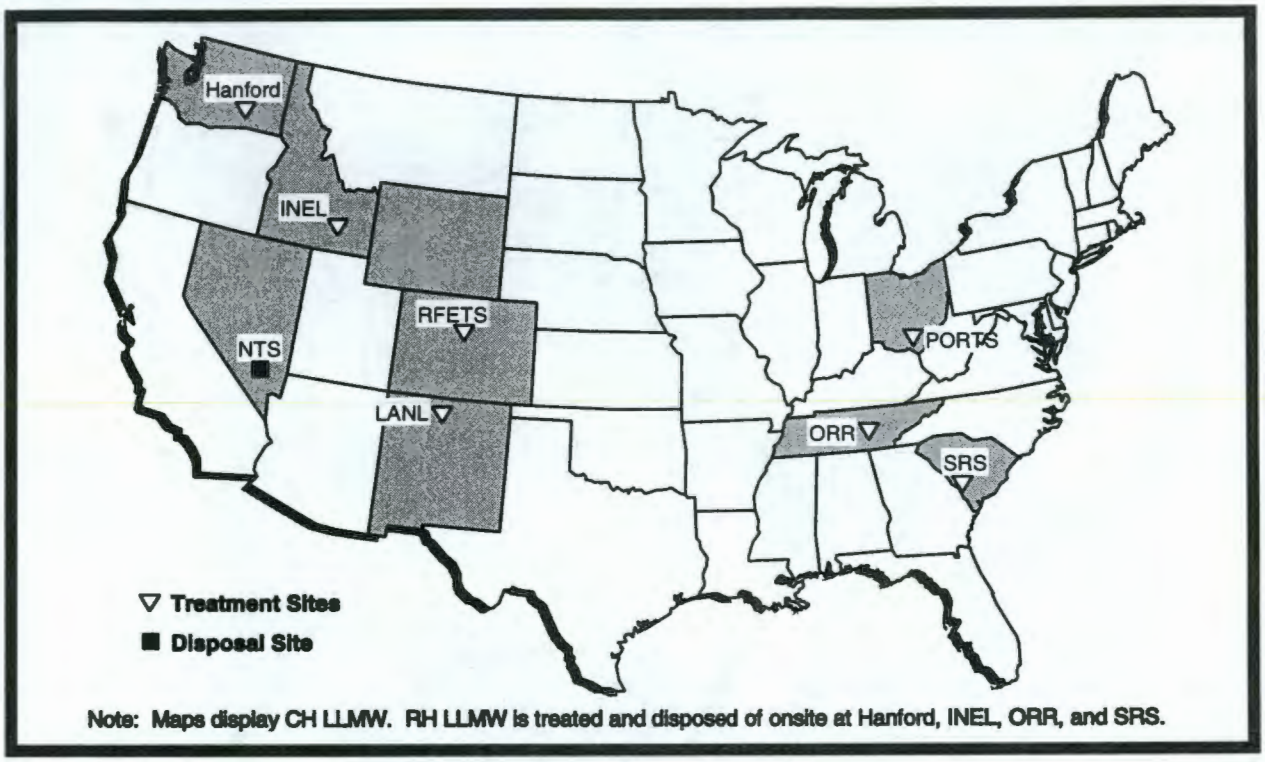


Figure 6.3–5. LLMW Regionalized Alternative 3

	Generating Sites						
	ANL-E Ames BCL BNL Bettis FEMP KAPL Mound Ports Nav PORTS PPPL RMI WVDP	Bettis∝ Charleston Mound∝ Norfolk Pinellas SRS SRS∝ UofMO∝ WVDP∝	ORR PGDP UofMO	ETEC GA INEL INEL∝ LBL∝ LLNL∝ NTS	GJPO KCP RFETS RFETS∝	Hanford LBL LEHR LLNL Mare Is Pearl H Puget So	LANL LANL∝ Pantex SNL-NM SNL-NM∝
Treat (% Rec'd From Offsite)	PORTS (9)	SRS (1)	ORR (1)	INEL (6)	RFETS (<1)	Hanford (7)	LANL (22)
Dispose (% Rec'd From Offsite)	NTS (100)						

Notes: ∝ = contact-handled alpha LLMW. Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 6.3–5. LLMW Regionalized Alternative 3

LLMW Regionalized Alternative 4—(Treatment at 4 Sites; Disposal at 6)

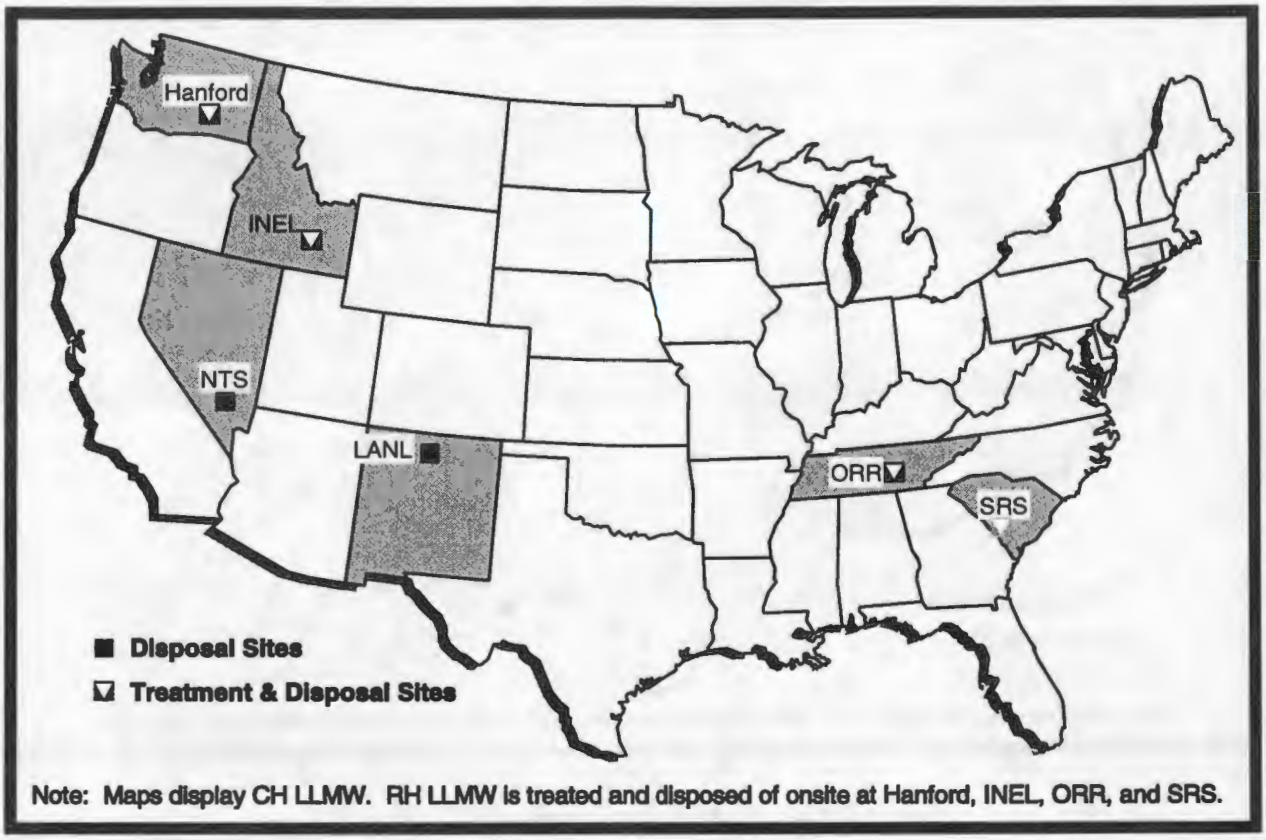


Figure 6.3–6. LLMW Regionalized Alternative 4

	Generating Sites					
		Bettis∝ Charleston Mound∝ Norfolk Pinellas SRS SRS∝ UofMO∝ WVDP∝	ANL-E, Ames, BCL, BNL, Bettis, FEMP, KAPL, KCP, Mound, ORR, PGDP, Ports Nav, PORTS, PPPL, RMI, WVDP, UofMO	ETEC, GA, GJPO, INEL, INEL∝, LANL, LANL∝, LBL∝, LLNL∝, NTS, Pantex, RFETS, RFETS∝, SNL-NM, SNL-NM∝		Hanford, LBL, LEHR, LLNL, Mare Is, Pearl H, Puget So
Treat (% Rec'd From Offsite)		SRS (1)	ORR (38)	INEL (44)		Hanford (7)
Dispose (% Rec'd From Offsite)	NTS[a] (0)	SRS (1)	ORR (38)	INEL (76)	LANL[a] (0)	Hanford (7)

Notes: ∝ = contact-handled alpha LLMW. Percentage of waste a site would receive from offsite is indicated in parentheses.
[a] These sites dispose of residues obtained from onsite wastewater treatment.

Table 6.3–6. LLMW Regionalized Alternative 4

LLMW Centralized Alternative—(Treatment and Disposal at 1 Site)

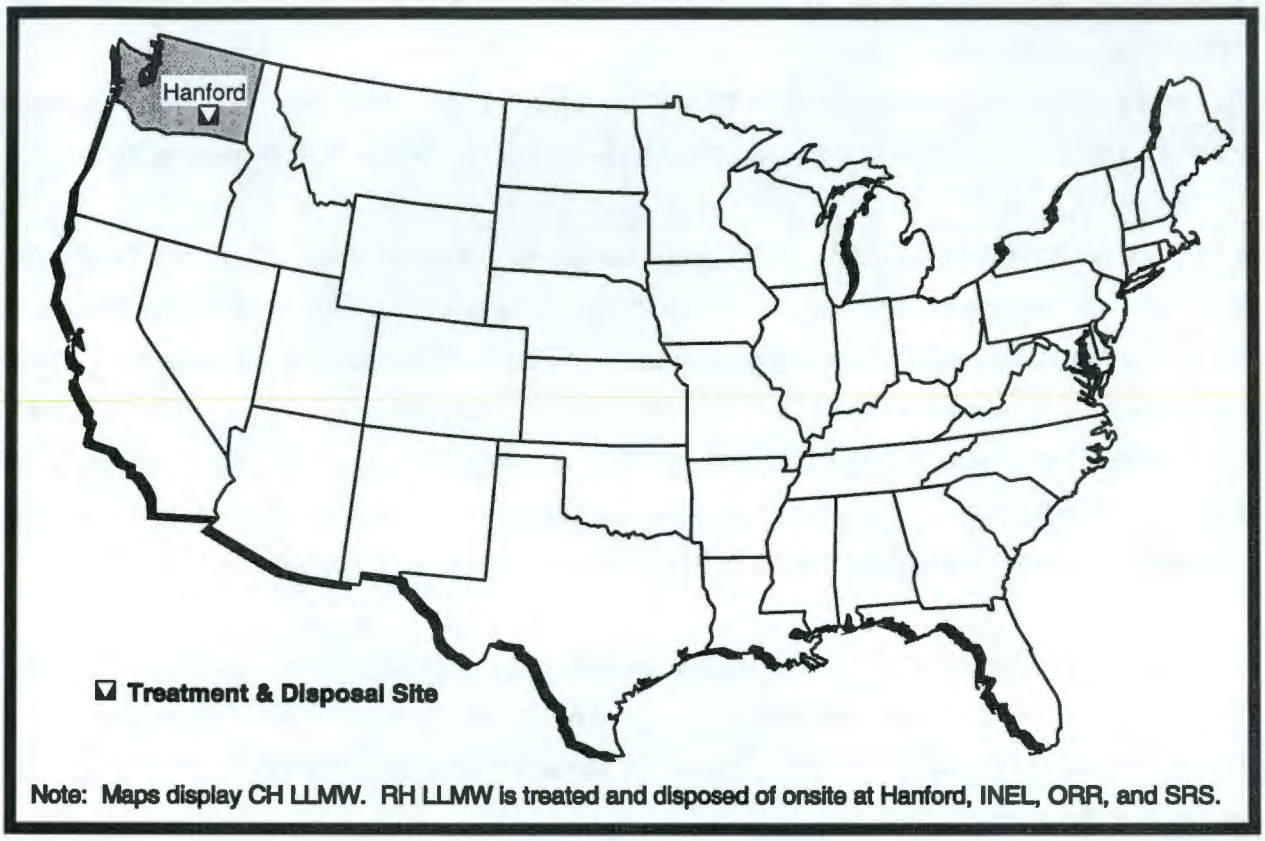


Figure 6.3–7. LLMW Centralized Alternative

	Generating Sites			
	Bettis∝, Charleston, Mound∝, Norfolk, Pinellas, SRS, SRS∝, UofMO∝, WVDP∝	ANL-E, Ames, BCL, BNL, Bettis, FEMP, KAPL, KCP, Mound, ORR, PGDP, Ports Nav, PORTS, PPPL, RMI, WVDP, UofMO	ETEC, GA, GJPO, INEL, LANL, LANL∝, LBL∝, LLNL∝, NTS, Pantex, RFETS, RFETS∝ SNL-NM, SNL-NM∝	Hanford, LBL, LEHR, LLNL, Mare Is, Pearl H, Puget So
Treat (% Rec'd From Offsite)	Hanford (83)			
Dispose (% Rec'd From Offsite)	Hanford (86)			

Notes: ∝ = contact-handled alpha LLMW. Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 6.3–7. LLMW Centralized Alternative

The Regionalized Alternatives consider the impacts of treatment to meet LDRs at selected waste consolidation sites. Regionalized Alternative 1 considers treatment at 11 sites. This alternative was developed by identifying the location of most of the DOE LLMW and looking for logical site groupings. Nine sites have 20-year projected levels of LLMW that exceed 1,000 cubic meters. The next largest site contains approximately half as much waste, and the other small sites follow with decreasing amounts.

In Regionalized Alternatives 2 and 3, seven sites are considered potential treatment locations. DOE chose the six sites with the highest waste volumes, and added LANL because it has a larger volume of transuranic waste (TRUW) that eventually may be reclassified as alpha LLMW due to its radionuclide content. Regionalized Alternative 4 consists of the sites with the three highest volumes (Hanford, INEL, and ORR), as well as SRS, which has the sixth largest volume. SRS was chosen because of its high volumes of alpha LLMW and TRUW, some of which eventually may be reclassified as LLMW. In addition, SRS has under construction an incinerator with an annual LLMW treatment capacity of 8,200 cubic meters.

In the Centralized Alternative, all LLMW would be shipped to the Hanford Site for treatment. The Hanford Site currently has the second largest volume of LLMW. However, as Hanford's HLW is treated, a substantial portion of that waste will be separated and thereafter managed as LLMW, thereby making the Hanford Site the largest LLMW site.

How were disposal sites selected?

Candidate disposal sites were selected to reflect a reasonable range of alternatives. However, unlike the treatment analysis, the disposal analysis did not evaluate every site for disposal. Instead, 16 candidate sites were selected as the reasonable upper bound based on screening performed by DOE for consistency with the FFCAct.

To narrow the number of possible LLMW disposal sites, DOE applied three exclusionary criteria to the 37 sites with LLMW: (1) sites could not be within a designated 100-year floodplain, (2) sites could not be within 200 feet of a seismic fault, and (3) sites were required to have sufficient area for a 100-meter buffer zone between the disposal structure and the site boundary.

Using the three criteria, DOE reduced the number of reasonable sites to 22 locations. Three additional sites (General Atomics, Pinellas Plant, and ETEC) were removed with the concurrence of the States for technical and practical considerations, leaving 19 sites for disposal consideration.

DOE eliminated three other sites based on the following rationales: (1) KAPL is a Navy site and thus was not considered as a DOE disposal site, (2) Mound was not considered because it is relatively small and some of its land is being returned to the State, and (3) Bettis was not considered because of sloping terrain and unstable geologic conditions and because it is a Navy site.

The Decentralized Alternative looked at disposal at the remaining 16 sites and the Centralized Alternative looked at disposal at one site—the Hanford Site. The Hanford Site was analyzed because it is expected to have the largest volume of LLMW. In addition, NTS was analyzed as the only disposal site under Regionalized Alternative 3.

DOE selected two intermediate alternatives, disposing at 12 and 6 sites (under the Regionalized Alternatives). To select these Regionalized Alternatives, DOE focused on the 11 sites with the largest volume of LLMW and added NTS because it has a LLMW disposal facility that has a pending permit application. The next logical consolidation point for LLMW disposal was a 6-site alternative, to be consistent with the six currently operating LLW disposal facilities—the Hanford Site, INEL, LANL, NTS, ORR, and SRS. NTS was considered in Regionalized Alternative 3 to provide a comparison and an alternative to the single disposal location selected under the Centralized Alternative. The Centralized Alternative coupled the selection of a treatment and disposal site at the Hanford Site because of the anticipated onsite large volumes of LLMW.

6.4 Health Risks

The number of worker fatalities is about three times higher than for other receptor groups, driven by physical injury hazards. As the number of sites decrease, facilities become larger and programwide physical injuries decrease, reflecting an economy of scale and fewer workers. The most important influence on offsite population risk is LLNL treatment of tritium in the Decentralized and Regionalized 1 Alternatives. There are no other notable trends for offsite population risks. For disposal, concentrations of radionuclides and chemicals in the groundwater near disposal facilities are estimated to exceed applicable standards at several sites, demonstrating the need for performance-based waste acceptance criteria. More extensive pretreatment of chemicals than assumed for the WM PEIS analysis and careful management of radionuclide concentrations and waste forms would be required to assure acceptable water quality and human health risks. Transportation risks are low in all alternatives, reflecting low vehicle miles.

Health risk impacts can result from exposure to radiation and chemicals and from physical trauma associated with constructing and operating treatment and disposal facilities or transporting waste. Health effects resulting from radiation and chemical exposure, whether from sources external or internal to the body, can affect either the exposed individual (known as "somatic" effects) or descendants of the exposed individual (known as "genetic" effects). This section discusses the estimated adverse health impacts resulting from radiation and chemical exposures as well as from physical hazards for each LLMW treatment and disposal alternative. Details of the LLMW results are contained in Appendices D, E, and F. Methodology details are contained in Chapter 5, Appendix D, and in ORNL technical reports (ORNL, 1995a-c).

Potential health risks to a number of receptor populations and individuals are presented including:

- The offsite population—those individuals living within a 50-mile radius of the site, as well as along transportation routes
- Noninvolved worker population—the workers on DOE sites who are not involved directly in waste management activities
- Waste management worker population (or "waste management workers")—onsite employees in a site's waste management facilities, including workers involved in the waste management process, construction workers who build the waste management facilities, and those operating the trucks and trains that transport the waste
- Maximally exposed individual (MEI) for the offsite population—hypothetical individual in the offsite population who would receive the highest total lifetime multimedia dose
- MEI for the noninvolved worker population—hypothetical individual in the noninvolved worker population who would receive the highest total lifetime multimedia dose
- Farm family most exposed lifetime MEI—hypothetical individual in the most exposed lifetime of the farm family who would receive the highest dose from disposal of LLMW
- Hypothetical intruder—an individual who would experience maximum potential future risks from disposal of LLMW upon the loss of institutional control
- Most exposed waste management worker—an individual who would experience potential

The following sections present the impacts for the LLMW alternatives:

6.4 Health Risks
6.5 Air Quality Impacts
6.6 Water Resources Impacts
6.7 Ecological Resources Impacts
6.8 Economic Impacts
6.9 Population Impacts
6.10 Environmental Justice Concerns
6.11 Land Use Impacts
6.12 Infrastructure Impacts
6.13 Cultural Resources Impacts
6.14 Costs
6.15 Environmental Restoration Analysis
6.16 Comparison of Alternatives Summary

noncancer effects, as estimated using the Exposure Index, following exposure to the hazardous chemical constituents of LLMW

The impacts evaluated were:

- Fatalities from physical hazards
- Cancer fatalities from radiation exposure
- Cancer incidences from radiation or chemical exposure
- Genetic effects from radiation exposure
- Noncancer effects from chemical exposure (e.g., headaches, nasal irritation, liver or kidney toxicity, neurotoxicity, immunotoxicity, and reproductive and developmental toxicity)

Maximally Exposed Individual

In keeping with standard risk assessment methodology, DOE analyzed the impacts to a "maximally exposed individual." The MEI is the hypothetical person within the receptor group who has the highest exposure. This individual is assumed to be located at the point of maximum concentration of contaminants 24 hours a day, 7 days a week, for the 10-year period of treatment operations analyzed in the WM PEIS.

Interpreting the results of health risk analyses involves consideration of both uncertainties and appropriate standards. See Section 5.4.1 and Appendix D for further discussion of these issues.

Understanding Scientific Notation

Scientific notation is used in this WM PEIS to express numbers that are so large or so small that they can be difficult to read or write. Scientific notation is based on the use of positive and negative powers (or exponents) of 10. A number written in scientific notation is expressed as the product of a number between 1 and 10 times a positive or negative power of 10. Some positive and negative powers of 10 include:

Positive Powers of 10	***Negative Powers of 10***
$10^{1} = 10 \times 1 = 10$	$10^{-1} = 1/10 = 0.1$
$10^{2} = 10 \times 10 = 100$	$10^{-2} = 1/100 = 0.01$
and so on; therefore,	*and so on; therefore,*
$10^{6} = 1{,}000{,}000$ *(or 1 million), etc.*	$10^{-6} = 0.000001$ *(or 1 in 1 million), etc.*

A power of 10 is also commonly expressed as "E," where "E" means "× 10." For example, 3×10^{5} *can also be written as 3E+05, and* 3×10^{-5} *is equivalent to 3E–05. Therefore, 3E+05 = 300,000 and 3E–05 = 0.00003.*

The health risk data tables in this section use "E" notation with negative exponents.

Probability is expressed as a number between 0 and 1. The notation 3E–06 can be read 0.000003, which means that there are three chances in 1,000,000 that the associated result (e.g., fatal cancer) will occur in the period covered by the analysis.

6.4.1 ROUTINE OPERATION IMPACTS

6.4.1.1 Treatment

For operations involving LLMW treatment, health effects were evaluated for the offsite population, the onsite worker population not involved in LLMW treatment ("noninvolved workers"), and waste management workers directly involved in treatment activities. Impacts were quantified using two approaches: analysis of *population* health risk impacts and analysis of *individual* health risk impacts. Note that risks from the storage of LLMW are included in the treatment risks for the No Action Alternative, as described in Section 6.3.1.

Population impacts focus on the *total number* of people in each receptor population who would experience adverse health impacts if a particular alternative is implemented.

The sizes of the offsite populations and waste management treatment worker populations used in the health risk analyses are presented in Table 6.4–1. The waste management treatment worker numbers are derived from generic baselines which established the number of personnel required to operate treatment facilities needed to manage a given amount of source term (defined by the respective alternative).

Individual impacts focus on the *probability* that the "maximally exposed individual" (MEI) within each receptor population would experience an adverse health impact. Because the focus is on the MEI, the risk is presented as a probability (e.g., one in one million or 1E–06) of that individual experiencing an adverse health impact, rather than the total number of impacts for a selected population.

DOE analyzed effects of exposure to both radionuclides and chemicals on the receptor groups. The pathways of exposure analyzed were inhalation, ingestion of plants and animals, direct gamma radiation, and absorption of tritium through the skin.

Worker risks associated with physical hazards were evaluated for 20 years: a 10-year period of construction of treatment and disposal facilities, and a subsequent 10-year period of operation. However, worker and public risks from exposure to radionuclides or chemicals (received during the 10-year operation period) were evaluated for an entire lifetime (70 years), because health impacts from airborne contaminants or direct radiation could occur throughout the lifetime of the exposed individual. Table 6.4–2 provides an

Table 6.4–1. Offsite Populations and Waste Management Treatment Worker Populations

Site	Offsite Population*	WM Treatment Worker Population by Alternative[a]						
		NA	D	R-1	R-2	R-3	R-4	C
ANL-E	7,939,785	22	50	23	23	23	23	23
BNL	5,738,554	24	62	16	16	16	16	16
FEMP	2,764,589	165	533	1,233	269	269	269	269
Hanford	377,645	506	2,196	2,065	2,132	2,132	2,268	6,706
INEL	153,061	782	1,588	1,587	2,010	2,010	3,281	278
LANL	159,152	136	590	597	679	679	146	146
LLNL	6,324,234	220	831	915	136	136	136	136
NTS	14,266	330	785	305	305	305	305	305
ORR	881,652	2,434	2,530	2,162	2,177	2,177	3,116	490
PGDP	500,502	55	144	144	48	48	48	48
Pantex	265,185	46	145	145	48	48	48	48
PORTS	639,602	435	1,853	1,353	1,951	1,951	405	405
RFETS	2,171,877	2,407	2,305	2,307	3,506	3,506	1,972	1,972
SNL-NM	610,714	8	20	5	5	5	5	5
SRS	620,618	1,005	1,289	1,290	1,290	1,290	1,291	207
WVDP	1,698,391	9	11	10	10	10	11	11

Notes: NA = No Action, D = Decentralized; R1–R4 = Regionalized; C = Centralized; * = within 50-mile radius of sites.
[a] Waste Management worker population estimates represent full-time equivalents (FTEs) over the entire construction and operation period.

overview of the health risk endpoints, receptor groups, hazard sources, pathways, and exposure periods evaluated for LLMW treatment.

6.4.1.2 Disposal

Health risks resulting from disposal were evaluated for waste management workers handling the treated LLMW, for an onsite "hypothetical farm family" located 300 meters from the center of the disposal facility, and for a hypothetical "intruder" into the disposal facility after the facility has been closed.

Table 6.4–2. LLMW Treatment Health Risk Analysis Components

LLMW Treatment[a]					
Endpoints	**Receptor**	**Source**	**Pathways**	**Exposure Period**	**Table Reference**
Number of trauma fatalities	WM workers	Physical hazards	Physical hazards	20 years	6.4–4
Number of cancer fatalities	Offsite population	Radionuclides	Inhalation, ingestion, direct radiation	10 years	6.4–4
	Noninvolved workers		Inhalation, direct radiation		
	WM workers		Inhalation, direct radiation		
Number of cancer incidences	Offsite population	Radionuclides	Inhalation, ingestion, direct radiation	10 years	6.4–5
		Chemicals	Inhalation, ingestion		
	Noninvolved workers	Radionuclides	Inhalation, direct radiation		
		Chemicals	Inhalation		
	WM workers	Radionuclides	Inhalation, direct radiation		
		Chemicals	Inhalation		
Number of genetic effects	Offsite population	Radionuclides	Inhalation, ingestion, direct radiation	10 years	6.4–5
	Noninvolved workers		Inhalation, direct radiation		
	WM workers		Inhalation, direct radiation		
Probability of cancer fatality	Offsite MEI	Radionuclides	Inhalation, ingestion, direct radiation	10 years	6.4–7 6.4–8
	Noninvolved worker MEI		Inhalation, direct radiation		
Probability of cancer incidence	Offsite MEI	Radionuclides	Inhalation, ingestion, direct radiation	10 years	6.4–9
		Chemicals	Inhalation, ingestion		
	Noninvolved worker MEI	Radionuclides	Inhalation, direct radiation		
		Chemicals	Inhalation		
Probability of genetic effects	Offsite MEI	Radionuclides	Inhalation, ingestion, direct radiation	10 years	6.4–9
	Noninvolved worker MEI		Inhalation, direct radiation		
Noncancer risk	Offsite MEI	Chemicals	Inhalation, ingestion	10 years	6.4–10
	Noninvolved worker MEI		Inhalation		
	WM worker		Inhalation		

[a] Treatment risks under the No Action Alternative include risks from storage of LLMW.

The waste management workers were assumed to be exposed through direct radiation during disposal operations. Risks to the WM workers were estimated for one lifetime.

For the farm family and intruder analyses, DOE assumed that waste was disposed of in either aboveground or belowground disposal units, depending on the site, each with a capacity of 18,000 and 12,000 cubic meters, respectively. Additional units were added as needed to dispose all of the waste on a site. Each disposal unit was assumed to affect a separate farm family and a separate intruder. Thus, the effects on the farm family (and on the intruder) were assumed to come from a single disposal unit, rather than from a combination of all the units at a site.

Hypothetical Farm Family and Intruder

The "hypothetical farm family" is an imaginary family assumed to live 300 meters downgradient of the center of a waste disposal unit. The family engages in farming activities such as growing and consuming their own crops and livestock, and uses groundwater for drinking water and for watering the crops and animals. This is an estimated maximum exposure scenario taking place in the future at a time when institutional controls no longer exist. The scenario is analyzed to determine potential upper-bound exposures by ingestion of contaminated groundwater.

The hypothetical "intruder" is an imaginary adult who drills a well directly through a LLMW disposal unit to the groundwater. As a result of the drilling, soil contaminated with radionuclides and hazardous chemicals from within the unit is brought to the surface, where it mixes with the top layers of the surface soil. The individual farms the land and eats the crops. The intruder scenario occurs after the failure of institutional control. This scenario is consistent with the analysis required for disposal facilities under DOE Order 5820.2A (DOE, 1988).

The exposure pathways for the hypothetical farm family were ingestion of groundwater and ingestion of plants and animals contaminated by irrigation water. The groundwater was assumed to be contaminated by a breach in each disposal unit immediately after shallow land burial, 300 years after disposal in aboveground vaults, or 750 years after disposal in belowground vaults. The contaminants were assumed to leach over time from their solidified waste form to create a plume of contamination. Individual contaminated plumes were then assumed to migrate to the receptor wells without mixing with each other. The risks to the hypothetical farm family were estimated over a 10,000-year period because the maximum exposure would occur in the future when the peak of contaminant concentration passes the well. Results of the farm family analyses are presented as the probability of cancer fatality or cancer incidence for an individual during the 70-year lifetime that presents the greatest exposure of the 143 lifetimes (i.e., 10,000 years) analyzed. The 10,000 year period was selected for the analysis to maintain consistency with the "Guidelines for Radiological Performance Assessment of DOE Low-Level Radioactive Waste Disposal Sites" that existed at the time the WM PEIS analysis was initiated. The guidance for performance assessments has since been changed; current guidance suggests that a 1,000-year time period should be used

in the performance assessments for waste disposal conducted to satisfy the requirements of DOE Order 5820.2A.

The exposure pathways for the hypothetical intruder were inhalation of resuspended contaminated soil, inadvertent ingestion of contaminated soil, ingestion of plants grown in contaminated soil, and direct radiation from contaminated soil. A hypothetical intruder who drills into the disposal facility was assumed to be exposed to contaminated wastes, including radionuclides and hazardous chemicals, that remain at the site. Two hypothetical intrusions were assumed to occur: 100 years and 300 years after closure of the disposal facility. The risks to the hypothetical intruder were estimated for one lifetime (70 years).

Table 6.4–3 provides an overview of the health risk endpoints, receptor groups, hazard sources, pathways, and exposure periods evaluated for LLMW disposal.

The health risk impacts associated with the routine operation of LLMW treatment and disposal facilities are presented in Tables 6.4–4 through 6.4–16 of this section. The tables show the estimates of human health risk for both treatment and disposal of LLMW. Summary tables show programwide results by alternative. The site tables in Volume II present the health risk impacts for the 16 major LLMW sites.

This human health risk analysis includes evaluation of both the potential numbers of fatal cancers as well as the numbers of total cancer incidences induced by exposure to radionuclides and direct radiation. The numbers of nonfatal cancers can be derived from the cancer incidence values by subtracting the estimated number of fatal cancer cases. Note that both the *total cancer incidence* and the *nonfatal cancer incidence* values are overestimated by a factor of about two because the estimates contain a relatively large component of skin cancers. The internal exposure pathways evaluated in this WM PEIS (e.g., inhalation or ingestion of radionuclides) are not likely to induce large numbers of skin cancer cases. However, the International Commission on Radiological Protection (ICRP) dose conversion factor used in this PEIS to estimate total cancer incidence values includes incidences of skin cancer (ICRP, 1990).

6.4.1.3 Estimated Number of Fatalities

Programwide Treatment and Disposal. Table 6.4–4 presents an overview, by alternative, of the total estimated programwide fatalities associated with both treatment and disposal of LLMW. This table presents

Table 6.4–3. LLMW Disposal Health Risk Analysis Components

LLMW Disposal					
Endpoints	**Receptor**	**Source**	**Pathways**	**Exposure Period**	**Table Reference**
Number of trauma fatalities	WM workers	Physical hazards	Physical hazards	20 years	6.4–4
Number of cancer fatalities	WM workers	Radionuclides	Direct radiation	10 years	6.4–4
Number of cancer incidences	WM workers	Radionuclides	Direct radiation	10 years	6.4–6
Number of genetic effects	WM workers	Radionuclides	Direct radiation	10 years	6.4–6
Probability of cancer fatality	Hypothetical farm family most exposed lifetime MEI	Radionuclides	Ingestion	70 years	6.4–11
	Hypothetical intruder		Inhalation, ingestion, direct radiation		6.4–15 6.4–16
Probability of cancer incidence	Hypothetical farm family most exposed lifetime MEI	Chemicals	Ingestion	70 years	6.4–12
	Hypothetical intruder	Radionuclides	Inhalation, ingestion, direct radiation		6.4–15
		Chemicals	Inhalation, ingestion		
Probability of genetic effects	Hypothetical intruder	Radionuclides	Inhalation, ingestion, direct radiation	70 years	6.4–15
Noncancer risk	Hypothetical intruder	Chemicals	Inhalation, ingestion	70 years	6.4–15

Table 6.4–4. LLMW Treatment and Disposal—Estimated Number of Fatalities Programwide

Alternative	Number of Sites		Treatment				Disposal	
			WM Workers		Number of Offsite Population Radiation Cancer Fatalities	Number of Noninvolved Worker Radiation Cancer Fatalities	WM Workers	
	T	D	Number of Radiation Cancer Fatalities	Number of Physical Hazard Fatalities			Number of Radiation Cancer Fatalities	Number of Physical Hazard Fatalities
No Action[a]	3	--	1	2	*	*	--	--
Decentralized	37	16	1	4	*	*	1	*
Regionalized 1	11	12	1	4	*	*	1	*
Regionalized 2	7	6	1	3	*	*	1	*
Regionalized 3	7	1	1	3	*	*	*	*
Regionalized 4	4	6	1	3	*	*	1	*
Centralized	1	1	1	3	*	*	*	*

Notes: T = treatment; D = disposal; -- = action not applicable for the alternative;* = greater than 0 but less than 0.5.
[a] Treatment risks under the No Action Alternative include risks from only the first 20 years of indefinite storage of LLMW; see Section 6.16 for additional information on longer term impacts.

the estimated number of latent cancer fatalities to the offsite population, noninvolved workers, waste management workers, and hypothetical farm family caused by radiological exposure. In addition, the table shows the estimated number of waste management worker deaths resulting from physical hazards during facility construction and operation.

None of the treatment alternatives results in a fatal cancer to the offsite or noninvolved worker populations. For each alternative, there is at least one estimated fatality associated with treatment operations. Most of these fatalities occur within the waste management worker population, and result from physical hazards involved in construction and operation of LLMW treatment facilities. Waste management workers are the only receptor group exposed to these physical hazards, and therefore, have more estimated fatalities than other receptor groups.

Disposal operations show one estimated fatal cancer for waste management workers in all alternatives, except where disposal is consolidated at one site.

For all alternatives, for both treatment and disposal, the estimated number of fatalities in the waste management worker population due to physical hazards exceeds estimated radiologically induced cancer fatalities in the offsite population and noninvolved workers. In general, fatality risk to waste management workers appears to decrease with increased centralization of activities. Fewer fatalities from physical hazards occur because fewer facilities and worker hours are required when waste management activities are consolidated at one or a few sites.

Site-Level. For all treatment and disposal alternatives, one or more fatalities are estimated only at the Hanford Site in the Centralized Alternative within the waste management worker population as a result of physical hazards. Site-level results for all alternatives are presented in Appendix D and Volume II.

6.4.1.4 Estimated Number of Cancer Incidences and Genetic Effects

Programwide Treatment. Table 6.4–5 presents an overview, by alternative, of the total estimated programwide cancer incidences and genetic effects associated with treatment of LLMW. These impacts result from chemical and radiation exposures of the offsite population, noninvolved workers, and waste management workers. In addition, the table includes radiation dose estimates for each receptor group.

The offsite population and waste management workers are the only receptor groups with estimated cancer incidences greater than or equal to one. The estimated number of cancer incidences from radiation exposure generally exceeds those from chemical exposure for the offsite population and waste management workers.

For waste management workers, impacts are similar across the alternatives, with two cancer incidences in each case except for the No Action Alternative, which has three cancer incidences. For the offsite population, three alternatives (No Action, Decentralized, and Regionalized 1) result in at least one cancer incidence. As the table indicates, consolidating treatment lowers the number of cancer incidences in the offsite population. This is because fewer treatment sites result in potential offsite exposure to fewer people.

Site-Level Treatment. Only one site (the Hanford Site) is estimated to exceed one cancer incidence as a result of treatment activities. The exceedance occurs in the Centralized Alternative within the waste management worker receptor group from radiation exposure. Genetic effects incidence is not estimated to

Table 6.4–5. LLMW Treatment—Estimated Number of Cancer Incidences and Genetic Effects Programwide

Alternative	Number of Sites		Offsite Population				Noninvolved Workers				WM Workers			
			Radionuclide			Chemical	Radionuclide			Chemical	Radiation			Chemical
	T	D	Dose (person-rem)	Number of Cancer Incidences	Number of Genetic Effects	Number of Cancer Incidences	Dose (person-rem)	Number of Cancer Incidences	Number of Genetic Effects	Number of Cancer Incidences	Dose (person-rem)	Number of Cancer Incidences	Number of Genetic Effects	Number of Cancer Incidences
No Action[a]	3	--	570	1	*	*	25	*	*	*	2,100	3	*	*
Decentralized	37	16	340	1	*	*	5	*	*	*	1,300	2	*	*
Regionalized 1	11	12	330	1	*	*	5	*	*	*	1,400	2	*	*
Regionalized 2	7	6	40	*	*	*	1	*	*	*	1,400	2	*	*
Regionalized 3	7	1	40	*	*	*	1	*	*	*	1,400	2	*	*
Regionalized 4	4	6	30	*	*	*	1	*	*	*	1,600	2	*	*
Centralized	1	1	50	*	*	*	1	*	*	*	1,600	2	*	*

Notes: T = treatment; D = disposal; * = greater than 0 but less than 0.5.
[a]Treatment risks under the No Action Alternative include risks from only the first 20 years of indefinite storage of LLMW; see Section 6.16 for additional information on longer term impacts.

exceed one for any site under any alternative. Site-level results for all alternatives are presented in Appendix D and Volume II.

Programwide Disposal. Table 6.4–6 presents an overview, by alternative, of the total estimated programwide cancer incidences and genetic effects associated with disposal of LLMW. These impacts result from exposure of waste management workers to direct radiation. Radiation dose estimates are also included in the table.

Each of the alternatives results in cancer incidences within the waste management worker receptor group. The alternatives involving only one disposal site (Regionalized 3 and Centralized) result in one cancer incidence each; all other alternatives each result in two. Thus, waste consolidation at one disposal site decreases the estimated number of cancers for waste management workers.

As shown in Table 6.4–6, less than one incidence of genetic effects resulting from radiation exposure is estimated to occur among the population of waste management workers under each alternative.

Table 6.4–6. LLMW Disposal—Estimated Number of Cancer Incidences and Genetic Effects Programwide

Alternative	Number of Sites		WM Workers		
	T	D	Radiation Dose (person-rem)	Number of Radiation Cancer Incidences	Number of Radiation Genetic Effects
No Action	3	--	--	--	--
Decentralized	37	16	1,400	2	*
Regionalized 1	11	12	1,400	2	*
Regionalized 2	7	6	1,300	2	*
Regionalized 3	7	1	1,000	1	*
Regionalized 4	4	6	1,600	2	*
Centralized	1	1	900	1	*

Notes: T = treatment; D = disposal; -- = action not applicable for the alternative; * = greater than 0 but less than 0.5.

Site-Level Disposal. Three sites (the Hanford Site, INEL, NTS) pose a risk of cancer incidence greater than one to waste management workers as a result of direct radiation exposure. NTS poses risk greater than one to waste management workers under Regionalized Alternative 3, INEL under Regionalized Alternative 4, and the Hanford Site under the Centralized Alternative.

6.4.1.5 Probability of MEI Cancer Fatalities

Table 6.4–7 summarizes, by alternative, the highest estimated *probability* at any site of fatal cancer from exposure to radiation associated with each LLMW alternative. This table presents the probability of cancer fatality to the MEI within the offsite and noninvolved worker populations. The numbers in this table are the estimated *probabilities* that the MEI will die of latent cancer from radiation exposure. The probability of a cancer fatality for the MEI was calculated at each site, and the highest value at a single site under each alternative is presented in Table 6.4–7. The MEI risk is not a combined total of risks across all of the sites.

Three treatment alternatives (No Action, Decentralized, and Regionalized 1) have estimated probabilities of fatal cancer for the offsite MEI that are approximately one order of magnitude higher than the values for the other alternatives.

Table 6.4–7. LLMW Treatment—Greatest Probability of Cancer Fatality at Any LLMW Site

Alternative	Number of Sites		Offsite MEI Cancer Fatality Probability	Noninvolved Worker MEI Cancer Fatality Probability
	T	D		
No Action	3	NA	3E–06	9E–06
Decentralized	37	16	3E–06	7E–07
Regionalized 1	11	12	3E–06	7E–07
Regionalized 2	7	6	3E–07	3E–07
Regionalized 3	7	1	3E–07	3E–07
Regionalized 4	4	6	3E–07	3E–07
Centralized	1	1	5E–07	6E–07

Notes: T = treatment; D = disposal; NA = not applicable. Treatment risks under the No Action Alternative include risks from only the first 20 years of indefinite storage of LLMW; see Section 6.16 for additional information on longer term impacts. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.

Table 6.4–8 presents the probability of a fatal cancer from radiological exposure for the offsite MEI for all sites by treatment alternative. The data in Table 6.4–8 are graphically presented in Figure 6.4–1. LLNL, under the Decentralized and Regionalized 1 Alternatives, is the site with the highest estimated cancer fatality probability. This risk is due to exposure to tritium that would be released during treatment operations if LLNL were used as a treatment site. It should be noted that the estimated releases of radionuclides that produce the cancer fatality probability estimates presented in Table 6.4–8 are based on the conceptual thermal treatment of LLMW. Emissions of particulate radionuclides from thermal treatment generally are limited by the use of effective engineering controls (e.g., HEPA filtration). However, tritium in the waste forms water vapor upon thermal treatment and readily escapes in the airborne emissions from the process. The largest estimated releases of radionuclides from the treatment of LLMW result from the thermal treatment of waste containing tritium. These estimated releases, and the resulting potential health risks, illustrate the need to carefully analyze and document risks associated with the use of thermal treatment of substantial quantities of tritium. DOE is exploring alternative technologies for treating LLMW for use when potential health risks from thermal treatment are determined to be unacceptable.

The release of tritium to the air based on updated waste loads would be projected to increase at LLNL. The resulting offsite MEI cancer fatality probability and other risks (e.g., MEI cancer incidence probability), driven by the release of tritium to the air at LLNL, could increase. This increase in tritium releases could also occur at Hanford in Regionalized and Centralized Alternatives, with similar increases in risk when the LLMW at LLNL is shipped to Hanford for treatment. As discussed in the preceding paragraph, mitigation measures would be employed, such as alternative technologies, to maintain safe emission levels (see Appendix I).

6.4.1.6 Probability of MEI Cancer Incidences and Genetic Effects

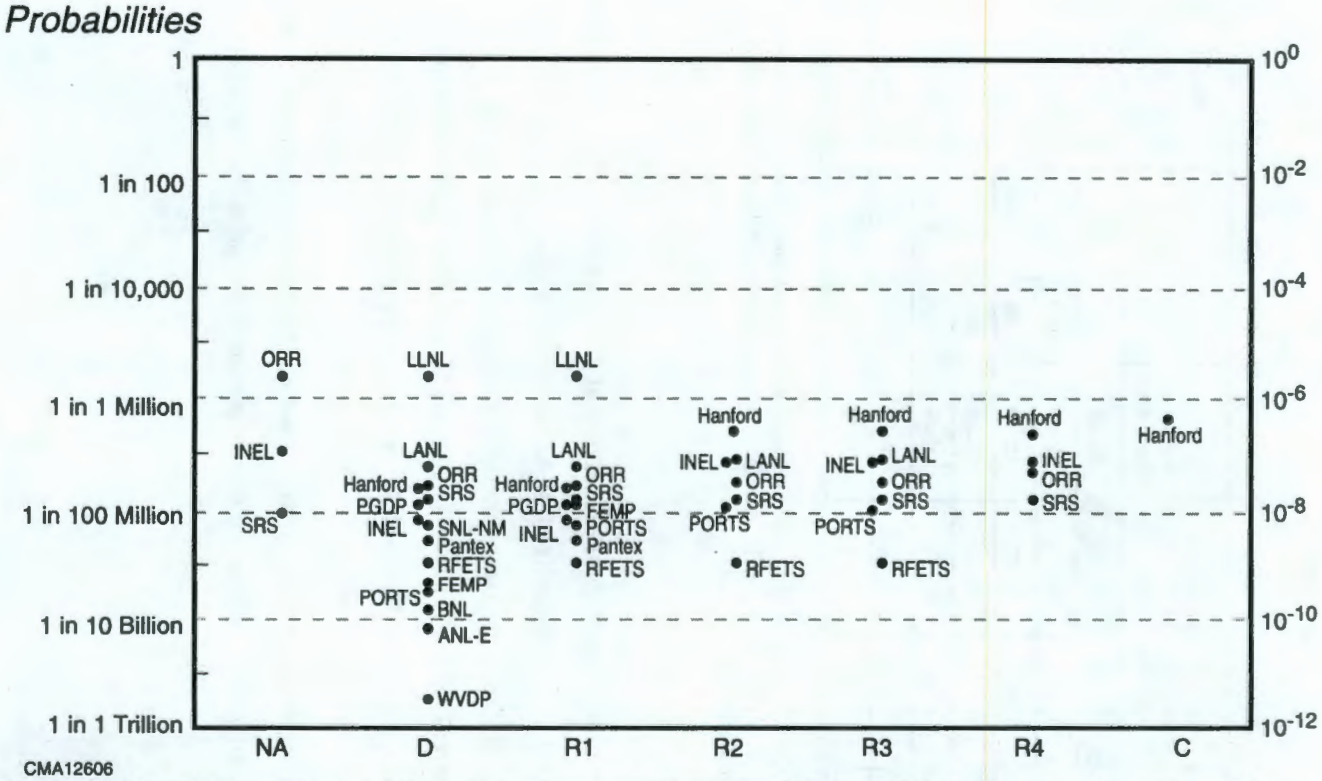
Table 6.4–9 summarizes, by alternative, the highest estimated *probability* at any site of cancer incidences and genetic effects resulting from chemical and radionuclide exposure. The table presents these estimated risks for the MEI of the offsite and the noninvolved worker populations.

The highest radiation cancer incidence probability for the offsite MEI, under each treatment alternative, is greater than the highest chemical cancer incidence probability. The same trend can be seen in the cancer incidence probabilities for the noninvolved worker MEI.

Table 6.4–8. LLMW Treatment—Offsite MEI Cancer Fatality Probabilities

Alternative	Number of Sites		ANL-E	BNL	FEMP	Hanford	INEL	LANL	LLNL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP
	T	D																
No Action	3	NA	—	—	—	—	7E-08	—	—	—	3E-06	—	—	8E-09	—	—	1E-08	—
Decentralized	37	16	9E-11	2E-10	5E-10	3E-08	7E-09	6E-08	3E-06	2E-10	3E-08	1E-08	3E-09	3E-10	1E-09	5E-09	2E-08	4E-12
Regionalized 1	11	12	—	—	1E-08	3E-08	7E-09	6E-08	3E-06	—	3E-08	1E-08	3E-09	6E-09	1E-09	—	2E-08	—
Regionalized 2	7	6	—	—	—	3E-07	8E-08	9E-08	—	—	4E-08	—	—	1E-08	1E-09	—	2E-08	—
Regionalized 3	7	1	—	—	—	3E-07	8E-08	9E-08	—	—	4E-08	—	—	1E-08	1E-09	—	2E-08	—
Regionalized 4	4	6	—	—	—	3E-07	8E-08	—	—	—	5E-08	—	—	—	—	—	2E-08	—
Centralized	1	1	—	—	—	5E-07	—	—	—	—	—	—	—	—	—	—	—	—

Notes: T = treatment; D = disposal; NA = not applicable; -- = action not applicable for the alternative. Treatment risks under the No Action Alternative include risks from only the first 20 years of indefinite storage of LLMW; see Section 6.16 for additional information on longer term impacts. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.



	NA	D	R1	R2	R3	R4	C
Treat at	3 sites	37 sites*	11 sites	7 sites	7 sites	4 sites	1 site
Dispose at		16 sites	12 sites	6 sites	1 site	6 sites	1 site

*15 major sites are shown

Note: Chart in logarithmic scale

Figure 6.4–1. LLMW Treatment—Probability of Cancer Fatality to Offsite MEI

Table 6.4–9. LLMW Treatment—Greatest Probability of Cancer Incidences and Genetic Effects at Any LLMW Site

Alternative	Number of Sites		Offsite MEI				Noninvolved Worker MEI			
			Radionuclide			Chemical	Radionuclide			Chemical
	T	D	Dose (rem)	Cancer Incidence Probability	Genetic Effects Probability	Cancer Incidence Probability	Dose (rem)	Cancer Incidence Probability	Genetic Effects Probability	Cancer Incidence Probability
No Action	3	NA	0.007	1E–05	7E–07	2E–08	0.02	3E–05	2E–06	3E–07
Decentralized	37	16	0.005	9E–06	5E–07	1E–09	0.002	3E–06	2E–07	7E–09
Regionalized 1	11	12	0.005	9E–06	5E–07	1E–09	0.002	3E–06	2E–07	6E–09
Regionalized 2	7	6	0.0005	9E–07	5E–08	1E–09	0.0006	1E–06	6E–08	6E–09
Regionalized 3	7	1	0.0005	9E–07	5E–08	1E–09	0.0006	1E–06	6E–08	6E–09
Regionalized 4	4	6	0.0005	9E–07	6E–08	2E–09	0.0006	1E–06	6E–08	9E–09
Centralized	1	1	0.001	2E–06	1E–07	4E–10	0.001	2E–06	1E–07	1E–08

Notes: T = treatment; D = disposal; NA = not applicable. Treatment risks under the No Action Alternative include risks from only the first 20 years of indefinite storage of LLMW; see Section 6.16 for additional information on longer term impacts. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.

Offsite MEI radiation cancer incidence probability is highest at ORR under the No Action Alternative, at LLNL under the Decentralized and Regionalized 1 Alternatives, and at the Hanford Site under the Centralized Alternative. Uranium-238 is the radionuclide that accounts for most of the risk at ORR under the No Action Alternative, whereas tritium is the controlling radionuclide at LLNL under the Decentralized and Regionalized 1 Alternatives and at the Hanford Site under the Centralized Alternative.

Radiation cancer incidence probability for the noninvolved worker MEI followed a similar pattern. Genetic effects incidence probability is highest at ORR under the No Action Alternative for the offsite MEI and the noninvolved worker MEI.

6.4.1.7 MEI Noncancer Risks

The "Hazard Index" is an EPA standard indicator of potential noncancer chemical health risk. It is derived by comparing the estimated exposure concentrations of noncarcinogenic chemicals to concentrations presumed to not produce adverse human health effects over an entire lifetime, assuming continuous low-level exposure. If the Hazard Index exceeds one, the potential exists for adverse health effects. In this PEIS,

the Hazard Index was estimated for the offsite MEI, the noninvolved worker MEI and the hypothetical farm family most exposed lifetime MEI (Section 6.4.1.8).

For waste management workers, an "Exposure Index" rather than a Hazard Index was estimated. The Exposure Index is derived by comparing the estimated exposure concentrations to appropriate occupational exposure limits. The Exposure Index was considered to be a better measure for waste management workers because the Hazard Index uses standards designed to protect the health of the general population, including sensitive subgroups, such as children. Workers are generally assumed to be healthier than the general population, and worker populations do not contain sensitive subgroups. Therefore, the concentrations of noncarcinogenic chemicals presumed to be protective of human health are different for these two groups of receptors. If the Exposure Index exceeds one, the estimated concentrations exceed the concentrations presumed to be without adverse health effects.

Programwide. Table 6.4–10 summarizes, by alternative, the programwide noncancer health risks resulting from chemical exposures associated with each LLMW alternative. This table presents the greatest noncancer health risks (presented as "Hazard Index") to the MEI within the offsite and noninvolved worker receptor groups, and to an individual waste management worker (presented as "Exposure Index") across the treatment sites.

Table 6.4–10. LLMW Treatment—Greatest Noncancer Health Risks From Chemical Exposure at Any LLMW Site

Alternative	Number of Sites		Offsite MEI Hazard Index	Noninvolved Worker MEI Hazard Index	WM Worker Exposure Index
	T	D			
No Action	3	NA	*	*	*
Decentralized	37	16	*	*	*
Regionalized 1	11	12	*	*	*
Regionalized 2	7	6	*	*	*
Regionalized 3	7	1	*	*	*
Regionalized 4	4	6	*	*	*
Centralized	1	1	*	*	*

Notes: T = treatment; D = disposal; NA = not applicable; * = greater than 0 but less than 1. Treatment risks under the No Action Alternative include risks from only the first 20 years of indefinite storage of LLMW; see Section 6.16 for additional information on longer term impacts.

No Hazard or Exposure Index values equal or exceed one as a result of treatment operations; therefore, noncancer toxicity is not expected to be of concern for these receptors.

6.4.1.8 Hypothetical Farm Family Risks

In addition to the worker disposal risks already presented, disposal risks were evaluated for hypothetical receptors, a farm family and an intruder, as defined in Section 6.4.1. Risks to both the hypothetical farm family and the hypothetical intruder (Section 6.4.1.10) were analyzed in keeping with the requirements of DOE Order 5820.2A, "Radioactive Waste Management" (DOE, 1988). This order requires that site-specific performance assessments be conducted in order to demonstrate that a given disposal practice is in compliance with the set of performance objectives quantified in the DOE Order. These objectives specify concentrations and dose limits that are intended to be protective of the general public, an inadvertent intruder, and groundwater resources. Releases from the disposal facility occur as the result of natural causes (e.g., through leaching upon breakdown of the facility) and by inadvertent human intrusion.

The farm family scenario addresses potential contamination of groundwater resources as well as the potential health effect consequences of exposure of the general public to radionuclides and chemicals released from the disposal facility. The radionuclides and chemicals are assumed to leach from the disposal site through the unsaturated zone to contaminate groundwater that is used by a future farm family as a source of drinking water and irrigation water. See Section 5.4.1 for a further discussion of the presentation of farm family risk results.

Although the disposal facility risk analyses conducted in this WM PEIS use scenarios that are similar to those used in the performance assessment process, it is important to note that the objectives of the two types of analyses are different. The WM PEIS hypothetical farm family and intruder scenario analyses assume the use of generic disposal facilities and generic waste forms (e.g., grout or polymers), and that the entire inventory of waste will be disposed (i.e., no exclusion of particular radionuclides or chemicals). These assumptions lead to overestimates of contaminant concentrations in groundwater. The objective of the WM PEIS analyses is to provide a relative comparison of potential risk among LLMW management alternatives. The outputs of the analyses are risk estimates for the hypothetical farm family and intruder.

In contrast, the performance assessment analysis process involves the use of more detailed site-specific data in the design of a disposal facility at a particular location on a site. The objective of the analysis is to design

a facility that will satisfy the performance objectives specified in DOE Order 5820.2A. These performance objectives include, in practice, (1) modifying the engineering design of the disposal facility (e.g., addition of a clay liner to increase adsorption or a concrete cap to reduce infiltration); (2) modifying the form of the waste to be disposed (such as changing to a vitrified waste form); (3) changing the specific location of the waste disposal facility so that it is sited over an area with more favorable hydrologic conditions; and (4) imposing waste acceptance criteria (i.e., restricting the amounts of radionuclides allowed in a given waste disposal facility). The output of the analysis is a set of waste disposal facility design criteria.

As a result of these differences, the WM PEIS analyses produce estimates of groundwater contamination and farm family risk that are higher than those that would be expected upon actual implementation of the LLMW disposal alternatives. For example, the generic WM PEIS analysis estimates that radionuclide groundwater contamination will exceed existing drinking water quality protection standards at certain sites (see Section 6.6.2). However, the drinking water resource protection performance objective contained in DOE Order 5820.2A would require that the waste disposal facility designs developed by the performance assessment analyses subsequently conducted at those sites ensure that drinking water standards would not be exceeded upon disposal of LLMW. Consequently, the hypothetical farm family risk estimates presented in this section have been adjusted to reflect groundwater contamination that does not exceed existing standards. That is, radionuclides whose estimated groundwater concentrations exceeded drinking water standards were adjusted to concentrations that represent 100% of drinking water standards. This assumes that mitigation has taken place and the appropriate groundwater standards will be met. If the standards cannot be met, the facility would fail the performance assessment analysis, and such a facility would not be built. The unadjusted risk estimates from the WM PEIS analysis are presented in the Volume II site tables and in Appendix D.

In addition, the concentrations of hazardous chemicals estimated to be released to groundwater from LLMW disposal facilities have been overestimated in the WM PEIS analyses as a result of assumptions used concerning the routing of wastes through LLMW treatment systems. Conventional technology assumed for pretreatment allowed some wastes containing solvents to bypass the thermal treatment processes used, as shown in the LLMW flow diagram (Figure 6.2–1). Some of the solvents contained in the wastes that would be destroyed by treatment instead remained in the disposed waste in concentrations that were estimated to produce groundwater contamination in excess of standards. In practice, more intensive pretreatment of LLMW would ensure that EPA land disposal restrictions (LDRs) were satisfied. Therefore, LLMW disposal should not produce major impacts to groundwater quality and subsequently to human health. In a manner

similar to radionuclides, the WM PEIS analysis estimates of hazardous chemical concentrations were adjusted to levels that did not exceed existing water quality standards.

The results of the hypothetical farm family analyses are presented in Table 6.4–11 for the MEI of the most exposed lifetime.

MEI cancer fatality probability estimates for each site that disposes under the various alternatives are presented in Table 6.4–11. The results of the WM PEIS analysis indicate that disposal of uranium-238 (U-238) must be carefully controlled at FEMP (under the Decentralized and Regionalized 1 Alternatives), the Hanford Site (under the Decentralized, Regionalized 1, 2, and 4, and Centralized Alternatives), and SRS (under the Decentralized and Regionalized 1, 2, and 4 Alternatives). Such controls are likely to result in additional costs and potentially to increased impacts in other resource areas. If the amount or form of U-238 is not controlled as previously described, the groundwater concentrations of the radionuclide at these sites are estimated to exceed drinking water standards. These elevated groundwater concentrations would produce cancer fatality probability estimates that are about four (at FEMP) to 10 (at the Hanford Site and SRS) times higher than those presented in Table 6.4–11 (see Volume II site tables and Appendix D). In a similar manner, the disposal of plutonium-240 (Pu-240) at SNL-NM would require careful control. The estimated times of maximum future radionuclide exposure at these sites are as follows:

- FEMP—U-238 at 4,010 years
- The Hanford Site—U-238 at 1,260 years
- SNL-NM—Pu-240 at 6,440 years
- SRS—U-238 at 11,460 years

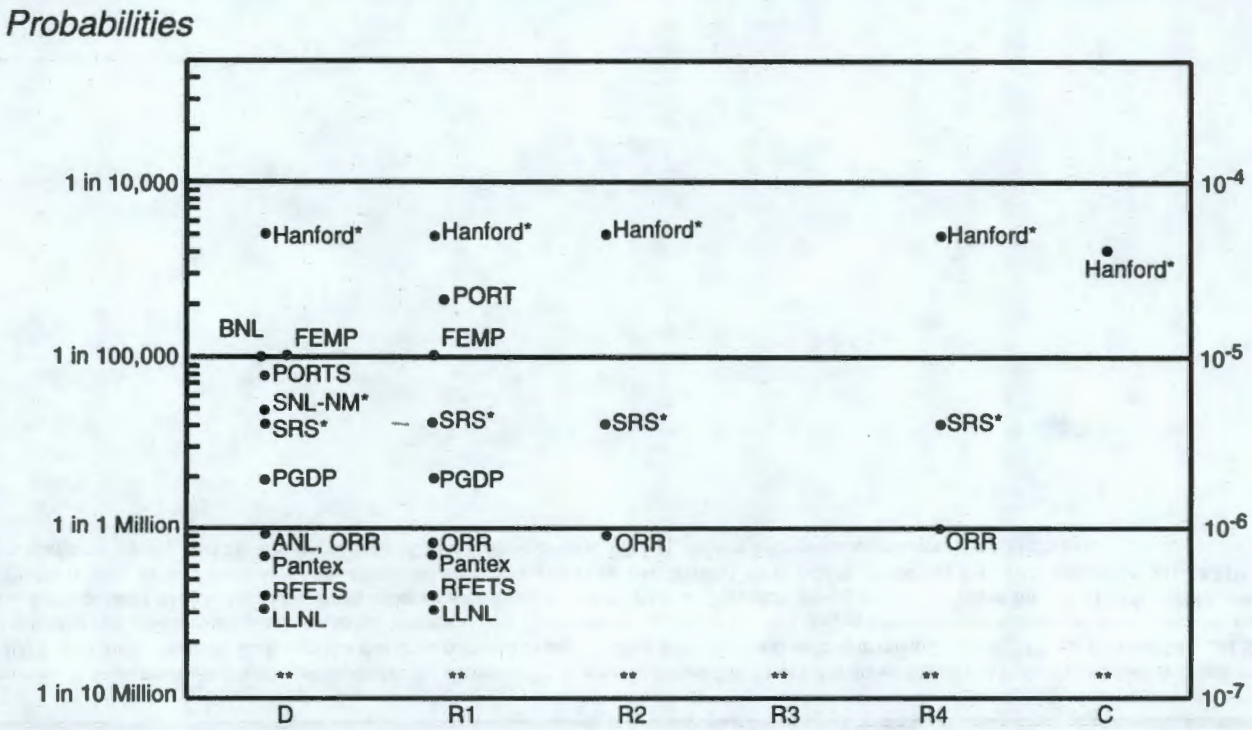
More recent estimates for the release of radionuclides to the groundwater based on updated waste loads project increases in the expected groundwater exceedances for particular radionuclides at these sites: FEMP (U-238), Hanford (U-238), SRS (U-238), and SNL-NM (Pu-240). Other risks associated with the release to the groundwater of these particular radionuclides at these sites could also be expected to increase for unconstrained disposal. Careful management would continue to be a requirement for these radionuclides at these sites (see Appendix I).

The results of this analysis, graphically presented in Figure 6.4–2, also indicate that, on the basis of estimated MEI cancer fatality probability, disposal of LLMW at ANL-E, BNL, INEL, LANL, LLNL, NTS, ORR, PGDP, the Pantex Plant, Portsmouth, and RFETS could be accomplished for

Table 6.4–11. LLMW Disposal: Hypothetical Farm Family Most Exposed Lifetime MEI Cancer Fatality Probabilities

Alternative	Number of Sites		ANL	BNL	FEMP	Hanford	INEL	LANL	LLNL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP
	T	D																
No Action	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Decentralized	37	16	9E–07	1E–05	1E–05*	5E–05*	~0	~0	3E–07	~0	9E–07	2E–06	7E–07	8E–06	4E–07	5E–06*	4E–06*	--
Regionalized 1	11	12	--	--	1E–05*	5E–05*	~0	~0	3E–07	~0	8E–07	2E–06	7E–07	2E–05	4E–07	--	4E–06*	--
Regionalized 2	7	6	--	--	--	5E–05*	~0	~0	--	--	9E–07	--	--	--	--	--	4E–06*	--
Regionalized 3	7	1	--	--	--	--	--	--	--	~0	--	--	--	--	--	--	--	--
Regionalized 4	4	6	--	--	--	5E–05*	~0	~0	--	--	1E–06	--	--	--	--	--	4E–06*	--
Centralized	1	1	--	--	--	4E–05*	--	--	--	--	--	--	--	--	--	--	--	--

Notes: T = treatment; D = disposal; -- = action not applicable for alternative; * = adjusted values. They represent the estimated risks when groundwater concentrations of radionuclides are adjusted to 100% of existing standards. Radionuclides that drive risks and exceed drinking water standards include uranium-238 at FEMP, the Hanford Site, and SRS, and plutonium-240 at SNL-NM. Unadjusted risk estimates are presented in the Volume II Site Tables and in Appendix D. At ORR, groundwater concentrations of radionuclides must be adjusted to meet existing standards for disposal of RH LLMW. This occurs under all alternatives except No Action. The cancer fatality probability values for RH-LLMW at ORR are 2E–06 for all disposal alternatives except No Action. These are adjusted values based on plutonium-239 as the risk driver. Cancer fatality probability values for disposal of RH-LLMW at INEL, the Hanford Site and SRS are near zero, 6E–08, and 5E–07, respectively. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.



Treat at	37 sites	11 sites	7 sites	7 sites	4 sites	1 site
Dispose at	16 sites	12 sites	6 sites	1 site	6 sites	1 site

Note: Chart in logarithmic scale

* Adjusted values = see text discussion.

** Waste disposed at INEL, LANL, and/or NTS did not produce a probability of cancer fatality.

At INEL, Hanford, ORR and SRS, the cancer fatality probability values for disposal of RH-LLMW are near zero, 6E-08, 2E-06, and 5E-07, respectively. The value for ORR was adjusted.

ANL-E values are higher than expected.

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Figure 6.4–2. LLMW Disposal—Probability of Cancer Fatality for Hypothetical Farm Family Most Exposed Lifetime MEI

WM PEIS-assumed wastes without additional radionuclide constraints. Of these sites, INEL, LANL, and NTS had the lowest (near zero) estimated cancer fatality probabilities.

Table 6.4–12 presents site-specific estimates of the most exposed lifetime MEI chemical cancer incidence probability. The data in Table 6.4–12 are graphically presented in Figure 6.4–3. The data indicate that, on the basis of chemical cancer incidence probability, 1,2-dichloroethane disposal would need to be controlled at ORR, Portsmouth, and the Hanford Site (under the Centralized Alternative), and that carbon tetrachloride disposal would need to be controlled at RFETS and SRS. The risk estimates presented for these sites in Table 6.4–12 have been adjusted to 100% of drinking water standards for these contaminants. The unadjusted risk estimates are presented in the Volume II site data tables. As previously described, these unadjusted values overestimate potential chemical cancer incidence probability because the pretreatment process stream used in this PEIS allows some solvents to remain in the buried waste, which would not occur upon compliance with EPA LDR requirements.

Noncancer adverse health risks from exposure to chemical contaminants in groundwater were also evaluated. They are of concern under the Decentralized and Regionalized Alternatives. Under Regionalized Alternatives 2 and 4, noncancer health risks are estimated to occur at ORR as a result of exposure to acetone. The acetone groundwater concentrations, like those of the other solvents, could be reduced to acceptable levels by providing more intensive treatment. Therefore, the noncancer risks at ORR under these alternatives could be mitigated. Under the Decentralized and Regionalized 1 Alternatives, noncancer risks occur at Portsmouth as a result of exposure to arsenic. Adjusting chemical contaminant concentrations to comply with drinking water quality standards is necessary to ensure that noncancer risks are not a concern at the Hanford Site (under all alternatives), RFETS (under Decentralized and Regionalized 1 Alternatives), and SRS (under Decentralized and Regionalized 1, 2, and 4 Alternatives). The chemicals that are estimated to drive the noncancer risks at these sites if groundwater concentrations are not adjusted include silver (at the Hanford Site) and carbon tetrachloride (at RFETS and SRS).

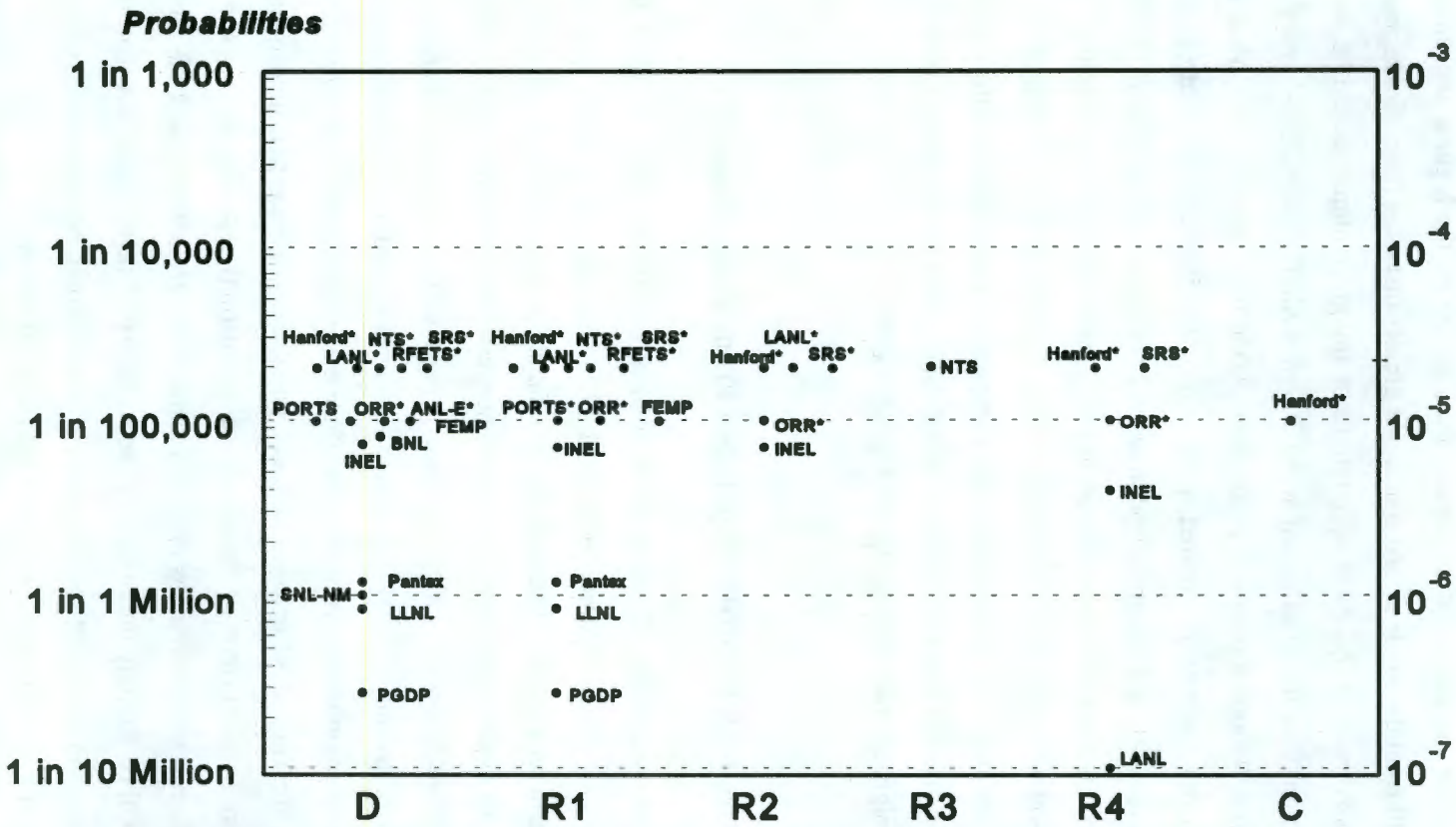
The hypothetical farm family risks represent individual receptors assumed to be exposed through location of a drinking water well at 300 m from the center of a single disposal unit. Concentrations of groundwater contaminants at this location are assumed to be higher than those that could be expected at greater distances from the unit due to dispersion of contaminants. Construction of multiple units is expected to be required at certain sites under the various LLMW alternatives to dispose of the projected waste volumes. While the farm family scenario evaluates only a single receptor 300 m from an individual unit, DOE assumes that each

Table 6.4–12. LLMW Disposal—Chemical Cancer Incidence Probability for Hypothetical Farm Family Most Exposed Lifetime MEI

Alternative	Number of Sites		ANL-E	BNL	FEMP	Hanford	INEL	LANL	LLNL	NTS[a]	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP
	T	D																
No Action	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Decentralized	37	16	1E-06	8E-06	1E-05	1E-04	7E-06	8E-05	8E-07	2E-06	1E-04*	3E-07	1E-06	2E-05	2E-04*	9E-07	2E-04*	--
Regionalized 1	11	12	--	--	1E-05	1E-04	7E-06	8E-05	8E-07	2E-06	1E-04*	3E-07	1E-06	3E-05*	2E-04*	--	2E-04*	--
Regionalized 2	7	6	--	--	--	1E-04	8E-06	4E-05	--	--	1E-04*	--	--	--	--	--	2E-04*	--
Regionalized 3	7	1	--	--	--	--	--	--	--	2E-04	--	--	--	--	--	--	--	--
Regionalized 4	4	6	--	--	--	1E-04	4E-06	1E-07	--	--	1E-04*	--	--	--	--	--	2E-04*	--
Centralized	1	1	--	--	--	1E-04*	--	--	--	--	--	--	--	--	--	--	--	--

Notes: T = treatment; D = disposal; -- = action not applicable for alternative; * = adjusted values. They represent the risks when groundwater concentrations of carcinogenic chemicals are adjusted to 100% of existing standards. Chemicals that drive risks and exceed drinking water standards include 1,2-dichloroethane at ORR, PORTS, and the Hanford Site (under Centralized) and carbon tetrachloride at RFETS and SRS. Unadjusted risk estimates are presented in the Volume II site tables and in Appendix D.

[a] The values for NTS overestimate potential risks at that site, since travel time through the vadose zone to the aquifer has been estimated from field-measured properties to be over 2 million years (Sully et al., 1995). Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.



	D	R1	R2	R3	R4	C
Treat at	37 sites	11 sites	7 sites	7 sites	4 sites	1 site
Dispose at	16 sites	12 sites	6 sites	1 site	6 sites	1 site

* Adjusted values - see text discussion

note: chart in logarithemic scale

Figure 6.4–3. LLMW Disposal—Probability of Chemical Cancer Incidence for Hypothetical Farm Family Most Exposed Lifetime MEI

of these close-in receptors will be affected primarily by the contaminant plume from the closest facility to him. However, DOE recognizes that commingling of contaminant plumes from multiple disposal units may occur as distance from the units increases, but anticipates that, at 300 m, the highest concentration of contaminants is likely to result from the single closest plume. At greater distances from the disposal units, where overlap of the plumes is more likely, the concentrations in any given plume should be lower as a result of dispersion and dilution than those estimated at the 300-m well. The WM PEIS cannot address groundwater contaminant concentrations at distances greater than 300 m from disposal units. More detailed analyses, such as the performance assessments required under DOE Order 5820.2A, will address the issues of existing groundwater contamination and multiple disposal units. For example, in April 1996, DOE issued guidance for the conduct of composite analyses in addition to performance assessments to help ensure that continuing disposal of low-level waste will not compromise the future radiological protection of the public. The composite analysis will estimate the potential cumulative impacts to a hypothetical future member of the public from an active or planned low-level waste disposal facility and other sources of radioactive material in the ground that might interact with the LLW disposal facility.

6.4.1.9 Potential Collective Risk to Offsite Population From Waste Disposal

Risk assessments generally evaluate both collective and individual health risks, that is, risks for both populations of receptors and for MEIs. However, the WM PEIS disposal risk analysis quantitatively estimates risks only for the farm family MEI. Although the farm family scenario disposal risk analysis uses site-specific hydrogeologic and meteorologic data, use of "conceptual" disposal units was assumed. The analysis did not attempt to identify exact locations of these generic units on a site; rather, they were assumed to be placed either near existing disposal units where such units existed, or at a location on the site expected to be most sensitive to groundwater contamination. Since the analysis does not attempt to actually locate the disposal units on the site, DOE believes it is not possible to develop plausible quantitative estimates of the collective risks to current or future offsite populations resulting from exposure to contaminated groundwater. Both the concentrations of contaminants in the groundwater and the number of people potentially exposed will be strongly influenced by the locations of the disposal units and receptor wells. A hypothetical siting decision to support such an analysis is not favored because the choice of a site so strongly influences the results as to make them a direct reflection of the choice.

To address the relative potential of the proposed disposal sites and alternatives for collective risk to offsite populations, values for site parameters that influence potential groundwater contamination or that are

associated with the relative size of populations at risk were statistically analyzed. These variables included the size of the site (acres), depth to aquifer, the size of the offsite population living within 50 miles of the site, annual rainfall, annual groundwater recharge, and time of travel of groundwater from the surface to a downgradient well. Statistical analysis of these variables produced clusters or groupings of sites according to their relative potential risk vulnerability. These groupings are believed to be more appropriate metrics for decision making, given the lack of facility siting and other relevant information, than quantitative estimates of person-rem doses and latent cancer fatalities.

Section C.4.1 of Appendix C contains additional information about the methodology and results of the collective risk vulnerability analysis. This section also describes other DOE efforts to assess potential risks from waste disposal, including those of the Federal Facility Compliance Act Disposal Workgroup and the performance assessment process required by DOE Order 5820.2A.

Section 5.4.1 of Chapter 5 contains a discussion of the results of the collective risk vulnerability analysis. Candidate disposal sites are grouped into three population risk vulnerability (PRV) groups, with PRV Group 1 having the lowest potential vulnerability for offsite population risks from groundwater contamination following LLMW disposal, and PRV Group 3 having the highest potential. The results of this analysis generally agree with those of the Federal Facility Compliance Act Disposal Workgroup analysis of potential radionuclide exposure via the groundwater pathway, as presented in the report, *Performance Evaluation of the Technical Capabilities of DOE Sites for Disposal of Mixed Low-Level Waste* (DOE 1996d). It is important to note that this is a screening-level analysis that does not take into account any measures that would limit migration of disposed wastes into the groundwater, such as engineered disposal units or changes in waste acceptance criteria. The objective of the analysis is not to rule out any sites for disposal but to indicate where such disposal mitigation measures are more likely to be necessary and where the costs of disposal would likely increase as a result. In particular, though some sites may be listed in Group 3, this does not mean that disposal would be unacceptable there. Rather, it means that mitigation would be an important part of a disposal plan for these sites.

As previously described, the waste volume, curie load, chemical volume, and number of potential disposal units required at a given site vary by waste management alternative. Table 6.4–13 presents data on disposal volumes, number of disposal units, curies, and chemical inventories for each site as they vary over the proposed alternatives, in conjunction with the results of the risk vulnerability factor and cluster analyses. This information is summarized across the sites for each alternative and displayed in Table 6.4–14. The

Table 6.4–13. Disposal Variables (by Site and Alternative) and Population Risk Vulnerability Group for LLMW

Disposal Alternative Variables	ANL-E[b]	BNL	FEMP	Hanford[a]	INEL[a]	LANL	LLNL	NTS[b]	ORR[a]	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS[a]	WVDP
Risk Vulnerability Group	2	2	3	1	1	1	2	1	3	3	1	3	2	2	3	2
Decentralized Alternative																
Number of disposal units	1	1	1	2	1	1	1	1	2	1	1	1	2	1	1	1
Disposal waste volume (m^3)	30	84	1,080	12,500	6,550	670	1,870	2,980	20,400	220	200	5,910	13,900	14	5,520	0
Total radioactivity (Ci × 0.001)	0.039	0.085	0.013	52	126	1.1	17.9	26	24	0.98	0.17	3.5	0.29	0.08	24	0
Total chemical inventory (kg × 0.001))	0.20	1.2	8.2	88	103	9.1	7.8	5.8	189	1.4	0.95	98	75	0.15	51	0
Regionalized 1 Alternative																
Number of disposal units			1	2	1	1	1	1	2	1	1	1	2		1	
Disposal waste volume			1,080	12,500	8,630	690	1,870	900	20,040	220	200	6,020	13,900		5,520	
Total radioactivity (Ci × 0.001)			0.013	52	128	1.2	17.9	24	24	0.98	0.17	3.6	0.29		24	
Total chemical inventory (kg × 0.001)			8.2	88	106	9.2	7.8	2.9	189	1.4	0.95	99	75		51	
Regionalized 2 Alternative																
Number of disposal units				2	1	2			3						1	
Disposal waste volume				13,300	9,530	14,800			27,700						5,520	
Total radioactivity (Ci × 0.001)				70	152	1.7			28						24	
Total chemical inventory (kg × 0.001)				96	109	85			297						51	
Regionalized 3 Alternative																
Number of disposal units								9								
Disposal waste volume								70,850								
Total radioactivity (Ci × 0.001)								276								
Total chemical inventory (kg × 0.001)								638								

Table 6.4–13. Disposal Variables (by Site and Alternative) and Population Risk Vulnerability Group For LLMW—Continued

Disposal Alternative Variables	ANL-E[b]	BNL	FEMP	Hanford[a]	INEL[a]	LANL	LLNL	NTS[b]	ORR[a]	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS[a]	WVDP
Regionalized 4 Alternative																
Number of disposal units				2	3				3						1	
Disposal waste volume				13,300	24,320				27,700						5,520	
Total radioactivity (Ci × 0.001)				70	154				28						24	
Total chemical inventory (kg × 0.001)				96	197				297						51	
Centralized Alternative																
Number of disposal units				9												
Disposal waste volume				70,850												
Total radioactivity (Ci × 0.001)				276												
Total chemical inventory (kg × 0.001)				638												

[a] Total radioactivity (curies) for remote-handled (RH) LLMW associated with the waste at Hanford (9), INEL (220,000), ORR (324,000), and SRS (4,920) for all the action alternatives are not included within the table.

[b] NTS and ANL-E are sites that have been analyzed using newer information (see Appendix I). NTS also accepts waste for disposal from sites whose analysis is based on data from an earlier database. Thus, the information on disposal at NTS is a composite of data obtained from both sources. This affects the analysis (to a lesser extent) of any disposal site in any alternative that accepts waste for disposal from NTS and ANL-E.

Table 6.4-14. Disposal Variables by LLMW Alternative and Population Risk Vulnerability Group

Alternative	Group 3	Group 2	Group 1
Decentralized Alternative			
Number of disposal units	6	5	8
Disposal waste volume (m^3)	33,100	1,998	36,800
Total radioactivity (Ci × 0.001)	52.5	18.1	205.6
Total chemical inventory (kg × 0.001)	347.6	9.3	281.8
Regionalized 1 Alternative			
Number of disposal units	6	1	8
Disposal waste volume (m^3)	33,240	1,870	36,800
Total radioactivity (Ci × 0.001)	52.6	17.9	205.1
Total chemical inventory (kg × 0.001)	348.6	7.8	282.0
Regionalized 2 Alternative			
Number of disposal units	4	0	5
Disposal waste volume (m^3)	33,220	0	37,630
Total radioactivity (Ci × 0.001)	52.0	0	223.7
Total chemical inventory (kg × 0.001)	348.0	0	290.0
Regionalized 3 Alternative			
Number of disposal units	0	0	9
Disposal waste volume (m^3)	0	0	70,850
Total Radioactivity (Ci × 0.001)	0	0	276.0
Total chemical inventory (kg × 0.001)	0	0	638.0
Regionalized 4 Alternative			
Number of disposal units	4	0	5
Disposal waste volume (m^3)	33,220	0	37,620
Total radioactivity (Ci × 0.001)	52.0	0	224.0
Total chemical inventory (kg × 0.001)	348.0	0	293.0
Centralized Alternative			
Number of disposal units	0	0	9
Disposal waste volume (m^3)	0	0	70,850
Total radioactivity (Ci × 0.001)	0	0	276.0
Total chemical inventory (kg × 0.001)	0	0	638.0

Note: Total radioactivity (curies) for remote-handled (RH) LLMW associated with the waste at Hanford (9), INEL (220,000), ORR (324,000), and SRS (4,920) for all the action alternatives are not included within the table.

summary data in Table 6.4–14 suggest that the Regionalized 3 and Centralized Alternatives present lower potential collective risk to offsite populations from disposal than the Decentralized or other Regionalized Alternatives.

Note that the results of this screening-level risk vulnerability analysis are useful in discussing the relative potentials among the sites and the proposed waste management alternatives. However, more refined risk analyses will be included in the site-specific performance assessments that will be conducted for the design and siting of new disposal facilities. In addition, DOE will consider a number of other factors in the development of waste disposal decisions. These include the results of safety analyses for disposal facility operation, the extent of existing contamination or waste disposal at a site, the costs and benefits involved in transporting waste among sites, and other environmental and socioeconomic concerns.

6.4.1.10 Disposal Intruder Scenario Risks

Table 6.4–15 presents an overview, by alternative, of the greatest programwide risks to a hypothetical intruder 100 and 300 years after the disposal facility has closed. Because the focus is on an individual intruder, the risks are presented as the *probability* of that individual experiencing an adverse health impact

Table 6.4–15 LLMW Disposal: Summary Risks to Hypothetical Intruders at LLMW Sites

Alternative	T	D	Radionuclide				Chemical	
			Dose (rem)	Cancer Fatality Probability	Cancer Incidence Probability	Genetic Effects Probability	Cancer Incidence Probability	Hazard Index[a]
100 Years After Disposal Facility Closure								
Decentralized	37	16	34	2E-02	6E-02	3E-03	2E-13	1E-07
Regionalized 2	7	6	33	2E-02	6E-02	3E-03	2E-13	1E-07
Centralized	1	1	7	4E-03	1E-02	7E-04	5E-14	1E-07
RH-LLMW	4	4	68	3E-02	1E-01	7E-03	1E-14	9E-09
300 Years After Disposal Facility Closure								
Decentralized	37	16	0.7	4E-04	1E-03	7E-05	2E-13	1E-07
Regionalized 2	7	6	0.6	3E-04	1E-03	6E-05	2E-13	1E-07
Centralized	1	1	0.2	7E-05	3E-04	2E-05	5E-14	1E-07
RH-LLMW	4	4	2	1E-03	4E-03	2E-04	1E-14	9E-09

Notes: T = treatment; D = disposal.
[a] Maximum of values for each site evaluated under the alternative.

(assuming that the intrusion occurs) rather than a total number of impacts for a selected population. Note that the intruder scenario risks were not estimated for all alternatives. Regionalized Alternative 2 was selected to be representative of the Regionalized Alternatives with disposal at six sites.

For both the 100-year and 300-year scenarios, each of the evaluated alternatives is estimated to result in relatively high maximum probabilities of cancer fatality, cancer incidence, and genetic effects from radionuclide and direct radiation exposure. Chemical exposures are much lower, resulting in lower risks of cancer incidence or adverse noncancer health effects.

Table 6.4–16 presents the cancer fatality probabilities by site for each of the alternatives evaluated 100 years and 300 years after the disposal facility has closed. The data in Table 6.4–16 are graphically presented in Figure 6.4–4. Under the Decentralized Alternative, cancer fatality probability values span a range of about four orders of magnitude. Cancer fatality probabilities generally are lower for the 300-year scenario by one to two orders of magnitude (i.e., 10–100 times) under all alternatives, which suggests that risks decrease as radionuclides decay. Strontium-90 (half-life 29 years) was the main radionuclide risk driver at 100 years, under each of the alternatives evaluated, whereas thorium-232 (half-life 1E+10 years), nickel-63 (half-life 96 years), and americium-241 (half-life 432 years) were the main risk drivers at 300 years. There is no general trend in intruder risk among the disposal alternatives evaluated.

The estimated doses presented in Tables 6.4–16 exceed the DOE Order 5820.2A performance assessment objective limits for intruders of 100 millirem per year for continuous exposure at the Hanford Site and INEL under the Decentralized and Regionalized 2 Alternatives and 500 millirem per year for acute exposure at ORR for RH-LLMW. Similar to the discussion in Section 6.4.1.8, site-specific considerations during design, construction, and operation would be expected to mitigate these exceedances. These mitigation measures are also described in Chapter 12.

6.4.2 Transportation-Related Impacts

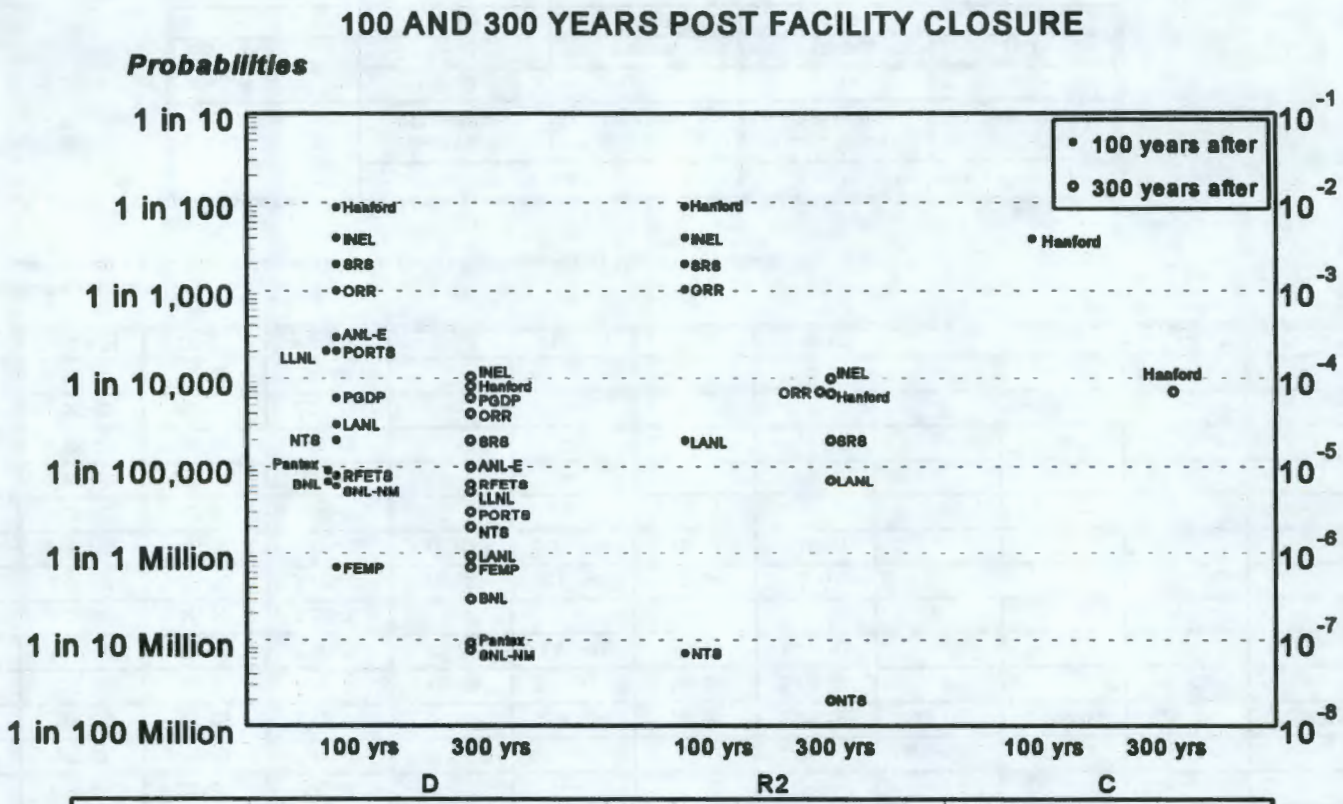
Transporting LLMW for treatment and disposal may affect the health of the truck or rail crew and the public along the transportation route. These impacts are the result of radiation exposure during normal operations, accidents in which the waste containers are assumed to be opened, exposure to vehicle exhaust during transport, and physical injury from vehicle accidents. In the No Action Alternative, no wastes are

Table 6.4-16 LLMW Disposal: Hypothetical Intruder Cancer Fatality Probabilities 100 and 300 Years After Facility Closure[a]

Sites	Decentralized Alternative				Regionalized Alternative 2				Centralized Alternative			
	100 Years		300 Years		100 Years		300 Years		100 Years		300 Years	
	Cancer Fatality Probability	Radiation Dose (rem)	Cancer Fatality Probability	Radiation Dose (rem)	Cancer Fatality Probability	Radiation Dose (rem)	Cancer Fatality Probability	Radiation Dose (rem)	Cancer Fatality Probability	Radiation Dose (rem)	Cancer Fatality Probability	Radiation Dose (rem)
ANL-E	3E-04	6.6E-01	1E-05	2.3E-02	--	--	--	--	--	--	--	--
BNL	7E-06	1.5E-02	3E-07	5E-04	--	--	--	--	--	--	--	--
FEMP	7E-07	1E-03	7E-07	1.4E-03	--	--	--	--	--	--	--	--
Hanford	9E-03	1.9E+01	8E-05	1.5E-01	9E-03	1.9E+01	7E-05	1.4E-01	4E-03	7.1E+00	7E-05	1.5E-01
INEL	4E-03	7.5E+00	1E-04	2.5E-01	4E-03	7.9E+00	1E-04	2.6E-01	--	--	--	--
LANL	3E-05	5.2E-02	9E-07	1.9E-03	2E-05	4.6E-02	7E-06	1.4E-02	--	--	--	--
LLNL	2E-04	3.2E-01	5E-06	9.3E-03	--	--	--	--	--	--	--	--
NTS	2E-05	4.9E-02	2E-06	3.1E-03	7E-08	1E-04	2E-08	3E-04	--	--	--	--
ORR	1E-03	2.6E+00	4E-05	8.5E-02	1E-03	2.5E+00	7E-05	1.5E-01	--	--	--	--
PGDP	6E-05	1.3E-01	6E-05	1.3E-01	--	--	--	--	--	--	--	--
Pantex	9E-06	1.9E-02	9E-08	2E-04	--	--	--	--	--	--	--	--
PORTS	2E-04	4.8E-01	3E-06	6E-03	--	--	--	--	--	--	--	--
RFETS	8E-06	1.6E-02	6E-06	1.1E-02	--	--	--	--	--	--	--	--
SNL-NM	6E-06	1.1E-02	8E-08	2E-04	--	--	--	--	--	--	--	--
SRS	2E-03	3.1E+00	2E-05	4.6E-02	2E-03	3.1E+00	2E-05	4.6E-02	--	--	--	--

Notes: -- = action not applicable for alternative.
[a] Results are provided for contact-handled wastes. Remote-handled LLMW results (all alternatives) are shown in the table below.

Sites	100 Years		300 Years	
	Cancer Fatality Probability	Dose (rem)	Cancer Fatality Probability	Dose (rem)
Hanford	3E-06	6E-03	2E-08	5E-05
INEL	6E-03	1.3E+01	1E-04	3E-01
ORR	3E-02	6E+01	1E-03	2E+00
SRS	4E-05	7E-02	5E-07	1E-03



	D	R2	C
Treat at	37 sites	7 sites	1 site
Dispose at	16 sites*	6 sites	1 site

*15 major sites are shown

note: chart in logarithemic scale

Figure 6.4–4. LLMW Disposal—Hypothetical Intruder Cancer Fatality Probabilities

shipped between sites. For all other alternatives, shipments were assumed to occur uniformly over a 10-year period.

The methods used to estimate transportation risk and the risks to the public along the transportation routes are described in Appendix E. Tables 6.4–17 and 6.4–18 present the total number of estimated fatalities associated with truck and rail transportation of LLMW, respectively. The total number of estimated fatalities resulting from radiation exposure and from nonradiological causes (i.e., vehicle exhaust-induced cancers and physical injury resulting from accidents) is less than one when LLMW is transported by rail (Table 6.4–18). The total number of radiological fatalities for truck transportation is also estimated to be less than one (Table 6.4–17). However, the number of fatalities for truck transportation is estimated to be approximately one for Regionalized Alternative 3 and the Centralized Alternative as a result of physical injuries received during traffic accidents.

The health impacts associated with exposure to the hazardous chemical components of LLMW that are released during transportation accidents are presented in Appendix E.

6.4.3 Facility Accident Impacts

6.4.3.1 Storage Facility Accidents

Accidents and source terms for current storage of LLMW were not analyzed explicitly. Unlike treatment, which will predominantly use new facilities that will have common characteristics, current (pretreatment) storage will use a variety of predominantly preexisting facilities that vary greatly in the amounts and types of waste inventories stored, the configurations in which they are stored, and the containment or confinement characteristics of the storage buildings or enclosures. However, recent DOE safety analysis reports (SARS) and NEPA information provide guidance on the potential risk impacts applicable to LLMW and TRUW storage facility accidents.

Information in these current SARs and DOE site EISs can be used as valid indicators of the predicted consequences for a range of waste storage facility accidents of varying frequency. A brief summary of some of the key accidents and assumptions used by the sites in preparing these analyses, and the related health

Table 6.4–17. LLMW Truck Transportation—Estimated Fatalities From Vehicular Accidents and Exposure to Radiation and Fuel Emissions

Alternative	Number of Sites		Number of Shipments	Shipment Miles (in Millions)	Estimated Number of Radiological Fatalities[a]		Estimated Number of Nonradiological Fatalities	
	T	D			Normal Operations Public	Normal Operations Crew	Fuel Emission	Injury From Traffic Accidents
No Action	3	NA	0	0	0	0	0	0
Decentralized	37	16	480	0.3	*	*	*	*
Regionalized 1	11	12	1,820	0.6	*	*	*	*
Regionalized 2	7	6	5,560	3	*	*	*	*
Regionalized 3	7	1	10,990	15	*	*	*	1
Regionalized 4	4	6	4,250	3	*	*	*	*
Centralized	1	1	7,520	14	*	*	*	1

Notes: T = treatment; D= disposal; * = greater than 0 but less than 0.5; NA = not applicable.
[a] Fatalities are from radiation-induced cancer.

Table 6.4–18. LLMW Rail Transportation—Estimated Fatalities From Rail Accidents and Exposure to Radiation and Fuel Emissions

Alternative	Number of Sites		Number of Shipments	Shipment Miles (in Millions)	Estimated Number of Radiological Fatalities[a]		Estimated Number of Nonradiological Fatalities	
	T	D			Normal Operations Public	Normal Operations Crew	Fuel Emission	Injury From Traffic Accidents
No Action	3	NA	0	0	0	0	0	0
Decentralized	37	16	350	0.2	*	*	*	*
Regionalized 1	11	12	1,030	0.5	*	*	*	*
Regionalized 2	7	6	2,490	1.4	*	*	*	*
Regionalized 3	7	1	4,540	6.8	*	*	*	*
Regionalized 4	4	6	2,050	1.6	*	*	*	*
Centralized	1	1	3,340	6.5	*	*	*	*

Notes: T = treatment; D= disposal; * = greater than 0 but less than 0.5; NA = not applicable.
[a] Fatalities are from radiation-induced cancer.

effects results, are shown in Appendix F. Examples of results applicable to LLMW storage facilities include accidents ranging from violent single drum breaches to large fires in Centralized facilities. The recent SARs and EISs that are relevant focus on TRUW accidents more than LLMW due to TRUW's higher radioactivity. However, the accident scenarios, estimates of airborne material releases due to the accidents, and atmospheric dispersion and health effects calculations are analogous. As a result, LLMW storage facility accident results can be directly related to TRUW facility analyses.

The most relevant recent analyses dealing with postulated accidents for LLMW and TRUW storage facilities were reviewed. Numerous accident scenarios were analyzed (e.g., fires, earthquakes, explosions, etc.). Predicted radiological doses to the MEI ranged from about 10 millirem per accident to about 3 rem for a severe TRUW facility accident (the effects of the latter accident exceeded those from all LLMW facility accidents). When multiplied by the risk conversion factor of 0.0005 latent cancer fatalities per person-rem of exposure (ICRP, 1990), the resultant estimated incremental cancer fatality risk to the MEI would range from about 5E-06 to 2E-03 if the accident were to occur. However, note that the accident frequencies in the reviewed documents ranged from greater than 1E-02 per year for the lower consequence accidents to less than 1E-06 per year for the high consequence accidents. Although there is considerable variation in the assumptions used by the various DOE sites in these recent studies to develop accident scenarios and predicted impacts, public risk from LLMW storage accidents should be very low.

It should be noted that explicitly analyzing risks from storage would not help to discriminate among alternatives because of the assumption used in the WM PEIS for estimating the treatment throughputs that dictate the inventories to be stored before treatment. This assumption is that all sites will accumulate or at least not reduce these inventories for roughly 10 years, at which time the complexwide treatment will begin. Thus, all sites will achieve their maximum inventories (leading to maximum potential releases during a storage facility accident) independent of alternative.

6.4.3.2 Treatment Facility Accidents

Although there are many processes used for treating LLMW, to date, thermal treatment technologies have been most effective in destroying the combustible hazardous constituents contained in LLMW. Since significant incineration data are available, public interest is heightened, and results achieved through incineration are representative and bounding of other thermal treatment processes, this risk analysis focused on incineration. Like other LLMW treatment processes, incineration operations/accidents can result in

airborne releases of radionuclides. Potential treatment facility accidents identified for all LLMW alternatives include: (1) incineration facility fires or explosions initiated from internal causes; (2) an earthquake or tornado that causes damage and possible fires in the facility; and (3) the crash of a large or small aircraft into the facility, resulting in fire and possible explosion. All of these accidents can involve release of the radioactive contents of the kiln, the stored ash byproduct of the incineration process, or the trapped contents of the filtration systems in the facility. The accident with the highest potential consequence at each site was evaluated.

The radiological risk and chemical health effects calculations were based upon conservative assumptions. Table 6.4–19 summarizes the estimated doses and cancer fatalities resulting from radiation exposures associated with potential treatment facility accidents. This table contains cancer fatality estimates for the maximum reasonably foreseeable accidents with the highest potential consequences at each site and the estimated frequency of those accidents occurring in any one year. The doses indicated are a function of the severity of the accident and the size and distribution of the population affected. The indicated probabilities of an excess cancer are based on the assumption that the accident occurs. Consistent with standard practice in radiological safety analysis, the fatalities are derived only from the cancers associated with radiation. In general, local worker fatalities in severe accidents from trauma would primarily result from the initiation of the accident, e.g., the initial impact and fire of an airplane crash. These trauma fatalities would tend to be independent of the inventory or process characteristics of a particular site for a given consolidation alternative, and therefore would not tend to be a significant discriminator among the alternatives. Trauma fatalities to the offsite populations from severe accidents would be almost totally independent of the site consolidation and process characteristics that are driven by alternative selection and also would not discriminate among alternatives.

Assuming that the accident occurs, none of the alternatives is estimated to result in a cancer fatality at any site to members of offsite populations or workers. Each of the alternatives poses a cancer fatality probability of greater than one in one million for the offsite MEI. Under the No Action Alternative, the cancer fatality probability is estimated to be greater than one in one million for the indicated accident affecting the offsite MEI at ORR. Under Regionalized Alternatives 2, 3 and 4, an offsite MEI cancer fatality probability of greater than one in one million is estimated for accidents at the Hanford Site and ORR. Under the Decentralized Alternative, 4 sites (the Hanford Site, LLNL, ORR and PGDP) are estimated to have offsite MEI cancer fatality risks greater than one in one million. The Regionalized Alternative 1 is expected to have an offsite MEI cancer fatality probability of greater than one in one million for the assumed accident at

Table 6.4–19. LLMW Facility Accidents—Radiation-Induced Cancer Fatalities From Maximum Reasonably Foreseeable Potential Treatment Facility Accidents

Site	Accident Type	Estimated Annual Accident Frequency	Offsite MEI Radiation Dose (rem)	Offsite MEI Cancer Fatality Probability	Population Radiation Dose (person-rem)	Offsite Population Number of Cancer Fatalities	Worker Radiation Dose (person-rem)	WM Workers Number of Cancer Fatalities
No Action								
INEL	Nonalpha, natural phenomena	1E-06 to 1E-04	2E-04	1E-07	1E+00	*	2E-01	*
ORR	Nonalpha, natural phenomena	1E-06 to 1E-04	1E-02	5E-06	2E+02	*	1E+01	*
SRS	Nonalpha, natural phenomena	1E-06 to 1E-04	5E-04	3E-07	2E+01	*	4E+00	*
Decentralized Alternative								
ANL-E	Nonalpha, natural phenomena	1E-06 to 1E-04	6E-05	3E-08	2E+00	*	7E-03	*
BNL	Nonalpha, natural phenomena	1E-06 to 1E-04	2E-03	9E-07	2E+01	*	2E-02	*
FEMP	Nonalpha, natural phenomena	1E-06 to 1E-04	8E-06	4E-09	4E-02	*	2E-04	*
Hanford	Nonalpha, natural phenomena	1E-06 to 1E-04	1E-02	6E-06	6E+02	*	2E+01	*
INEL	Alpha, natural phenomena	1E-06 to 1E-04	4E-04	2E-07	4E+00	*	8E+00	*
LANL	Alpha, natural phenomena	1E-06 to 1E-04	8E-04	4E-07	2E+00	*	5E-01	*
LLNL	Nonalpha, natural phenomena	1E-06 to 1E-04	4E-03	2E-06	2E+01	*	3E-01	*
NTS	Nonalpha, natural phenomena	1E-06 to 1E-04	2E-04	9E-08	5E-01	*	3E+00	*
ORR	Nonalpha, natural phenomena	1E-06 to 1E-04	2E-02	1E-05	4E+02	*	3E+01	*
Pantex	Nonalpha, natural phenomena	1E-06 to 1E-04	1E-04	6E-08	1E+00	*	1E-02	*
PGDP	Nonalpha, natural phenomena	1E-06 to 1E-04	2E-02	9E-06	6E+01	*	5E+00	*
RFETS	Alpha, natural phenomena	1E-06 to 1E-04	4E-04	2E-07	1E+01	*	1E+00	*
SRS	Nonalpha, natural phenomena	1E-06 to 1E-04	1E-03	6E-07	4E+01	*	8E+00	*
Regionalized Alternative 1								
INEL	Alpha, natural phenomena	1E-06 to 1E-04	4E-04	2E-07	4E+00	*	8E+00	*
LANL	Alpha, natural phenomena	1E-06 to 1E-04	8E-04	4E-07	2E+00	*	5E-01	*
LLNL	Nonalpha, natural phenomena	1E-06 to 1E-04	4E-03	2E-06	2E+01	*	3E-01	*
RFETS	Alpha, natural phenomena	1E-06 to 1E-04	4E-04	2E-07	1E+01	*	1E+00	*
SRS	Nonalpha, natural phenomena	1E-06 to 1E-04	1E-02	5E-08	4E+00	*	3E-01	*
Regionalized Alternatives 2 & 3								
Hanford	Nonalpha, natural phenomena	1E-06 to 1E-04	1E-02	6E-06	6E+02	*	3E+01	*
INEL	Alpha, natural phenomena	1E-06 to 1E-04	4E-04	2E-07	4E+00	*	8E+00	*
LANL	Alpha, natural phenomena	1E-06 to 1E-04	8E-04	4E-07	2E+00	*	5E-01	*
ORR	Nonalpha, natural phenomena	1E-06 to 1E-04	4E-02	2E-05	4E+02	*	5E+01	*
RFETS	Alpha, natural phenomena	1E-06 to 1E-04	4E-04	2E-07	1E+01	*	1E+00	*
SRS	Nonalpha, natural phenomena	1E-06 to 1E-04	1E-03	6E-07	4E+01	*	8E+00	*
Regionalized Alternative 4								
Hanford	Nonalpha, natural phenomena	1E-06 to 1E-04	1E-02	6E-06	6E+02	*	3E+01	*
INEL	Alpha, natural phenomena	1E-06 to 1E-04	4E-04	2E-07	4E+00	*	1E+01	*
ORR	Nonalpha, natural phenomena	1E-06 to 1E-04	4E-02	2E-05	4E+02	*	3E+01	*
SRS	Nonalpha, natural phenomena	1E-06 to 1E-04	1E-03	6E-07	4E+01	*	8E+00	*
Centralized Alternative								
Hanford	Nonalpha, natural phenomena	1E-06 to 1E-04	2E-02	9E-06	8E+02	*	3E+02	*

Notes: * = greater than 0 but less than 0.5. Natural phenomena refer to accidents initiated either by earthquake or by high wind or tornado, depending on the site and the associated recurrence frequencies. Incineration was the thermal treatment analyzed. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.

LLNL. The Hanford Site and ORR have the highest offsite MEI cancer fatality risk under each of the alternatives, with the exception of the Regionalized Alternative 1. However, when the frequencies of the accidents are considered, none of the alternatives pose an offsite MEI cancer risk of greater than one in one million.

Table 6.4–20 summarizes the estimated cancer incidences and noncancer risks resulting from chemical exposures associated with potential treatment facility accidents. This table contains cancer incidence and noncancer risk estimates for a maximum reasonably foreseeable accident at each site and the estimated annual accident frequency. As with the previous tables, only the cancer incidence and noncancer risks from chemical exposures are presented; fatalities resulting from physical hazards directly associated with the accident are not included. The overall risk from these potential chemical exposures, when the frequency of the assumed accidents is considered, is very small.

None of the alternatives is estimated to result in cancer incidence equal to or greater than one within the offsite population as a result of chemical exposures. For the offsite MEI, cancer incidence probability is not estimated to exceed one in one million for any site. None of the alternatives is estimated to result in cancer incidence equal to or greater than one within the waste management worker population as a result of chemical exposure. Each of the alternatives has noncancer risks above acceptable levels for the most exposed waste management worker with IDLH (Immediately Dangerous to Life and Health) Index values equal to or greater than one for all sites. Accidents at ORR and Portsmouth also result in noncancer risks to the offsite MEI.

It is also important to note that use of the latest safety analysis documentation (described in the preceding section on storage facility accidents) would reduce all predicted impacts. In addition, the consequences and risks provided here assume no mitigation of the accident and take no credit for emergency response actions. The reduction in impacts due to these mitigation actions would be significant.

6.4.3.3 Disposal Facility Accidents

As discussed in Appendix F, disposal facility accidents were not evaluated because of the lack of details of ultimate disposal. However, except for dedicated centralized disposal facilities (e.g., Yucca Mountain and WIPP for HLW and TRUW, respectively), disposal sites would generally lack a concentrated volume of material at risk being stored in a configuration susceptible to phenomena such as fires and explosions

Table 6.4–20. LLMW Facility Accidents—Chemical-Related Health Risks From Maximum Reasonably Foreseeable Potential Treatment Facility Accidents

Site	Accident Type	Estimated Annual Accident Frequency	Offsite Population Number of Cancer Incidences	Offsite MEI Probability of Cancer Incidence	WM Workers Number of Cancer Incidences	Offsite MEI Hazard Index	Maximally Exposed WM Worker IDLH[a] Index
No Action							
INEL	Nonalpha, facility fire	>1E-02	*	1E-10	*	0.002	1
ORR	Nonalpha, facility fire	>1E-02	*	3E-07	*	4	2
SRS	Nonalpha, facility fire	>1E-02	*	3E-09	*	0.04	7
Decentralized Alternative							
ANL-E	Nonalpha, facility fire	>1E-02	*	2E-11	*	0.0003	1
BNL	Nonalpha, facility fire	>1E-02	*	6E-10	*	0.01	1
FEMP	Nonalpha, facility fire	>1E-02	*	1E-08	*	0.2	2
Hanford	Nonalpha, facility fire	>1E-02	*	2E-09	*	0.03	5
INEL	Alpha, facility fire	>1E-02	*	8E-09	*	0.1	5
LANL	Alpha, facility fire	>1E-02	*	8E-09	*	0.1	3
LLNL	Nonalpha, facility fire	>1E-02	*	2E-08	*	0.4	3
NTS	Nonalpha, facility fire	>1E-02	*	7E-14	*	0.000001	1
ORR	Nonalpha, facility fire	>1E-02	*	6E-07	*	9	36
Pantex	Nonalpha, facility fire	>1E-02	*	5E-10	*	0.007	2
PGDP	Nonalpha, facility fire	>1E-02	*	2E-08	*	0.3	2
PORTS	Nonalpha, facility fire	>1E-02	*	8E-08	*	1	10
RFETS	Alpha, facility fire	>1E-02	*	1E-08	*	0.2	2
SNL-NM	Nonalpha, facility fire	>1E-02	*	1E-09	*	0.02	1
SRS	Nonalpha, facility fire	>1E-02	*	5E-09	*	0.09	14
Regionalized Alternative 1							
FEMP	Nonalpha, facility fire	>1E-02	*	1E-08	*	0.2	2
Hanford	Nonalpha, facility fire	>1E-02	*	2E-09	*	0.03	5
INEL	Alpha, facility fire	>1E-02	*	8E-09	*	0.1	5
LANL	Alpha, facility fire	>1E-02	*	8E-09	*	0.1	3
LLNL	Nonalpha, facility fire	>1E-02	*	3E-08	*	0.4	3
ORR	Nonalpha, facility fire	>1E-02	*	6E-07	*	9	36
Pantex	Nonalpha, facility fire	>1E-02	*	5E-10	*	0.007	2
PGDP	Nonalpha, facility fire	>1E-02	*	2E-08	*	0.3	2
PORTS	Nonalpha, facility fire	>1E-02	*	8E-08	*	1	10
RFETS	Alpha, facility fire	>1E-02	*	1E-08	*	0.2	2
SRS	Nonalpha, facility fire	>1E-02	*	5E-09	*	0.09	14
Regionalized Alternatives 2 & 3							
Hanford	Nonalpha, facility fire	>1E-02	*	3E-09	*	0.04	8
INEL	Alpha, facility fire	>1E-02	*	1E-08	*	0.2	6
LANL	Alpha, facility fire	>1E-02	*	8E-09	*	0.1	3
ORR	Nonalpha, facility fire	>1E-02	*	6E-07	*	9	36
PORTS	Nonalpha, facility fire	>1E-02	*	9E-08	*	2	11
RFETS	Alpha, facility fire	>1E-02	*	1E-08	*	0.2	2
SRS	Nonalpha, facility fire	>1E-02	*	5E-09	*	0.09	14
Regionalized Alternative 4							
Hanford	Nonalpha, facility fire	>1E-02	*	3E-09	*	0.04	8
INEL	Alpha, facility fire	>1E-02	*	2E-08	*	0.3	9
ORR	Nonalpha, facility fire	>1E-02	*	7E-07	*	0.1	46
SRS	Nonalpha, facility fire	>1E-02	*	5E-09	*	0.09	14
Centralized Alternative							
Hanford	Nonalpha, facility fire	>1E-02	*	3E-08	*	0.4	68

Notes: * = greater than 0 but less than 0.5. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.
[a] Immediately dangerous to life and health.

capable of causing significant releases. These repositories have accident analyses performed as part of their site-specific EISs. Although seismic events could breach in-ground containers, leading to airborne releases, such events would be bounded by accidents breaching the concentrated volumes of waste being held in a treatment or storage facility. The available safety literature does not indicate any credible accident sequence in which the risk from airborne releases in a low-level mixed waste disposal facility would be sufficiently significant to rule out a site from consideration and thereby serve as a discriminator among disposal alternatives.

6.5 Air Quality Impacts

The management of LLMW would not appreciably affect the air quality at most sites. However, centralization of treatment at the Hanford site could cause adverse air quality impacts requiring special emission control measures for criteria air pollutants. Emissions at RFETS could result in adverse air quality impacts if the waste at this site is treated or disposed of onsite. Emissions of hazardous air pollutants, including radionuclides, were estimated to be below the applicable standards at any site.

As illustrated in Table 6.5–1, DOE evaluated air quality impacts at each proposed LLMW treatment and disposal site based on estimated increases in emissions of the six criteria air pollutants, hazardous air pollutants (which include radionuclides), and toxic air pollutants. Pollutant emission estimates were made for the construction, and operations and maintenance (O&M) activities of LLMW facilities.

The Clean Air Act (42 USC 7401 *et seq.*) regulates emissions of air pollutants. In those areas where air pollution standards are not met (known as "nonattainment areas"), activities that introduce new sources of emissions from both "stationary" (e.g., treatment and storage facilities) and mobile (e.g., vehicles and construction equipment) sources are regulated under the "General Conformity Rule." In this rule, EPA has established limits for each criteria air pollutant for nonattainment areas. An entity which seeks to engage in an activity that will result in emissions equal to or greater than those limits in a nonattainment area must first obtain a permit.

In "attainment areas" (where air pollution standards are met), only new sources of emissions from stationary sources are regulated. In these areas, regulations for the Prevention of Significant Deterioration (PSD) of ambient air quality apply. Allowable emission increases are known as PSD increments. A permit

Table 6.5–1. Air Quality Impacts Evaluated for LLMW Alternatives

Impacts Assessed	Period of Analysis	Activities for Which Impacts Are Assessed	Impacts Measure	Location of Impacts Assessment
Criteria air pollutant emissions	Construction	Estimated for construction equipment and worker vehicles	Percent of standard	Table 6.5–2
	Operations	Estimated for thermal treatment units, for fuel use by all other LLMW facilities, for worker vehicles, and for waste shipment vehicles	Percent of standard	Table 6.5–3
Radionuclide emissions	Operations	For all LLMW treatment and disposal facilities	Percent of standard	Text discussion only
Hazardous and toxic air pollutant emissions	Operations	For all LLMW treatment and disposal facilities	Percent of standard	Text discussion only

is required for a new stationary source that equals or exceeds the allowable increase. However, a permit is not required for criteria pollutant emissions from mobile sources.

Subsequent to December 6, 1995, hazardous waste and LLMW facilities are subject to the requirements of the Resource Conservation Recovery Act regulations found at 40 CFR Part 264, subpart AA regarding air emission standards from process vents and subpart BB regarding air emission standards for process leaks. Compliance with the requirements of 40 CFR Part 264, subpart CC, regarding air emissions of volatile organic compounds from tanks, surface impoundments, and containers began June 6, 1996 (60 FR 56952).

6.5.1 Criteria Air Pollutant Emissions From Construction

Criteria air pollutants can be emitted from construction equipment and from vehicles that workers use to drive to the construction site. Both are considered to be "mobile sources."

For purposes of analysis, DOE identified sites in nonattainment areas where construction activities

Major Types of Air Pollutants

***Criteria Air Pollutants**: carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), lead (Pb), ozone (O_3), and particulate matter less than or equal to 10 micrometers in diameter (PM_{10})*

***Hazardous Air Pollutants:** 189 hazardous substances (including radionuclides) whose emissions are regulated by the Clean Air Act*

***Toxic Air Pollutants**: Other toxic compounds regulated by EPA and state or local governments*

under all the LLMW alternatives would result in emissions that would equal or exceed 10% of the allowable limit of a particular criteria air pollutant. Table 6.5–2 lists those sites. DOE chose the 10% threshold to highlight those sites where criteria air pollutant emissions could result in adverse air quality impacts.

As indicated in Table 6.5–2, five of the 16 major proposed LLMW sites are located in nonattainment areas and, as a result of LLMW construction activities, would have emissions that equal or exceed 10% of the allowable limit for a particular criteria air pollutant. All five sites would exceed the 10% threshold in the Decentralized Alternative. Under the Regionalized 2, Regionalized 3, Regionalized 4, and Centralized Alternatives, ANL-E, NTS, and RFETS would exceed the 10% threshold.

DOE estimates that emissions from construction activities at RFETS could exceed the allowable level; thus, RFETS needs to obtain a Clean Air Act permit. In addition, construction activities at NTS would result in emissions at approximately 94% of the allowable limit for carbon monoxide. This percentage may overestimate potential impacts because it assumes that NTS is in a nonattainment region since it is adjacent to the Clark County nonattainment region for CO and PM_{10}. The NTS EIS (DOE, 1996b) does not show any exceedances for criteria pollutants.

6.5.2 Criteria Air Pollutant Emissions From Operations and Maintenance

Criteria air pollutants are also emitted during operations and maintenance of LLMW facilities (stationary sources) and by vehicles that are driven by workers to the facility or used to transport waste (mobile sources). DOE evaluated air quality impacts for these pollutants at each site by comparing estimated increases in tons per year to the allowable emission limits (General Conformity Rules in nonattainment areas or PSD increments in attainment areas).

Eight of the 16 major proposed LLMW sites would equal or exceed 10% of applicable air pollutant emission standards (Table 6.5–3). Of these, two sites are located in nonattainment areas; six sites are in attainment areas. As many as seven sites would have pollutant standards that equal or exceed 10% of the levels under an alternative. Only the Hanford Site is estimated to exceed the standard: particulates would be approximately 50% above the standard in the Centralized Alternative, primarily from thermal destruction

Table 6.5–2. Percent of Sites' Allowable Air Emissions Discharged During Construction—LLMW Sites Equaling or Exceeding 10% of Standard in Nonattainment Regions[a]

Alternative	Number of Sites		Criteria Pollutants—Construction[b]					
			ANL-E	BNL	FEMP		NTS	
	T	D	NO_2	NO_2	VOC	NO_2	CO	PM_{10}
No Action[c]	3	NA	10 (9/1)			22 (20/2)	25(18/7)	
Decentralized	37	16	44 (39/5)	14 (5/9)	11 (3/8)	22 (16/6)	94 (64/30)	13(13/0)
Regionalized 1	11	12	27 (20/7)		16 (4/12)	30 (20/10)	26 (12/14)	
Regionalized 2	7	6	27 (20/7)				25 (12/13)	
Regionalized 3	7	1	27 (20/7)				73 (41/32)	
Regionalized 4	4	6	27 (20/7)				25(12/13)	
Centralized	1	1	27 (20/7)				25 (12/13)	

Alternative	Number of Sites		Criteria Pollutants—Construction[b]		
			RFETS		
	T	D	CO	NO_2	VOC
No Action	3	NA	95 (31/64)	94 (81/13)	31 (16/15)
Decentralized	37	16	169 (33/136)	114 (87/27)	50 (17/33)
Regionalized 1	11	12	169 (33/136)	114 (87/27)	50 (17/33)
Regionalized 2	7	6	107 (5/102)	32 (12/20)	27 (2/25)
Regionalized 3	7	1	107 (5/102)	32 (12/20)	27 (2/25)
Regionalized 4	4	6	48 (3/45)	16 (7/9)	12 (1/11)
Centralized	1	1	48 (3/45)	16 (7/9)	12 (1/11)

Notes: T = treatment; D = disposal; NA = not applicable; blanks indicate that a site does not exceed 10% of the standard under the specified alternative.
[a] Pollutants: CO = carbon monoxide; SO_2 = sulfur dioxide; PM_{10} = particulate matter less than or equal to 10 micrometers in diameter; NO_2 = nitrogen dioxide; VOC = volatile organic compounds.
[b] Sites which exceed 10% of the limit specified by the General Conformity Rule; total % of limit (% equipment/% worker vehicles).
[c] The No Action Alternative includes impacts from only the first 20 years of indefinite storage of LLMW; see Section 6.16 for additional information on longer term impacts.

Table 6.5–3. Percent of Sites' Allowable Air Emissions Discharged During Operations—LLMW Sites Equaling or Exceeding 10% of Standard[a]

Alternative	Number of Sites		Criteria Pollutants—Operation and Maintenance PSD or General Conformity						
			FEMP	Hanford		INEL		NTS	
	T	D	PM_{10}[c]	NO_2[c]	PM_{10}[c]	NO_2[c]	PM_{10}[c]	CO[d]	PM_{10}[d]
No Action[e]	3	NA				10			
Decentralized	37	16		12	22	15	13	21 (1/20)	10 (10/0)
Regionalized 1	11	12	12	13	23	15	13		
Regionalized 2	7	6		14	25		14		
Regionalized 3	7	1		14	25		14	39 (0/39)	
Regionalized 4	4	6		14	25	25	45		
Centralized	1	1		82	147				

Alternative	Number of Sites		Criteria Pollutants—Operation and Maintenance PSD or General Conformity								
			ORR		PORTS		RFETS			SRS	
	T	D	NO_2[c]	PM_{10}[c]	NO_2[c]	PM_{10}[c]	CO[d]	NO_2[b]	VOC[b]	NO_2[c]	PM_{10}[c]
No Action	3	NA	19	26			23 (1/22)			13	10
Decentralized	37	16	33	50		13	81 (1/80)	25 (9/16)	20 (1/19)		10
Regionalized 1	11	12	33	50	11	15	81 (1/80)	25 (9/16)	20 (1/19)		10
Regionalized 2	7	6	33	50	13	25	53 (1/52)	17 (6/11)	13 (0/13)		10
Regionalized 3	7	1	26	46	13	25	53 (1/52)	17 (6/11)	13 (0/13)		
Regionalized 4	4	6	51	77			24 (0/24)				10
Centralized	1	1					24 (0/24)				

Notes: T = treatment; D = disposal; NA = not applicable; blanks indicate that a site does not exceed 10% of the standard under the specified alternative.

[a] Pollutants: CO = carbon monoxide; SO_2 = sulfur dioxide; PM_{10} = particulate matter equal to or less than 10 micrometers in diameter; NO_2 = nitrogen dioxide; VOC = volatile organic compounds.

[b] Nonattainment area for the pollutant ozone. NO_2 and VOC are ozone precursor pollutants; total % (% stationary-source/% mobile-source).

[c] Attainment area for this pollutant. PSD regulations applied; total % represents stationary source emissions only.

[d] Nonattainment area for this pollutant. General Conformity regulations applied; total % (% stationary-source/% mobile-source).

[e] The No Action Alternative includes impacts from only the first 20 years of indefinite storage of LLMW; see Section 6.16 for additional information on longer term impacts.

emissions. Therefore, additional control measures may be needed at this site to reduce emissions of particulates to acceptable levels.

The most stringent PSD requirements are for Class I areas (40 CFR 52.21). Class I areas are regions of special concern because they include national parks, monuments, seashores, wildlife refuges, or wilderness areas. A proposed action may affect air quality in a PSD Class I area if it will emit more than the allowable PSD increment of a criteria air pollutant and will be located within 100 kilometers (62 miles) of a PSD Class I area. Nine sites proposed for LLMW activities under the alternatives are located within 100 kilometers of a PSD area: BNL, FEMP, INEL, LANL, LLNL, NTS, ORR, RFETS, and SNL-NM. None of these would have sufficient quantities of emissions to affect a PSD Class I area.

Estimated concentrations resulting from criteria air pollutant emissions from facilities were also compared to the National Ambient Air Quality Standards (NAAQS) (40 CFR 50). No site was estimated to equal or exceed 10% of the standards.

6.5.3 Hazardous and Toxic Air Pollutant Emissions

Thermal treatment of LLMW will result in emission of small quantities of hazardous and toxic air pollutants. Hazardous air pollutants, other than radionuclides, and toxic air pollutants were evaluated by comparing estimated ambient concentrations to EPA guidelines and State Ambient Allowable Limits (AALs). Radionuclides from air emissions were evaluated by comparing the annual radiation dose to the MEI to the National Emissions Standard for Hazardous Air Pollutants (NESHAP)—10 millirem per year (40 CFR 61).

Doses from airborne radionuclides were estimated not to equal or exceed 10% of the dose standard at any site. In addition, nonradiological hazardous or toxic air pollutant concentrations at the treatment sites were estimated to be below 10% of the applicable guidelines or standards.

6.6 Water Resources Impacts

Impacts to water availability tend to decrease as the LLMW management facilities are Centralized. Major impacts to water availability from increased water use at the sites are unlikely, although there is the potential for adverse impacts at LLNL-Site 300. Modeling indicates that groundwater concentration reduction measures may be needed for radionuclides when disposal occurs at FEMP, the Hanford Site, ORR, SNL-NM, and SRS. Concentration reduction measures for radionuclides would not be needed when disposal occurs at NTS, even under the Regionalized 3 (one disposal site) Alternative.

As illustrated in Table 6.6–1, DOE analyzed the impacts on water resources of treatment and disposal activities. DOE evaluated the effects on water availability from building and operating treatment, storage and disposal facilities. DOE examined the effects of migration of radionuclides and chemicals from disposal facilities on groundwater quality.

In addition, the following impacts were examined for all waste types collectively, and are discussed in Chapter 5, Section 5.4.3:

- Impacts on surface water caused by floodplain encroachment
- Impacts on surface water from runoff and sedimentation

Table 6.6–1. Water Resources Impacts Evaluated for LLMW Alternatives

Impacts Assessed	Period of Analysis	Activities for Which Impacts Are Assessed	Impacts Measure	Location of Impacts Assessment
Water availability	Construction	Estimated for water used: • by personnel • for concrete • for dust suppression	Percent increase in current water use	Table 6.6–2
			Percent decrease in stream flow	Text discussion only
	Operations	Estimated for water used: • by personnel • by treatment and disposal processes	Percent increase in current water use	Table 6.6–2
			Percent decrease in stream flow	Text discussion only
		Estimated for effluent discharged from sanitary and process wastewater treatment facilities	Percent increase in stream flow	Text discussion only
Groundwater quality	Post-closure	Disposal of LLMW	Percent of drinking water quality standard	Table 6.6–3

- Impacts on surface water and groundwater quality from wastewater discharges
- Impacts on small onsite streams from wastewater discharges
- Impacts on existing areas of groundwater contamination from groundwater withdrawal
- Impacts on surface and groundwater water quality from routine transportation and transportation accidents

6.6.1 WATER AVAILABILITY

Impacts on surface water and groundwater availability were assessed by comparing current water use rates from municipal, surface water, or groundwater sources to projected requirements for construction or operation of LLMW facilities. In addition, impacts on surface water were further assessed by examining the effect of potential withdrawals from and discharges to the major offsite stream at a given site.

Table 6.6–2 identifies sites where projected water usage under any alternative would increase by more than 1%. This 1% threshold is based on the assumption that lesser changes are not likely to have significant impacts.

Table 6.6–2. Maximum Percent of Current Water Use for Construction or Operations—LLMW Sites Predicted to Exceed 1%

Alternative	Number of Sites		FEMP	INEL	LANL	LLNL	NTS	RFETS	SRS	WVDP
	T	D								
No Action[a]	3	NA	4.4	1.3	1.7	81	1.3	28	4.7	
Decentralized	37	16	4.4	1.9		20	3.9	33	2.2	2.8
Regionalized 1	11	12	5.9	1.9		22		33	2.2	
Regionalized 2	7	6				1.5		7.6	2.2	
Regionalized 3	7	1				1.5	2.4	7.6		
Regionalized 4	4	6				1.5		2.7	2.2	
Centralized	1	1				1.5		2.7		

Notes: T = treatment; D = disposal; NA = not applicable; blank cells are less than or equal to 1%. Water sources assumed as follows: Groundwater for FEMP, INEL, LANL, LLNL, NTS, and SRS; municipal water for RFETS; surface water for WVDP.
[a] The No Action Alternative includes impacts from only the first 20 years of indefinite storage of LLMW; see Section 6.16 for additional information on longer term impacts.

Eight of the 16 major sites are predicted to exceed the 1% threshold. Most exceedances shown are due largely to water used during the 2–3 year period for construction of treatment facilities; however, under the No Action Alternative, large quantities of water for concrete would be needed to build storage facilities. Although projected water requirements exceed current water use by 1% or more at FEMP, INEL, LANL, NTS, SRS, and WVDP, these six sites are not likely to experience adverse impacts because of sufficient capacities and the relatively small amount of additional water needed (DOE, 1995a). Adverse impacts could be experienced at two sites, LLNL and RFETS, which are discussed further below.

Water use at LLNL would exceed 1% of current use for all alternatives and approach 81% under the No Action Alternative. This is based on the conservative assumption that water at Site 300, the assumed location for proposed WM facilities at LLNL, would be supplied by groundwater. However, most of the water would probably be supplied by a new municipal hookup for Site 300, or the Livermore Valley municipal system that serves LLNL. If the water were supplied by the new 500,000-gallons-per-day municipal hookup at Site 300, the maximum water use would be 14% of the capacity of the system. If the water were supplied by the municipal system in Livermore Valley, it would be less than 10% of the current water use rate of 717,000 gallons per day. If water for LLNL is supplied by an offsite municipal system, onsite water resources would not be affected. Therefore, adverse impacts to onsite water resources, though possible, are unlikely. Impacts on the source of the municipal supply are not within the scope of this PEIS.

Water use at RFETS would exceed 1% of current use for all alternatives. RFETS does not withdraw water from any onsite surface water or groundwater body. Instead, water is supplied by Denver Water from the South Boulder Creek and Ralston Reservoir via the South Boulder Diversion Canal. Under the Decentralized and Regionalized 1 Alternatives, construction of treatment and disposal facilities would require an additional 9.4% of the 1,000,000 gallon-per-day capacity of the water supply distribution system. The increases in water use result from adding new alpha LLMW treatment and disposal facilities. However, because water for RFETS is supplied by an offsite municipal system, onsite water resources would not be affected. Impacts on the source of the municipal supply are not within the scope of this PEIS, but would be expected to be very small, since the maximum usage for WM activities would be less than 0.05% of the 178.8 mgd of water supplied by Denver Water (Denver Water, 1996) to its customers in 1995.

As shown in the Volume II tables, for DOE sites that withdraw water directly from a surface water source (Hanford, ORR, PGDP, and WVDP), water use would be less than 1% of the average flow in the surface water body. In addition, for this analysis, it was assumed that 100% of the water used at the facility during

operations would be discharged as effluent from a wastewater treatment plant. For sites that discharge wastewater to natural surface waters (ANL-E, BNL, FEMP, ORR, Paducah, Portsmouth, RFETS, SRS, and WVDP), effluent discharges would be less than 1% of the average flow in the principal receiving water body at all sites. These are negligible changes in flow that would not affect surface water levels.

6.6.2 WATER QUALITY

DOE evaluated the impacts to groundwater quality caused by the migration of radionuclides and chemicals that leach from disposal facilities over time. DOE calculated concentrations of radionuclides and hazardous components at a hypothetical well located 300 meters from the center of the disposal facility, and compared these to EPA's drinking water standards (which have been adopted in DOE's internal orders). For radionuclides, the allowable drinking water concentrations equate to a 4 millirem-per-year effective dose equivalent.

The drinking water standards are used as comparison criteria for groundwater quality. Although they are not enforceable standards, they are often used as goals for contaminated site cleanup actions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC 9601 *et seq.*). Because EPA established the drinking water standards to protect human health, groundwater concentrations of radionuclides and chemicals at or below these levels present a low risk.

Concentrations in the groundwater that equal or exceed 25% of the drinking water standard are presented, although the discussion of impacts concentrates on contaminants that are near or exceed drinking water standards. (See Appendix C for discussion on the methodology used in this analysis.)

6.6.2.1 Radionuclides

Table 6.6–3 and Table 6.6–4 identify sites where CH- and RH-LLMW would be disposed and where, under any alternative, the calculated value for any pollutant would exceed 25% of the drinking water standards for radionuclides.

Table 6.6–3. Percent of Drinking Water Standards for Radionuclides in Groundwater From Disposal of CH LLMW—Sites Exceeding 25% of Standard [a]

Alternative	Number of Sites		FEMP	Hanford			ORR			SNL-NM	SRS
	T	D	U-238	Tc-99	U-234	U-238	Pu-239	Pu-240	Tc-99	Pu-240	U-238
No Action	3	--	--	--	--	--	--	--	--	--	--
Decentralized	37	16	100*			100*	50	30	40	100*	100*
Regionalized 1	11	12	100*			100*	40		30	--	100*
Regionalized 2	7	6	--			100*	40	30	100*	--	100*
Regionalized 3	7	1	--	--	--	--	--	--	--	--	--
Regionalized 4	4	6	--			100*	50	30	100*	--	100*
Centralized	1	1	--	40	40	100*	--	--	--	--	--

Notes: T = treatment; D= disposal; -- = no disposal at this site under this alternative; * = WM PEIS modeling indicates that a reduction in the estimated concentration in the groundwater would be necessary to meet drinking water standards. See Volume II tables for the value of the exceedance. Blanks indicate that a site does not exceed 25% of the standard under the specified alternative.

[a] Only radionuclides equal to or above 25% of drinking water standards are listed. Blanks indicate concentrations less than 25% of standards. See Appendix C for a list of the drinking water standards.

Table 6.6–4. Percent of Drinking Water Standards for Radionuclides in Groundwater From Disposal of RH LLMW—Sites Exceeding 25% of Standard [a]

Alternative	Number of Sites		ORR				
	T	D [b]	Np-237	Pu-239	Pu-240	Tc-99	U-238
No Action	3	--	--	--	--	--	--
Decentralized	37	16	30	100*	100*	100*	100
Regionalized 1	11	12	30	100*	100*	100*	100
Regionalized 2	7	6	30	100*	100*	100*	100
Regionalized 3	7	1	30	100*	100*	100*	100
Regionalized 4	4	6	30	100*	100*	100*	100
Centralized	1	1	30	100*	100*	100*	100

Notes: T = treatment; D = disposal; -- = no disposal at this site under this alternative; * = WM PEIS modeling indicates that a reduction in the estimated concentration in the groundwater would be necessary to meet drinking water standards. See Volume II tables for the value of the exceedance.

[a] Only radionuclides equal to or above 25% of drinking water standards are listed. See Appendix C for a list of the drinking water standards.

[b] Number of disposal sites includes those disposing of CH-LLMW; disposal of RH-LLMW occurs at four sites (Hanford, INEL, ORR, and SRS) for all alternatives (except No Action, for which there is no disposal).

Disposal of CH-LLMW at FEMP, Hanford, ORR, SNL-NM, and SRS is predicted to cause 25% of drinking water standards for radionuclides to be exceeded in the groundwater. Of these sites, only FEMP is located above an EPA-designated sole-source aquifer. Twenty-five percent of standards would not be exceeded when CH-LLMW is disposed at ANL-E, BNL, INEL, LANL, LLNL, NTS, the Pantex Plant, Paducah, Portsmouth, or RFETS. A maximum of five sites would exceed 25% of drinking water standards under the Decentralized Alternative. Only under the Regionalized 3 Alternative (disposal of all CH-LLMW at NTS) are 25% of drinking water standards not exceeded.

Radionuclides that would exceed 25% of the drinking water standards are plutonium-239, plutonium-240, technetium-99, uranium-234, and uranium-238. These are all long half-life radionuclides, with the minimum half-life being 6,537 years for plutonium-240. Shorter half-life radionuclides (e.g., cesium-137, strontium-90) tend to decay to acceptable levels before reaching the 300-meter well.

For radionuclides with long half-lives, disposal inventory, infiltration rate, depth to groundwater, and the character of the media through which the water flows, are some of the primary factors that determine the concentration in the groundwater. The infiltration rate is related to rainfall, such that sites in arid regions generally perform better than sites in humid regions because of their smaller infiltration rate. Sites with a large depth to groundwater are generally better due to longer travel times. Sites located over areas with large percentages of materials that retard the movement of radionuclides (e.g., clays and organic materials) generally perform better than sites located over areas devoid of these materials.

For CH-LLMW, uranium-238 is the most problematic radionuclide, exceeding 100% of the standard at three sites (FEMP, the Hanford site, and SRS). In all of these cases, concentrations in the groundwater would have to be reduced to meet drinking water standards. Technetium-99 (ORR) and plutonium-240 (SNL-NM) would also have to be reduced to meet drinking water standards.

More recent estimates for the release of radionuclides to the groundwater based on updated waste loads project increases in the expected groundwater exceedances for particular radionuclides at these sites: FEMP (U-238), Hanford (U-238), SRS (U-238), and SNL-NM (Pu-240). See Appendix I of the Final WM PEIS.

Disposal of RH-LLMW at ORR is predicted to cause 25% of the drinking water standards to be exceeded for neptunium-237, plutonium-239, plutonium-240, technetium-99 and uranium-238. Drinking water standards would be exceeded for all alternatives except No Action, when all LLMW would be stored.

Concentrations of plutonium-239, plutonium-240, and technetium-99 would have to be reduced to meet drinking water standards. Disposal of RH-LLMW at Hanford, INEL, or SRS would not exceed 25% of standards.

Measures that could be used to reduce the estimated concentration of radionuclides in the groundwater include:

- Modifying the engineering design of the disposal facility (e.g., addition of a clay liner to increase adsorption or a concrete cap to reduce infiltration)
- Modifying the form of the waste to be disposed to reduce the release rate (e.g., changing to a vitrified waste form)
- Changing the specific location of the disposal facility so it is sited over an area with more favorable hydrologic conditions
- Imposing waste acceptance criteria (i.e., restricting the amount of the radionuclide allowed in the disposal facility)

The performance of disposal facilities at a specific site would be evaluated in greater detail in DOE's Performance Assessment process under DOE Order 5820.2A (DOE, 1988). This process would help to ensure that all regulatory requirements are met and significant contamination of groundwater would not occur.

6.6.2.2 Hazardous Constituents

The concentrations of hazardous constituents in the groundwater from disposal of LLMW are largely due to assumptions on the routing of wastes through the treatment system. As shown in the LLMW flow diagram (Figure 6.2–1), some wastes containing solvents were assumed to bypass the thermal treatment processes. The solvents in these wastes were not destroyed, but instead, ended up in the disposal facility. Some of these wastes contain solvents in large enough concentrations to cause standards to be exceeded when the wastes are disposed. In practice, LLMW to be disposed would meet EPA standards for treatment and disposal, and therefore should not produce major impacts to groundwater quality. Therefore, although the absolute values of the results for hazardous constituent contamination in groundwater are higher than would result from wastes treated to EPA standards, the results are still useful in showing the relative suitability of the sites. Even with the conservative assumptions used in the WM PEIS, drinking water

standards were not exceeded at some sites. This may indicate that these sites are better for LLMW disposal than other sites.

As shown in Table 6.6–5, the WM PEIS analysis indicates that disposal of CH-LLMW at ANL-E, the Hanford Site, LANL, NTS, ORR, Portsmouth, RFETS, and SRS would cause 25% of drinking water standards for hazardous constituents to be exceeded in the groundwater.

A maximum of 8 sites would exceed 25% of drinking water standards under the Decentralized Alternative. Disposal of CH-LLMW at BNL, FEMP, INEL, LLNL, Paducah, Pantex, and SNL-NM would not exceed 25% of drinking water standards for hazardous constituents. Therefore, disposal at these latter sites is likely to pose less risk of groundwater contamination.

Hazardous constituents that exceed 25% of drinking water standards in the WM PEIS analysis include benzene, carbon tetrachloride, chromium, 1,2-dichloroethane, methylene chloride, selenium, and silver. Only chromium, selenium, and silver would not require reduction of concentrations to meet standards. Of these constituents, the solvents appear to be the most problematic, with methylene chloride requiring reductions at seven sites and with 1,2-dichloroethane requiring reductions at six sites.

Measures that could be used to reduce the concentration of hazardous constituents in the groundwater include those described for radionuclides. In addition, more rigorous treatment could be used to provide a greater removal/destruction efficiency than that assumed in the WM PEIS analysis.

Disposal of RH-LLMW at the Hanford Site, INEL, ORR, and SRS would not exceed 25% of drinking water standards. Reductions of groundwater concentrations of hazardous constituents would not be required for disposal of RH-LLMW.

As illustrated by Table 6.7–1, DOE analyzed the effects of construction site clearing to build LLMW treatment and disposal facilities, and the operation of treatment facilities on ecological resources at representative sites. DOE also considered the effects of accidental spills of LLMW in transportation, extrapolating the results from an assessment conducted for LLW.

Although DOE intends to select sites for waste management activities based on the WM PEIS, the PEIS will not be the basis for selecting specific locations for facilities on the sites. When selecting locations for

Table 6.6–5. Percent of Drinking Water Standards for Hazardous Constituents in Groundwater From Disposal of CH LLMW— Sites Exceeding 25% of Standard [a]

Alternative	Number of Sites		ANL-E	Hanford					LANL		NTS[b]		
	T	D	B	B	CT	DCA	MC	Ag	DCA	MC	B	DCA	MC
No Action	3	--	--	--	--	--	--	--	--	--	--	--	--
Decentralized	37	16	30	100*	60	80	90		50	100*	50		40
Regionalized 1	11	12	--	100*	60	70	90		50	100*			40
Regionalized 2	7	6	--	100*	60	80	90	30	30	70			
Regionalized 3	7	1	--	--	--	--	--	--	--	--	100*	100*	100*
Regionalized 4	4	6	--	100*	70	80	100	30	--	--			
Centralized	1	1	--	100*	100*	100*	100*	40	--	--	--	--	--

Alternative	Number of Sites		ORR			PORTS		
	T	D	B	DCA	MC	B	DCA	MC
No Action	3	--	--	--	--	--	--	--
Decentralized	37	16	50	100*	100*		80	100*
Regionalized 1	11	12	50	100*	100*	30	100*	100*
Regionalized 2	7	6	70	100*	100*	--	--	--
Regionalized 3	7	1	--	--	--	--	--	--
Regionalized 4	4	6	70	100*	100*	--	--	--
Centralized	1	1	--	--	--	--	--	--

Alternative	Number of Sites		RFETS			SRS					
	T	D	CT	DCA	MC	B	Cr	CT	DCA	MC	Se
No Action	3	--	--	--	--	--	--	--	--	--	--
Decentralized	37	16	100*	100*	100*	100*	40	100*	100*	100*	30
Regionalized 1	11	12	100*	100*	100*	100*	40	100*	100*	100*	30
Regionalized 2	7	6	--	--	--	100*	40	100*	100*	100*	30
Regionalized 3	7	1	--	--	--	--	--	--	--	--	--
Regionalized 4	4	6	--	--	--	100*	40	100*	100*	100*	30
Centralized	1	1	--	--	--	--	--	--	--	--	--

Notes: T = treatment; D = disposal; -- = no disposal at this site under this alternative; * = WM PEIS modeling indicates that a reduction in the estimated concentration in the groundwater would be necessary to meet drinking water standards. See Volume II tables for the value of the exceedance. Blanks indicate that a site does not exceed 25% of the standard under the specified alternative.

[a] Only hazardous constituents equal to or above 25% of drinking water standards are listed. See Appendix C for a list of the drinking water standards. Blanks indicate concentrations less than 25% of the standards. Ag = silver; B = benzene; Cr = chromium; CT = carbon tetrachloride; DCA = 1,2-dichloroethane; MC = methylene chloride; Se = selenium.

[b] Note that the NTS EIS (DOE, 1996b) shows no exceedances of groundwater quality comparison criteria from disposal. The values presented here for NTS overestimate potential risks at that site since travel time through the vadose zone to the aquifer has been estimated from field-measured properties to be over two million years (Sully et al., 1995).

6.7 Ecological Resources Impacts

Loss of limited acreages of habitat at some sites during construction of LLMW facilities would not significantly affect populations of nonsensitive plant and animal species because these species habitats are well established regionally. DOE should be able to locate new LLMW facilities to avoid impacts to nearby wetlands and other sensitive habitats because construction site acreages are small compared to the total acreage at each site suitable for waste operations. A screening level risk assessment of facility airborne emissions indicated that terrestrial wildlife species are not likely to be affected. Transportation accidents leading to spills of LLMW into aquatic environments would have serious short and long term consequences; however, the probability of such accidents is low but would increase with increased waste shipping.

Table 6.7–1. Ecological Resources Impacts Analyzed for LLMW Alternatives

Ecological Impact Analyzed	Affected Ecological Resource	Analysis Method	Presentation of Results
Nonsensitive habitat effects	Terrestrial plants and animals	Comparison of habitat loss at LLMW construction sites to general habitat range	Text discussion only
Terrestrial species exposures	Terrestrial animal species	Comparison of estimated radiation dose of representative species with toxicity standard	Text discussion only
Sensitive habitat effects	Nearby wetlands and other sensitive habitats	Likelihood of impacts to nearby sensitive habitats based on comparing construction acreage to available acreage of nonsensitive habitats	Text discussion only
Sensitive species concerns	Federally and State-listed endangered and threatened species	Numbers of Federally and State-listed species displayed by site/alternative	Table 6.7–2
Effects of transportation accidents	Aquatic species in streams crossing transportation corridors	Results of scenario-based modeling analysis of accidental spill; effects on fish in various size streams	Text discussion only

facilities on sites, DOE will consider the results of relevant existing or required new sitewide or project-level NEPA analyses, which would include analyses of potential impacts to sensitive species and habitats based on site-specific conditions.

6.7.1 General Impacts of Site Clearing

None of the alternatives would require extensive site clearing for construction of LLMW facilities. No more than 55 acres would be disturbed at any site, for any alternative. These acreage requirements are small

compared to the available habitat for nonsensitive species represented at the sites. Although site clearing would destroy individual plants and would kill or displace individual animals (particularly small mammals and songbirds with limited home ranges), no significant effects to populations of these species are expected from implementation of any proposed LLMW alternatives because nonsensitive species habitats are well established regionally.

6.7.2 Site Clearing Effects on Sensitive Habitats

For those sites that contain sensitive habitats, the degree to which these habitats may be affected by noise or vibration disturbance, human presence, vehicle or equipment emissions, runoff, or encroachment by nearby LLMW construction activities depends on DOE's ability to avoid siting near those habitats. A measure of this ability is the percentage of available land required at a site for facility construction under any LLMW alternative. Available acreage was estimated from site development plans either using land designated for waste operations or subtracting the acreage of existing structures and sensitive habitats, such as wetlands and wildlife management areas, from the total site acreage. The analysis showed that the percentage of available acreage required for the LLMW facilities ranged from 0.0009% at NTS under the Regionalized 1, 2, and 4 and the Centralized Alternatives to 4.4% at FEMP under the Regionalized 1 Alternative. Considering these small fractions of land required for LLMW facilities, DOE would have a great degree of flexibility in its siting and can employ a range of mitigative measures, so that site clearing to implement any of the LLMW alternatives would not affect adjacent sensitive habitats.

Aquatic resources may be indirectly affected through increased runoff of water and soil to surface waters from construction sites. However, proper construction practices would minimize these effects. Direct discharges to surface waters from the routine operation of treatment facilities would comply with applicable regulations and would be limited by the use of accepted engineering techniques. Therefore, the impacts to aquatic organisms are expected to be minimal.

6.7.3 Effects of LLMW Treatment Facility Emissions

DOE used atmospheric emissions and deposition modeling to estimate the toxicity to terrestrial animals from airborne emissions of radionuclides and hazardous chemicals from treatment facilities. This analysis used

the same atmospheric emissions estimates as the human health risk assessment and provided estimates of radionuclides and hazardous chemicals deposited on surface soils.

For this analysis, DOE examined those sites with the highest anticipated emissions. Six radionuclides were evaluated: tritium, Ni-63, Cs-137, Pu-241, Th-234, and U-238. Potential toxicity to terrestrial wildlife was analyzed for selected sites for these radionuclides, which comprise 80% of the total activity expected to be emitted. The remaining activity was contributed by smaller emissions of a large number of radionuclides. The conservative assumptions used to characterize the scenario (e.g., accumulation of contaminants for 10-year period with no loss due to decay or transport) might compensate for limiting the analyses to 80% of the released activity.

The concentrations of these radionuclides were used in calculating Hazard Indexes for each selected site/alternative combination as composite ratios between the estimated species exposures to each of the contaminants and known, contaminant-specific toxic levels. A Hazard Index greater than one would indicate a potential for the combined exposures to adversely affect the health of terrestrial species. Nine hazardous chemicals were evaluated—arsenic, barium, cadmium, chromium VI, cyanide, lead, mercury, selenium, and silver. The resulting maximum estimated Hazard Index values for the radionuclides and for the chemicals were less than 0.01. Therefore, no impacts to terrestrial animal populations are expected from LLMW facility airborne emissions.

6.7.4 Consideration of Sensitive Species

For comparison of the LLMW management program's potential to affect sensitive species, Table 6.7–2 lists the numbers of Federally and State-listed endangered and threatened species occurring or potentially occurring at each LLMW site under each alternative. Site-specific analysis would be required for an assessment of sensitive species impacts. That analysis would take into account specific locations for the LLMW facilities in relation to the location of sensitive habitats and sensitive species at each site, including species listed by the U.S. Fish and Wildlife Service as endangered or threatened.

Table 6.7–2. Numbers of Federally Listed and State-Listed Endangered and Threatened Species Occurring or Potentially Occurring at the LLMW Sites by Alternative (Federal/State)

Alternative	Number of Sites		ANL-E	BNL	FEMP	Hanford	INEL	LANL	LLNL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP
	T	D																
No Action	3	NA	2/5	2/6	2/10	3/11	2/2	2/4	6/5	2/2	1/11	9/12	5/8	1/9	2/2	1/8	8/8	1/8
Decentralized	37	16	2/5	2/6	2/10	3/11	2/2	2/4	6/5	2/2	1/11	9/12	5/8	1/9	2/2	1/8	8/8	1/8
Regionalized 1	11	12	--	--	2/10	3/11	2/2	2/4	6/5	2/2	1/11	9/12	5/8	1/9	2/2	--	8/8	--
Regionalized 2	7	6	--	--	--	3/11	2/2	2/4	--	2/2	1/11	--	--	1/9	2/2	--	8/8	--
Regionalized 3	7	1	--	--	--	3/11	2/2	2/4	--	2/2	1/11	--	--	1/9	2/2	--	8/8	--
Regionalized 4	4	6	--	--	--	3/11	2/2	2/4	--	2/2	1/11	--	--	--	--	--	8/8	--
Centralized	1	1	--	--	--	3/11	--	--	--	--	--	--	--	--	--	--	--	--

Notes: T = treatment; D = disposal; NA = not applicable; -- = no major actions are proposed for the site under the alternative.

6.7.5 Effects of LLMW Transportation Accidents

DOE believes that the radiologic effects on aquatic resources from transportation accidents involving LLMW would be similar to those estimated for LLW (See Chapter 7, Section 7.7.5). However, because LLMW also contains hazardous chemical components, transportation accidents could result in greater adverse effects to aquatic resources depending upon the specific chemical constituents contained in the waste. The number of expected accidents is related to the total number of miles traveled during LLMW shipment. Thus, as fewer shipments of LLMW occur, as in the Decentralized Alternative, the number of accidents is expected to decrease. The greatest potential for such accidents is under the Centralized Alternative. The toxic effects on aquatic resources from hazardous constituents in LLMW may be severe immediately following a spill, depending upon the chemicals involved, but are unlikely to have long-term effects due to emergency spill response efforts.

6.8 Economic Impacts

Nationwide, the largest economic effects resulting from LLMW management would be for the Decentralized Alternative and generally decrease as the alternatives become more Centralized. The greatest benefit at any site occurs when LLMW is treated, stored and disposed of at that site. The greatest percentage increases in the number of jobs would occur at the Hanford Site and INEL. The national economy would not be affected by total project expenditures for the construction, operation, or transportation to LLMW facilities under any alternative (DOE, 1995a).

DOE estimated the effects of expenditures for LLMW management on the local and national economies (Table 6.8–1). Local economic effects were based on direct expenditures at each site for construction, operation and maintenance, and decontamination of treatment and disposal facilities. The socioeconomic region of influence (ROI), where local effects were evaluated, consists essentially of the counties of residence of site employees. The local economy at each site was represented by employment, personal income, and industry data for the ROI counties. Local jobs and personal income were considered to be substantial benefits where they were 1% or greater than the 1990 baseline. Transportation expenditures were considered at a national level only.

Table 6.8–1. Economic Impacts Analyzed for LLMW Alternatives

Economic Impact Analyzed	Affected Aspect of the Economy	Analysis Method	Presentation of Results
Increased regional employment	Regional employment for direct, indirect, and induced jobs	Proposed site expenditures for LLMW management multiplied by regional employment multiplier at each LLMW site	Text discussion only
Increased regional incomes	Regional personal income	Proposed site expenditures for LLMW management multiplied by regional income multiplier at each site	Text discussion only
National economic effects	National employment and personal income	Proposed site expenditures at all LLMW sites and total transportation expenditures multiplied by national employment and income multipliers	Text discussion only

Local economic effects were estimated on an annual basis. The impacts resulting from the construction and operation phase expenditures were combined to estimate total project effects at each site. For all alternatives, except No Action, construction was assumed to take 4 years of the 10-year construction period; the operations phase was assumed to take 15 years (a 10-year operations and maintenance period and a 5-year decontamination period undertaken after the conclusion of operations). Under the No Action Alternative, in place of distinct construction and operational phases, all costs were assumed to occur in a 20-year work off of all existing waste (plus 5 years for decontamination and decommissioning). Five years were added to the decontamination and decommissioning phase to account for the continued effects on employment and income after each project phase ended. Job and personal income increases are shown for each site in the Volume II site tables.

Across the LLMW alternatives, only the Hanford site, INEL, and Portsmouth regions would experience greater than a 1% change in the number of new direct, indirect, and induced jobs as a result of expenditures to implement the alternatives. The Hanford region would experience an increase in the number of direct, indirect, and induced jobs of 1.7% under the Centralized Alternative. Regionalized Alternative 4 would result in the greatest increase in the number of regional jobs at INEL which is 2%. In the Decentralized and Regionalized 1, 2 and 3 Alternatives, the INEL region would experience a change ranging from 1.4% to 1.6% in the number of jobs in its ROI. The Portsmouth region would experience an increase in the number of new jobs of about 1% in the Decentralized Alternative and Regionalized Alternatives 1, 2 and 3. No ROIs would experience a 1% or greater increase in personal income under any of the alternatives.

The sum of the new direct, indirect, and induced jobs from the combined weighted construction and O&M activities across site ROIs for all the alternatives ranges from approximately 3,840 (under the No Action Alternative) to 11,250 (under the Decentralized Alternative).

In addition to analyzing the impacts on the regional economy, a comparison of these impacts was made on the national economy. None of the LLMW alternatives would substantially affect the national economy. The total number of jobs generated in the national economy from combined weighted construction and operations phase activities ranges from 5,650 under the No Action Alternative, due to long-term storage requirements, to 16,500 jobs under the Decentralized Alternative. Although the number of jobs appears large in absolute terms, 16,500 jobs represent only 0.01% of the 137 million jobs in the national economy. There are no substantial changes in personal income for the nation as a whole as a result of implementing any of the alternatives. It is likely that any changes would represent a shift in the source of income from previous employment to employment in LLMW projects rather than a net change in national personal income.

6.9 Population Impacts

No major population increases are expected at any site under any alternative, and thus community characteristics and the provision of services would not be affected.

Potential population changes in the ROI at each LLMW site were estimated using the direct labor requirement to calculate potential worker in-migration. These estimates were used to evaluate the likelihood that population changes would cause effects, such as changes in community size and diversity, and effects on the provision of necessary services.

No site would experience 1% or greater increases in the ROI population. Regions containing two sites—INEL under Regionalized Alternative 4 and the Hanford site under the Centralized Alternative—would experience an estimated population increase of more than one-half of 1%, which may marginally affect community characteristics and services.

6.10 Environmental Justice Concerns

Assessment of potential environmental justice impacts from management of LLMW indicated that minority and low-income populations at the LLMW sites would not experience disproportionately high and adverse health risks or environmental impacts under any of the LLMW alternatives.

Analysis of environmental justice impacts from management of LLMW was based on a review of the impacts reported in this chapter regarding the LLMW alternatives. This analysis was performed to identify any disproportionately high and adverse human health or environmental impacts on minority populations or low-income populations surrounding each of the 16 major LLMW sites. Chapter 5 summarizes the methods and Appendix C provides the details of how this analysis was done and includes maps illustrating the distribution of minority and low-income populations residing within 50 miles of each LLMW site.

6.10.1 RESULTS

The potential for adverse human health effects from exposures to radionuclide emissions from LLMW treatment facility operations is low for all LLMW management alternatives for all LLMW sites. Incident-free LLMW treatment facility operations were analyzed (see Section 6.4.1) in terms of risk to workers and the public. The analysis indicated that incident-free operations present no significant risk and do not constitute a reasonably foreseeable adverse impact to the population surrounding any site. No disproportionately high and adverse health effects would be expected for any particular segment of the population, minority populations and low-income populations included. The number of potential fatalities due to both radiological and nonradiological exposures to truck or rail transportation of LLMW is small. A more detailed analysis of environmental justice impacts would be presented in NEPA reviews that deal with site-specific activities.

6.10.1.1 Transportation

Because incident-free LLMW transportation and reasonably foreseeable transportation accidents are not expected to result in disproportionately high and adverse human health effects to minority or low-income populations, no environmental justice impacts are expected. As Section 6.4.2 indicates, the estimated total

cancer fatalities resulting from incident-free transportation are less than 0.5 under all LLMW alternatives. The expected number of cancer fatalities due to radiation exposure from transportation accident releases, taking into account both the consequences of such a release and the probability that such a release will occur, is less than 0.5 under all alternatives. The expected number of transportation accident fatalities from trauma is no higher than 1 under any LLMW alternative. Therefore, disproportionately high and adverse health effects to minority or low-income populations from LLMW transportation are not expected to occur.

6.10.1.2 Environmental Impacts

In addition to the above, reviews of other technical disciplines pursuant to the methodology in Section 6.10 did not indicate any adverse impacts to water resources, ecology, economics, populations, land use, infrastructure, or cultural resources. Air quality impacts are possible at three sites, but no disproportionately high and adverse impacts are expected for any segment of the population.

None of the alternatives would have an adverse impact on land use, ecology, or cultural resources because of the limited amount of previously undisturbed land which would be needed for use onsite (no offsite lands are involved) and the mitigation programs already in place. These programs include working closely under agreements with State Historical Preservation Officers and Tribal governments regarding preservation of historic and cultural resources. Consultations with Tribal governments have expanded the DOE's awareness of Tribal interests and values with respect to nature, religion, and the land, and are designed to avoid or relocate these resources if possible. If avoidance were not possible, data recovery (such as archiving artifacts) or other mitigation measures may be developed in consultation with affected Tribes and the respective State Historical Preservation Officer, as appropriate. Similarly, the DOE is aware of sensitive ecological resources, and avoids wetlands and endangered plant or animal species habitats. Disturbance of certain ecological resources (which are not federally listed as threatened or endangered) is possible, but not likely. The reasonably foreseen environmental impacts, if any, to land use, ecological resources, or cultural resources are expected to be small under any of the alternatives, and DOE expects no disproportionately high and adverse environmental impacts to minority and low-income populations at the LLMW sites.

6.11 Land Use Impacts

Only at FEMP, under the No Action, Decentralized, and Regionalized Alternative 1, did the land requirement for facility construction exceed the 1% threshold of the acreage designated or suitable for waste operations. Further evaluation indicates the land requirements at FEMP are not expected to impact current onsite or offsite land uses. Site development plans indicated no conflict between proposed treatment or disposal facilities and other plans for the LLMW sites.

DOE examined the impacts of the LLMW alternatives on land use by comparing the acreage required for new treatment and disposal facilities to the acreage either designated for waste operations or suitable for development (see Table 6.11-1). Suitable land is the total site acreage, minus the acreage required for known cultural resource areas, sensitive habitats (including wetlands and wildlife management areas), prohibitive topographic features, and surface waters. Available site development plans were also used to identify potential conflicts among the proposed facilities required under each alternative and plans for future site uses.

Under all alternatives, only the land requirements at FEMP exceeded the 1% threshold. In addition, proposed treatment or disposal facilities were not in conflict with the development plans for any site.

For FEMP, the 1% threshold was exceeded when facilities were built or expanded: the No Action Alternative would require 2.3% (6 acres) of the designated waste management area, the Decentralized Alternative would require 3.1% (9 acres), and Regionalized Alternative 1 would require 4.5% (12 acres). However, because only a small fraction of the 275 acres of designated waste operations land at FEMP is

Table 6.11-1. Land Use Impacts Analyzed for LLMW Alternatives

Land Use Impact	Affected Resource	Analysis Method	Presentation of Results
Effect on land use onsite at each LLMW site	Land use shown in site development plans	Comparison of required acreage with amount designated (or estimated) for LLMW in site development plan—all instances where requirements are 1% or higher are noted	Text discussion only
Conflicts with offsite uses	Adjacent land use	Consideration of conflict between proposed LLMW uses and nearby land uses	Text discussion only

required under these alternatives, no significant onsite land use impacts are expected to occur. For the same reason, no conflicts with adjacent land uses are expected.

Although DOE intends to select sites for waste management activities based on the WM PEIS, the PEIS will not be the basis for selecting specific locations for facilities on the sites. When selecting locations for facilities on sites, DOE will consider the results of relevant existing or required new sitewide or project-level NEPA analyses, which would include analyses of potential land-use conflicts or restrictions at particular locations within a site.

6.12 Infrastructure Impacts

Although no offsite infrastructure impacts are expected to occur, proposed LLMW activities would affect the onsite infrastructure at 14 sites. Nine sites experience increased requirements for water, wastewater treatment, or electrical power of 5% or greater of current system capacity. However, only the wastewater requirement at the Hanford Site (under the Centralized Alternative) is estimated to exceed the existing treatment capacity. Onsite transportation infrastructure would be affected at 12 sites because of site employment increases of 5% or more above current levels.

DOE evaluated the impacts on site infrastructure by comparing existing onsite capacities to requirements for water, wastewater treatment, and power (see Table 6.12–1). Water and power were evaluated for both construction and operations; wastewater treatment was evaluated only for operations because wastewater from construction activities was assumed to be negligible. Where onsite maximum capacity information was unavailable, the proposed requirement was evaluated as a percentage of current use. Increased site employment was used as an indicator of potential impacts to onsite transportation infrastructure. Offsite infrastructure impacts were evaluated using estimates of increased population from the proposed activities as an indicator of increased demand on the community infrastructure.

Table 6.12–2 shows the increase in onsite demand for water, wastewater treatment, and power at sites where the increase exceeds 5%. The potential for a major impact is assumed to exist where an increase of 5% or greater causes total demand to exceed 90% of capacity. A moderate impact is assumed where total demand remains below 90% of capacity. Impacts to offsite infrastructure are not expected because population increases do not exceed 5% at any site under any alternative.

Table 6.12–1. Infrastructure Impacts Analyzed for LLMW Alternatives

Infrastructure Impact Analyzed	Affected Infrastructure Elements	Analysis Method	Presentation of Results
Onsite capacity to support LLMW facilities	Onsite water, power, and wastewater systems	Add increased LLMW facility use to current use—compare to current capacities	Table 6.12–2
	Onsite transportation infrastructure	Compare new site employment with current site employment as an index of increased stress	Table 6.12–3
Capacity of community infrastructure to support increased worker populations and their families	Regional water, power, wastewater, and transportation infrastructure	Compare population increase with current regional population as an index of increased demand	Text discussion only

Table 6.12–2. Increase in Demand for Water, Wastewater Treatment, or Power as a Percent of Current Capacity—LLMW Sites With Increases Exceeding 5%

Alternative	Number of Sites		ANL-E	FEMP	Hanford	INEL	LANL	LLNL	NTS	RFETS	SRS
	T	D									
No Action[a]	3	NA	**P (19)**	P (8)		P (25)	P (8)	P (10)	P (9)	P (31) W (8)	P (6)
Decentralized	37	16		P (7)		P (13)			P (15) Ww (6)	P (33) W (9)	
Regionalized 1	11	12	--			P (13)				P (33) W (9)	
Regionalized 2	7	6	--	--	Ww (5)			--		P (5)	
Regionalized 3	7	1	--	--				--	P (8)	P (5)	
Regionalized 4	4	6	--	--	Ww (5)	P (6)		--			
Centralized	1	1	--	--	**Ww (22)**	--	--	--			--

Notes: T = treatment; D = disposal; NA = not applicable; W = water; Ww = wastewater; P = power; -- = no major actions are proposed for the site under the alternative. Bold indicates major impact, all others moderate. Blank cells indicate less than 5% of current capacities. Numbers in parentheses represent percentage increases.

[a] The No Action Alternative includes impacts from only the first 20 years of indefinite storage of LLMW. Beyond 20 years, waste storage infrastructure requirements would be expected to be the same or greater; however, site infrastructure capacity changes could change the percentages in the table. See Section 6.16 for additional information on longer term impacts.

As shown in Table 6.12–2, most of the infrastructure impacts relate to demand for power. Major wastewater treatment impacts would occur only at the Hanford Site under the Centralized Alternative, increasing the current demand by 22%. A further evaluation found that this increase also could cause the current system capacity to be exceeded by 1%. If new construction were needed to increase system capacity, additional environmental impacts and costs would result.

Table 6.12–3 identifies sites at which the increase in site employment from construction activities exceeds 5%. These sites could experience impacts to the onsite transportation infrastructure from increased worker traffic (DOE, 1995a).

6.13 Cultural Resources Impacts

Construction of LLMW facilities could adversely affect cultural resources. When selecting locations for waste management facilities on sites, DOE will consider the results of relevant existing or required new sitewide or project-level NEPA analyses, which would include analyses of potential impacts to cultural resources based on site-specific conditions.

Cultural and paleontological resources, including prehistoric, historic, fossil, and Native American sacred sites (Executive Order 13007) may be affected at sites where LLMW treatment and disposal facilities are proposed to be built. Table 4.3–8 in Chapter 4 describes the status of cultural resources surveys at the 16 major proposed LLMW sites and lists the reported cultural resources at those sites. However, the impacts of the construction of LLMW facilities on cultural resources cannot be effectively analyzed at the programmatic level because the extent of those impacts depends upon their specific location at a site (DOE, 1995a).

Although DOE intends to select sites for waste management activities based on the WM PEIS, the PEIS will not be the basis for selecting specific locations for facilities on the sites. When selecting locations for facilities on sites, DOE will consider the results of relevant existing or required new sitewide or project level NEPA analyses, which would include analyses of potential impacts to cultural resources based on site-specific conditions.

Table 6.12–3. Percent Increase in Site Employment From Construction—LLMW Sites With Employment Increases Equal to or Greater Than 5%

Alternative	Number of Sites		FEMP	Hanford	INEL	LANL	LLNL	ORR	Pantex	PGDP	PORTS	RFETS	SRS	WVDP
	T	D												
No Action[a]	3	--			5							7		5
Decentralized	37	16	13		7	6		5	5	11	20	14		
Regionalized 1	11	12	20		7	6	6	5	5	8	20	14		
Regionalized 2	7	6	--		6	8	--	5		--	19	11		
Regionalized 3	7	1	--		5	6	--			--	19	11		
Regionalized 4	4	6	--		9		--	6		--	5	5	5	
Centralized	1	1	--	14		--	--			--	5	5		

Notes: T = treatment; D = disposal; NA = not applicable; -- = no major actions are proposed at the site under the alternative. Blank cells indicate site employment increases of less than 5%.

[a] The No Action Alternative includes impacts from only the first 20 years of indefinite storage of LLMW. Beyond 20 years, requirements to rehabilitate or replace aging facilities could result in equal or greater impacts from construction. See Section 6.16 for additional information on longer term impacts.

Land requirements for the construction of LLMW waste management facilities are sufficiently small under all alternatives so that DOE would probably have enough flexibility in siting LLMW facilities to avoid impacts on cultural resources. If not, measures would be taken to mitigate negative effects on these resources.

6.14 Costs Impacts

Costs decrease as the number of treatment and disposal sites decrease, ranging from $12.3 billion for the Decentralized Alternative to $7.7 billion for the Centralized Alternative. Transportation costs are much lower than facility costs, making shipment to available facilities at another site generally less expensive than building a new facility on site.

As indicated in Table 6.14–1, DOE estimated costs for building and operating treatment and disposal facilities, and for transportation (INEL, 1995a,b). DOE evaluated costs associated with LLMW management from both a life-cycle and process perspective, using 1994 dollars.

Table 6.14–1. Components of Cost Analysis

Impacts Assessed	Function Analyzed	Activities for Which Impacts Are Assessed	Location of Impacts Assessment
Process Costs	Treatment	Life-cycle costs for treatment including support facilities	Table 6.14–2
	Storage[a]	Life-cycle costs for storage facilities	Table 6.14–2
	Disposal[b]	Life-cycle costs for disposal facilities	Table 6.14–2
Transportation Costs	Truck	Inter-site common carrier costs for transportation from generating sites to treating sites, and to disposal sites	Table 6.14–2
	Rail	See above	Table 6.14–2

[a] No Action Alternative includes 20 years of storage and limited operations and maintenance.
[b] Disposal includes closure and 300 years of post-closure custodial support.

6.14.1 LIFE-CYCLE COSTS

DOE evaluated facility costs for four phases representing the life cycle of the facilities and their operations: pre-operations, construction, operations and maintenance, and decontamination and decommissioning. Life-cycle costs do not include speculative factors, such as the impacts on long-term value of land.

Costs for pre-operation activities consist of technology and site adaptation, including bench-scale tests and demonstrations; permitting; plant startup and cold run costs; and related reference design, safety analysis, project management, and contingencies.

Facility construction costs consist of building construction, equipment purchase and installation, contractor overhead, and related design, construction management, project management, and contingencies. Mobilization and demobilization costs are included for portable treatment units.

Operations and maintenance costs consist of annual operations labor and material, maintenance labor and equipment, utilities, contractor supervision and overhead, and related project management and contingencies.

Decontamination and decommissioning costs consist of facility decontamination and demolition, closure, post-closure, and environmental monitoring activities.

6.14.2 PROCESS COSTS

DOE also analyzed costs based on treatment, storage, and disposal activities. Treatment costs include costs to build and operate treatment facilities (such as grout solidification or thermal destruction) and common support facilities (such as maintenance and certification/shipping facilities).

For the purpose of the WM PEIS analysis, LLMW storage capacity is assumed to be sufficient, except for the No Action Alternative. DOE estimated the costs to build and operate sufficient storage capacity to contain all LLMW managed in the No Action Alternative.

Disposal costs include costs to build and operate front-end administration and receiving facilities for disposal as well as the actual disposal units.

Transportation costs include the costs associated with the physical movement of the waste from one site to another, for either treatment or disposal. Transportation costs are evaluated for both truck transportation and rail shipments (INEL, 1995a).

The summary of costs is shown in Table 6.14–2 (INEL, 1996). Construction accounts for 27% to 32% of the total costs and O&M accounts for 56% to 55% of those costs. As waste is consolidated at fewer sites, costs for treatment and disposal facilities decrease, reflecting the economy of scale of using larger and fewer facilities. The difference between the Decentralized Alternative and Centralized Alternative is $4.6 billion—of which $3.0 billion (65%) would be for treatment.

Under the No Action Alternative, DOE would treat LLMW at existing or planned facilities, and would then store the waste for the period of analysis. Although the costs for this alternative are the lowest of any LLMW alternative, the No Action Alternative does not comply with RCRA. The No Action Alternative costs provide a baseline for comparison with the other alternatives that would be in compliance.

Table 6.14–2. Life-Cycle Costs (Billions of 1994 Dollars)

Alternative	Number of Sites		Total Costs[a] (Including Truck Transportation)	Life-Cycle Costs				Process Costs			Transportation Costs	
	T	D		Pre-ops	Const	O&M	D&D	T	S[b]	D	Truck	Rail
No Action[c]	3	NA	5.2	0.4	1.4	2.7	0.7	2.5	2.7	0	0	0
Decentralized	37	16	12.3	1.4	3.9	6.1	0.9	9.8	0	2.5	0.001	0.0007
Regionalized 1	11	12	11.0	1.1	3.3	5.7	0.9	8.6	0	2.4	0.004	0.002
Regionalized 2	7	6	9.5	0.9	2.8	5.1	0.7	7.6	0	1.9	0.02	0.005
Regionalized 3	7	1	8.4	0.8	2.5	4.6	0.5	7.6	0	0.7	0.06	0.02
Regionalized 4	4	6	8.4	0.8	2.4	4.7	0.5	7.0	0	1.4	0.006	0.005
Centralized	1	1	7.7	0.7	2.2	4.3	0.5	6.8	0	0.9	0.03	0.01

Notes: T = treatment; S = storage; D = disposal; NA = not applicable; Pre-ops = preoperations; Const = construction; O&M = operations and maintenance; D&D = decontamination and decommissioning.

[a] Total Facility Costs are presented twice in this table: as life-cycle costs and as process costs. The sum of life-cycle costs is equal to the sum of process costs. Total Costs, also in the table, add truck costs to the facility costs. Therefore, Total Costs equals the sum of life-cycle costs and truck costs and also equals the sum of process costs and truck costs.

[b] RCRA-compliant storage facilities are constructed under the No Action Alternative; for the other alternatives, the existing onsite storage was assumed to be adequate since treatment or packaging for transportation to regional treatment sites would reduce the amount of waste currently being stored on the site. The cost of current storage is included in the site infrastructure accounts which are not included in this PEIS.

[c] Costs under the No Action Alternative include those from only the first 20 years of indefinite storage; see Section 6.16 for additional information on longer term impacts.

Although the quantity of waste requiring transport is at its maximum in the alternatives that centralize functions at NTS or the Hanford Site, the relative proportion of transportation costs remains small, less than approximately 0.7% of total costs.

6.15 Environmental-Restoration-Transferred Waste

The volume of LLMW generated by environmental restoration activities that would be transferred to the waste management program is currently estimated to be about 90% of the volume of waste management LLMW. Because the radiological profiles and physical characteristics of the environmental restoration (ER) transferred LLMW have not yet been determined to the extent necessary to allow a meaningful evaluation of the potential environmental and human health impacts, the ER transferred LLMW volumes are discussed separately in the WM PEIS. When the radiological profiles and physical characteristics of the ER transferred waste are better known, DOE may be required to assess the impacts of managing the ER transferred LLMW on a site-specific basis.

DOE is responsible for the management of wastes currently in inventory and those generated by future operations (referred to as "waste management" wastes). As discussed in Chapter 1, DOE is also responsible for the management and remediation of contaminated media, including soils, groundwater, and buildings. DOE expects that most of the contaminated media at its sites will be remediated under the Environmental Restoration Program. The extent to which media are "cleaned up" is site specific and will depend largely on regulatory requirements and decisions regarding future land use. For analyses purposes, a standard "base case" scenario has been developed that estimates remediation costs across the DOE complex (DOE 1996c). Although most waste generated by cleanup activities will be managed within the Environmental Restoration Program, a certain subset of the waste generated by these activities will be transferred to waste management facilities. In this PEIS, these wastes are referred to as "environmental restoration (ER) transferred wastes." At present, only estimates of the volumes of ER transferred waste are available. These estimates were used to provide a qualitative assessment about how the addition of ER transferred waste may affect LLMW alternatives.

Appendix B provides more detail on how certain wastes generated during environmental restoration will be transferred to the waste management program for final disposition, and provides estimates of the volumes of ER transferred LLMW. Appendix B also discusses the assumptions and uncertainties involved in assessing how ER transferred LLMW may affect waste management alternatives.

To conduct a health risk impact analysis for the additional ER transferred LLMW similar to that conducted for waste management LLMW, additional information is needed on the ER transferred waste streams. In addition to the volume of ER transferred waste, information is needed on the treatability of the individual transferred LLMW streams that would include data about the radiological profile, chemical constituents, and physical form of the ER transferred waste. The wastes would also have to be categorized according to alpha and non-alpha radionuclide composition. Physical characterization of the ER transferred wastes into one of the treatment categories identified for LLMW is needed to estimate management costs. Information about the timing for the transfer of ER wastes to the waste management program is needed to determine the capacities of treatment and disposal facilities. This information is also crucial to conduct transportation and socioeconomic analyses. However, in many cases, this information will not be available until site-specific cleanup is conducted.

To identify how the addition of ER transferred LLMW could affect the comparison among waste management alternatives in the WM PEIS, DOE compared the volumes of waste management LLMW with the expected volumes of ER transferred LLMW. This analysis reveals the potential for overloading treatment facilities for those sites and alternatives where the volumes of ER transferred LLMW are projected to equal or exceed the volumes of waste management LLMW. Strategies to manage the additional loading of ER transferred LLMW in order to avoid overloading facilities include increasing operational capacity and operating a facility longer to "work off" the increased waste load. The WM PEIS treatment facilities are assumed to have an operational life of at least 30 years, which allows for an additional 20 years of operational capacity beyond the 10 years needed to work off the waste management wastes.

Increased radiation and chemical exposure risks to site workers, offsite populations, and the environment are related to the chemical constituents and radiological activity in the ER transferred wastes which, at present, cannot be reliably predicted. However, because radiological activities and chemical concentrations in ER transferred waste are, in general, expected to be lower than those for comparable waste management waste, risks from the addition of ER transferred wastes are expected to be lower than the risks resulting from the treatment of equivalent volumes of waste management wastes. Site-specific performance assessments would be conducted and appropriate restrictions would be imposed to manage any potential increased risks. The risks from physical hazards associated with operating facilities to manage the ER transferred waste are related to the volume relationship between the ER transferred and waste management wastes. Transportation risks and costs are also dependent upon waste volumes rather than the composition of the waste.

Overall, the volume of ER transferred LLMW is expected to be about 90% of the waste management LLMW load (200,000 cubic meters compared with 219,000 cubic meters, respectively). See Table B.6–1. The additional ER transferred waste would affect waste treatment at two sites, RFETS and SRS under the Decentralized and Regionalized Alternatives (see Table B.7–2). The ER transferred LLMW load at RFETS is expected to be up to 200% of the waste management LLMW load while at SRS the ER transferred LLMW is expected to be 750% of the waste management LLMW. The additional ER transferred LLMW would have little effect on the Centralized Alternative.

6.16 Comparison of Alternatives Summary

The LLMW impacts were evaluated across all the LLMW alternatives to identify trends and ultimately the preferred alternative. Although some impact areas, including cost, illustrated clear trends across the alternatives, most did not. Rather, the analysis of the impacts illustrated sensitivities at particular sites, regardless of the alternative.

The following discussion focuses on each impact area, identifying alternative trends when appropriate, and highlighting noteworthy findings at particular sites.

Health Risks. Risks at sites treating or disposing of LLMW are principally to workers, rather than for other receptor groups, driven by physical injury hazards. As the number of sites decreases, facilities become larger and programwide physical injuries decrease, reflecting an economy of scale and fewer total workers.

The most important influence on offsite population risk is treatment of tritium in the Decentralized and Regionalized 1 Alternatives. There are no other notable trends for offsite population risks.

For disposal, concentrations of radionuclides and chemicals in the groundwater near disposal facilities could exceed applicable standards at several sites, demonstrating the need for performance-based waste acceptance criteria and other site-specific considerations. More extensive pretreatment of chemicals and management of radionuclide concentrations and waste forms could be required to assure acceptable water quality and human health risks. One of the most prevalent causes of the exceedances was unconstrained disposal of uranium-238 at the Hanford Site and SRS, which was evaluated under most of the alternatives. Disposal

of LLMW containing this radionuclide must be carefully managed at these sites. Exceedances were also recorded for all disposal alternatives at FEMP (uranium-driven), SNL-NM (plutonium-driven), and ORR (disposal of contact-handled and remote-handled waste with high concentrations of uranium-238, technetium-99, and plutonium-239 and plutonium-240). Up to four chemicals could exceed standards at seven sites, demonstrating the need for more rigorous pretreatment and primary treatment to meet LDRs than was evaluated in the WM PEIS.

Intruder risks are generally higher at sites that combine high radioactivity and long-lived radionuclides. These risks decrease with time, with the lowest risks after 300 years experienced at three sites with new disposal facilities in the Decentralized Alternative (BNL, the Pantex Plant, and SNL-NM). Transportation risks are low in all alternatives, reflecting low vehicle miles.

Air Quality Impacts. The management of LLMW does not affect the air quality at most sites. However, centralization of treatment at Hanford could cause adverse air quality impacts requiring special emission control measures for criteria air pollutants. Emissions from equipment and vehicles during construction at RFETS could result in adverse air quality impacts if the waste at this site is managed onsite as proposed in the Decentralized and Regionalized 1, 2, and 3 Alternatives. Emissions of hazardous air pollutants, including radionuclides, were estimated to be below the applicable standards at any site.

Water Resources Impacts. Impacts to water availability tend to decrease as the LLMW management facilities are Centralized. Major impacts to water availability from increased water use at the sites are unlikely, although there is the potential for adverse impacts at LLNL–Site 300.

Impacts to water quality were discussed under health risks. Careful management of waste through performance-based acceptance criteria would be required, as well as careful selection of technology, to avoid exceedance of drinking water standards at a number of sites.

Ecological Resources, Cultural Resources, Environmental Justice Concerns, and Land Use. The WM PEIS did not provide discriminators among the alternatives in these four impact areas. The programmatic analysis that was conducted did not reveal any major impacts in any alternative. However, impacts to ecological and cultural resources are dependent to some degree on specific technologies and their location at each site. These were not determined at the programmatic level of the WM PEIS, and consequently these impact areas would be evaluated in more detail when such site-level details are evaluated. Assessment of

potential environmental justice impacts indicated that minority and low-income populations at the LLMW sites would not experience disproportionately high and adverse impacts under any LLMW alternative. Land use is not a discriminator because the LLMW alternatives do not use much land compared to the amount available at every site.

Economic Impacts. Nationwide, the largest economic effects resulting from LLMW management would be for the Decentralized Alternative and generally decrease as the alternatives become more Centralized. The greatest benefit at any site occurs when LLMW is managed at that site. The greatest percentage increases in the number of jobs would occur at the Hanford Site in the Centralized Alternative and INEL in Regionalized Alternative 4. The national economy would not be affected by total project expenditures for the construction, operation, or transportation to LLMW facilities under any alternative.

Population Impacts. No major population increases are expected at any site under any alternative, and thus community characteristics and the provision of services would not be affected.

Infrastructure Impacts. Although no offsite infrastructure impacts are expected to occur, proposed LLMW activities would affect the onsite infrastructure at 14 sites. Nine sites experience increased requirements for water, wastewater treatment, or electrical power of 5% or greater of current system capacity. Greatest increases are at RFETS in the Decentralized and Regionalized Alternative 1, and the Hanford Site in the Centralized Alternative, when waste is consolidated for treatment and disposal at these sites. However, only the wastewater requirement at the Hanford Site (under the Centralized Alternative) is estimated to exceed the existing treatment capacity. Onsite transportation infrastructure would be affected at 12 sites because of site employment increases of 5% or more above current levels.

Costs. Costs decrease as the number of treatment and disposal sites decrease, ranging from $12.3 billion for the Decentralized Alternative to $7.7 billion for the Centralized Alternative. Transportation costs are much lower than facility costs, making shipment to available facilities at another site generally less expensive than building a new facility onsite. Actual cost differences have not been calculated for this document for the privatization or commercialization of DOE waste management activities. The reason for pursuing both privatization and commercialization is the belief that private vendors could be able to perform the same tasks faster and at a lower cost than DOE, through innovative technology, efficient oversight, and application of other streamlined business practices. In the experience of other institutions that have

attempted privatization, savings are more common than increased costs. The details of cost estimating are covered in Section 5.3.3 of Chapter 5.

Summary of Impacts by Alternative. Tables 6.16–1 and 6.16–2 summarize key impacts for each alternative.

Long-Term (Beyond 20 Years) Effects of Indefinite Storage Under the No Action Alternative. The risks, environmental impacts, and costs identified in the WM PEIS from storage of LLMW under the No Action Alternative are based on a 20-year period of analysis. As shown in Tables 6.16–1 and 6.16–2, these impacts and costs are less than for the action alternatives in some impact categories. Impacts are expected beyond this 20-year time frame, however, not only as a result of routine indefinite storage operations, but also from degradation of facilities and containers. These impacts are likely to be greater than those for the first 20 years. This differs from the effects predicted for the action alternatives for management of the 20-year forecast of LLMW, where risks to workers and to the offsite population and other impacts and costs are greatly reduced following disposal. (Potential migration of contaminants into the environment and potential intrusions, which could result in long-term risks for all alternatives, are discussed further below.)

For the period beyond 20 years, risks and other impacts associated with monitoring and maintaining the LLMW storage facilities are likely to increase as waste containers and storage facilities deteriorate. Added to the 20-year risks presented in the No Action Alternative would be those to the public from increased package and facility emissions and to workers from increased inspections and corrective actions around degrading facilities. At some point beyond 20 years, increasing maintenance would require replacement of the facilities and repackaging of the waste. The risks and costs of such actions would be greater than for the earlier new construction and packaging because of the deteriorated condition of materials.

Over time, the potential for chronic leakage and accidents increases. The waste under the No Action Alternative is largely untreated waste, so it contains both hazardous chemicals and unstabilized radioactive waste. The corrosion of the containers may interact with these chemicals, leading to pressure buildup within the containers and a corresponding greater likelihood of leakage. Once released, the untreated wastes would pose a greater risk to human health than the treated, stabilized waste produced in the action alternatives.

Risks from emissions during routine operations or from accidents and leakage could be further increased for the offsite public if the population near storage sites continues to grow. The population density near sites

Table 6.16–1. Comparison of LLMW Alternatives—Projected Risk Results

Alternative	Number of Sites		Treatment Worker Physical Hazard Fatalities	Treatment Worker Cancer Fatalities	Offsite Population Cancer Fatalities	Disposal Worker Physical Hazard Fatalities	Disposal Worker Cancer Fatalities	Groundwater Impacts from Disposal			Truck Radiation Fatalities	Truck Non-Radiation Fatalities
	T	D						Number of Sites That Meet Groundwater Standards for Radionuclides Without Additional Constraints	Number of Sites That Require Additional Constraints to Meet Standards	Radionuclides[a] Which Must Be Constrained for Sites to Meet Standards		
No Action[b]	3	--	2	1	*	NA	NA	--	--	--	--	--
Decentralized	37	16	4	1	*	*	1	11	4	U-238, Pu-240	*	*
Regionalized 1	11	12	4	1	*	*	1	9	3	U-238	*	*
Regionalized 2	7	6	3	1	*	*	1	3	3	U-238, Tc-99	*	*
Regionalized 3	7	1	3	1	*	*	*	1	0	--	*	1
Regionalized 4	4	6	3	1	*	*	1	3	3	U-238, Tc-99	*	*
Centralized	1	1	3	1	*	*	*	0	1	U-238	*	1

Notes: T = treatment; D = disposal; * = greater than 0 but less than 0.5; -- = action not applicable for this alternative.

[a] Additional reductions to chemical concentrations may also be required to meet chemical groundwater standards at each site (see Section 6.6). This requires treatment options not evaluated in the WM PEIS. RH-LLMW, disposed of in every alternative except No Action at ORR, would also require additional constraints to assumed concentrations of Pu-239, Pu-240, and Tc-99 in order to meet groundwater standards.

[b] The No Action Alternative includes impacts from only the first 20 years of indefinite storage of LLMW; see Section 6.16 for additional information on longer term impacts.

Table 6.16–2. Comparison of LLMW Alternatives—Selected Impacts

Alternative	Number of Sites		Number of Sites With Air Pollutants That Exceed Standards	Highest Air Pollutant Percentages at Any Site	Cost ($ Billions)	Truck Shipments	Comment
	T	D					
No Action[a]	3	NA	0	95 (CO-RFETS)	5.2	NA	Extended storage at every site—does not comply with RCRA
Decentralized	37	16	1	169(CO-RFETS)	12.3	500	Maximum number of sites treat and dispose
Regionalized 1	11	12	1	169(CO-RFETS)	11.0	1,800	LDRs treatment at 6 western, 5 eastern sites; disposal at 12
Regionalized 2	7	6	1	107(CO-RFETS)	9.5	5,600	LDRs treatment at 4 western, 3 eastern sites; disposal at current LLW disposal sites
Regionalized 3	7	1	1	107(CO-RFETS)	8.4	11,000	LDRs treatment at 4 western, 3 eastern sites; Centralized disposal at NTS
Regionalized 4	4	6	0	77(PM_{10}-ORR)	8.4	4,300	LDRs treatment and disposal at 2 western, 2 eastern large generators; disposal at current LLW disposal sites
Centralized	1	1	1	147 (PM_{10}-HS)	7.7	7,500	Centralized treatment and disposal at the Hanford site

Notes: T = treatment; D= disposal; NA = not applicable.
[a] The No Action Alternative includes impacts from only the first 20 years of indefinite storage of LLMW; see Section 6.16 for additional information on longer term impacts.

could be expected to increase over time, and the possibility of encroachment into current buffer areas would also increase.

Although it is DOE's intent to maintain control as long as necessary to assure public health and safety, at some date in the future, loss of institutional control of the storage facility must be assumed for a conservative analysis. With loss of control, the potential for intrusion into the facility and movement of contaminants into the environment sharply increases. The risks predicted for a human intruder into a storage facility containing untreated wastes are likely to be as high or higher than those presented in Section 6.4.1.10 for intrusion into a disposal facility. In particular, the presence of untreated chemicals in the stored wastes would increase the risk from chemical exposures. Migration of the waste into the groundwater from a storage facility, which could also be expected at some time after maintenance and control of the facility has ended, could pose risks as high or higher than those presented for the hypothetical farm family and population in Sections 6.4.1.8 and 6.4.1.9. The untreated condition of the waste could result in faster movement of contaminants through the groundwater, which could contain both a greater concentration of short-lived radionuclides and a higher concentration of chemicals. These conditions would add to the risks predicted for migration from a disposal facility.

Should the No Action Alternative be selected in the near term, it would be reasonable to expect a decision to treat and dispose of the waste at some point in the future, both because of the continued accumulation of effects already noted and because indefinite storage of untreated waste does not fulfill obligations under existing laws or agreements. Should such a decision be made, it is likely that the impacts and risks for treating and disposing would be greater than those shown for the action alternatives; the further deterioration of the waste containers over time would present a more difficult management situation. Consequently, for a course of action that continues storage of untreated LLMW for 20 years or more and then accomplishes treatment and disposal at some future date, the total impacts and costs would be likely to exceed the sum of the No Action Alternative impacts over 20 years plus those presented in Chapter 6 under any action alternative pursued for treatment and disposal.

The Preferred Alternative for Treatment. A number of the Department's sites (generally sites with small amounts of LLMW) would send their LLMW to other sites for treatment. The sites that would receive these wastes and treat them under the Department's preferred alternative are Hanford, INEL, ORR, and SRS. ANL-E, FEMP, LLNL, LANL, Pantex, PORTS, RFETS, and SNL would treat LLMW onsite.

DOE's preferred alternative is a combination of parts of the Decentralized Alternative and several Regionalized Alternatives as shown in Table 3.7–1 in Chapter 3. The potential environmental impacts of all alternatives for treatment of LLMW evaluated in the WM PEIS are small. DOE's preferred alternative is generally consistent with the Site Treatment Plans prepared under the FFCAct; these plans include the use of commercial facilities to treat some LLMW. DOE realizes that the compliance orders issued by State and Federal regulators on the basis of these Site Treatments Plans establish the requirements for treatment of DOE's LLMW.

The Preferred Alternative for Disposal. The Department's preferred alternative at this time is to send its LLMW to regional disposal sites after it is treated. After consultations with stakeholders, the Department intends to select two or three sites from the following six: Hanford, INEL, LANL, NTS, ORR, and SRS.

The six sites named above are those at which DOE already has established LLW or LLMW disposal operations and, except for NTS and LANL, each has relatively large LLMW volumes for disposal. Because these six sites would have more than adequate capacity for the amounts of LLMW the Department will need to dispose of, there is no need for additional candidate sites. Fewer than the six sites would provide adequate capacity at a substantially lower overall cost. Relying on only one disposal site, however, would require the most transportation of the waste, and would be operationally inflexible if disposal activities were interrupted.

While all six current disposal sites remain candidates for future disposal operations and the potential health and environmental impacts of regionalized disposal are small, further consideration of various factors may affect the DOE's site preferences. For example, hydrological characteristics indicate that disposal at sites with high rainfall, such as ORR and SRS, would require mitigation costs that would not be needed at more arid sites. Preliminary cost analyses indicate that regional disposal at ORR, LANL, and INEL may not be as cost effective as disposal at SRS, NTS, and Hanford.

Because of these sometimes contravening factors and the permanence associated with disposal decisions, it is prudent to further evaluate costs and discuss all pertinent aspects of potential configurations with stakeholders before identifying two or three preferred sites for disposal. The Department will notify the public which specific sites it prefers for disposal of LLMW by publishing a notice in the *Federal Register* and by other means. DOE will not issue a Record of Decision selecting any regional disposal sites for LLMW sooner than 30 days after publication of its preferred sites in the *Federal Register*.

Table 6.16–3 provides potential impacts for the preferred alternative by combining the impacts evaluated in the WM PEIS for the preferred alternative at each site. Although it is not possible to estimate disposal impacts with precision until the disposal sites have been selected, the table provides approximate values and ranges expected for the preferred LLMW alternatives. Treatment and disposal impacts are taken from Volume II site data tables for the preferred alternatives specified in the second and third rows of Table 6.16–3. Values presented in the table for regionalized disposal are the high and low values at each site when impacts are estimated for Hanford, INEL, LANL, NTS, ORR, and SRS under Regionalized Alternative 2 (six disposal sites), Regionalized Alternative 3 (one disposal site—NTS), and the Centralized Alternative (one disposal site—Hanford). These values provide a range for potential impacts. Impact estimates under Regionalized Alternative 3 at NTS and the Centralized Alternative at Hanford provide an upper limit for the range of impacts at these sites, using impacts that result when all LLMW is disposed of at one site—NTS or Hanford. The preferred disposal alternative would distribute disposal impacts over two to three sites, lowering values shown for NTS or Hanford.

Table 6.16–3. The Preferred LLMW Alternative — Selected Impacts

Impact Area	Decision	ANL	BNL	FEMP	Hanford	INEL	LLNL	LANL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP	Total
Preferred alternative	T	D	R1[a]	D	R1	R4	D	D	R1[a]	R2	R2	D	D	D	D	R1	R1[a]	
	D[b]	—	—	—	R	R	—	R	R	R	—	—	—	—	—	R	—	—
Worker physical hazard fatalities	T	6.4E-03	4.0E-03	1.6E-01	4.8E-01	8.8E-01	2.7E-01	2.0E-01	4.6E-02	4.8E-01	1.3E-02	3.8E-02	4.8E-01	6.2E-01	5.1E-03	3.3E-01	3.2E-03	4.0E+00
	D	—	—	—	0.0E+00–<1.5E-01	0.0E+00–5.5E-02	—	0.0E+00–1.3E-01	0.0E-00–<8.4E-02	0.0E+00–5.6E-02	—	—	—	—	—	0.0E+00–1.0E-01	—	8.4E-02–4.2E-01
	Total	6.4E-03	4.0E-03	1.6E-01	4.8E-01–<6.3E-01	8.8E-01–9.4E-01	2.7E-01	2.0E-01–3.3E-01	4.6E-02–<1.3E-01	4.8E-01–5.4E-01	1.3E-02	3.8E-02	4.8E-01	6.2E-01	5.1E-03	3.3E-01–4.3E-01	3.2E-03	4.1E+00–4.4E+00
Worker cancer fatalities	T	6.7E-05	5.7E-05	2.9E-04	1.2E-01	1.2E-01	7.8E-03	1.6E-03	2.9E-03	1.2E-01	1.5E-04	3.4E-04	1.4E-03	1.0E-03	3.3E-04	1.1E-01	2.8E-05	4.9E-01
	D	—	—	—	0.0E+00–<3.6E-01	0.0E+00–1.7E-01	—	0.0E+00–1.2E-02	0.0E-00–<3.9E-01	0.0E+00–9.3E-02	—	—	—	—	—	0.0E+00–3.9E-02	—	3.6E-01–5.2E-01
	Total	6.7E-05	5.7E-05	2.9E-04	1.2E-01–<4.8E-01	1.2E-01–2.9E-01	7.8E-03	1.6E-03–1.4E-02	2.9E-03–<3.9E-01	1.2E-01–2.1E-01	1.5E-04	3.4E-04	1.4E-03	1.0E-03	3.3E-04	1.1E-01–1.5E-01	2.8E-05	8.5E-01–1.0E+00
Offsite population cancer fatalities	T	1.7E-05	5.2E-08	2.6E-05	1.4E-03	6.7E-04	1.5E-01	5.9E-04	6.4E-09	1.2E-03	8.1E-07	3.5E-05	2.7E-06	8.8E-05	1.4E-04	1.8E-03	1.7E-07	1.6E-01
Radionuclides requiring constraints to meet groundwater standards	D	—	—	—	None or U-238	None	—	None	None	None or PU-239 PU-240 TC-99 U-238	—	—	—	—	—	None or U-238	—	0-3 sites exceed

Table 6.16–3. The Preferred LLMW Alternative — Selected Impacts—Continued

Impact Area	Decision	ANL	BNL	FEMP	Hanford	INEL	LLNL	LANL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP	Total
Preferred alternative	T	D	R1[a]	D	R1	R4	D	D	R1[a]	R2	R2	D	D	D	D	R1	R1[a]	
	D[b]	—	—	—	R	R	—	R	R	R	—	—	—	—	—	R	—	
Truck radiation fatalities	These numbers reflect intersite transportation results and are not attributable to individual sites																	<0.5
Truck nonradiation fatalities																		≤1.0
Highest air pollutant percentage	T	44% NO_2	1% NO_2	22% NO_2	23% PM_{10}	45% PM_{10}	5% PM_{10}	2% NO_2/PM_{10}	25% CO	50% PM_{10}	1% VOC	1% NO_2	13% PM_{10}	107% CO	9% CO	10% PM_{10}	0%	1 site exceeds (RFETS)
	D	—	—	—	—	—	—	—	0-73% CO	—	—	—	—	—	—	—	—	No sites exceed
Cost $ billions	T	0.06	0.01	0.34	0.70	1.87	0.33	0.40	0.18	1.46	0.06	0.15	0.69	1.23	0.07	0.96	0.01	8.5
	D	0	0	0	0-<1.04	0-0.33	0	0-0.42	0-<0.52	0-0.32	0	0	0	0	0	0-0.29	0	0.7-1.6
	Total[c]	0.06	0.01	0.34	0.70–<1.74	1.87–2.20	0.33	0.40–0.82	0.18-<0.70	1.46–1.78	0.06	0.15	0.69	1.23	0.07	0.96–1.25	0.01	9.2-10.1
Truck shipments[d]		20	20	110	40–7,520	1,740–5,840	210	130–2,610	160–9,640	1,660–2,100	50	40	650	2,520	30	110–710	30	10,000–23,770

[a] Wastes from these sites (BNL, NTS, and WVDP) undergo shipment offsite to regional treatment centers.
[b] DOE prefers to further narrow its configuration of disposing sites to two or three sites from these six sites. DOE has no site preferences pending further deliberations with regulators and stakeholders. For the preferred disposal alternative, disposal volumes would range between zero and quantities disposed of in the Regionalized Alternative 2 at INEL, LANL, ORR, and SRS. At NTS, disposal volumes would range between zero and a quantity less than those evaluated for Regionalized Alternative 3. At Hanford, disposal volumes would range between zero and a quantity less than those evaluated in the Centralized Alternative.
[c] Costs for truck transportation (≤ $.06 billion) were added to these site totals for the total alternative cost as presented in Table 6.16-2.
[d] Total one-way shipments between two sites, as defined for shipment totals in Table 6.16-2, are (10,000 – 23,770) ÷ 2 = 5,000 – 11,885 shipments.

Chapter 6
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Proposed Waste Management Actions at Each Site Under the Low-Level Mixed Waste Alternatives[a]

Alternatives	Number of Sites		ANL-E	BNL	FEMP	Hanford	INEL	LANL	LLNL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP
	T	D																
No Action	3	0	S	S	S	S	TS	S	S	S	TS	S	S	S	S	S	TS	S
Decentralized	37[b]	16	TD	TD	TD	TD	TDα[c]	TDα	TDα	TDα	TD	TD	TD	TD	TDα	TD	TDα	TD
Regionalized 1	11	12			TD	TD	TDα	TDα	TDα	Dα	TD	TD	TD	TD	TDα		TDα	
Regionalized 2	7	6				TD	TDα	TDα		Dα	TD			T	Tα		TDα	
Regionalized 3	7	1				T	Tα	T		Dα	T			T	Tα		Tα	
Regionalized 4	4	6				TD	TDα	Dα		Dα	TD						TDα	
Centralized	1	1				TDα												

Notes: T = treatment to meet land disposal restrictions; D = disposal; S = indefinite storage. A blank indicates that no treatment or disposal takes place at a site. All sites have wastewater treatment capability as needed.

[a] The actions shown are for contact-handled (CH) wastes. Remote-handled (RH) wastes would be treated and disposed of onsite at the Hanford Site, INEL, ORR, and SRS in all alternatives except No Action. RH waste is stored under No Action. Facilities with the α symbol treat or dispose of contact-handled alpha and nonalpha waste.

[b] Although 37 sites generate LLMW, only 17 have been designated major sites in the WM PEIS (see Section 1.6.1 for details).

[c] Treatment and disposal facilities identified for one site with the α symbol can manage both alpha and nonalpha waste.

CHAPTER 7
Impacts of the Management of Low-Level Waste

Chapter 7 describes the environmental consequences associated with the No Action, Decentralized, Regionalized, and Centralized Alternatives for low-level waste (LLW). This chapter provides information on existing and anticipated LLW volumes, and existing and planned facilities available at DOE sites. This is followed by an overview of the analysis and assumptions relating to LLW characteristics and the treatment and disposal technologies considered, as well as the rationale for selecting the specific sites analyzed under each alternative. This chapter discusses the human health risks, environmental impacts, and costs of the alternatives, and provides a comparison of them.

The methods used to evaluate impacts are outlined in Chapter 5. Impacts tables for each major DOE site are contained in Volume II. Details of the LLW analysis are contained in a technical report entitled "Low-Level Waste Inventory, Characteristics, Generation, and Facility Assessment for Treatment, Storage, and Disposal Alternatives Considered in the U.S. Department of Energy Waste Management Programmatic Environmental Impact Statement" (ANL, 1996). Additional information can be found in the appendices in Volumes III and IV and the technical reports provided in Chapter 15.

7.1 Background

- *LLW includes all radioactive waste not classified as High-Level Waste, Transuranic Waste, Spent Nuclear Fuel, or byproduct tailings.*
- *LLW is currently generated, projected to be generated, or stored at 27 DOE sites as a result of nuclear weapons technology production and dismantlement, nuclear reactor operations, environmental restoration activities, and research.*
- *DOE will need to manage an estimated 1.5 million cubic meters of LLW over the next 20 years.*
- *DOE must select treatment and disposal sites for LLW.*

7.1.1 DEFINITION AND ORIGIN

Low-level waste (LLW) is defined as all radioactive waste not classified as either HLW, TRUW, spent nuclear fuel, or byproduct tailings containing uranium or thorium from processed ore (as defined in Section 11 (e) (2) of the Atomic Energy Act of 1954 [42 USC 2011 *et seq.*]) and not containing hazardous or toxic wastes under RCRA or TSCA. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as LLW provided that the concentration of transuranics is less than 100 nanocuries per gram. Since the Manhattan Project during World War II, LLW has been generated by DOE and its predecessor agencies from a variety of activities including weapons production, nuclear reactor operations, environmental restoration activities, and research.

DOE also has the responsibility for two other classes of waste frequently categorized as LLW: special case waste, which is waste generated by DOE that does not fit into any typical LLW management activity (i.e., treatment, storage, and disposal), and commercially generated Greater-Than-Class-C (GTCC) LLW. However, because special case waste has unique site-specific considerations and the GTCC LLW program has not been fully defined, these LLW groups are excluded from the WM PEIS analysis (see discussion in Chapter 1, Section 1.5.6).

7.1.2 Volumes and Locations

Approximately 1.5 million cubic meters of LLW is generated, projected to be generated, or stored at 27 DOE sites. Table 7.1–1 presents the total estimated LLW volumes at those sites. LLW volume data are derived primarily from data in the 1992 Integrated Data Base (IDB) (DOE, 1992) and the Waste Management Information System (WMIS) (ORNL, 1992). (Details of the amounts and characteristics of LLW are provided in ANL [1996].) Although 27 DOE sites manage LLW, 7 sites generate more than 80% of the LLW load: the Hanford Site, INEL, LANL, ORR, Paducah, Portsmouth, and SRS. Figure 7.1–1 presents the total LLW volumes at the 16 major sites considered under the LLW alternatives and illustrates LLW distribution across the country. The naval shipyards (i.e., Norfolk, Pearl Harbor, Puget Sound, and Portsmouth) generate small quantities of LLW not included here. Impacts from the minor amounts of naval shipyard LLW are not expected to affect the overall conclusions reached in the WM PEIS.

Owing primarily to improvements in waste characterization, projected waste volumes and inventories of LLW have changed since the analysis of these wastes was carried out for the WM PEIS. Updated LLW volumes for all sites were derived from information in the IBD Report–1994 (DOE, 1995c) and are given in Appendix I. The appendix also identifies criteria for reanalyzing site wastes using more recent data, compares the waste load data used in the Draft WM PEIS with the more recent data and describes DOE's conclusions about the need to analyze the more recent data for specified sites. For five sites—BNL, NTS, ORR, Pantex, and WVDP—updated LLW data are used in the alternatives analyses only when these sites treat their own waste.

Table 7.1–1. Low-Level Waste Volumes [a,b]
(cubic meters)

DOE Site	Inventory	20-Year Projected Generation	Estimated Inventory Plus 20-Years Generation
1. Ames Laboratory	26	80	110
2. Argonne National Laboratory-East	880	5,800	6,700
3. Bettis Atomic Power Laboratory	0	12,000	12,000
4. Brookhaven National Laboratory	560[c]	5,080[c]	5,600[c]
5. Fermi National Accelerator Laboratory	45	1,400	1,500
6. Fernald Environmental Management Project	d	d	d
7. Hanford Site[e]	0	89,000	89,000
8. Idaho National Engineering Laboratory[f]	3,500	101,000	105,000
9. Kansas City Plant	4	20	24
10. Knolls Atomic Power Laboratory	0	19,000	19,000
11. Lawrence Berkeley Laboratory	53	1,200	1,300
12. Lawrence Livermore National Laboratory[g]	780	2,800	3,600
13. Los Alamos National Laboratory	0	150,000	150,000
14. Mound Plant	1,600	37,000	38,000
15. Nevada Test Site	270[c]	1,400[c]	1,700[c]
16. Oak Ridge Reservation	20,000[c]	250,000[c]	270,000[c]
17. Paducah Gaseous Diffusion Plant	5,300	45,000	50,000
18. Pantex Plant	210[c]	2,440[c]	2,700[c]
19. Pinellas Plant	16	1,300	1,300
20. Portsmouth Gaseous Diffusion Plant	1,500	96,000	97,000
21. Princeton Plasma Physics Laboratory	2	220	220
22. RMI Titanium Company	2,500	48,000	51,000
23. Rocky Flats Environmental Technology Site	2,400	39,000	41,000
24. Sandia National Laboratories-New Mexico[h]	680	1,800	2,500
25. Savannah River Site[i]	11,000	500,000	510,000
26. Stanford Linear Accelerator Center	2,200	280	2,500
27. West Valley Demonstration Project	14,000[c]	28,000[c]	42,000[c]
Total	**67,500**	**1,440,000**	**1,500,000**

[a] Volume data are rounded from field estimates and columns may not add. Updated inventories and waste generation rates are summarized in Appendix I, "Update of Site-Specific Waste Volumes for LLW, LLMW, and TRUW."
[b] Potential waste to be generated by environmental restoration activities are not included in the totals in this table. See Section 7.15 for a discussion of environmental-restoration-generated LLW.
[c] Data from the IDB Report–1994 were used in the analysis (DOE, 1995c).
[d] Waste is ER waste only; no WM waste is generated at Fernald.
[e] Excludes LLW fraction of the Hanford Site tank wastes.
[f] Includes Argonne National Laboratory-West and Naval Reactor Facility.
[g] Includes Sandia National Laboratories, California.
[h] Includes Inhalation Toxicology Research Institute.
[i] Excludes SRS saltstone—29,600 m^3/yr.
Sources: DOE (1992) and ORNL (1992), except where noted.

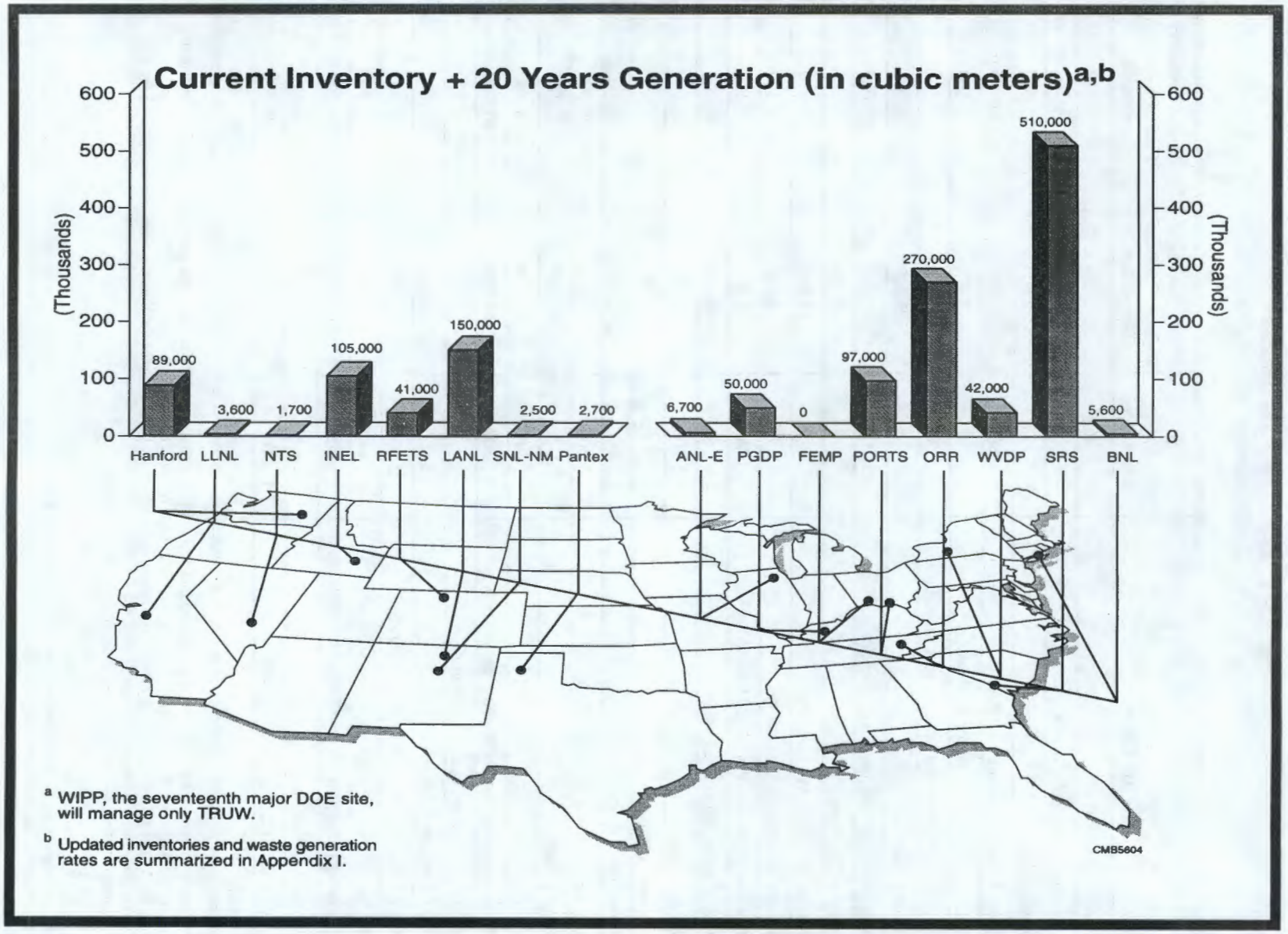


Figure 7.1-1. Low Level Waste—Total Inventory and Generation

7.1.3 EXISTING AND PLANNED FACILITIES AVAILABLE AT DOE SITES

DOE used the existing and planned LLW facilities and capacities listed in Table 7.1–2 to establish the baseline capacities for treatment and disposal and to determine the need for new or expanded facilities. Planned facilities include only the facilities for which a Title II design has been initiated.

Analysis in the WM PEIS assumes use of existing and planned facilities until their capacities are met. If additional capacity is needed, use of new generic facilities is assumed. These conceptual facilities provide the difference in TSD capacity between the baseline reported in Table 7.1–2 and what is necessary to manage the particular LLW stream which a given site would receive under any given alternative.

Table 7.1–2. Capacities of Existing and Planned LLW Facilities[a]

Site	Treatment (m^3/yr)				Disposal (m^3/yr)	
	Incineration	Size Reduction	Compaction	Solidification	Engineered Disposal	Shallow Land
Hanford			4,040			8,500
INEL	2,300	5,000	5,700	27,770		3,900
LANL						1,300
NTS						44,900
ORR			1,400		600	
SRS	8,200*		4,000	210*	5,370	
LBL			Sufficient for LBL Needs	105		
LLNL		115	1,500			
PGDP				Sufficient for PGDP Needs		
Mound				252		
Pantex			1,083			
RFETS			5,600			
RMI	102					

Note: * = planned capacity; blanks indicate that the treatment or disposal operation does not take place at the specified site.
[a] The capacities of these existing and planned units may be used for several waste types in accordance with site plans.
Source: DOE (1996a).

Conceptual facilities are based on generic designs with set impacts (e.g., cost, performance/efficiency). Where necessary for analysis, an assumption was made that the impact of existing facilities essentially reflects the impact of generic facilities.

Eleven sites conduct different degrees of LLW treatment using existing facilities. Size reduction and compaction facilities typically used to reduce the total volume of waste requiring disposal are the most prevalent existing facilities for LLW treatment. Seven DOE sites have operating LLW disposal facilities. Of these, three (INEL, LANL, and ORR) accept only onsite wastes, one (SRS) accepts small amounts of waste from several small generators, and two (the Hanford Site and NTS) accept large quantities of offsite waste from other DOE sites.

7.2 Analytical Methods and Assumptions

The character of the waste is as important as waste volume in determining the potential impacts resulting from LLW management. LLW can contain many different radionuclides in many combinations and can be present in many physical forms ranging from dilute liquids to activated metal equipment. For the purposes of analysis, DOE categorized LLW by radiological and physical properties, and assigned the waste into an appropriate treatability category to calculate risk, costs, and other impacts. This process is further described below.

7.2.1 CHARACTERISTICS

7.2.1.1 Physical

DOE defined the treatment requirements for LLW based on physical characteristics of the waste. Using site data and information contained in the Waste Management Information System database (ORNL, 1992), LLW at each site was characterized into the following 10 treatability categories: solid LLW classified as (1) combustible, (2) noncombustible-noncompactible, (3) noncombustible-compactible, (4) surface-contaminated bulk metal/equipment, (5) activated bulk metal/equipment, (6) sludge/resin, (7) other (wastes that do not fit into the previous categories); liquid LLW classified as either (8) small-volume dilute/aqueous or (9) liquids containing organic materials; and (10) remote-handled (RH) LLW, which requires special

shielding during waste handling. These categories determined the treatment and processing techniques required for LLW to produce a final waste form suitable for disposal.

7.2.1.2 Radiological Profiles

After categorizing the waste into the 10 treatability categories, DOE further categorized LLW by its radiological characteristics. Six radiological categories, or radiological profiles, defined in the 1992 Integrated Data Base (DOE, 1992) were assigned to LLW streams at the 16 major sites. These categories, described in Table 7.2–1, identify the radionuclides likely to be encountered based on the origin of the waste. A detailed listing of the radionuclides that compose each radiological category is available in ANL (1996).

7.2.2 Technologies and Treatment Processes

DOE analyzed two treatment strategies for LLW: minimum treatment, defined as the least amount of treatment required to meet applicable requirements for either onsite disposal or transport to another site for disposal; and volume reduction, which reduces the overall disposal volume of LLW using a variety of treatment techniques. Minimum treatment includes solidification of liquids and fines, and packaging.

Table 7.2–1. LLW Radiological Profiles

Category	Description
Uranium/thorium	Waste material primarily containing the naturally occurring radioactive elements of uranium or thorium.
Fission products	Waste containing radionuclides (e.g., cesium-137 and strontium-90) that result when a heavy nucleus is split.
Induced activity	Waste that contains elements that were initially not radioactive but became radioactive as a result of absorbing neutrons (e.g., cobalt-60).
Tritium	Waste material containing trace amounts of tritium (a synthetically produced radioactive isotope of hydrogen).
Alpha	Waste materials contaminated with alpha-emitting (helium nuclei) radionuclides not listed under uranium/thorium or low levels (less than 100 nCi/g) of transuranic isotopes.
Other	Waste material that is combined or undefined.

Volume reduction uses several different available technologies, including thermal treatment, compaction/supercompaction, and size reduction to decrease the volume of combustible and/or compactible LLW. Minimal treatment is used for wastes that are not amenable to the volume reduction technologies.

LLW is treated by one or more treatment processes (or "modules"). Individual modules were linked together to form a complete treatment flow process. Figure 7.2–1 illustrates the treatment flow diagrams which include thermal treatment, solidification, compaction/supercompaction, and size reduction.

Figure 7.2–2 illustrates the percentage of waste that could be treated by each technology under the policies of minimum treatment and volume reduction. Because treatment is based primarily on physical waste characteristics, not all the wastes are eligible for all the treatment technologies.

For LLW disposal, DOE evaluated the impacts associated with both shallow land burial and engineered disposal facilities.

7.2.3 WM PEIS Assumptions: Facilities, Treatment, and Disposal

In addition to the assumptions regarding the physical and radiological characteristics of LLW, DOE made other assumptions to conduct the LLW analysis. These assumptions are summarized below.

Facilities

- The WM PEIS uses a 20-year period for the analysis of waste management operations. Within this 20-year period, new facilities will be constructed within the first 10 years, and inventory waste and annually generated waste will be treated within the following 10-year period.
- In the LLW analysis, each site is assumed to build and operate facilities with capacities sufficient to handle only LLW. This avoids linking results of one waste type to decisions not yet made in another and results in conservative estimates of risk, cost, and impacts. However, the alternatives were structured to accommodate locating LLMW and LLW facilities at the same sites to more accurately reflect the reality of coordinated treatment and disposal. Chapter 11 discusses cumulative effects for sites hosting more than one waste type facility.

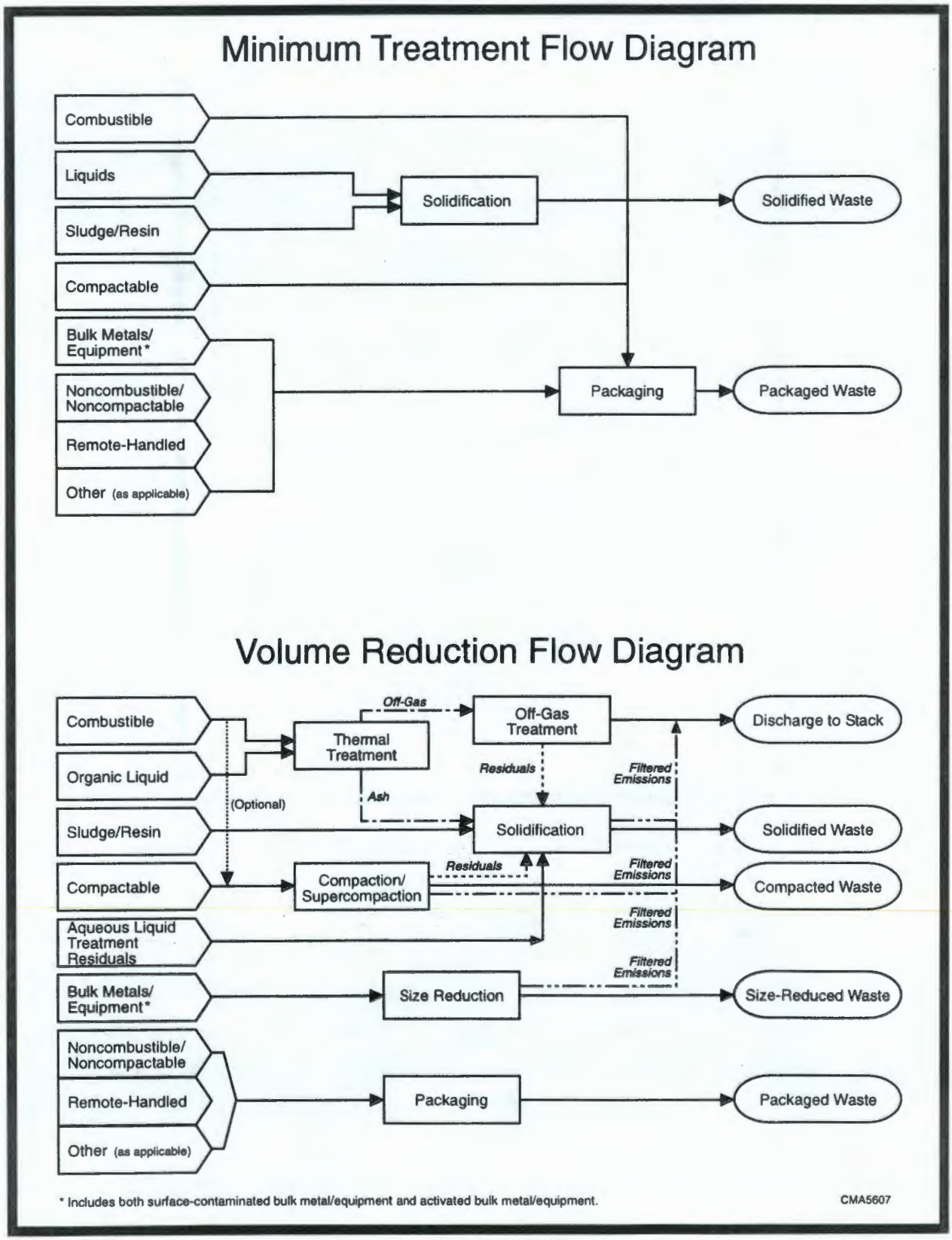


Figure 7.2–1. Low-Level Waste Flow Diagram

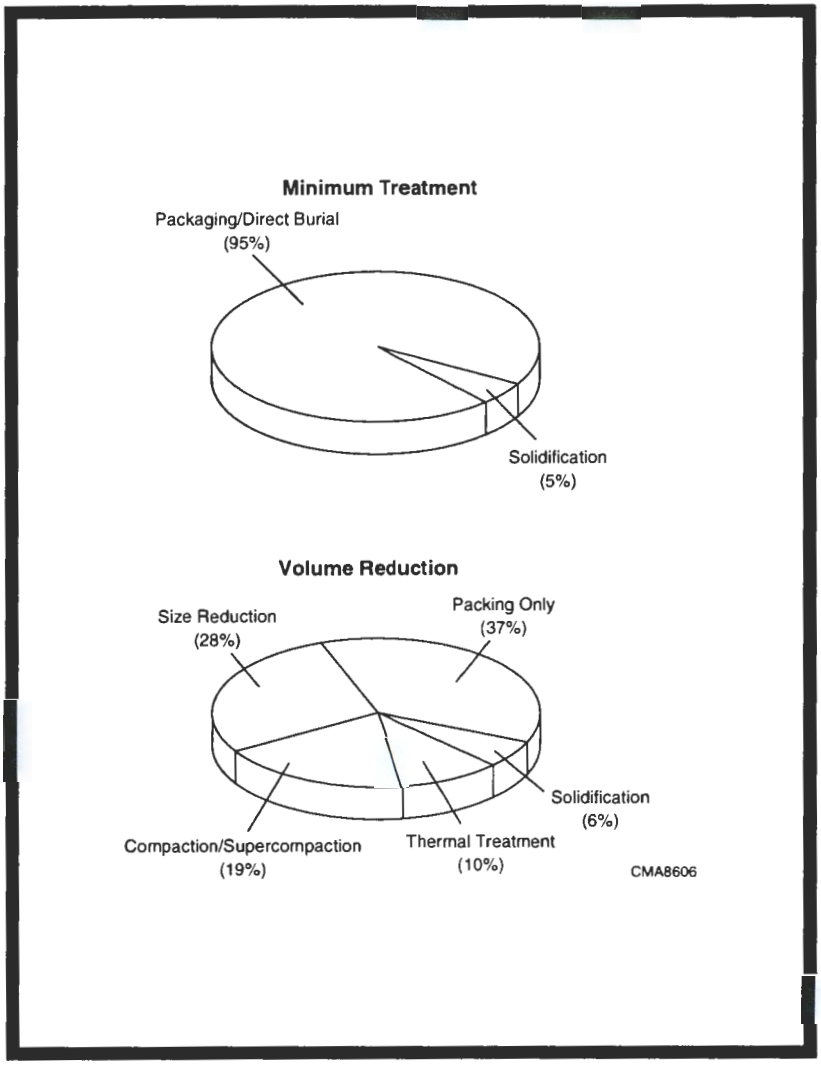


Figure 7.2–2. LLW Treatment Processes

Treatment

- Aqueous liquid LLW treatment facilities are assumed to exist in sufficient capacities at all facilities with wastewater. The sludges (fine material and residuals) from aqueous treatment are to be solidified at the site of generation; therefore, aqueous liquid LLW is not shipped for treatment or disposal in any of the alternatives. LLW sludges resulting from treatment are transported primarily to move the waste to a final disposal location.
- For all alternatives, some treatment is considered practical and will occur at every site in both the minimum treatment and volume reduction approaches.

- LLW storage capacities are sufficient at individual sites or can be expanded to meet future requirements.
- For analytical purposes, incineration was modeled as the representative thermal treatment for LLW.

Disposal

- Two types of disposal were analyzed in the WM PEIS: shallow land burial and engineered disposal. Shallow land disposal is generally used where the groundwater table is far below the surface and therefore was the primary disposal method assumed at western sites, except at RFETS which used aboveground facilities because of shallow groundwater conditions. Engineered concrete structures are typically used for disposal at sites with shallow groundwater and high precipitation rates to reduce potential radionuclide migration. In addition to RFETS, DOE assumed the use of aboveground engineered concrete structures for sites located in the eastern United States, except at SRS which currently uses belowground vaults.

7.2.4 Transportation Analysis and Assumptions

DOE analyzed transportation impacts associated with each alternative. Both truck and rail transportation were analyzed using routing models following the general principle of minimizing distance and transportation time. The routes were selected to be consistent with existing routing practices and all applicable routing regulations and guidelines; however, because the routes were determined for the purposes of risk assessment, they do not necessarily represent actual routes that would be used to transport waste in the future. Actual routes would be determined during the transportation planning process described in Section 4.3.10.

In general, the impacts resulting from transportation of radioactive materials are directly proportional to the external dose rate, which is a measure of the external radiation (principally gamma radiation) emitted from the shipment. For analytical purposes, DOE assumed the average dose rate of each shipment would not exceed 1 millirem per hour at 1 meter from the shipping container (consistent with DOE's historical practices), although DOT regulations allow a dose rate of 10 millirem per hour at 2 meters from the container.

7.3 Low-Level Waste Alternatives

The WM PEIS LLW alternatives cover two approaches for solid LLW treatment. As considered in this section, the minimal treatment approach simply includes procedures (e.g., packaging, solidification) that can be employed to enable the waste to meet applicable criteria for LLW transport and/or disposal. All LLW will undergo only minimal treatment at each waste generation site under the Decentralized Alternative, Regionalized Alternatives 1, 3, 6, and 7, and the Centralized Alternatives 1 and 2. The volume reduction approach includes procedures and technologies (e.g., incineration, supercompaction) that would reduce the waste volume prior to undergoing final treatment to meet applicable LLW acceptance criteria. Only certain waste types, such as compactible and combustible LLW, would be amenable to volume reduction technologies. Under the LLW No Action Alternative, Regionalized Alternatives 2, 4, and 5, and the Centralized Alternatives 3, 4, and 5, all generating sites would conduct minimal treatment for their own noncombustible, noncompactible waste streams, while the remaining wastes would undergo volume reduction at designated regional treatment sites prior to final disposition.

The WM PEIS LLW analysis considers 14 alternatives for treatment and disposal facilities within the four broad categories of alternatives: No Action, Decentralized, Regionalized, and Centralized. Treatment and disposal activities vary by alternative and by site. Each of the 14 alternatives was developed in order to capture and quantify the human health risks, environmental impacts, and costs associated with the range of LLW treatment and disposal options available to DOE, and to provide input for decisions about where to locate LLW treatment and disposal facilities. The foldout table at the end of this chapter shows the sites at which LLW would be treated and disposed of under each alternative. This table is designed to be used as a quick reference when reading the LLW impact sections.

In the table at the end of this chapter, the sites identified with a "T" or "D" for treatment or disposal are candidate sites. The evaluation of impacts for treatment or disposal at a candidate site is based on waste that either exists at the site or is routed there from off site. In some alternatives, a candidate site does not receive waste or have waste on site for waste management. In these alternatives, the site is listed as a candidate with a "T" or "D," but there was no impact evaluation.[1]

[1]FEMP is shown as a candidate site for disposal in the Decentralized, Regionalized 1, and Regionalized 2 Alternatives; however, this disposal would be for onsite waste only, if FEMP is determined to have waste management LLW. At present, FEMP does not report waste management LLW (see Section 7.15 and Appendix B).

Transportation of hazardous and radioactive materials, substances, and wastes is governed by the U.S. Department of Transportation, U.S. Nuclear Regulatory Commission (NRC), and U.S. Environmental Protection Agency (EPA) regulations and by the Hazardous Materials Transportation Act. These regulations may be found in 49 CFR Parts 171-178, 49 CFR Parts 383-397, 10 CFR Part 71, and 40 CFR Parts 262 and 265, respectively.

In Tables 7.3–1 through 7.3–14, the percentages represent the relative proportion of the waste managed at the respective regional treatment or disposal site that originates from offsite locations. The percentages are developed based on the shipped volumes of LLW. In the Decentralized Alternative, Regionalized Alternatives 1, 3, 6, and 7, and Centralized Alternatives 1 and 2, where all LLW undergoes only minimal treatment at the waste generating site, the percentages are derived from the generating site waste totals and include the small volume increases due to waste solidification or packaging prior to shipment. In the Regionalized Alternatives 2, 4, and 5 and Centralized Alternatives 3, 4, and 5, where volume reduction treatment is conducted on certain wastes, the percentages reflect a more complex set of waste shipping parameters. Under these alternatives, the volume of waste sent to regional treatment sites includes only the LLW streams that are amenable to volume reduction as described in Section 7.2.2. These volumes are then compared with the total volume of waste that is to be treated at the designated regional treatment site. The volume of waste sent from the treatment site to the regional disposal site is calculated based on the reduced waste volume after treatment. Waste from generating sites that is not amenable to volume reduction treatment undergoes only minimal treatment and is then sent directly to the regional disposal site. More detail on the breakdown of LLW by site and waste treatment category and shipment volumes is given in the report by Argonne National Laboratory (ANL, 1996).

7.3.1 No Action Alternative

The No Action Alternative provides a baseline for the analysis that approximates the current DOE program. Under the No Action Alternative, LLW would be treated using existing facilities and shipped to one of six authorized DOE disposal sites. Today, most offsite LLW disposal occurs at NTS and the Hanford Site. The six sites currently operating have sufficient unused designated disposal area onsite for the proposed LLW disposal operations, or the disposal area could be expanded as required. Figure 7.3–1 and Table 7.3–1 illustrate the No Action Alternative.

LLW No Action Alternative—(Disposal at 6 Sites)

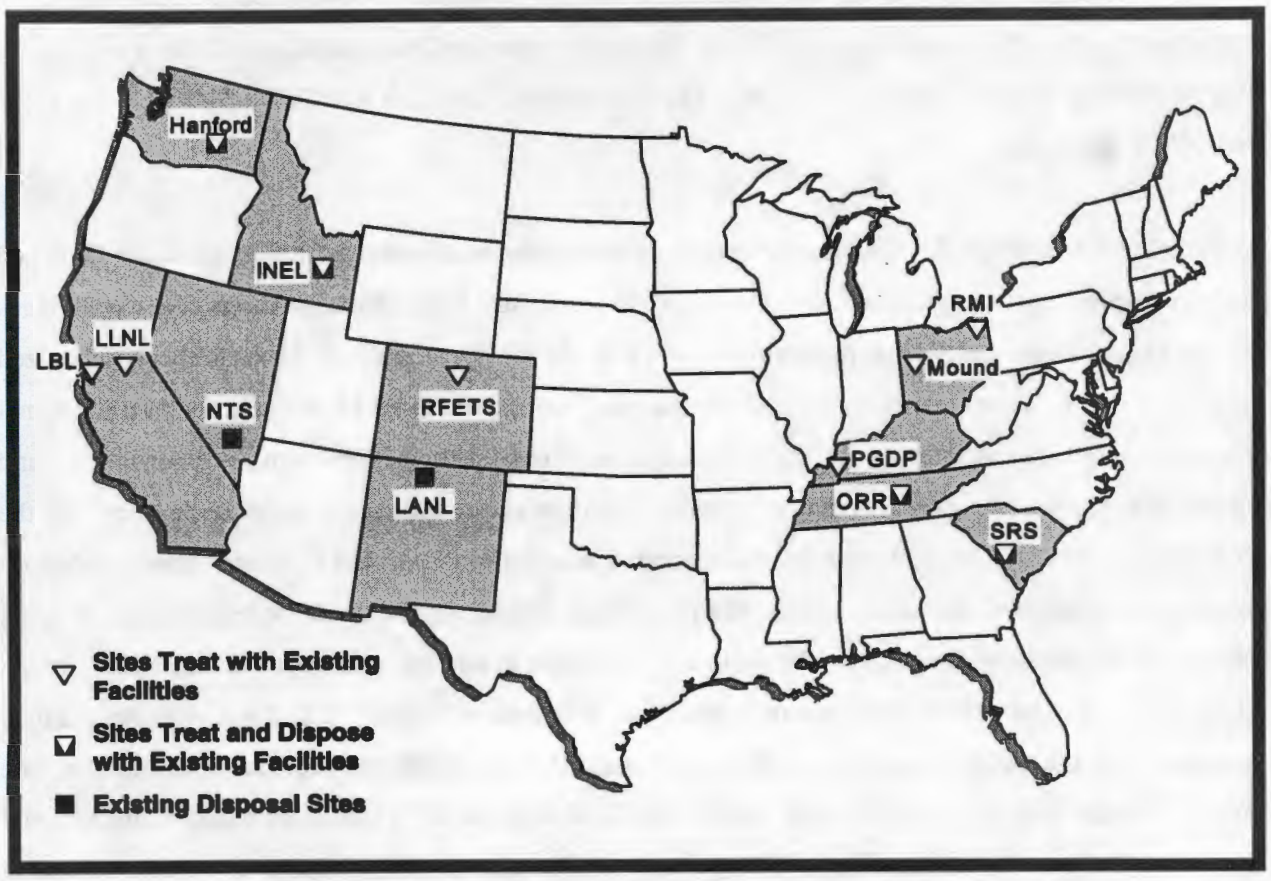


Figure 7.3–1. LLW No Action Alternative

	Generating Sites					
	ORR	Ames, Hanford, ANL-E, BNL, Fermi, LBL, KAPL, PGDP, PORTS, PPPL, SLAC, WVDP, Bettis	INEL	LANL	LLNL, NTS, FEMP, SNL-NM, Pantex, RFETS, RMI, KCP, Mound	Pinellas, SRS
Treat	ALL SITES MINIMUM TREAT AND SOME SITES VOLUME REDUCE USING EXISTING FACILITIES, AS APPLICABLE					
Dispose (% Rec'd From Offsite)	ORR (0)	Hanford (73)	INEL (0)	LANL (0)	NTS (97)	SRS (< 1)

Note: Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 7.3–1. LLW No Action Alternative

7.3.2 DECENTRALIZED ALTERNATIVE

The Decentralized Alternative considers disposal at 16 DOE sites following minimum treatment at all 27 LLW sites. Figure 7.3–2 and Table 7.3–2 illustrate the Decentralized Alternative.

7.3.3 REGIONALIZED ALTERNATIVES

The Regionalized Alternatives consider minimum treatment at all sites; volume reduction treatment at 11, 7, and 4 sites; and disposal at 12, 6, and 2 sites. Regionalized Alternative 1 considers disposal at 12 sites after minimum treatment at all sites. Regionalized Alternative 2 analyzes the impacts resulting from disposal at the same 12 sites after volume reduction at 11 of these sites. In addition to the Decentralized Alternative, Regionalized Alternatives 1 and 2 are the only alternatives that propose disposal activities at FEMP, LLNL, the Pantex Plant, and Paducah.

The remainder of the LLW Regionalized Alternatives (Regionalized Alternatives 3 through 7) focus most LLW treatment and disposal activities at eight sites: the Hanford Site, INEL, LANL, NTS, ORR, Portsmouth, RFETS, and SRS. Although the sites are the same for most of the Regionalized Alternatives, impacts at the sites vary because of the use of different treatment technologies and incoming waste volumes. For example, Regionalized Alternatives 3 and 4 would dispose of waste at the same six sites. However, Regionalized Alternative 3 would conduct only minimum treatment before disposal, whereas Regionalized Alternative 4 would use volume reduction techniques on the waste that can be reduced, in addition to conducting minimum treatment prior to disposal. Because Portsmouth and RFETS become waste consolidation sites for volume reduction before disposal in Regionalized Alternative 4, they would have a greater potential to experience impacts than under the minimum treatment scenario in Regionalized Alternative 3, although both configurations use the same six sites for disposal. Regionalized Alternative 5 considers volume reduction at four sites and disposal at six, compared to volume reduction at seven sites under Regionalized Alternative 4. Regionalized Alternatives 6 and 7 each consider disposal at two sites after minimum treatment: the Hanford Site and SRS under Regionalized Alternative 6, and NTS and SRS under Regionalized Alternative 7.

Figures 7.3–3 through 7.3–9 and Tables 7.3–3 through 7.3–9 illustrate Regionalized Alternatives 1 through 7.

LLW Decentralized Alternative—(Disposal at 16 Sites)

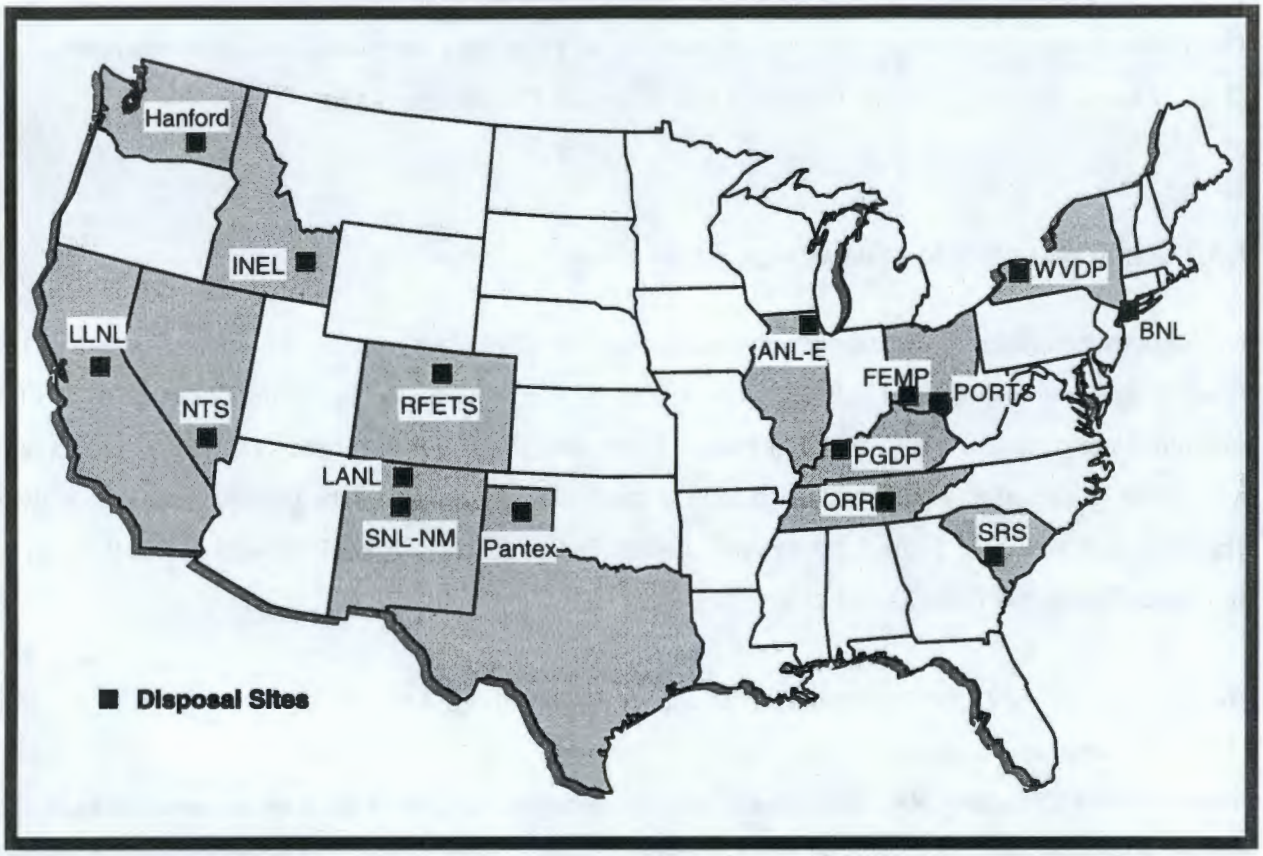


Figure 7.3–2. LLW Decentralized Alternative

	Generating Sites															
	Bettis KAPL PPPL Mound PORTS RMI	ANL-E Ames Fermi	WVDP	BNL	FEMP	Hanford	INEL	KCP PGDP	LANL	LBL LLNL SLAC	NTS	ORR	Pantex	Pinellas SRS	RFETS	SNL-NM[a]
Treat	MINIMUM TREAT AT ALL GENERATING SITES															
Dispose (% Rec'd From Offsite)	PORTS (55)	ANL-E (19)	WVDP (0)	BNL (0)	FEMP (0)	Hanford (0)	INEL (0)	PGDP (<1)	LANL (0)	LLNL (55)	NTS (0)	ORR (0)	Pantex (0)	SRS (<1)	RFETS (0)	SNL-NM (0)

Notes: Alpha-LLW would be treated and disposed of at the closest of five sites: the Hanford Site, INEL, RFETS, LANL, and SRS. RH LLW would be treated and/or disposed of at one of four sites with RH facilities: the Hanford Site, INEL, ORR, and SRS. Percentage of waste a site would receive from offsite is indicated in parentheses.

[a] Includes ITRI in all alternatives.

Table 7.3–2. LLW Decentralized Alternative

LLW Regionalized Alternative 1—(Disposal at 12 Sites)

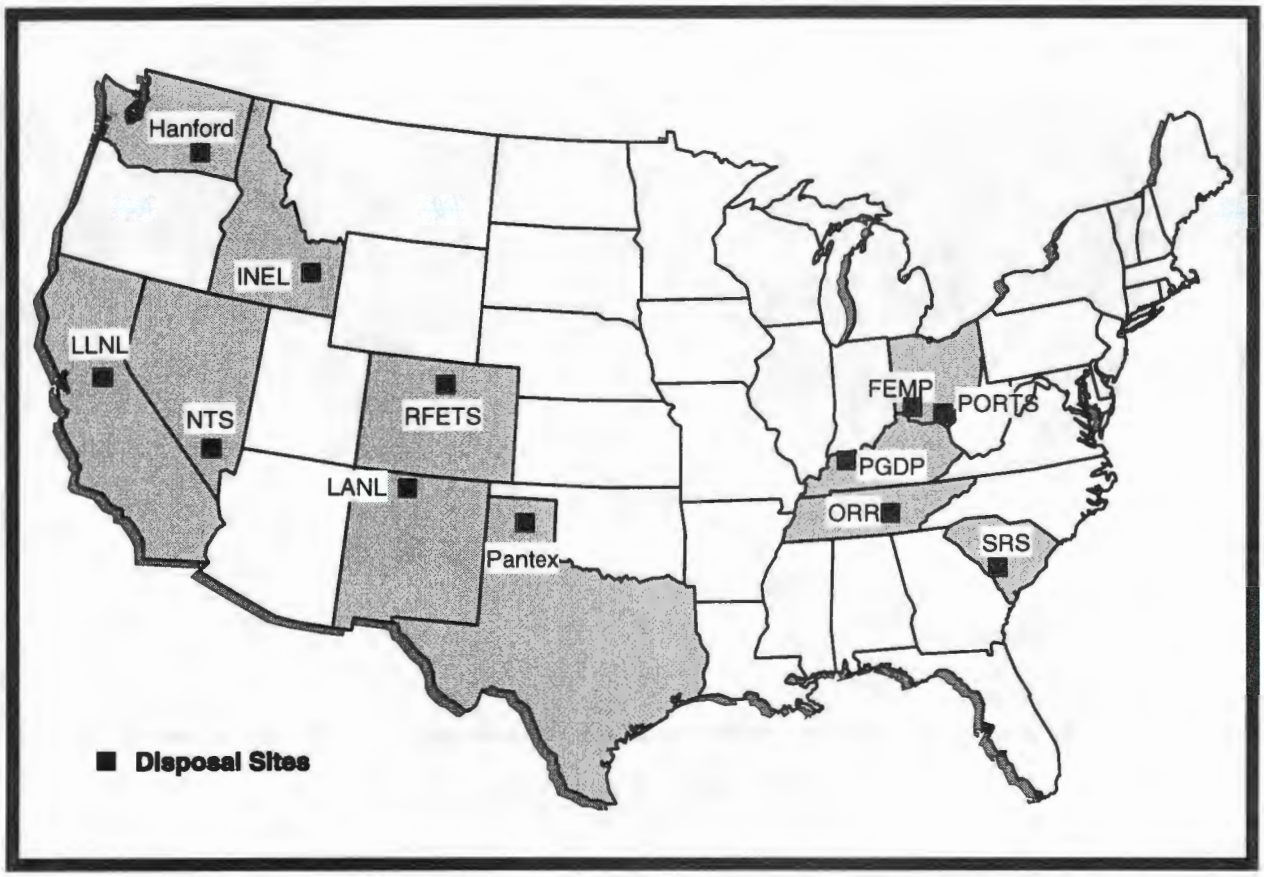


Figure 7.3–3. LLW Regionalized Alternative 1

	Generating Sites											
	Ames, ANL-E, Bettis, BNL, Fermi, KAPL, Mound, PORTS, PPPL, RMI, WVDP	FEMP	Hanford	INEL	KCP, PGDP	LANL, SNL-NM	LBL, LLNL, SLAC	NTS	ORR	Pantex	Pinellas, SRS	RFETS
Treat	MINIMUM TREAT AT ALL GENERATING SITES											
Dispose (% Rec'd From Offsite)	PORTS (61)	FEMP (0)	Hanford (0)	INEL (0)	PGDP (<1)	LANL (2)	LLNL (55)	NTS (0)	ORR (0)	Pantex (0)	SRS (<1)	RFETS (0)

Notes: Alpha-LLW would be treated and disposed of at the closest of five sites: the Hanford Site, INEL, RFETS, LANL, and SRS. RH LLW would be treated and/or disposed of at one of four sites with RH facilities: the Hanford Site, INEL, ORR, and SRS. Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 7.3–3. LLW Regionalized Alternative 1

LLW Regionalized Alternative 2—(Treatment at 11 Sites; Disposal at 12)

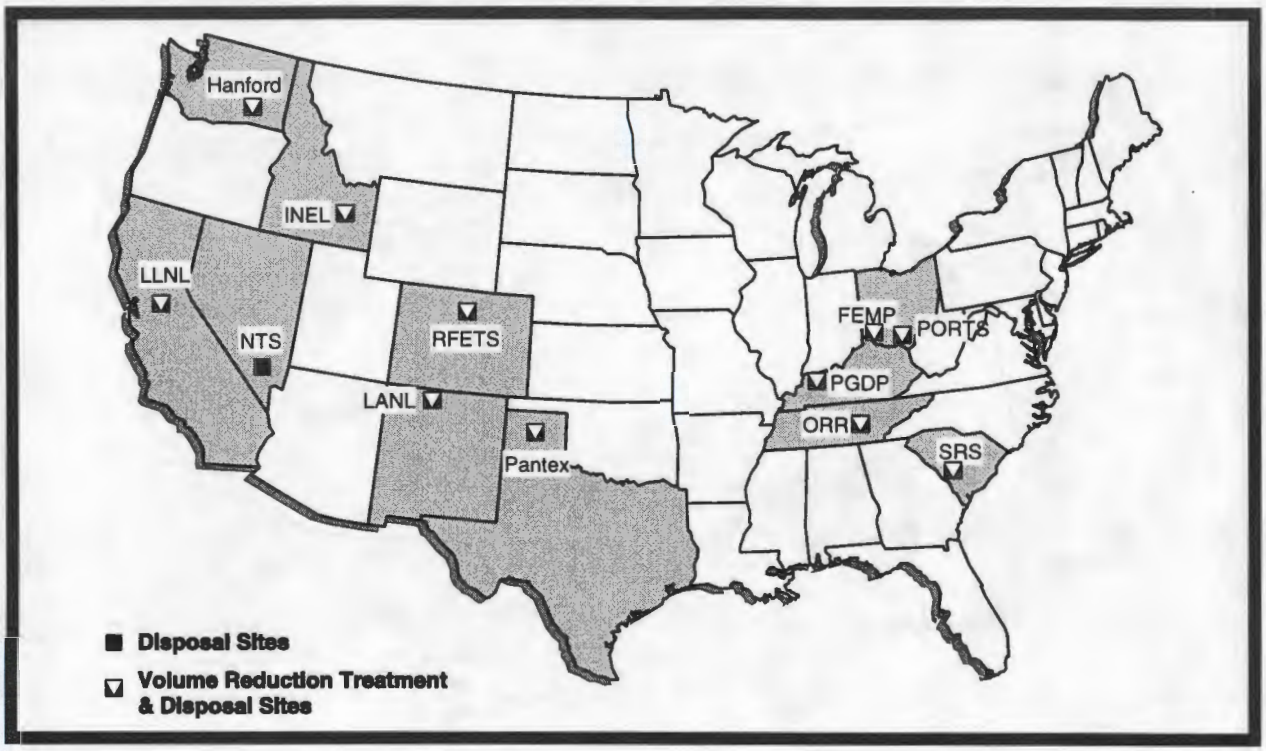


Figure 7.3–4. LLW Regionalized Alternative 2

	Generating Sites												
	Bettis, BNL, KAPL, PORTS, PPPL, RMI, WVDP	Ames, ANL-E, Fermi, Mound	FEMP	Hanford	INEL, NTS	KCP, PGDP	LBL, LLNL, SLAC	LANL, SNL-NM	NTS[a]	ORR	Pantex	Pinellas, SRS	RFETS
Treat (% Rec'd From Offsite)	PORTS (27)	FEMP (100)		Hanford (0)	INEL (0)	PGDP (<1)	LLNL (55)	LANL (2)		ORR (0)	Pantex (0)	SRS (<1)	RFETS (0)
Dispose (% Rec'd From Offsite)	PORTS (90)		FEMP[b] (ND)	Hanford (0)	INEL (0)	PGDP (<1)	LLNL (55)	LANL (2)	NTS (0)	ORR (0)	Pantex (0)	SRS (<1)	RFETS (0)

Notes: Alpha-LLW would be treated and disposed of at the closest of five sites: the Hanford Site, INEL, RFETS, LANL, and SRS. RH LLW would be treated and/or disposed of at one of four sites with RH facilities: the Hanford Site, INEL, ORR, and SRS. All sites minimum treat those waste streams that cannot be volume reduced, and send that waste to disposal at the volume reduction site, if applicable, or to another disposal site. Percentage of waste a site would receive from offsite is indicated in parentheses.

[a] LLW requiring minimum treatment only.

[b] FEMP should be viewed as a candidate disposal site for this alternative; whether waste will be disposed of there is contingent on whether there is WM waste onsite. ND = not determined.

Table 7.3–4. LLW Regionalized Alternative 2

LLW Regionalized Alternative 3—(Disposal at 6 Sites)

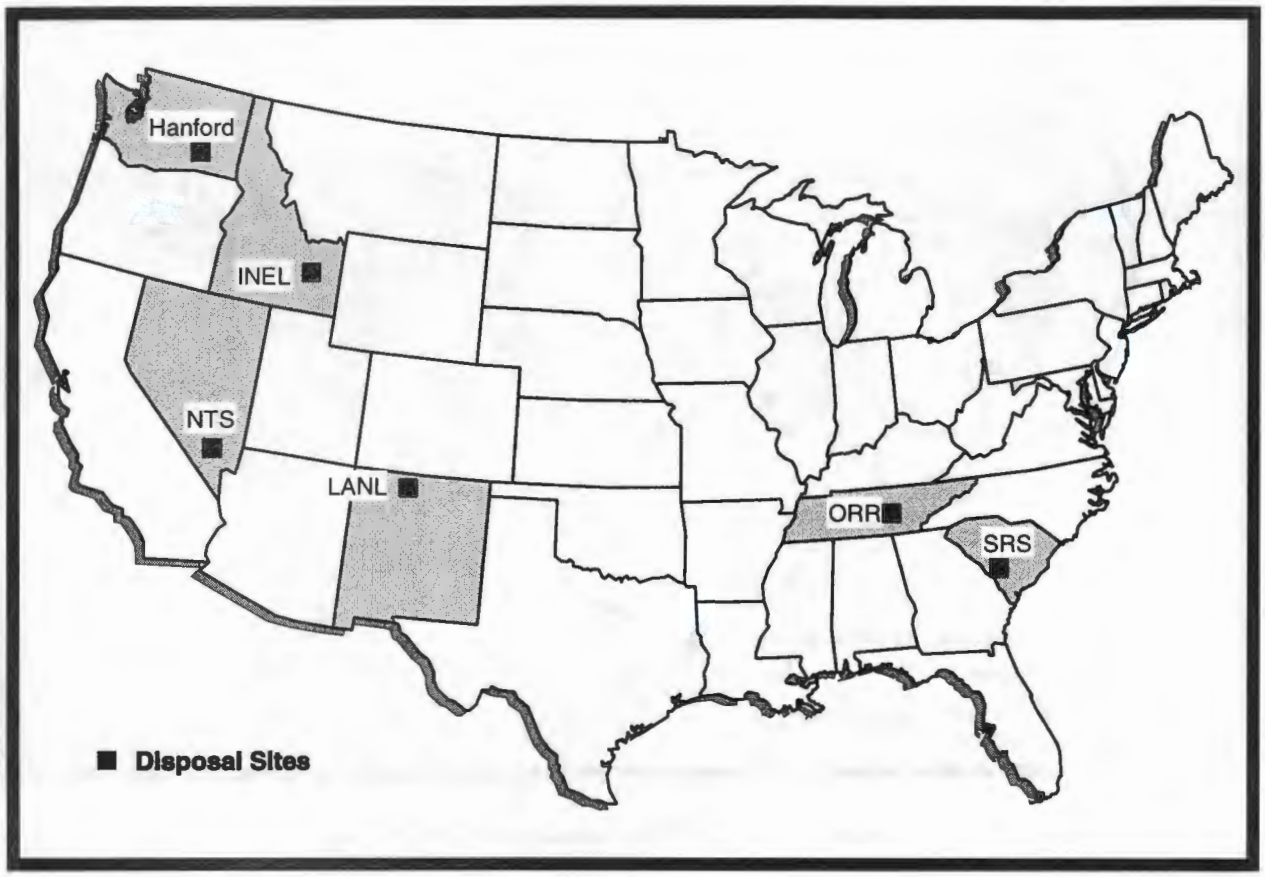


Figure 7.3–5. LLW Regionalized Alternative 3

	Generating Sites					
	Ames, ANL-E, Bettis, BNL, FEMP, Fermi, RMI, KAPL, PGDP, PORTS, PPPL, KCP, Mound, ORR, WVDP	Hanford	INEL	LANL, Pantex, RFETS, SNL-NM	LBL, LLNL, NTS, SLAC	Pinellas, SRS
Treat	MINIMUM TREAT AT ALL GENERATING SITES					
Dispose (% Rec'd From Offsite)	ORR (45)	Hanford (0)	INEL (0)	LANL (24)	NTS (80)	SRS (<1)

Notes: Alpha-LLW would be treated and disposed of at the closest of five sites: the Hanford Site, INEL, RFETS, LANL, and SRS. RH LLW would be treated and/or disposed of at one of four sites with RH facilities: the Hanford Site, INEL, ORR, and SRS. Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 7.3–5. LLW Regionalized Alternative 3

LLW Regionalized Alternative 4—(Treatment at 7 Sites; Disposal at 6)

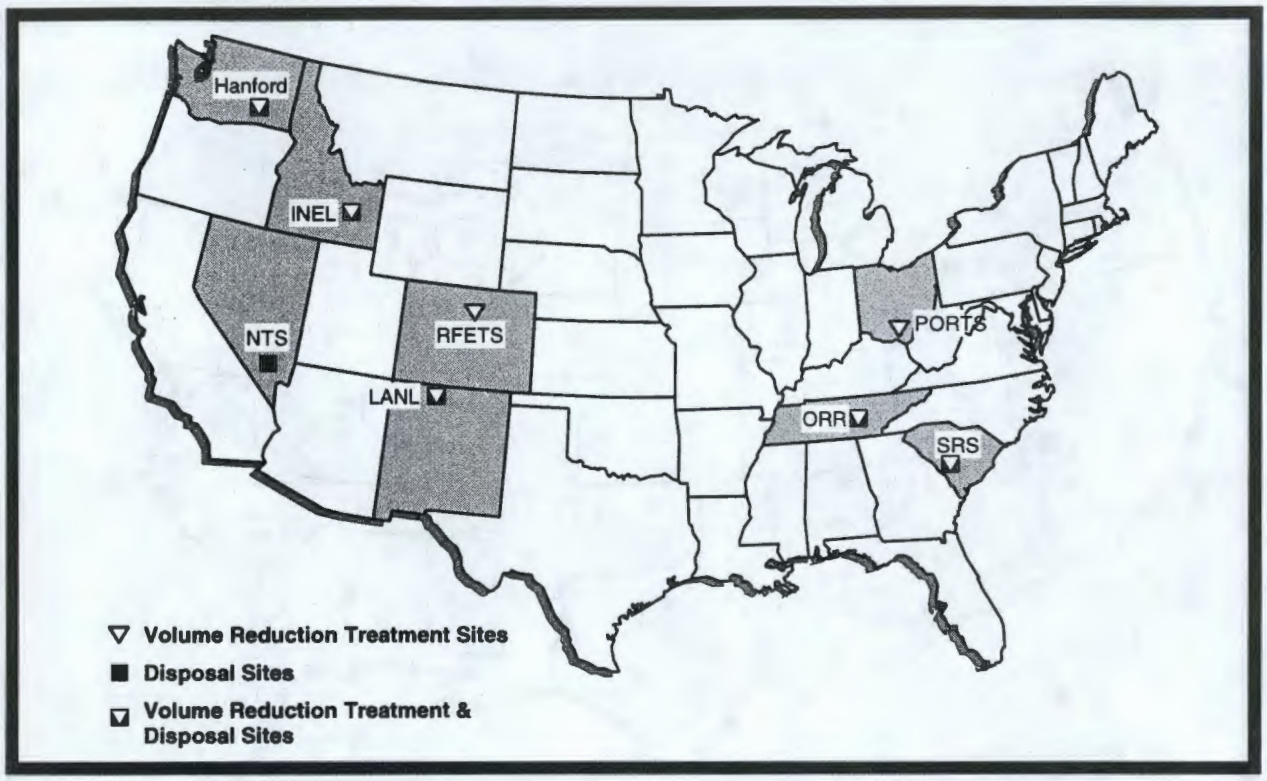


Figure 7.3–6. LLW Regionalized Alternative 4

	Generating Sites							
	Ames, ANL-E, Bettis, BNL, Fermi, FEMP, KAPL, KCP[a], Mound, PORTS, PPPL, RMI, WVDP	ORR, PGDP	Hanford, LBL, LLNL, SLAC	NTS[a], LLNL[a], LBL[a], SLAC[a]	INEL NTS	KCP, RFETS	LANL, Pantex, SNL-NM	Pinellas, SRS
Treat (% Rec'd From Offsite)	PORTS (30)	ORR (4)	Hanford (3)		INEL (1)	RFETS (<1)	LANL (<1)	SRS (<1)
Dispose (% Rec'd From Offsite)	ORR (60)		Hanford (12)	NTS (80)	INEL (1)	LANL (6)		SRS (<1)

Notes: Alpha-LLW would be treated and disposed of at the closest of five sites: the Hanford Site, INEL, RFETS, LANL, and SRS. RH LLW would be treated and/or disposed of at one of four sites with RH facilities: the Hanford Site, INEL, ORR, and SRS. All sites minimum treat those waste streams that cannot be volume reduced, and send that waste to disposal at the volume reduction site, if applicable, or to another disposal site. Percentage of waste a site would receive from offsite is indicated in parentheses.
[a] LLW requiring minimum treatment only.

Table 7.3–6. LLW Regionalized Alternative 4

LLW Regionalized Alternative 5—(Treatment at 4 Sites; Disposal at 6)

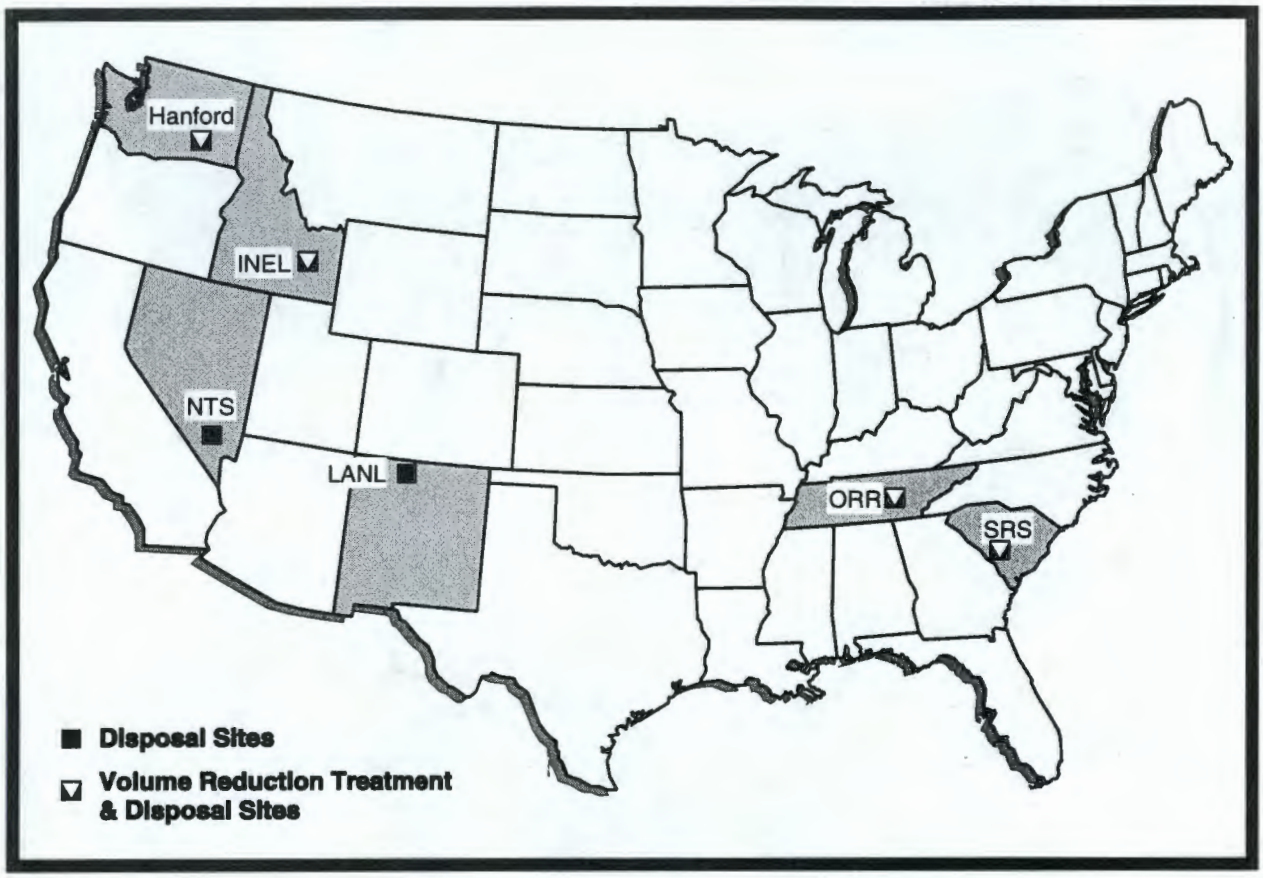


Figure 7.3–7. LLW Regionalized Alternative 5

	Generating Sites					
	Ames, ANL-E, Bettis, BNL, Fermi, FEMP, KCP, KAPL, Mound, ORR, PGDP, PORTS, PPPL, RMI, WVDP	Hanford, LBL, LLNL, SLAC	INEL, LANL, NTS, Pantex, RFETS, SNL-NM	Pinellas, SRS	LLNL[a], LBL[a], SLAC[a], NTS[a]	SNL-NM[a], LANL[a], Pantex[a], RFETS[a]
Treat (% Rec'd From Offsite)	ORR (36)	Hanford (3)	INEL (60)	SRS (<1)		
Dispose (% Rec'd From Offsite)	ORR (60)	Hanford (12)	INEL (80)	SRS (<1)	NTS (80)	LANL (24)

Notes: Alpha-LLW would be treated and disposed of at the closest of five sites: the Hanford Site, INEL, RFETS, LANL, and SRS. RH LLW would be treated and/or disposed of at one of four sites with RH facilities: the Hanford Site, INEL, ORR, and SRS. All sites minimum treat those waste streams that cannot be volume reduced, and send that waste to disposal at the volume reduction site, if applicable, or to another disposal site. Percentage of waste a site would receive from offsite is indicated in parentheses.
[a] LLW requiring minimum treatment only.

Table 7.3–7. LLW Regionalized Alternative 5

LLW Regionalized Alternative 6—(Disposal at 2 Sites)

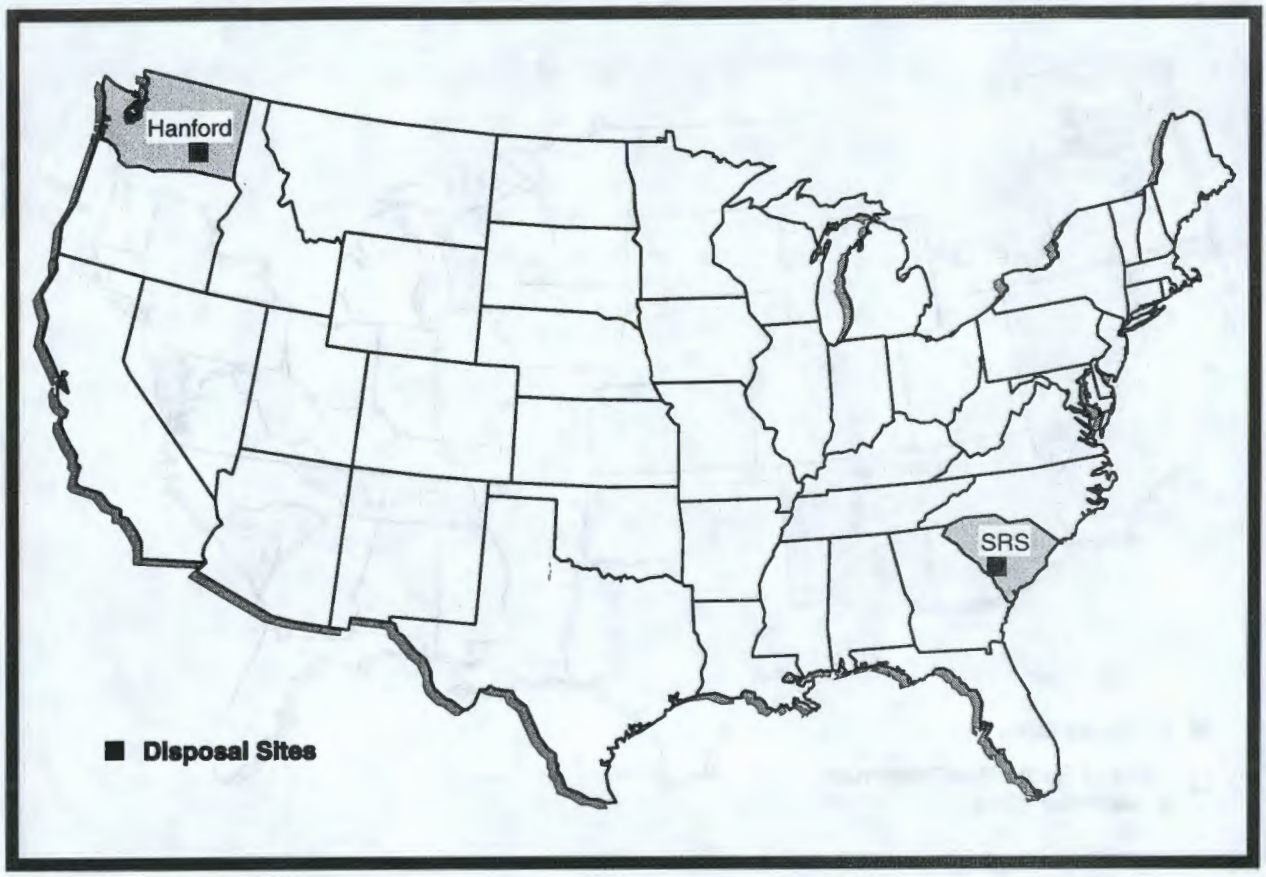


Figure 7.3–8. LLW Regionalized Alternative 6

	Generating Sites	
	Hanford, INEL, LANL, LBL, LLNL, NTS, Pantex, RFETS, SLAC, SNL-NM	Ames, ANL-E, Bettis, BNL, FEMP, Fermi, KAPL, KCP, Mound, ORR, PGDP, Pinellas, PORTS, PPPL, RMI, SRS, WVDP
Treat	MINIMUM TREAT AT ALL GENERATING SITES	
Dispose (% Rec'd From Offsite)	Hanford (75)	SRS (53)

Notes: Alpha-LLW would be treated and disposed of at the closest of five sites: the Hanford Site, INEL, RFETS, LANL, and SRS. RH LLW would be treated and/or disposed of at one of four sites with RH facilities: the Hanford Site, INEL, ORR, and SRS. Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 7.3–8. LLW Regionalized Alternative 6

LLW Regionalized Alternative 7—(Disposal at 2 Sites)

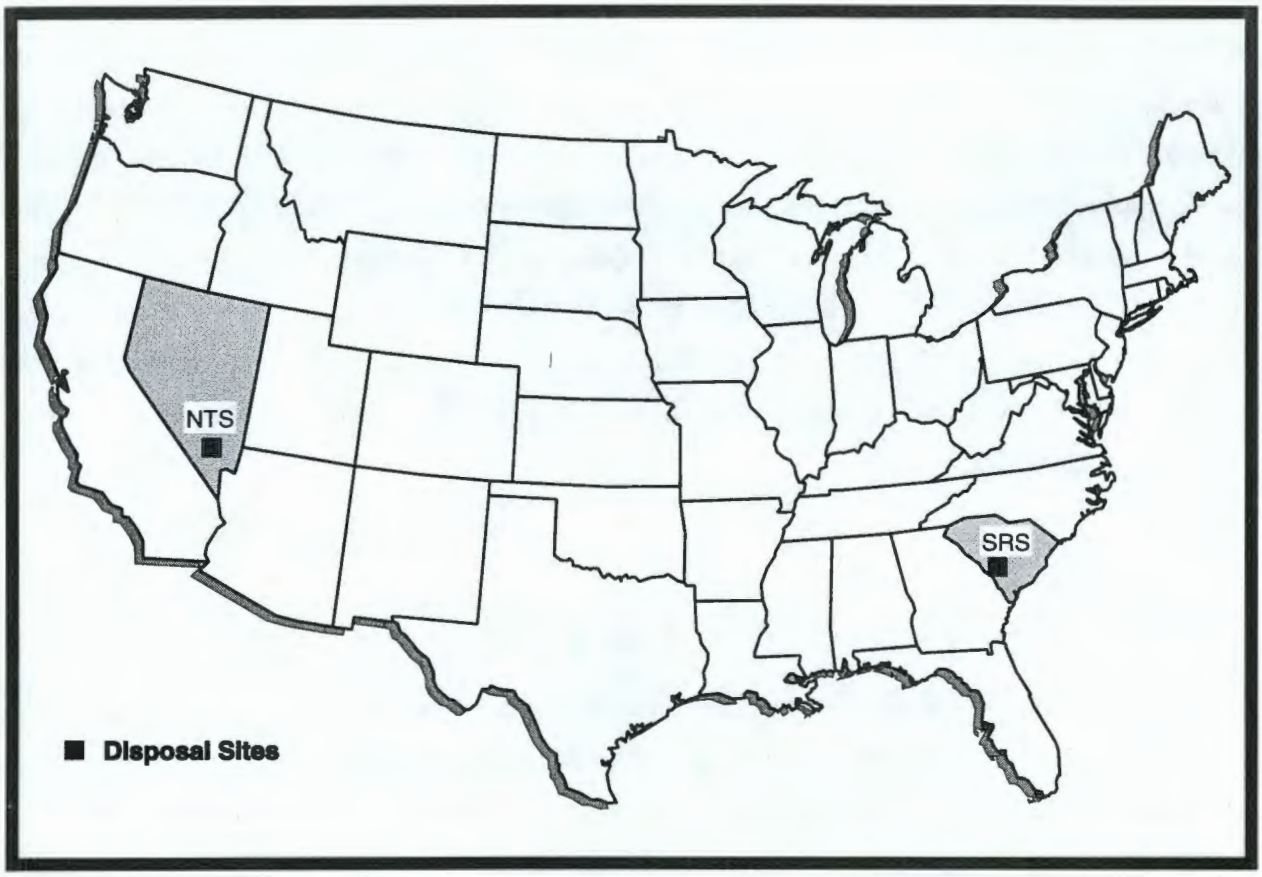


Figure 7.3-9. LLW Regionalized Alternative 7

	Generating Sites	
	Hanford, INEL, LANL, LBL, LLNL, NTS, Pantex, RFETS, SLAC, SNL-NM	Ames, ANL-E, Bettis, BNL, FEMP, Fermi, KAPL, KCP, Mound, ORR, PGDP, Pinellas, PORTS, PPPL, RMI, SRS, WVDP
Treat	MINIMUM TREAT AT ALL GENERATING SITES	
Dispose (% Rec'd From Offsite	NTS (99)	SRS (53)

Notes: Alpha-LLW would be treated and disposed of at the closest of five sites: the Hanford Site, INEL, RFETS, LANL, and SRS. RH LLW would be treated and/or disposed of at one of four sites with RH facilities: the Hanford Site, INEL, ORR, and SRS. Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 7.3-9. LLW Regionalized Alternative 7

7.3.4 CENTRALIZED ALTERNATIVES

DOE analyzed disposal at one site under the Centralized Alternatives. Five alternatives were considered. Centralized Alternatives 1 and 2 would dispose of LLW at the Hanford Site and NTS, respectively, after minimum treatment at all DOE sites. Centralized Alternative 3 evaluates disposal at the Hanford Site after volume reduction treatment at seven sites. In Centralized Alternative 4, NTS would be the single disposal site after volume reduction at the same seven sites considered in Centralized Alternative 3. Centralized Alternative 5 considers both the consolidation of LLW for volume-reducible treatment and disposal at the Hanford Site. Figures 7.3–10 through 7.3–14 provide views of the geographic proximity of the DOE sites involved in the Centralized Alternatives, and Tables 7.3–10 through 7.3–14 describe the Centralized Alternatives 1 through 5.

7.3.5 RATIONALE FOR SELECTION OF SITES

DOE generally selected LLW sites as candidates for treatment and disposal facilities if the sites had large volumes of waste. In addition, the alternatives were formulated to consolidate LLW for treatment and disposal at locations which minimized offsite transportation by shipping to the closest available treatment or disposal site.

Because of the interrelationship between LLW and LLMW, DOE used the same treatment (volume reduction) and disposal locations for LLW as those identified for the LLMW alternatives in Chapter 6.

The number of disposal sites considered covers a reasonable range of sites—from 1 to 16, with intermediate numbers of 2, 6, and 12. Sixteen candidate sites were identified to be consistent with those under consideration for LLMW. Likewise, the actual sites used for each LLW alternative mirror those for comparable LLMW alternatives. As discussed in Chapter 6, Section 6.3.5, the LLMW alternatives were selected using criteria established by DOE in coordination with the States under the Federal Facility Compliance Act (FFCAct) (42 USC 6961 *et seq.*).

LLW Centralized Alternative 1—(Disposal at 1 Site)

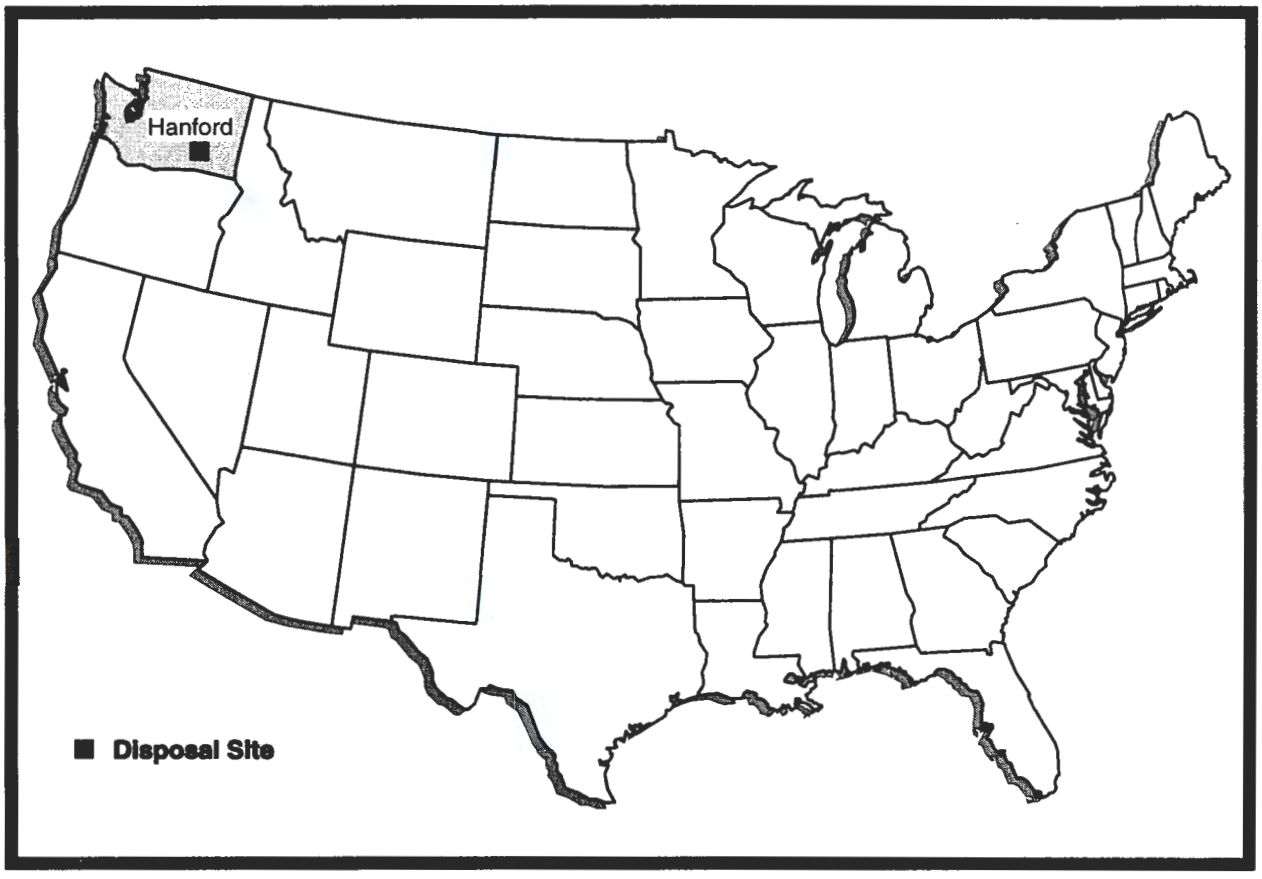


Figure 7.3-10. LLW Centralized Alternative 1

	Generating Sites All Sites
Treat	MINIMUM TREAT AT ALL GENERATING SITES
Dispose (% Rec'd From Offsite)	Hanford (94)

Notes: Alpha-LLW would be treated and disposed of at the closest of five sites: the Hanford Site, INEL, RFETS, LANL, and SRS. RH LLW would be treated and/or disposed of at one of four sites with RH facilities: the Hanford Site, INEL, ORR, and SRS. Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 7.3-10. LLW Centralized Alternative 1

LLW Centralized Alternative 2—(Disposal at 1 Site)

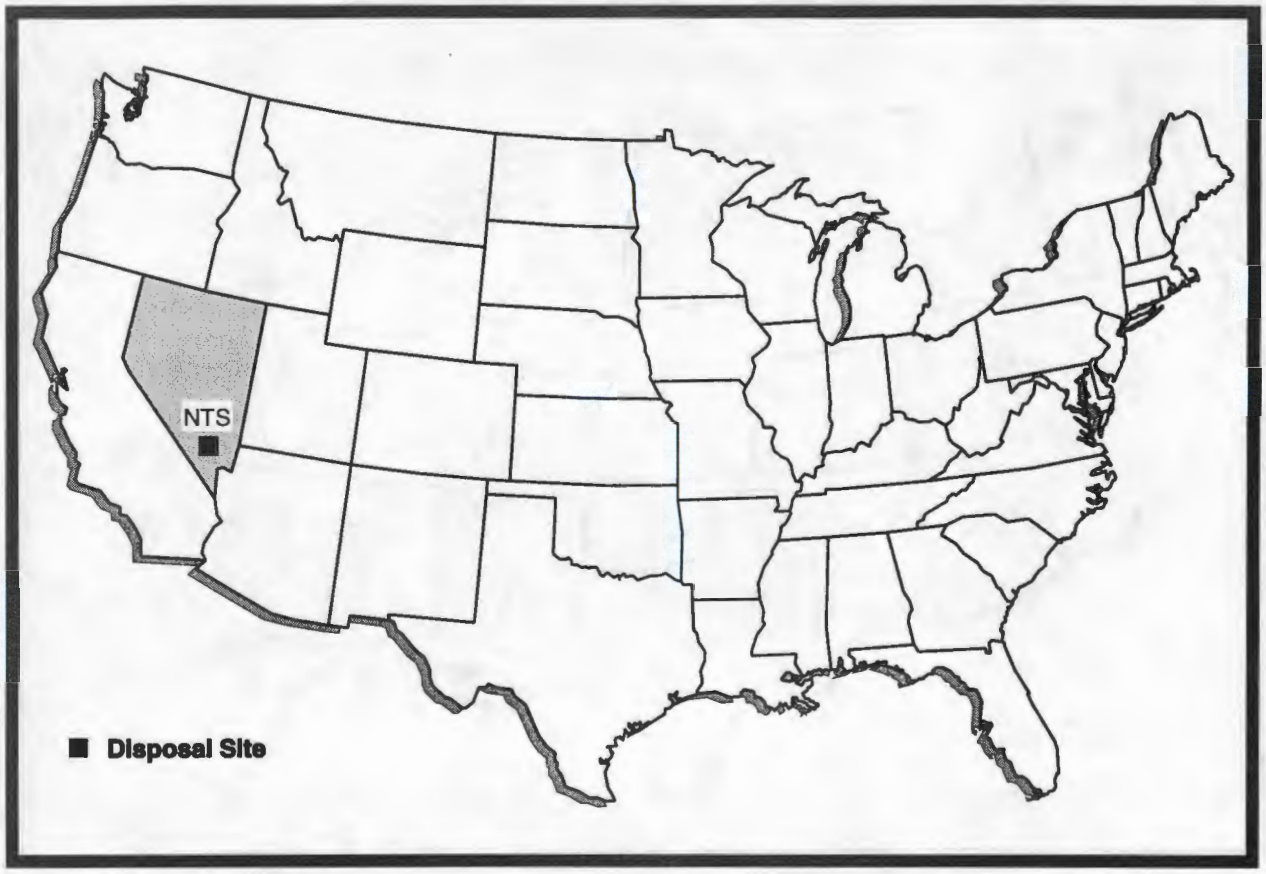


Figure 7.3-11. LLW Centralized Alternative 2

	Generating Sites All Sites
Treat	MINIMUM TREAT AT ALL GENERATING SITES
Dispose (% Rec'd From Offsite)	NTS (99)

Notes: Alpha-LLW would be treated and disposed of at the closest of five sites: the Hanford Site, INEL, RFETS, LANL, and SRS. RH LLW would be treated and/or disposed of at one of four sites with RH facilities: the Hanford Site, INEL, ORR, and SRS. Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 7.3-11. LLW Centralized Alternative 2

LLW Centralized Alternative 3—(Treatment at 7 Sites; Disposal at 1)

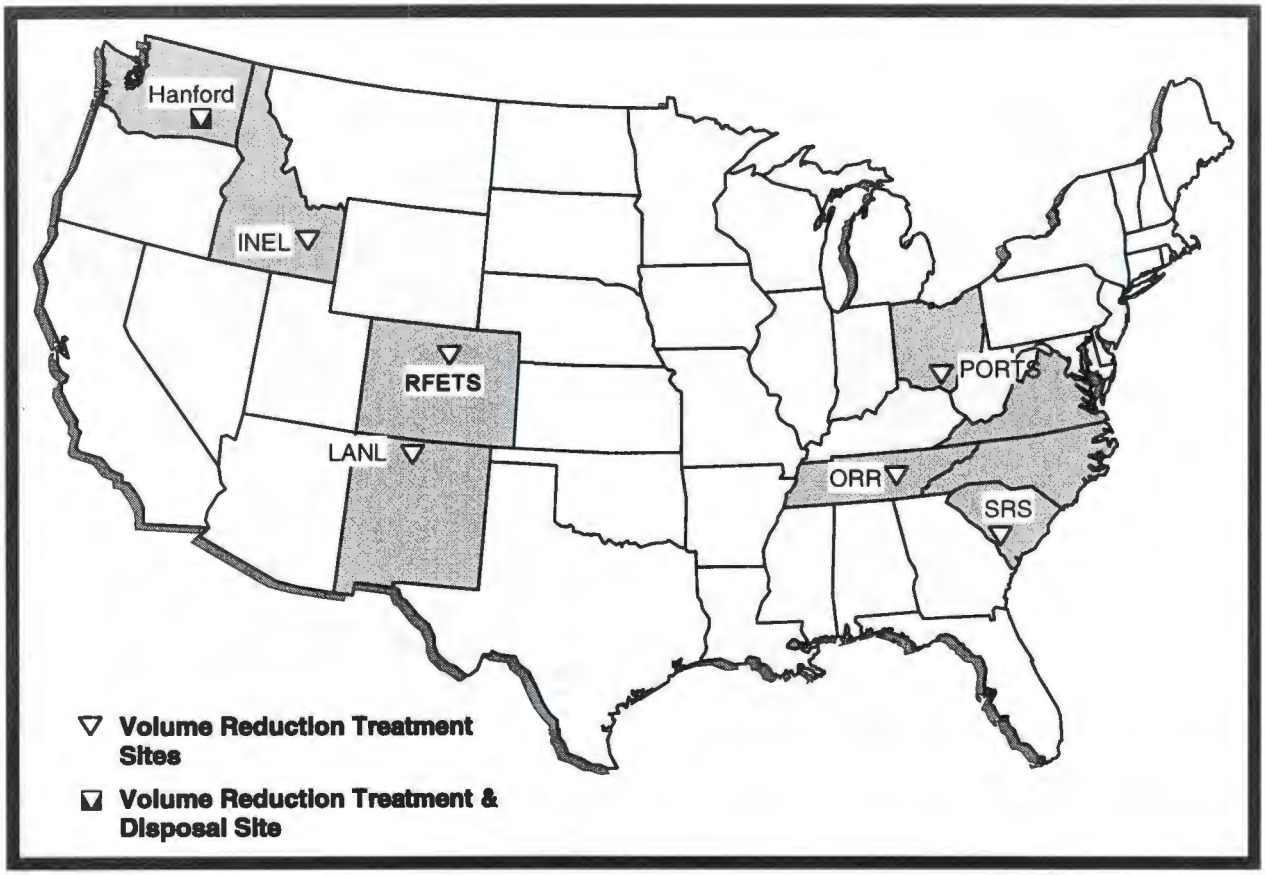


Figure 7.3–12. LLW Centralized Alternative 3

	Generating Sites						
	Ames, ANL-E, Bettis, BNL, Fermi, FEMP, KAPL, Mound, PORTS, PPPL, RMI, WVDP	Hanford, LBL, LLNL, SLAC	INEL NTS	KCP, RFETS	LANL, Pantex, SNL-NM	ORR, PGDP	Pinellas, SRS
Treat (% Rec'd From Offsite)	**PORTS** (30)	**Hanford** (3)	**INEL** (<1)	**RFETS** (<1)	**LANL** (<1)	**ORR** (4)	**SRS** (<1)
Dispose (% Rec'd From Offsite)	**Hanford** (97)						

Notes: All sites send minimum treatment wastes directly to the Hanford Site for disposal. Alpha-LLW would be treated and disposed of at the closest of five sites: the Hanford Site, INEL, RFETS, LANL, and SRS. RH LLW would be treated and/or disposed of at one of four sites with RH facilities: the Hanford Site, INEL, ORR, and SRS. Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 7.3–12. LLW Centralized Alternative 3

LLW Centralized Alternative 4—(Treatment at 7 Sites; Disposal at 1)

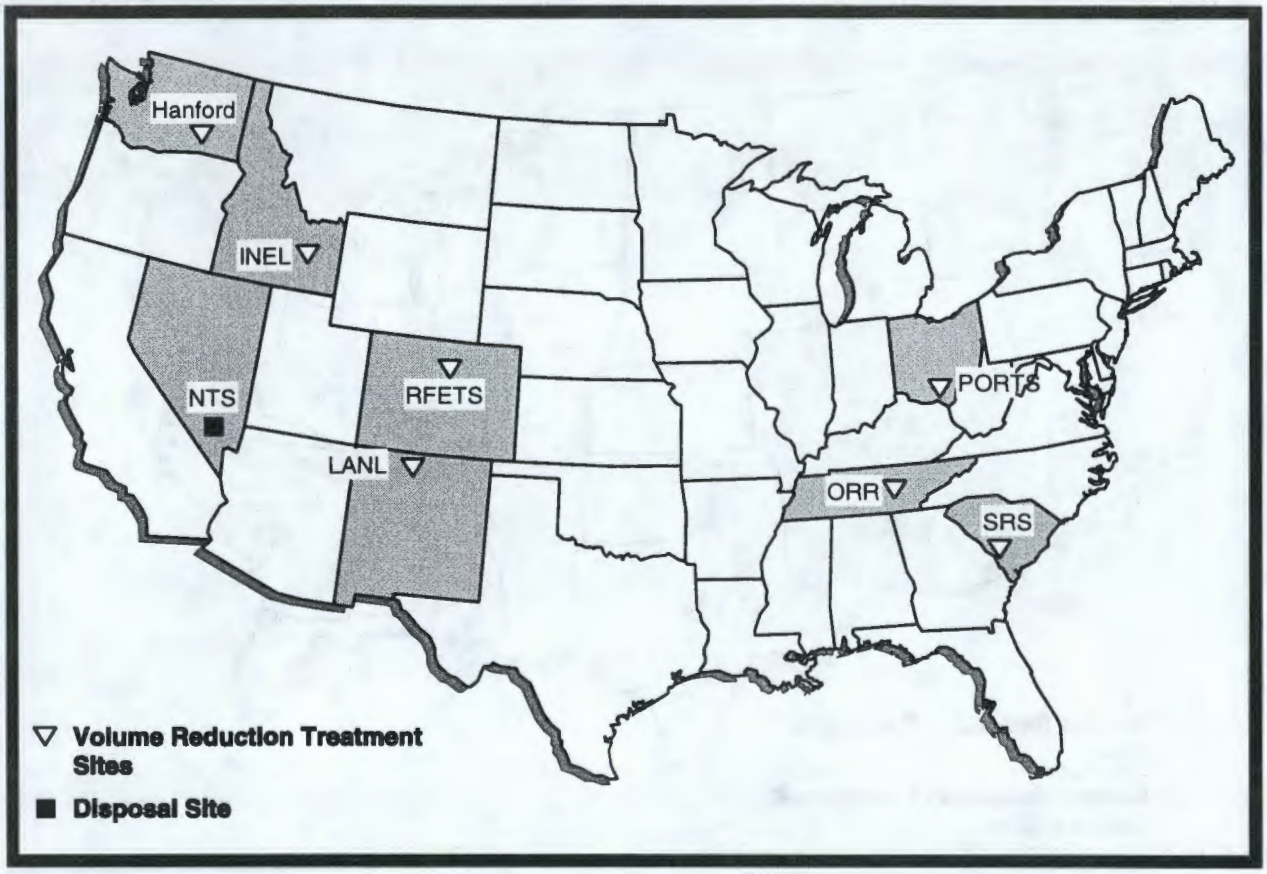


Figure 7.3–13. LLW Centralized Alternative 4

	Generating Sites						
	Ames, ANL-E, Bettis, BNL, Fermi, FEMP, KAPL, Mound, PORTS, PPPL, RMI, WVDP	Hanford, LBL, LLNL, SLAC	INEL, NTS	KCP, RFETS	LANL, Pantex, SNL-NM	ORR, PGDP	Pinellas, SRS
Treat (% Rec'd From Offsite)	PORTS (30)	Hanford (3)	INEL (<1)	RFETS (<1)	LANL (<1)	ORR (4)	SRS (<1)
Dispose (% Rec'd From Offsite)	NTS (99)						

Notes: All sites send minimum treatment wastes directly to NTS for disposal. Alpha-LLW would be treated and disposed of at the closest of five sites: the Hanford Site, INEL, RFETS, LANL, and SRS. RH LLW would be treated and/or disposed of at one of four sites with RH facilities: the Hanford Site, INEL, ORR, and SRS. Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 7.3–13. LLW Centralized Alternative 4

LLW Centralized Alternative 5—(Treatment and Disposal at 1 Site)

Figure 7.3–14. LLW Centralized Alternative 5

	Generating Sites All Sites
Treat (% Rec'd From Offsite)	Hanford (95)
Dispose (% Rec'd From Offsite)	Hanford (94)

Notes: All sites send minimum treatment waste to the Hanford Site for disposal. Alpha-LLW would be treated and disposed of at the closest of five sites: the Hanford Site, INEL, RFETS, LANL, and SRS. RH LLW would be treated and/or disposed of at one of four sites with RH facilities: the Hanford Site, INEL, ORR, and SRS. Percentage of waste a site would receive from offsite is indicated in parentheses.

Table 7.3–14. LLW Centralized Alternative 5

7.4 Health Risks

The greatest fatality risk is to waste management workers, primarily for physical hazards. The number of worker fatalities would decrease as the volume of LLW decreases through volume reduction. Radiation exposure risks to noninvolved worker and offsite populations are a function of the treatment technology and the DOE site. The highest risks to offsite populations would occur at FEMP, Hanford, LLNL, ORR, and Portsmouth as a result of volume reduction of tritium-contaminated waste at these sites. Concentrations of radionuclides in the groundwater near disposal facilities exceed applicable standards at several sites, demonstrating the need for performance based waste acceptance criteria. Management of radionuclide concentrations and waste forms would be required to assure acceptable water quality and human health risks. Transportation risks from both traffic accidents and radiation exposure would be greatest under the Centralized Alternatives, which involves the largest number of vehicle miles traveled.

Health risk impacts can result from exposure to radiation and from physical trauma associated with constructing and operating treatment and disposal facilities or transporting waste. Health effects resulting from radiation exposure, whether from sources external or internal to the body, can affect either the exposed individual's body (known as a "somatic" effect; e.g., cancer) or descendants of the exposed individual (known as a "genetic" effect). This section discusses the estimated adverse health impacts resulting from radiation exposures as well as from physical hazards for each LLW treatment and disposal alternative. Details of the LLW results are contained in Appendices D, E, and F. Methodology details are contained in Chapter 5, Appendix D, and in ORNL technical reports (ORNL, 1995a-c).

The following sections present the impacts for the LLW Alternatives:

7.4 Health Risks
7.5 Air Quality Impacts
7.6 Water Resources Impacts
7.7 Ecological Resources Impacts
7.8 Economic Impacts
7.9 Population Impacts
7.10 Environmental Justice Concerns
7.11 Land Use Impacts
7.12 Infrastructure Impacts
7.13 Cultural Resources Impacts
7.14 Costs
7.15 Environmental Restoration Analysis
7.16 Comparison of Alternatives Summary

Potential health risks to a number of receptor populations and individuals are presented including:

- The offsite population—those individuals living within a 50-mile radius of the site, as well as along transportation routes
- Noninvolved worker population—the workers on DOE sites who are not involved directly in waste management activities

- Waste management worker population (or "waste management workers")—onsite employees working in a site's waste management facilities, including workers involved in the waste management process, construction workers who build the waste management facilities, and those operating the trucks and trains that transport the waste
- Maximally exposed individual (MEI) for the offsite population—hypothetical individual in the offsite population who would receive the highest total lifetime multimedia dose
- MEI for the noninvolved worker population—hypothetical individual in the noninvolved worker population who would receive the highest total lifetime multimedia dose
- Farm family most exposed lifetime MEI—hypothetical individual in the most exposed lifetime of the farm family who would receive the highest dose from disposal of LLW
- A hypothetical intruder—an individual who would experience maximum potential future risks from disposal of LLW upon the loss of institutional control

Maximally Exposed Individual

In keeping with the standard risk assessment methodology, DOE analyzed the impacts to a "maximally exposed individual." The MEI is the hypothetical person within the receptor group who has the highest exposure. This individual is assumed to be located at the point of maximum concentration of contaminants 24 hours a day, 7 days a week, for the 10-year period of operations analyzed in the WM PEIS.

The impacts evaluated were:

- Fatalities from physical hazards
- Cancer fatalities from radiation exposure
- Cancer incidences from radiation exposure
- Genetic effects from radiation exposure

Interpreting the results of health risk analyses involves consideration of both uncertainties and appropriate standards. See Section 5.4.1 and Appendix D for a further discussion of these issues.

7.4.1 ROUTINE OPERATION IMPACTS

7.4.1.1 Treatment

For operations involving LLW treatment, health effects were evaluated for the offsite population, the onsite worker population not involved in LLW treatment ("noninvolved workers"), and waste management workers directly involved in treatment activities. Impacts were quantified using two approaches: analysis of *population* health risk impacts and analysis of *individual* health risk impacts.

Population impacts focus on the *total number* of people in each receptor population who would experience adverse health impacts if a particular alternative is implemented. Table 7.4–1 provides estimates of the sizes of the offsite and waste treatment worker populations by site. The waste management worker numbers are derived from generic baselines which established the number of personnel required to operate treatment facilities to manage a given amount of waste.

Individual impacts focus on the *probability* that the MEI within each receptor population would experience an adverse health impact. Because the focus is on the MEI, the risk is presented as a probability (e.g., one-in-one million or 1E–06) of that individual experiencing an adverse health impact, rather than a total number of impacts for a selected population.

DOE analyzed effects of LLW radionuclides on the receptor groups. The pathways of exposure analyzed were inhalation, ingestion of plants and animals, direct gamma radiation, and absorption of tritium through the skin.

Worker risks associated with physical hazards were evaluated for 20 years: a 10-year period of construction of treatment and disposal facilities, and a subsequent 10-year period of operation. However, worker and public risks from exposure to radionuclides (received during the 10-year operation period) were evaluated for an entire lifetime (70 years) because health impacts from airborne contaminants or direct radiation could occur throughout the lifetime of the exposed individual.

Understanding Scientific Notation

Scientific notation is used in this PEIS to express numbers that are so large or so small that they can be difficult to read or write. Scientific notation is based on the use of positive and negative powers (or exponents) of 10. A number written in scientific notation is expressed as the product of a number between 1 and 10 times a positive or negative power of 10. Some positive and negative powers of 10 include:

Positive Powers of 10	***Negative Powers of 10***
$10^{1} = 10 \times 1 = 10$	$10^{-1} = 1/10 = 0.1$
$10^{2} = 10 \times 10 = 100$	$10^{-2} = 1/100 = 0.01$
and so on, therefore,	*and so on, therefore,*
$10^{6} = 1{,}000{,}000$ *(or 1 million)*	$10^{-6} = 0.000001$ *(or 1 in 1 million)*
etc.	*etc.*

A power of 10 is also commonly expressed as "E", where "E" means "× 10". For example, 3×10^{5} *can also be written as 3E+05, and* 3×10^{-5} *is equivalent to 3E-05. Therefore, 3E+05 = 300,000 and 3E-05 = 0.00003.*

The health risk data tables in this section use "E" notation with negative exponents.

Probability is expressed as a number between 0 and 1. The notation 3E-06 can be read 0.000003, which means that there are three chances in 1,000,000 that the associated result (e.g., fatal cancer) will occur in the period covered by the analysis.

Table 7.4-2 provides an overview of the health risk endpoints, receptor groups, hazard sources, pathways, and exposure periods evaluated for LLW treatment.

7.4.1.2 Disposal

Health risks resulting from LLW disposal were evaluated for waste management workers handling the treated LLW, for an onsite "hypothetical farm family" located 300 meters from the center of the disposal facility, and for a hypothetical "intruder" into the disposal facility after the facility has been closed.

The waste management workers were assumed to be exposed through direct radiation during disposal operations. Risks to the waste management workers (resulting from the 10-year operation/exposure period) were estimated for one lifetime (70 years).

Table 7.4–1. Offsite Population and Waste Management Treatment Worker Populations by Site

Site	Offsite Population[a]	WM Treatment Worker Population by Alternative[b]													
		NA	D	R1	R2	R3	R4	R5	R6	R7	C1	C2	C3	C4	C5
ANL-E	7,939,785	402	224	224	224	224	224	224	224	224	224	224	224	224	224
BNL	5,738,554	695	273	417	417	417	417	417	417	417	417	417	417	197	417
FEMP	2,764,589	--	--	--	461	--	--	--	--	--	--	--	--	--	--
Hanford	377,645	997	577	577	1,569	577	1,634	1,634	577	843	577	843	1,634	1,634	9,856
INEL	153,061	2,169	677	677	1,809	677	1,809	3,954	1,032	1,032	1,032	1,032	1,809	1,809	677
LANL	159,152	920	653	653	1,362	653	2,731	902	902	902	902	902	2,731	2,731	902
LLNL	6,324,234	426	191	191	483	227	227	227	227	227	227	227	227	227	227
NTS	14,266	78	64	64	108	64	108	108	108	64	108	64	108	108	108
ORR	881,652	2,895	1,892	1,892	5,198	1,811	5,117	5,819	2,259	2,259	2,259	2,259	5,246	5,246	2,259
PGDP	500,502	654	501	501	800	503	497	497	503	503	503	503	497	497	497
Pantex	265,185	333	214	214	216	214	214	214	214	214	214	214	214	214	214
PORTS	639,602	1,450	730	730	3,434	1,075	3,483	1,087	1,075	1,075	1,075	1,075	3,481	3,481	1,087
RFETS	2,171,877	656	298	298	800	344	800	344	344	344	344	344	800	800	344
SNL-NM	610,714	277	187	210	210	210	210	210	210	210	210	210	232	232	210
SRS	620,618	3,032	1,986	1,986	2,598	1,986	2,598	2,598	1,986	1,986	2,008	2,008	2,598	2,598	1,986
WVDP	1,698,391	539	433	464	463	464	463	463	464	464	464	464	463	463	463

Notes: NA = No Action; D = Decentralized; R1-R7 = Regionalized; C1-C5 = Centralized. -- = no waste treatment at this site under this alternative.
[a] Within 50-mile radius of sites.
[b] Waste management worker population estimates represent full-time equivalents (FTEs) over the entire construction and operation period.

For the farm family and intruder analyses, DOE assumed that waste was disposed of in either aboveground or belowground disposal units, depending on the site, each with a capacity of 18,000 and 12,000 cubic meters, respectively. Additional units were added as needed to dispose all of the waste on a site. Each disposal unit was assumed to affect a separate farm family and a separate intruder. Thus, the effects on the farm family (and on the intruder) were assumed to come from a single disposal unit, rather than from a combination of all the units at a site.

The exposure pathways for the hypothetical farm family were ingestion of groundwater and ingestion of plants and animals contaminated by irrigation water. The groundwater was assumed to be contaminated by a breach in each disposal unit immediately after shallow land burial, 300 years after disposal in aboveground vaults, or 750 years after disposal in belowground vaults. The contaminants are assumed to leach over time from their solidified waste form to create a plume of contamination. Individual contaminant plumes were then assumed to migrate to the receptor wells without mixing with each other. The risks to

Table 7.4–2. LLW Treatment Health Risk Analysis Components

LLW Treatment					
Endpoints	**Receptor**	**Source**	**Pathways**	**Exposure Period**	**Table Reference**
Number of Physical Hazard Fatalities	WM Workers	Physical Hazards	Physical Hazards	20 years	7.4–4
Number of Cancer Fatalities	Offsite Population	Radionuclides	Inhalation, Ingestion, Direct Radiation	10 years	7.4–4
	Noninvolved Workers		Inhalation, Direct Radiation		
	WM Workers		Inhalation, Direct Radiation		
Number of Cancer Incidences	Offsite Population	Radionuclides	Inhalation, Ingestion, Direct Radiation	10 years	7.4–5
	Noninvolved Workers		Inhalation, Direct Radiation		
	WM Workers		Inhalation, Direct Radiation		
Number of Genetic Effects	Offsite Population	Radionuclides	Inhalation, Ingestion, Direct Radiation	10 years	7.4–5
	Noninvolved Workers		Inhalation, Direct Radiation		
	WM Workers		Inhalation, Direct Radiation		
Probability of Cancer Fatality	Offsite MEI	Radionuclides	Inhalation, Ingestion, Direct Radiation	10 years	7.4–6 7.4–7
	Noninvolved Worker MEI		Inhalation, Direct Radiation		7.4–6
Probability of Cancer Incidence	Offsite MEI	Radionuclides	Inhalation, Ingestion, Direct Radiation	10 years	7.4–8
	Noninvolved Worker MEI		Inhalation, Direct Radiation		
Probability of Genetic Effects	Offsite MEI	Radionuclides	Inhalation, Ingestion, Direct Radiation	10 years	7.4–8
	Noninvolved Worker MEI		Inhalation, Direct Radiation		

the hypothetical farm family were estimated over a 10,000-year period because the maximum exposure would occur in the future when the peak of contaminant concentration passes the well. The 10,000-year period was selected for the analysis to maintain consistency with the "Guidelines for Radiological Performance Assessment: DOE Low-Level Radioactive Waste Disposal Sites" that existed at the time the WM PEIS analysis was initiated. The guidance for performance assessments has since been changed; current guidance suggests that a 1,000-year time period should be used in the performance assessments for waste disposal conducted to satisfy the requirements of DOE Order 5820.2A. Results of the farm family

analyses are presented as the probability of cancer fatality for an individual during the 70-year lifetime that presents the greatest exposure of the 143 lifetimes (i.e., 10,000 years) analyzed.

The exposure pathways for the hypothetical intruder were inhalation of resuspended contaminated soil, inadvertent ingestion of contaminated soil, ingestion of plants grown in contaminated soil, direct radiation from contaminated soil, and absorption of tritium through the skin. A hypothetical intruder who drills into the disposal unit was assumed to be exposed to radioactively contaminated wastes that remain at the site. Two hypothetical intrusions were assumed to occur: 100 years and 300 years after closure of the disposal unit. The risks to the hypothetical intruder were estimated for one lifetime (70 years).

Hypothetical Farm Family and Intruder

The "hypothetical farm family" is an imaginary family assumed to live 300 meters downgradient of the center of a waste disposal unit. The family engages in farming activities such as growing and consuming their own crops and livestock, and uses groundwater for watering the crops and animals. This is an estimated maximum scenario taking place in the future at a time when institutional controls no longer exist. The scenario is analyzed to determine potential upper-bound exposures by ingestion of contaminated groundwater.

The hypothetical "intruder" is an imaginary adult who drills a well directly through a LLW disposal unit to the groundwater. As a result of the drilling, radioactively contaminated soil from within the unit is brought to the surface, where it mixes with the top layers of the surface soil. The individual farms the land and eats the crops. The intruder scenario occurs after the failure of institutional control. This is consistent with the analysis required for disposal facilities under DOE Order 5820.2A (DOE, 1988).

Table 7.4–3 provides an overview of the health risk endpoints, receptor groups, hazard sources, pathways, and exposure periods evaluated for LLW disposal.

The health risk impacts associated with the routine operation of LLW treatment and disposal facilities are presented in Tables 7.4–4 through 7.4–13 of this section. The tables show the estimates of human health risk for both treatment and disposal of LLW. Summary tables show programwide results by alternative. The site tables in Volume II present the health impacts for the 16 major LLW sites.

This human health risk analysis includes evaluation of both the potential numbers of fatal cancers as well as the numbers of total cancer incidences induced by exposure to radionuclides and direct radiation. The numbers of nonfatal cancers can be derived from the cancer incidence values by subtracting the estimated number of fatal cancer cases. Note that both the *total cancer incidence* and the *nonfatal cancer incidence* values are overestimated by a factor of about two because the estimates contain a relatively large component

Table 7.4–3. LLW Disposal Health Risk Analysis Components

LLW Disposal					
Endpoints	**Receptor**	**Source**	**Pathways**	**Exposure Period**	**Table Reference**
Number of Physical Hazard Fatalities	WM Workers	Physical Hazards	Physical Hazards	20 years	7.4–4
Number of Cancer Fatalities	WM Workers	Radionuclides	Direct Radiation	10 years	7.4–4
Number of Cancer Incidences	WM Workers	Radionuclides	Direct Radiation	10 years	7.4–5
Number of Genetic Effects	WM Workers	Radionuclides	Direct Radiation	10 years	7.4–5
Probability of Cancer Fatality	Hypothetical Farm Family Most Exposed Lifetime MEI	Radionuclides	Ingestion	70 years	7.4–9
	Hypothetical Intruder		Inhalation, Ingestion, and Direct Radiation		7.4–12 7.4–13
Probability of Cancer Incidence	Hypothetical Intruder	Radionuclides	Inhalation, Ingestion, Direct Radiation	70 years	7.4–12
Probability of Genetic Effects	Hypothetical Intruder	Radionuclides	Inhalation, Ingestion, Direct Radiation	70 years	7.4–12

of skin cancers. The internal exposure pathways evaluated in this PEIS (e.g., inhalation or ingestion of radionuclides) are not likely to induce large numbers of skin cancer cases. However, the International Commission on Radiological Protection (ICRP) dose conversion factor used in the WM PEIS to estimate total cancer incidence includes incidences of skin cancer (ICRP, 1990).

7.4.1.3 Estimated Number of Fatalities

7.4.1.3.1 Programwide

Table 7.4–4 presents an overview, by alternative, of the total estimated programwide fatalities associated with both treatment and disposal of LLW. This table presents the estimated number of latent cancer fatalities

Table 7.4–4. LLW Treatment and Disposal: Estimated Number of Fatalities Programwide

Alternative	Number of Sites		Treatment				Disposal	
			WM Workers				WM Workers	
	T[a]	D	Number of Radiation Cancer Fatalities	Number of Physical Hazard Fatalities	Number of Offsite Population Radiation Cancer Fatalities	Number of Noninvolved Worker Radiation Cancer Fatalities	Number of Radiation Cancer Fatalities	Number of Physical Hazard Fatalities
No Action	10[b]	6	1	3	*	*	3	4
Decentralized		16	1	2	*	*	2	6
Regionalized 1		12	1	2	*	*	3	6
Regionalized 2	11	12	1	4	1	*	2	4
Regionalized 3		6	1	2	*	*	3	5
Regionalized 4	7	6	2	4	*	*	2	4
Regionalized 5	4	6	2	4	*	*	2	4
Regionalized 6		2	1	2	*	*	2	6
Regionalized 7		2	1	2	*	*	1	6
Centralized 1		1	1	2	*	*	3	1
Centralized 2		1	1	2	*	*	2	1
Centralized 3	7	1	1	4	*	*	2	1
Centralized 4	7	1	1	4	*	*	2	*
Centralized 5	1	1	2	4	*	*	2	1

Notes: T = treatment; D = disposal. * = greater than 0 but less than 0.5.

[a] All sites perform "minimum treatment" under all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.

[b] Ten sites use existing facilities for volume reduction.

in the offsite population, noninvolved workers, and waste management workers caused by radiological exposure. In addition, the table shows the estimated number of waste management worker deaths resulting from physical hazards during facility construction and operation.

For each alternative, there are at least three estimated fatalities associated with treatment operations. These fatalities occur primarily within the waste management worker population, and result mainly from physical hazards involved in construction and operation of LLW treatment facilities. Waste management workers are the only receptor group exposed to these physical hazards, and therefore, have more estimated fatalities than other receptor groups. A single fatality in the offsite population is estimated under Regionalized Alternative 2; no fatalities are estimated in the noninvolved worker population under any treatment alternative. In general, alternatives involving volume reduction present greater treatment risks to workers than alternatives involving only minimum treatment.

Disposal operations show at least six estimated fatalities to waste management workers in all alternatives, except where disposal is consolidated at one site. Waste management worker disposal radiation cancer fatalities are generally greater than those estimated for treatment. Under the single disposal site alternatives, the number of physical hazard fatalities decreases, whereas cancer fatalities from radiation exposure are similar to those estimated for the other disposal alternatives.

For all alternatives, the estimated number of fatalities to waste management workers due to physical hazards exceeds estimated radiological fatalities to the offsite and noninvolved worker populations. In general, risk to waste management workers appears to decrease with increased centralization of disposal activities. Fewer fatalities from physical hazards occur because fewer facilities and worker hours are required when waste management activities are consolidated at one or a few sites.

7.4.1.3.2 Site-Level

At least one fatality resulting from physical hazards or radiation exposure associated with implementing the LLW alternatives is estimated to occur at seven sites: the Hanford Site, NTS, INEL, LANL, ORR, PORTS, and SRS. All of these fatalities are estimated to occur within the waste management worker population, primarily as a result of physical hazards during treatment or disposal activities. Although fewer in number, fatalities due to radiation exposure of waste management workers during treatment and disposal are estimated to occur at the Hanford Site and NTS.

Each of the LLW alternatives results in at least one site with one or more estimated fatalities. Under Regionalized Alternatives 2, 4, 5, 6 and 7 and Centralized Alternatives 3 and 4, at least two of the above sites have estimated waste management worker fatalities exceeding one.

7.4.1.4 Estimated Number of Cancer Incidences and Genetic Effects

7.4.1.4.1 Programwide

Table 7.4–5 presents an overview, by alternative, of the total number of programwide cancers and genetic effects associated with treatment and disposal of LLW. These impacts result from radiation exposure of the offsite population (treatment-related only), noninvolved workers (treatment-related only), and waste management workers (treatment and disposal). In addition, the table includes radiation dose estimates for each receptor group.

Each of the treatment alternatives results in at least three cancer incidences in the waste management workers. Cancer incidence in the other receptor groups is limited to an estimated two cancers in the offsite population under Regionalized Alternative 2 and one cancer incidence under Regionalized Alternative 5. The number of genetic effects was not estimated to equal or exceed one in any receptor group.

At least six radiation-induced cancers among the waste management workers were estimated under each of the disposal alternatives. The volume reduction alternatives (Regionalized 2, 4, and 5 and Centralized 3, 4, and 5) generally had lower estimated numbers of cancers.

7.4.1.4.2 Site-Level

At least one latent cancer incidence resulting from radiation exposure associated with implementation of the LLW alternatives is estimated to occur at seven sites: the Hanford Site, INEL, LANL, LLNL, NTS, ORR, and SRS.

Table 7.4-5. LLW Treatment and Disposal: Estimated Number of Cancer Incidences and Genetic Effects Programwide

Alternative	Number of Sites		Treatment									Disposal		
			Offsite Population			Noninvolved Workers			WM Workers			WM Workers		
	T[a]	D	Radiation Dose (person-rem)	Radiation Cancer Incidence	Radiation Genetic Effects	Radiation Dose (person-rem)	Radiation Cancer Incidence	Radiation Genetic Effects	Radiation Dose (person-rem)	Radiation Cancer Incidence	Radiation Genetic Effects	Radiation Dose (person-rem)	Radiation Cancer Incidence	Radiation Genetic Effects
No Action	10[b]	6	5	*	*	*	*	*	2,900	4	*	8,000	11	*
Decentralized		16	58	*	*	*	*	*	1,900	3	*	5,600	8	*
Regionalized 1		12	58	*	*	*	*	*	2,000	3	*	6,100	9	*
Regionalized 2	11	12	1,300	2	*	13	*	*	3,200	5	*	4,900	7	*
Regionalized 3		6	58	*	*	*	*	*	2,000	3	*	6,900	10	*
Regionalized 4	7	6	200	*	*	4	*	*	3,600	5	*	5,300	7	*
Regionalized 5	4	6	750	1	*	10	*	*	4,200	6	*	5,300	7	*
Regionalized 6		2	58	*	*	*	*	*	2,100	3	*	4,400	6	*
Regionalized 7		2	58	*	*	*	*	*	2,100	3	*	3,500	5	*
Centralized 1		1	58	*	*	*	*	*	2,100	3	*	6,900	10	*
Centralized 2		1	58	*	*	*	*	*	2,100	3	*	5,500	8	*
Centralized 3	7	1	200	*	*	4	*	*	3,600	5	*	4,400	6	*
Centralized 4	7	1	200	*	*	4	*	*	3,600	5	*	3,900	6	*
Centralized 5	1	1	200	*	*	2	*	*	5,500	8	*	4,400	6	*

Notes: T = treatment; D = disposal. * = greater than 0 but less than 0.5.
[a] All sites perform "minimum treatment" under all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.
[b] Ten sites use existing facilities for volume reduction.

At all of these sites except LLNL and ORR, waste management workers are the only receptor group with cancer incidence equal to or greater than one. At LLNL, the cancer incidence is estimated to occur within the offsite population under Regionalized Alternative 2 as a result of exposure to tritium. At ORR, the cancer incidence is estimated to occur within the offsite population under Regionalized Alternative 5 as a result of exposure to tritium. No sites are estimated to have one or more genetic effects.

7.4.1.5 Probability of MEI Cancer Fatalities

Table 7.4–6 summarizes, by alternative, the highest estimated *probability* at any site of fatal cancer from exposure to radiation associated with each LLW alternative. This table presents the probability of cancer fatality to the MEIs within the offsite and noninvolved worker populations. The numbers in this table are the estimated *probabilities* that the MEI will die of latent cancer from radiation exposure.

The probability of a cancer fatality for the MEI was calculated at each site, and the highest value at a single site under each alternative is presented in Table 7.4–6. The MEI risk is not a combined total of risks across all of the sites.

The volume reduction alternatives generally have cancer fatality probability values that are about one order of magnitude higher than the values in other alternatives for the offsite MEI and about one to two orders of magnitude higher than the values in the other alternatives for the noninvolved worker MEI.

Table 7.4–7 presents the probability of a latent cancer fatality from radiological exposure for the offsite MEI for all sites by treatment alternative. The data in Table 7.4–7 are graphically presented in Figure 7.4–1. The highest cancer fatality probabilities are found at FEMP, the Hanford Site, LLNL, ORR, and Portsmouth. The radionuclide contaminant released during treatment operations that drives the cancer risk at each of these sites is tritium.

7.4.1.6 Probability of MEI Cancer Incidence and Genetic Effects

Table 7.4–8 summarizes, by alternative, the highest estimated *probability* at any site of cancer incidences and genetic effects resulting from radiation exposure. This table presents these estimated risks for the MEIs within the offsite and the noninvolved worker populations.

Table 7.4–6. LLW Treatment: Greatest Probability of Cancer at Any LLW Site

Alternative	Number of Sites		Offsite MEI Cancer Fatality Probability	Noninvolved Worker MEI Cancer Fatality Probability
	T[a]	D		
No Action	10[b]	6	2E–08	3E–08
Decentralized		16	2E–07	5E–08
Regionalized 1		12	2E–07	5E–08
Regionalized 2	11	12	6E–06	2E–06
Regionalized 3		6	2E–07	5E–08
Regionalized 4	7	6	2E–06	9E–07
Regionalized 5	4	6	9E–06	4E–06
Regionalized 6		2	2E–07	5E–08
Regionalized 7		2	2E–07	5E–08
Centralized 1		1	2E–07	5E–08
Centralized 2		1	2E–07	5E–08
Centralized 3	7	1	2E–06	6E–07
Centralized 4	7	1	2E–06	6E–07
Centralized 5	1	1	2E–06	2E–06

T = treatment; D = disposal. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.
[a] All sites perform "minimum treatment" under all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.
[b] Ten sites use existing facilities for volume reduction.

Table 7.4–8 indicates that the highest radiation cancer incidence probability for the offsite MEI is found under Regionalized Alternative 5. Cancer incidence probabilities generally are 5–20 times higher for the volume reduction alternatives than for the minimum treatment alternatives. A similar trend can be seen in the cancer incidence probabilities for the noninvolved worker MEI.

Offsite MEI radiation cancer incidence probability is highest for alternatives involving Regionalized or Centralized volume reduction, including thermal treatment. Highest values are at FEMP (under Regionalized Alternative 2), the Hanford Site (under Regionalized Alternatives 4 and 5 and Centralized Alternatives 3, 4, and 5), LANL (under Regionalized Alternatives 2 and 4 and Centralized Alternatives 3 and 4), LLNL (under Regionalized Alternative 2), ORR (under Regionalized Alternative 5), and at

Table 7.4–7. LLW Treatment: Offsite MEI Cancer Fatality Probabilities

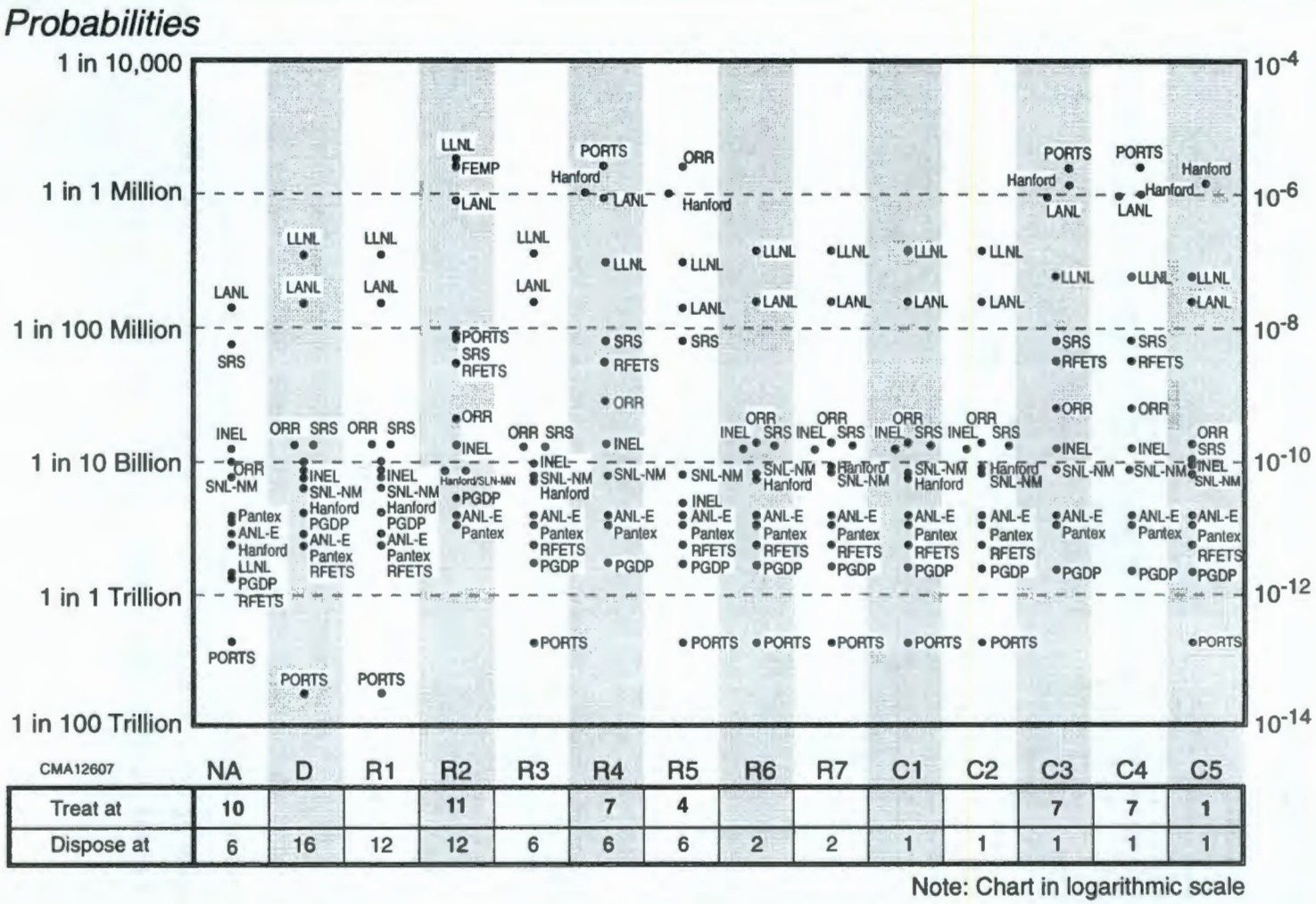
Alternative	Number of Sites		ANL-E	BNL	FEMP	Hanford	INEL	LANL	LLNL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP[c]
	T[a]	D																
No Action	10[b]	6	1E–11	3E-11	--	9E–12	2E–10	2E–08	6E–12	~0	1E–10	2E–12	8E–11	2E–13	2E–12	7E–11	6E–09	5E–11
Decentralized		16	1E–11	1E–13	--	6E–11	1E–10	2E–08	2E–07	~0	2E–10	4E–11	4E–11	3E–14	5E–12	7E–11	2E–10	2E–11
Regionalized 1		12	1E–11	3E-11	--	6E–11	1E–10	2E–08	2E–07	~0	2E–10	4E–11	4E-11	3E–14	5E–12	7E–11	2E–10	3E-11
Regionalized 2	11	12	1E–11	3E-11	4E–06	7E–11	2E–10	8E–07	6E–06	~0	3E–09	4E–11	4E-11	7E–09	3E–09	7E–11	6E–09	3E-11
Regionalized 3		6	1E–11	3E-11	--	6E–11	1E–10	2E–08	2E–07	~0	2E–10	2E–10	4E-11	2E–13	5E–12	7E–11	2E–10	3E-11
Regionalized 4	7	6	1E–11	3E-11	--	1E–06	2E–10	8E–07	7E–08	~0	3E–09	2E–12	4E-11	2E–06	3E–09	7E–11	6E–09	3E-11
Regionalized 5	4	6	1E–11	3E-11	--	1E–06	5E–09	2E–08	7E–08	~0	9E–06	2E–12	4E-11	2E–13	5E–12	7E–11	6E–09	3E-11
Regionalized 6		2	1E–11	3E-11	--	6E–11	2E–10	2E–08	2E–07	~0	4E–10	2E–12	4E-11	2E–13	5E–12	7E–11	2E–10	3E-11
Regionalized 7		2	1E–11	3E-11	--	9E–11	2E–10	2E–08	2E–07	~0	4E–10	2E–12	4E-11	2E–13	5E–12	7E–11	2E–10	3E-11
Centralized 1		1	1E–11	3E-11	--	6E–11	2E–10	2E–08	2E–07	~0	4E–10	2E–12	4E-11	2E–13	5E–12	7E–11	2E–10	3E-11
Centralized 2		1	1E–11	3E-11	--	9E–11	2E–10	2E–08	2E–07	~0	4E–10	2E–12	4E-11	2E–13	5E–12	7E–11	2E–10	3E-11
Centralized 3	7	1	1E–11	3E-11	--	1E–06	2E–10	8E–07	7E–08	~0	3E–09	2E–12	4E-11	2E–06	3E–09	7E–11	6E–09	3E-11
Centralized 4	7	1	1E–11	3E-11	--	1E–06	2E–10	8E–07	7E–08	~0	3E–09	2E–12	4E-11	2E–06	3E–09	7E–11	6E–09	3E-11
Centralized 5	1	1	1E–11	3E-11	--	2E–06	1E–10	2E–08	7E–08	~0	4E–10	2E–12	4E-11	2E–13	5E–12	7E–11	1E–10	3E-11

Notes: T = treatment; D = disposal; -- = action not applicable for the alternative. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.

[a] All sites perform "minimum treatment" under all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.

[b] Ten sites use existing facilities for volume reduction.

[c] No waste reported for WVDP.



	NA	D	R1	R2	R3	R4	R5	R6	R7	C1	C2	C3	C4	C5
Treat at	10			11		7	4					7	7	1
Dispose at	6	16	12	12	6	6	6	2	2	1	1	1	1	1

Note: Chart in logarithmic scale

Figure 7.4–1. LLW Treatment: Probability of Cancer Fatality to Offsite MEI

Table 7.4–8. LLW Treatment: Greatest Probability of Cancer Incidences and Genetic Effects at Any LLW Site

Alternative	Number of Sites		Offsite MEI			Noninvolved Worker MEI		
	T[a]	D	Radiation Dose (rem)	Radiation Cancer Incidence Probability	Radiation Genetic Effects Probability	Radiation Dose (rem)	Radiation Cancer Incidence Probability	Radiation Genetic Effects Probability
No Action	10[b]	6	4E–05	7E–08	4E–09	6E–05	1E–07	6E–09
Decentralized		16	6E–04	1E–06	6E–08	9E–05	2E–07	9E–09
Regionalized 1		12	6E–04	1E–06	6E–08	9E–05	2E–07	9E–09
Regionalized 2	11	12	1E–02	2E–05	1E–06	4E–03	6E–06	4E–07
Regionalized 3		6	6E–04	1E–06	6E–08	9E–05	2E–07	9E–09
Regionalized 4	7	6	5E–03	8E–06	5E–07	2E–03	3E–06	2E–07
Regionalized 5	4	6	2E–02	3E–05	2E–06	8E–03	1E–05	8E–07
Regionalized 6		2	6E–04	1E–06	6E–08	9E–05	2E–07	1E–08
Regionalized 7		2	6E–04	1E–06	6E–08	9E–05	2E–07	9E–09
Centralized 1		1	6E–04	1E–06	6E–08	9E–05	2E–07	1E–08
Centralized 2		1	6E–04	1E–06	6E–08	1E–04	2E–07	1E–08
Centralized 3	7	1	5E–03	8E–06	5E–07	1E–03	2E–06	1E–07
Centralized 4	7	1	5E–03	8E–06	5E–07	1E–03	2E–06	1E–07
Centralized 5	1	1	3E–03	5E–06	3E–07	3E–03	6E–06	3E–07

Notes: T = treatment; D = disposal; * = greater than 0 but less than 0.0005. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.
[a] All sites perform "minimum treatment" under all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.
[b] Ten sites use existing facilities for volume reduction.

Portsmouth (under Centralized Alternatives 3 and 4). Tritium is the radionuclide that accounts for most of the risk at FEMP, the Hanford Site, LLNL, ORR, and Portsmouth, whereas uranium-238 (U-238) accounts for most of the risk at LANL. More recent estimates show potential increased air releases of tritium at FEMP, Hanford, and Portsmouth and U-238 at LANL (see Appendix I). Genetic effects incidence probability for the offsite MEI is highest at LLNL under Regionalized Alternative 2 as a result of exposure to tritium released during treatment of LLW. Cancer incidence probabilities for the noninvolved worker MEI are highest at FEMP, the Hanford Site, LANL, LLNL, ORR, and Portsmouth.

7.4.1.7 Hypothetical Farm Family Risk

In addition to the disposal risks to workers, already presented, disposal risks were evaluated using hypothetical receptors—a farm family and an intruder—as defined in Section 7.4.1. Risks to both the

hypothetical farm family and the hypothetical intruder (Section 7.4.1.9) were analyzed in keeping with the requirements of DOE Order 5820.2A, "Radioactive Waste Management" (DOE, 1988). This order requires that site-specific performance assessments be conducted in order to demonstrate that a given disposal practice is in compliance with the set of performance objectives quantified in the DOE Order. These objectives specify concentrations and dose limits that are intended to be protective of the general public, an inadvertent intruder, and groundwater resources. Releases from the disposal facility occur as the result of natural causes (e.g., through leaching upon breakdown of the facility) and by inadvertent human intrusion.

The farm family scenario generically addresses potential contamination of groundwater resources as well as the potential health effect consequences of exposure of the general public to radionuclides released from the disposal facility. The radionuclides are assumed to leach from the disposal site through the unsaturated zone to contaminate groundwater that is used by a future farm family as a source of drinking water and irrigation water. See Section 5.4.1 for a further discussion of the presentation of farm family risk results.

Although the disposal facility risk analysis conducted in this WM PEIS uses scenarios that are similar to those used in the performance assessment process, it is important to note that the objectives of the two types of analysis are different. The WM PEIS hypothetical farm family and intruder scenario analyses assume the use of generic disposal facilities and generic waste forms (e.g., grout or polymers), and that the entire inventory of waste will be disposed (i.e., no exclusion of particular radionuclides). These assumptions lead to overestimates of contaminant concentration in groundwater. The objective of the WM PEIS analyses is to provide a relative comparison of potential risk among LLW management alternatives. The outputs of the analyses are risk estimates for the hypothetical farm family and intruder.

In contrast, the performance assessment analysis process involves the use of more detailed site-specific data in the design of a disposal facility at a particular location on a site. The objective of the analysis is to design a facility that will satisfy the performance objectives specified in DOE Order 5820.2A (DOE, 1988). In practice, implementation of this latter requirement may involve: (1) modifying the engineering design of the disposal facility (e.g., addition of a clay liner to increase adsorption or a concrete cap to reduce infiltration); (2) modifying the form of the waste to be disposed (such as changing to a vitrified waste form); (3) changing the specific location of the waste disposal facility so that it is sited over an area with more favorable hydrologic conditions; and (4) imposing waste acceptance criteria (i.e., restricting the amounts

of radionuclides allowed in a given waste disposal facility). The output of the analysis is a set of waste disposal facility design criteria.

As a result of these differences, the WM PEIS analyses produce estimates of groundwater contamination and farm family risk that are higher than those that would be expected upon actual implementation of the LLW disposal alternatives. For example, the generic WM PEIS analysis estimates that radionuclide groundwater contamination will exceed existing drinking water quality protection standards at certain sites (see Section 7.6.2). However, the groundwater resource protection objectives contained in DOE Order 5820.2A would require that the waste disposal facility designs developed by the performance assessment analyses subsequently conducted at those sites ensure that drinking water standards would not be exceeded upon disposal of LLW. Consequently, the hypothetical farm family risk estimates presented in this section have been adjusted to reflect groundwater contamination that does not exceed existing standards. That is, radionuclides whose estimated groundwater concentrations exceeded drinking water standards were adjusted to concentrations that represent 100% of existing standards. The unadjusted risk estimates from the WM PEIS analysis are presented in the Volume II site tables and in Appendix D.

MEI cancer fatality probability estimates for each site that disposes LLW under the various alternatives are presented in Table 7.4–9. The results of the WM PEIS analysis indicate that disposal of uranium-238 (U-238) must be carefully controlled at the Hanford Site (under all alternatives), SNL-NM (under the Decentralized Alternative), and SRS (under all alternatives except Regionalized 6 and 7). More recent estimates show potential increased release of U-238 to the groundwater at Hanford and SRS (see Appendix I). Requisite controls are likely to result in additional costs and potentially to increased impacts in other resources areas. If the amount or form of U-238 is not controlled as previously described, the groundwater concentrations of the radionuclide at these sites are estimated to exceed drinking water standards. These elevated groundwater concentrations would produce cancer fatality probability estimates that are about an order of magnitude higher than those presented in Table 7.4–9 at SRS, one to two orders of magnitude higher at the Hanford Site, and more than two orders of magnitude higher at SNL-NM (see Volume II site tables and Appendix D). In a similar manner, the disposal of neptunium-237 (Np-237) would require careful control at Paducah (under the Decentralized and Regionalized Alternatives 1 and 2).

Table 7.4-9. LLW Disposal: Hypothetical Farm Family Most Exposed Lifetime MEI Cancer Fatality Probabilities

Alternative	Number of Sites		ANL-E	BNL	FEMP	Hanford	INEL	LANL	LLNL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP
	T[a]	D																
No Action	10[b]	6	--	--	--	4E-05[c]	~0	~0	--	~0	2E-07	--	--	--	--	--	4E-06[c]	--
Decentralized		16	3E-05	5E-04	--	4E-05[c]	~0	~0	1E-06	~0	2E-07	8E-05[c]	~0	6E-08	3E-08	5E-05[c]	4E-06[c]	1E-04
Regionalized 1		12	--	--	--	4E-05[c]	~0	~0	1E-06	~0	2E-07	8E-05[c]	~0	5E-07	3E-08	--	4E-06[c]	--
Regionalized 2	11	12	--	--	--	4E-05[c]	~0	~0	1E-06	~0	4E-07	8E-05[c]	~0	9E-07	8E-08	--	4E-06[c]	--
Regionalized 3		6	--	--	--	4E-05[c]	~0	~0	--	~0	1E-07	--	--	--	--	--	4E-06[c]	--
Regionalized 4	7	6	--	--	--	4E-05[c]	~0	~0	--	~0	2E-07	--	--	--	--	--	4E-06[c]	--
Regionalized 5	4	6	--	--	--	4E-05[c]	~0	~0	--	~0	2E-07	--	--	--	--	--	4E-06[c]	--
Regionalized 6		2	--	--	--	4E-05[c]	--	--	--	--	--	--	--	--	--	--	9E-06	--
Regionalized 7		2	--	--	--	--	--	--	--	~0	--	--	--	--	--	--	9E-06	--
Centralized 1		1	--	--	--	4E-05[c]	--	--	--	--	--	--	--	--	--	--	--	--
Centralized 2		1	--	--	--	--	--	--	--	~0	--	--	--	--	--	--	--	--
Centralized 3	7	1	--	--	--	4E-05[c]	--	--	--	--	--	--	--	--	--	--	--	--
Centralized 4	7	1	--	--	--	--	--	--	--	~0	--	--	--	--	--	--	--	--
Centralized 5	1	1	--	--	--	4E-05[c]	--	--	--	--	--	--	--	--	--	--	--	--

Notes: T = treatment; D = disposal; -- = action not applicable for alternative. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.

[a] All sites perform "minimum treatment" under all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those sites or alternatives where only minimum treatment occurs, the cells are left blank.

[b] Ten sites use existing facilities for volume reduction.

[c] These are adjusted values. They represent the estimated risks when groundwater concentrations of radionuclides are adjusted to 100% of existing standards. Radionuclides that drive risks and exceed groundwater standards include uranium-238 at the Hanford Site, SRS, and SNL-NM and neptunium-237 at Paducah. Unadjusted risk estimates are presented in the Volume II site data tables and in Appendix D.

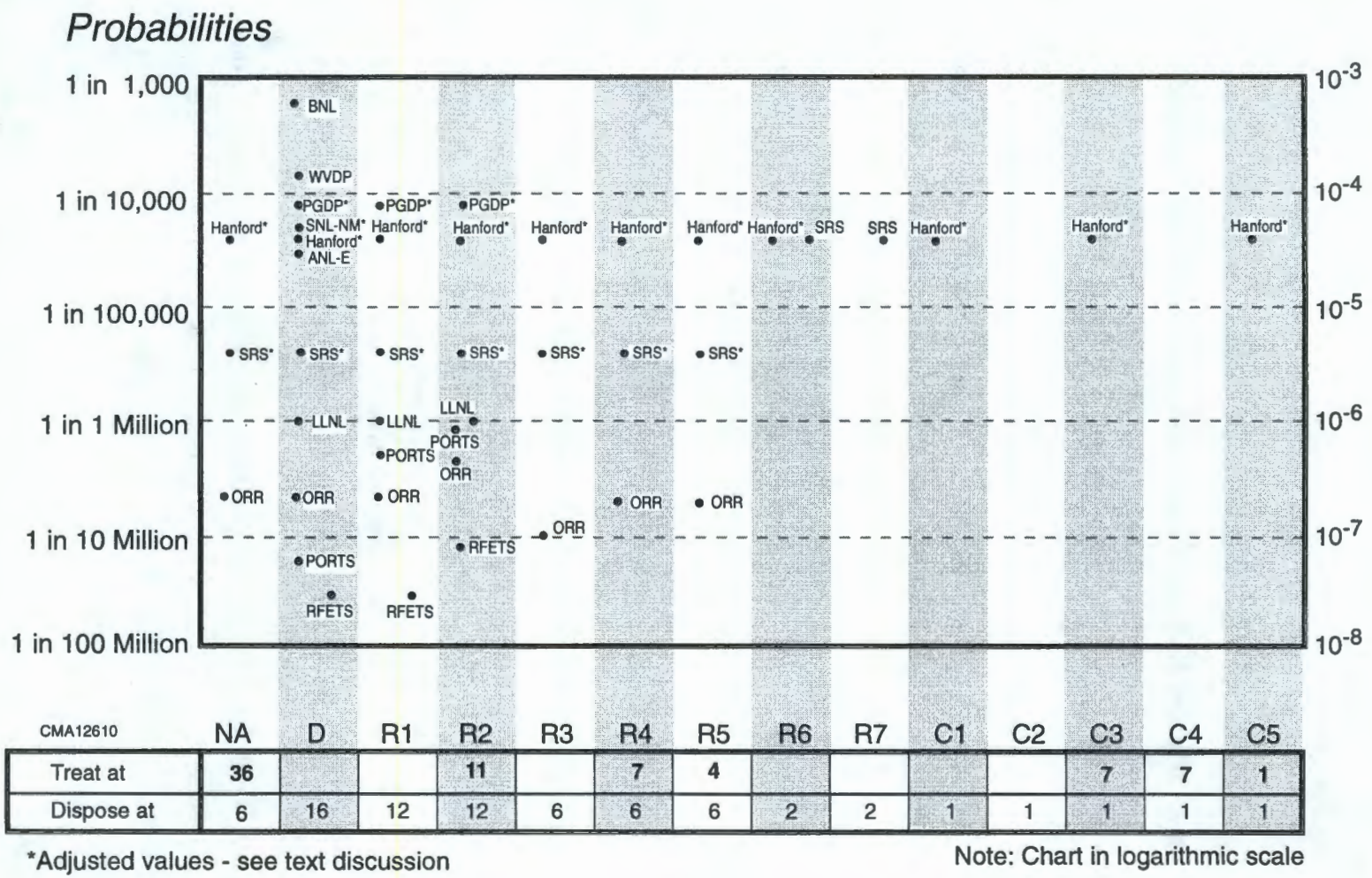
The estimated times of maximum future radionuclide exposure at these sites are as follows:

- The Hanford Site—U-238 at 1,260 years
- SNL-NM—U-238 at 1,050 years
- SRS—U-238 at 11,460 years
- Paducah—Np-237 at 3,240 years

In addition, although groundwater concentrations of radionuclide contaminants are not estimated to exceed drinking water standards, the estimated cancer fatality probabilities at BNL and WVDP under the Decentralized Alternative are high. Technetium-99 is the contaminant that accounts for most of the risk at BNL, whereas neptunium-237 drives the estimated farm family risk at WVDP.

The results of this analysis, graphically presented in Figure 7.4–2, also indicate that, on the basis of estimated MEI cancer fatality probability, disposal of LLW at ANL-E, INEL, LANL, LLNL, NTS, ORR, the Pantex Plant, PORTS, and RFETS could be accomplished for the WM PEIS-assumed wastes without additional radionuclide constraints. Of these sites, INEL, LANL, NTS, and the Pantex Plant had the lowest (zero) estimated cancer fatality probabilities.

The hypothetical farm family risks represent individual receptors assumed to be exposed through location of a drinking water well at 300 m from the center of a single disposal unit. Concentrations of groundwater contaminants at this location are assumed to be higher than those that could be expected at greater distances from the unit due to dispersion of contaminants. Construction of multiple units is expected to be required to dispose of the projected waste volumes at certain sites under the various LLW alternatives. Although the farm family scenario evaluates only a single receptor 300 m from an individual unit, DOE assumes that each of these close-in receptors will be affected primarily by the contaminant plume from the closest facility. DOE recognizes that commingling of contaminant plumes from multiple disposal units may occur as distance from the units increases but anticipates that, at 300 m, the highest concentration of contaminants is likely to result from the single closest plume. At greater distances from the disposal units, where overlap of the plumes is more likely, the concentrations in any given plume should be lower than those estimated at the 300-m well as a result of dispersion and dilution. However, the WM PEIS cannot address groundwater contaminant concentrations at distances greater than 300 meters from disposal units. More detailed analyses, such as the performance assessments required under DOE Order 5820.2A, will address the issues of existing groundwater contamination and multiple disposal units. For example, in April 1996, DOE issued guidance for the conduct of composite analyses in addition to performance assessments to help



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	NA	D	R1	R2	R3	R4	R5	R6	R7	C1	C2	C3	C4	C5
Treat at	36			11		7	4					7	7	1
Dispose at	6	16	12	12	6	6	6	2	2	1	1	1	1	1

*Adjusted values - see text discussion

Note: Chart in logarithmic scale

Figure 7.4–2. LLW Disposal: Probability of Cancer Fatality to Hypothetical Farm Family Most Exposed Lifetime MEI

ensure that continuing disposal of LLW will not compromise the future radiological protection of the public. A composite analysis will estimate the potential cumulative impacts to a hypothetical future member of the public from an active or planned LLW disposal facility and other sources of radioactive material in the ground that might interact with the LLW disposal facility.

7.4.1.8 Potential Collective Risk to Offsite Population From Waste Disposal

Risk assessments generally evaluate both collective and individual health risks, that is, risks for both populations of receptors and for MEIs. However, the WM PEIS disposal risk analysis quantitatively estimates risks only for the farm family MEI. Although the farm family scenario disposal risk analysis uses site-specific hydrogeologic and meteorologic data, use of "conceptual" disposal units was assumed. The analysis did not attempt to identify exact locations of these generic units on a site; rather, they were assumed to be placed either near existing disposal units where such units existed, or at a location on the site expected to be most sensitive to groundwater contamination. Since the analysis does not attempt to actually locate the disposal units on the site, DOE believes it is not possible to develop plausible quantitative estimates of the collective risks to current or future offsite populations resulting from exposure to contaminated groundwater. Both the concentrations of contaminants in the groundwater and the number of people potentially exposed will be strongly influenced by the locations of the disposal units and receptor wells. A hypothetical siting decision to support such an analysis is not favored because the choice of a site so strongly influences the results as to make them a direct reflection of the choice.

To address the relative potential of the proposed disposal sites and alternatives for collective risk to offsite populations, values for site parameters that are expected to influence potential groundwater contamination or that are associated with the relative size of populations at risk were statistically analyzed. These variables included the size of the site (acres), depth to aquifer, size of offsite population living within 50 miles of the site, annual rainfall, natural recharge rate, and time of travel of groundwater from the surface to a downgradient well. Statistical analysis of these variables produced clusters or groupings of sites according to their relative potential risk vulnerability. These groupings are believed to be more appropriate metrics for decision making, given the lack of facility siting and other relevant information, than quantitative estimates of person-rem doses and latent cancer fatalities.

Section C.4.1 of Appendix C contains additional information about the methodology and results of the offsite population risk vulnerability analysis. This section also describes other DOE efforts to assess

potential risks from waste disposal, including those of the Federal Facility Compliance Act Disposal Workgroup and the performance assessment process required by DOE Order 5820.2A.

Section 5.4.1 of Chapter 5 contains a discussion of the results of the collective risk vulnerability analysis. The sites are grouped into three population risk vulnerability (PRV) roups, with Group 1 having the lowest potential vulnerability for offsite population risks from groundwater contamination following LLW disposal, and Group 3 having the highest potential. It is important to note that this is a screening-level analysis that does not take into account any measures that would limit migration of disposed wastes into the groundwater, such as engineered disposal units or changes in waste acceptance criteria. The objective of the analysis is not to rule out any sites for disposal—a number of sites are currently disposing LLW—but to indicate where such disposal mitigation measures are more likely to be necessary and where the costs of disposal would likely increase as a result. In particular, though some sites may be listed in Group 3, this does not mean that disposal would be unacceptable there. Rather, it means that mitigation would be an important part of a disposal plan for these sites.

As previously described, the waste volume, total radioactivity, and number of potential disposal units required at a given site varies by waste management alternative. Table 7.4–10 presents data on disposal volumes, number of disposal units, and curies for each site as they vary over the proposed alternatives, in conjunction with the results of the population risk vulnerability factor and cluster analyses. This information is summarized by risk vulnerability cluster for each alternative and is displayed in Table 7.4–11. The summary data in Table 7.4–11 suggest that the Centralized Alternatives present lower potential collective risks to offsite populations from disposal than the Decentralized or Regionalized Alternatives.

Note that the results of this screening-level risk vulnerability analysis are useful in discussing the relative potentials among the sites and the proposed waste management alternatives. However, more refined risk analyses will be included in the site-specific performance assessments that will be conducted for the design and siting of new disposal facilities. In addition, DOE will consider a number of other factors in the development of waste disposal decisions. These include the results of safety analyses for disposal facility operation, the extent of existing contamination or waste disposal at a site, the costs and benefits involved in transporting waste among sites, and other environmental and socioeconomic concerns.

Table 7.4–10. Disposal Variables (by Site and Alternative) and Population Risk Vulnerability Group For LLW

Disposal Alternative Variables	ANL-E	BNL	FEMP	Hanford	INEL	LANL	LLNL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP
Population Risk Vulnerability Group	**2**	**2**	**3**	**1**	**1**	**1**	**2**	**1**	**3**	**3**	**1**	**3**	**2**	**2**	**3**	**2**
No Action Alternative																
Number of disposal units				6	5	14		29	12						39	
Disposal waste volume (m^3)				240,000	36,000	160,000		150,000	260,000						420,000	
Total radioactivity (Ci × 100,000)				76.6	27.6	77.3		330	1.27						17.9	
Decentralized Alternative																
Number of disposal units	1	1	NA	9	8	15	1	1	17	4	1	12	3	1	51	3
Disposal waste volume (m^3)	9,100	5,760		94,000	94,000	163,000	8,300	1,830	294,000	53,800	2,900	231,000	45,000	2,700	560,000	49,440
Total radioactivity (Ci × 100,000)	5.3E-02	0.12		1.55	27.6	77.3	6.37	3.6E-05	1.27	2.5E-04	9.6E-05	75	2.3E-03	5.1E-02	17.9	0.14
Regionalized 1 Alternative																
Number of disposal units			NA	9	7	14	1	NA	14	4	4	12	3		48	
Disposal waste volume (m^3)				94,000	94,000	166,000	8,300	1,830	294,000	53,800	2,900	295,000	45,000		560,000	
Total radioactivity (Ci × 100,000)				1.55	27.6	77.3	3.6	0	1.27	2.5E-04	9.6E-05	75	2.33E-02		17.9	
Regionalized 2 Alternative																
Number of disposal units			NA	2	4	5	1	NA	3	3	1	7	1		40	
Disposal waste volume (m^3)				20,700	51,000	50,900	6,200	0	130,000	41,500	2,920	123,000	12,000		455,000	
Total radioactivity (Ci × 100,000)				1.55	27.6	77.3	3.6	0	1.27	2.5E-04	9.6E-05	75	2.33E-02		17.9	
Regionalized 3 Alternative																
Number of disposal units				9	7	22		1	30						48	
Disposal waste volume (m^3)				94,000	94,000	255,000		6,840	415,000						560,000	
Total radioactivity (Ci × 100,000)				1.55	27.6	77.3		0.90	345						17.9	
Regionalized 4 Alternative																
Number of disposal units				2	4	7		1	13						40	
Disposal waste volume (m^3)				21,000	51,000	72,000		1,970	264,000						455,000	
Total radioactivity (Ci × 100,000)				2.87	27.6	77.3		5.4E-04	346						17.9	
Regionalized 5 Alternative																
Number of disposal units				2	5	7		1	13						40	
Disposal waste volume (m^3)				21,000	59,000	63,700		1,970	264,000						455,000	
Total radioactivity (Ci × 100,000)				2.87	27.6	77.2		5.4E-04	346						17.9	
Regionalized 6 Alternative																
Number of disposal units				37											94	
Disposal waste volume (m^3)				460,000											1,100,000	
Total radioactivity (Ci × 100,000)				113											93	

Table 7.4–10. Disposal Variables (by Site and Alternative) and Population Risk Vulnerability Group For LLW—Continued

Disposal Alternative Variables	ANL-E	BNL	FEMP	Hanford	INEL	LANL	LLNL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP
Regionalized 7 Alternative																
Number of disposal units								37							94	
Disposal waste volume (m^3)								270,000							1,100,000	
Total radioactivity (Ci × 100,000)								79							93	
Centralized 1 Alternative																
Number of disposal units				131												
Disposal waste volume (m^3)				1,500,000												
Total radioactivity (Ci × 100,000)				427												
Centralized 2 Alternative																
Number of disposal units								131								
Disposal waste volume (m^3)								1,500,000								
Total radioactivity (Ci × 100,000)								427								
Centralized 3 Alternative																
Number of disposal units				72												
Disposal waste volume (m^3)				810,000												
Total radioactivity (Ci × 100,000)				427												
Centralized 4 Alternative																
Number of disposal units								73								
Disposal waste volume (m^3)								810,000								
Total radioactivity (Ci × 100,000)								427								
Centralized 5 Alternative																
Number of disposal units				72												
Disposal waste volume (m^3)				810,000												
Total radioactivity (Ci × 100,000)				427												

Table 7.4–11. Disposal Variables by LLW Alternative and Population Risk Vulnerability Group

Alternative	Group 3	Group 2	Group 1
No Action Alternative			
Number of disposal units	51	0	54
Disposal waste volume (m^3)	680,000	0	586,000
Total radioactivity (Ci × 100,000)	17.9	0	511
Decentralized Alternative			
Number of disposal units	84	10	34
Disposal waste volume (m^3)	1,140,000	120,000	355,000
Total radioactivity (Ci × 100,000)	93	6.4	105
Regionalized 1 Alternative			
Number of disposal units	78	4	34
Disposal waste volume (m^3)	1,200,000	53,000	355,000
Total radioactivity (Ci × 100,000)	93	3.6	105
Regionalized 2 Alternative			
Number of disposal units	53	2	12
Disposal waste volume (m^3)	750,000	14,000	126,000
Total radioactivity (Ci × 100,000)	93	3.6	116
Regionalized 3 Alternative			
Number of disposal units	78	0	39
Disposal waste volume (m^3)	975,000	0	450,000
Total radioactivity (Ci × 100,000)	362	0	107
Regionalized 4 Alternative			
Number of disposal units	53	0	14
Disposal waste volume (m^3)	719,000	0	146,000
Total radioactivity (Ci × 100,000)	362	0	107
Regionalized 5 Alternative			
Number of disposal units	53	0	15
Disposal waste volume (m^3)	719,000	0	146,000
Total radioactivity (Ci × 100,000)	362	0	107
Regionalized 6 Alternative			
Number of disposal units	94	0	37
Disposal waste volume (m^3)	1,100,000	0	460,000
Total radioactivity (Ci × 100,000)	93	0	113

Table 7.4–11. Disposal Variables by LLW Alternative and Population Risk Vulnerability Group—Continued

Alternative	Group 3	Group 2	Group 1
Regionalized 7 Alternative			
Number of disposal units	94	0	37
Disposal waste volume (m^3)	1,100,000	0	270,000
Total radioactivity (Ci × 100,000)	93	0	79
Centralized 1 Alternative			
Number of disposal units	0	0	131
Disposal waste volume (cubic meters)	0	0	1,500,000
Total radioactivity (Ci × 100,000)	0	0	427
Centralized 2 Alternative			
Number of disposal units	0	0	131
Disposal Waste Volume (m^3)	0	0	1,500,000
Total radioactivity (Ci × 100,000)	0	0	427
Centralized 3 Alternative			
Number of disposal units	0	0	72
Disposal waste volume (m^3)	0	0	810,000
Total radioactivity (Ci × 100,000)	0	0	427
Centralized 4 Alternative			
Number of disposal units	0	0	73
Disposal waste volume (cubic meters)	0	0	810,000
Total radioactivity (Ci × 100,000)	0	0	427
Centralized 5 Alternative			
Number of disposal units	0	0	72
Disposal waste volume (cubic meters)	0	0	810,000
Total Radioactivity (Ci × 100,000)	0	0	427

7.4.1.9 Intruder Scenario Risks

Table 7.4–12 presents an overview, by alternative, of the total programwide risks to a hypothetical intruder 100 and 300 years after the disposal facility has closed. Because the focus is on an individual intruder, the risks are presented as the probability of that individual experiencing an adverse health impact rather than a total number of impacts for a selected population.

Table 7.4–12. LLW Disposal: Summary Risks to Hypothetical Intruders at LLW Sites

Alternative	Number of Sites		Radionuclides			
	T[a]	D	Dose (rem)	Cancer Fatality Probability	Cancer Incidence Probability	Genetic Effects Probability
100 Years After Disposal Facility Closure						
Decentralized		16	160	8E–02	3E–01	2E–02
Regionalized 3		6	110	5E–02	2E–01	1E–02
Centralized 1		1	2	8E–03	3E–02	2E–03
300 Years After Disposal Facility Closure						
Decentralized		16	2	8E–03	3E–03	2E–04
Regionalized 3		6	1	6E–04	2E–03	1E–04
Centralized 1		1	0.2	8E–05	3E–04	2E–05

Notes: T = treatment; D = disposal. Please refer to Section 5.4.1 of Volume 1 for guidance in interpreting hypothetical intruder risks.
[a] All sites perform "minimum treatment" under all alternatives, consisting of solidification of liquids and "fines" (powdered material), packaging, and shipment.

The intruder scenario risks were not estimated for all alternatives. Regionalized Alternative 3 and Centralized Alternative 1 were selected to be representative of the Regionalized and Centralized Alternatives, respectively. For both the 100-year and 300-year scenarios, each of the evaluated alternatives is estimated to result in relatively high maximum probabilities of cancer fatality, cancer incidence, and genetic effects from radionuclide and direct radiation exposure.

Table 7.4–13 presents the cancer fatality probabilities by site for each of the alternatives evaluated 100 years and 300 years after the disposal facility has closed. The data in Table 7.4–13 are graphically presented in Figure 7.4–3. Under the Decentralized Alternative, cancer fatality probability values span a range of about five orders of magnitude. Cancer fatality probabilities generally are lower for the 300-year scenario by one to two orders of magnitude under all alternatives, which suggests that risks decrease as radionuclides decay. Strontium-90 (half-life 29 years) was the main radionuclide risk driver at 100 years, under each of the alternatives evaluated, whereas the risk drivers at 300 years included thorium-232 (half-life 1E+10 years), uranium-238 (half-life 2E+09 years), nickel-63 (half-life 96 years), americium-241 (half-life 432 years),

Table 7.4–13. LLW Disposal: Hypothetical Intruder Cancer Fatality Probabilities 100 and 300 Years After Disposal Facility Closure

Site	Decentralized Alternative				Regionalized Alternative 3				Centralized Alternative 1			
	100 years		300 years		100 years		300 years		100 years		300 years	
	Cancer Fatality Probability	Dose (rem)	Cancer Fatality Probability	Dose (rem)	Cancer Fatality Probability	Dose (rem)	Cancer Fatality Probability	Dose (rem)	Cancer Fatality Probability	Dose (rem)	Cancer Fatality Probability	Dose (rem)
ANL-E	3E–04	6.6E–01	4E–06	8.0E–03	--	--	--	--	--	--	--	--
Hanford	3E–03	6.8E+00	3E–05	6.0E–02	3E–03	6.8E+00	3E–05	6.0E–02	8E–04	1.7E+00	8E–05	1.7E–01
INEL	4E–04	7.0E–01	7E–05	1.3E–01	4E–04	7.0E–01	7E–05	1.3E–01	--	--	--	--
LANL	7E–02	1.4E+02	6E–04	1.2E+00	5E–02	9.1E+01	4E–04	7.6E–01	--	--	--	--
LLNL	3E–03	5.8E+00	5E–05	1.0E–01	--	--	--	--	--	--	--	--
NTS	--	--	--	--	3E–03	5.8E+00	5E–05	1.0E–01	--	--	--	--
ORR	7E–04	1.3E+00	5E–06	1.1E–02	4E–04	8.1E–01	3E–05	6.0E–02	--	--	--	--
PGDP	3E–06	7.0E–03	3E–06	7.0E–03	--	--	--	--	--	--	--	--
Pantex	3E–06	5.0E–03	3E–06	5.0E–03	--	--	--	--	--	--	--	--
PORTS	2E–04	4.8E–01	6E–05	1.2E–01	--	--	--	--	--	--	--	--
RFETS	1E–06	2.0E–03	1E–06	2.0E–03	--	--	--	--	--	--	--	--
SNL-NM	7E–04	1.5E+00	1E–05	3.0E–02	--	--	--	--	--	--	--	--
SRS	1E–03	2.3E+00	1E–05	3.0E–02	1E–03	2.3E+00	1E–05	3.0E–02	--	--	--	--

Notes: -- = action not applicable for the alternative. Please refer to Section 5.4.1 of Volume I for guidance in interpreting hypothetical intruder risks.

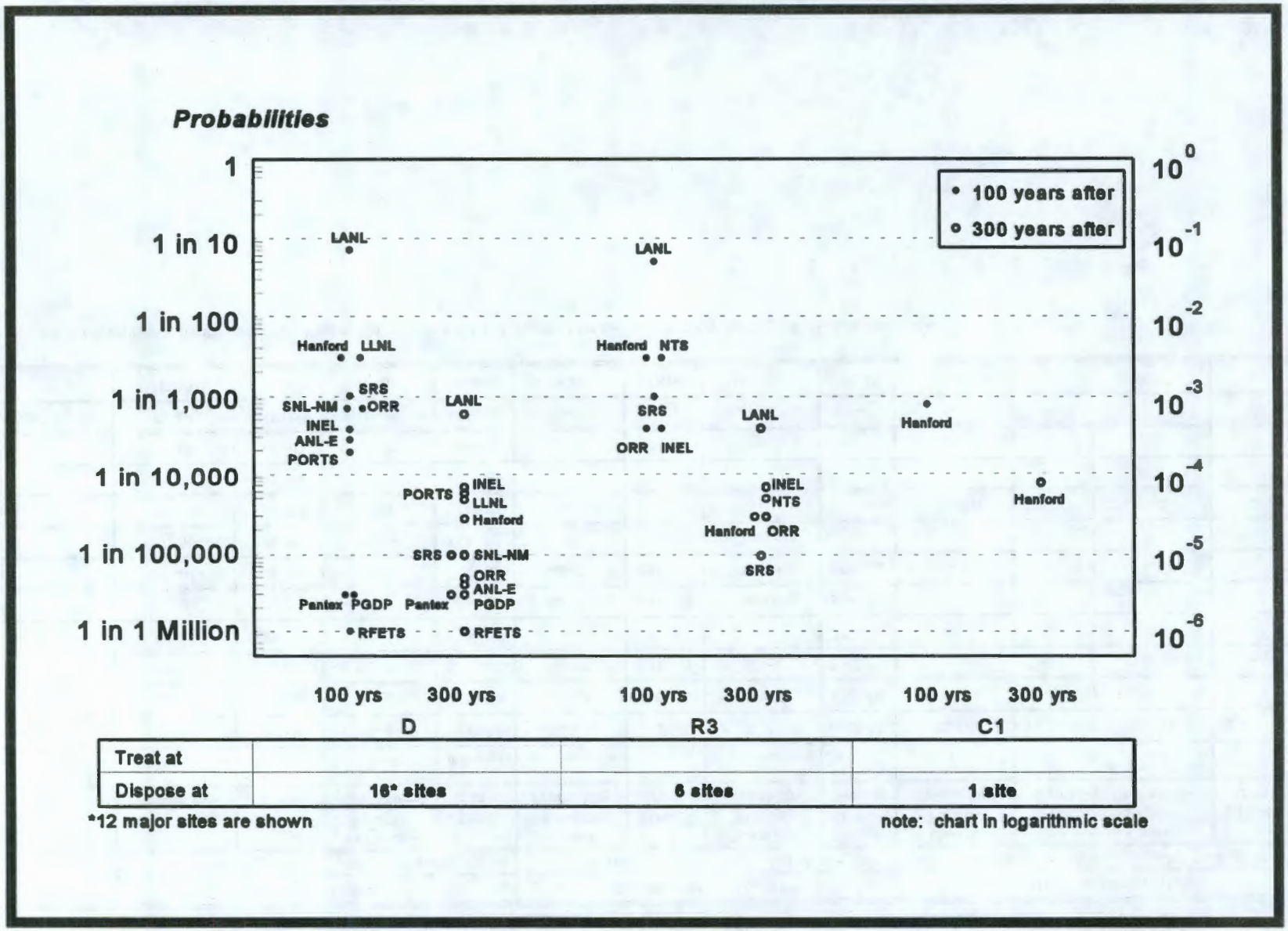

Figure 7.4–3. LLW Disposal: Probability of Cancer Fatality to an Intruder Into Disposal Facility 100 and 300 Years Post Closure

and neptunium-237 (half-life 2E+06 years). There is no general trend in intruder risk among the disposal alternatives evaluated.

The estimated doses presented in Tables 7.4–13 exceed the DOE Order 5820.2A (DOE, 1988) performance assessment objective limits for intruders of 100 millirem per year for continuous exposure and 500 millirem per year for acute exposure at LANL under the Decentralized and Regionalized 3 Alternatives. Figure 7.4–3 shows the intruder cancer fatality risks. Similar to the discussion in Section 7.4.1.7, site-specific considerations during design, construction, and operation would be expected to mitigate these exceedances. These mitigation measures are also described in Chapter 12.

7.4.2 Transportation-Related Impacts

Transporting LLW for treatment and disposal may affect the health of the truck or rail crew and the public along the transportation route. These impacts are the result of radiation exposure during normal operations, and accidents in which the waste containers are assumed to be opened, as well as exposure to vehicle exhaust and physical injury after vehicle accidents. For the No Action Alternative shipments, it was assumed that the shipments would be distributed uniformly over a 20-year period. For all other alternatives, shipments were assumed to occur uniformly over a 10-year period, assuming a 10-year period to build treatment, storage, and disposal facilities.

Tables 7.4–14 and 7.4–15 present the total number of estimated fatalities associated with truck and rail transportation of LLW, respectively. The total number of estimated fatalities resulting from radiation exposure when LLW is transported by truck ranges from less than 1 to 16 for the normal operations population and crew combined (Centralized Alternative 1). The number of estimated fatalities resulting from nonradiological causes (vehicle exhaust-induced cancers and physical injury resulting from accidents) ranges from 1 to 38 when LLW is transported by truck (Table 7.4–14). The number of estimated fatalities resulting from both radiological exposure and nonradiological causes ranges from less than 1 to approximately 5 when the LLW is transported by rail (Table 7.4–15).

Table 7.4–14. LLW Truck Transportation: Estimated Fatalities From Vehicular Accidents and Exposure to Radiation and Fuel Emissions

Alternative	Number of Sites		Number of Shipments	Shipment Miles (in Millions)	Estimated Number of Radiological Fatalities[a]			Estimated Number of Nonradiological Fatalities	
	T[b]	D			Normal Operations Public	Normal Operations Crew	Exposure From Traffic Accidents	Fuel Emission	Injury From Traffic Accidents
No Action	10[c]	6	87,360	166	3	2	*	1	11
Decentralized		16	24,420	9	*	*	*	*	1
Regionalized 1		12	25,800	9	*	*	*	*	1
Regionalized 2	11	12	25,880	9	*	*	*	*	1
Regionalized 3		6	84,200	38	1	1	*	*	3
Regionalized 4	7	6	87,390	37	1	1	*	*	3
Regionalized 5	4	6	92,200	64	1	1	*	*	4
Regionalized 6		2	174,390	124	2	2	*	1	9
Regionalized 7		2	188,930	125	2	2	*	1	9
Centralized 1		1	242,730	563	10	6	*	2	35
Centralized 2		1	257,270	505	9	6	*	3	35
Centralized 3	7	1	250,020	530	9	6	*	2	33
Centralized 4	7	1	264,060	478	8	6	*	3	34
Centralized 5	1	1	241,540	560	9	6	*	2	35

Notes: T = treatment; D = disposal; * = greater than 0 but less than 0.5.
[a] Fatalities are from radiation-induced latent cancer.
[b] All sites perform "minimum treatment" under all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.
[c] Ten sites use existing facilities for volume reduction.

Table 7.4–15. LLW Rail Transportation: Estimated Fatalities From Rail Accidents and Exposure to Radiation and Fuel Emissions

Alternative	Number of Sites		Number of Shipments	Shipment Miles (in Millions)	Estimated Number of Radiological Fatalities[a]			Estimated Number of Nonradiological Fatalities	
	T[b]	D			Normal Operations Public	Normal Operations Crew	Exposure From Traffic Accidents	Fuel Emission	Injury From Traffic Accidents
No Action	10[c]	6	33,420	70	*	*	*	1	*
Decentralized		16	9,210	4	*	*	*	*	*
Regionalized 1		12	9,740	4	*	*	*	*	*
Regionalized 2	11	12	9,900	4	*	*	*	*	*
Regionalized 3		6	31,850	17	*	*	*	*	*
Regionalized 4	7	6	33,460	17	*	*	*	*	*
Regionalized 5	4	6	35,430	25	*	*	*	*	*
Regionalized 6		2	66,040	51	*	*	*	1	*
Regionalized 7		2	71,480	54	*	*	*	1	*
Centralized 1		1	91,440	224	1	1	*	2	1
Centralized 2		1	96,880	219	1	1	*	2	1
Centralized 3	7	1	96,710	218	1	1	*	2	1
Centralized 4	7	1	102,100	212	1	1	*	2	*
Centralized 5	1	1	90,980	223	1	1	*	2	1

Notes: T = treatment; D = disposal; * = greater than 0 but less than 0.5.
[a] Fatalities are from radiation-induced latent cancer.
[b] All sites perform "minimum treatment" under all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.
[c] Ten sites use existing facilities for volume reduction.

The number of fatalities estimated for both truck and rail transportation is directly related to the number of shipments and shipment miles required under each alternative. Therefore, most fatalities from both truck and rail transport are estimated to occur in the alternatives that have the most shipments and vehicle miles, which are the Centralized Alternatives (when treatment and/or disposal of all LLW occur at one site). Approximately 250,000 truck shipments covering 500 to 600 million vehicle miles or approximately 100,000 rail shipments covering 200 million vehicle miles are required in the Centralized Alternatives. The least number of fatalities is estimated to occur in the Decentralized and Regionalized Alternatives, which require approximately 25,000 to 190,000 truck shipments covering 9 to 125 million vehicle miles, or approximately 10,000 to 70,000 rail shipments covering 4 to 50 million vehicle miles. Due to the uncertainties involved in the calculations (see Section E.8 of Volume I), these results suggest that there may not be significant differences between the radiological risks associated with truck and rail transport. However, members of the public traveling on the truck routes have a potential to receive higher exposures than those members of the public traveling near rail routes. The risks from injury directly related to traffic accidents suggest rail transport may be slightly less hazardous than truck transport.

7.4.3 Facility Accident Impacts

7.4.3.1 Storage Facility Accidents

Accidents and source terms for current storage of LLW were not analyzed. Unlike treatment, which will predominantly use new facilities that will have common characteristics, current (pretreatment) storage will use a variety of predominantly preexisting facilities that vary greatly in the amounts and types of waste inventories stored, the configurations in which they are stored, and the containment or confinement characteristics of the storage buildings or enclosures. However, recent DOE safety analysis reports (SARs) and NEPA information provide guidance on the potential risk impacts applicable to LLMW and TRUW storage facility accidents and can be used to evaluate the anticipated risks of LLW storage facility accidents.

Information in these current SARs and DOE site EISs can be used as indicators of the predicted consequences for a range of waste storage facility accidents of varying frequency. A brief summary of some of the key accidents and assumptions used by the sites in preparing these analyses, and the related health effects results are shown in Appendix F. Examples of results applicable to LLW storage facilities include accidents ranging from violent single drum breaches to large fires in centralized facilities. The recent SARs

and EISs that are relevant portray results for TRUW and LLMW releases, and thus the consequences, per se, are not directly comparable to those for LLW. However, the accident scenarios, estimates of airborne material due to the accidents, and atmospheric dispersion and health effects calculations are analogous. As a result, LLW storage facility accident results are analogous to LLMW storage facility results because of their similar radionuclide profiles. See Section 6.4.3 for a discussion of these results which suggest that the public risk from storage accidents is very low.

It should be noted that explicitly analyzing risks from storage would not help to discriminate among alternatives because of the assumption used in the WM PEIS for estimating the treatment throughputs that dictate the inventories to be stored prior to treatment. This assumption is that all sites will accumulate or at least not reduce these inventories for roughly 10 years, at which time complex-wide treatment will begin. Thus, all sites will achieve their maximum inventories (leading to maximum potential releases during a storage facility accident) independently of alternative.

7.4.3.2 Treatment Facility Accidents

Although there are many processes used for treating LLW, to date, thermal treatment technologies have been the most effective in destroying and reducing in volume the combustible materials contained in LLW. Because significant data on incineration are available and because the results achieved through incineration are representative and bounding of other thermal treatment processes, this risk analysis focused on incineration. Like other LLW treatment processes, incinerator operations/accidents can result in airborne releases of radionuclides. Potential treatment facility accidents identified for all LLW alternatives include: (1) incineration facility fires or explosions initiated from internal causes; (2) an earthquake or tornado that causes damage and possible fires in the facility; and (3) the crash of a large or small aircraft into the facility resulting in fire and possible explosion. All of these accidents can involve release of the radioactive contents of the kiln, the stored ash byproduct of the incineration process, or the trapped contents of the filtration systems in the facility. The accident with the highest potential consequences at each site was evaluated.

The radiological risks and health effects calculations were based upon very conservative assumptions. Table 7.4–16 summarizes the estimated cancer fatalities resulting from radiation exposures associated with potential treatment facility accidents. This table contains cancer fatality estimates for the maximum reasonably foreseeable accidents with the highest potential consequences at each site and the estimated

Table 7.4–16. LLW Facility Accidents: Radiation-Induced Cancer Fatalities From Maximum Reasonably Foreseeable Potential Treatment Facility Accidents

Site	Accident Type	Estimated Annual Accident Frequency	Offsite MEI Dose (rem)	Offsite MEI Cancer Fatality Probability	Offsite Population Dose (person-rem)	Offsite Population Number of Cancer Fatalities	Worker Dose (person-rem)	WM Workers Number of Cancer Fatalities
No Action Alternative								
INEL	Thermal Treatment, Aircraft Crash[a]	< 1E–06	1E–05	7E–09	1E–01	*	5E–02	*
SRS	Thermal Treatment, Aircraft Crash[a]	< 1E–06	2E–03	1E–06	1E+02	*	3E+01	*
Regionalized Alternative 2								
FEMP	Thermal Treatment, Natural Phenomena	< 1E–06 to < 1E–04	4E–05	2E–08	1E–01	*	1E–03	*
Hanford	Thermal Treatment, Aircraft Crash[a]	< 1E–06	1E–04	6E–08	4E+00	*	3E–02	*
INEL	Thermal Treatment, Aircraft Crash[a]	1E–06 to 1E–04	1E–05	7E–09	1E–01	*	5E–02	*
LANL	Thermal Treatment, Natural Phenomena	1E–06 to 1E–04	8E–01	4E–04	2E+03	1	8E+02	*
LLNL	Thermal Treatment, Natural Phenomena	1E–06 to 1E–04	8E–01	4E–04	6E+03	3	1E+01	*
ORR	Thermal Treatment, Natural Phenomena	1E–06 to 1E–04	2E–03	1E–06	3E+01	*	2E+00	*
PGDP	Thermal Treatment, Natural Phenomena	1E–06 to 1E–04	1E–04	7E–08	6E–01	*	1E–01	*
PORTS	Thermal Treatment, Natural Phenomena	1E–06 to 1E–04	4E–05	2E–08	6E–02	*	1E–02	*
RFETS	Thermal Treatment, Natural Phenomena	1E–06 to 1E–04	2E–03	1E–06	6E+01	*	5E+00	*
SRS	Thermal Treatment, Aircraft Crash	< 1E–06	2E–03	1E–06	1E+02	*	3E+01	*
Centralized Alternative 5								
Hanford	Thermal Treatment, Aircraft Crash	< 1E–06	2E–01	1E–04	1E+04	5	2E+03	1

Notes: "Natural Phenomena" refer to accidents initiated either by earthquake or by high wind or tornado, depending on the site and the associated recurrence frequencies. Incineration was the thermal treatment analyzed. * = greater than 0 but less than 0.5. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.

[a] The aircraft crash scenario is included because of its high estimated consequences even though it may not be considered "reasonably foreseeable" in terms of accident frequency (i.e., annual frequency of occurrence greater than 1E–06).

frequency of those accidents occurring annually. The doses indicated are a function of the severity of the accident and the size and distribution of the population affected. The indicated probabilities of excess cancer are based on the assumption that the accident occurs.

Consistent with standard practice in radiological safety analysis, the fatalities are derived only from the cancers associated with radiation. In general, local worker fatalities in severe accidents from trauma would primarily result from the initiation of the accident, e.g., the initial impact and fire of an airplane crash. These trauma fatalities would tend to be independent of the inventory or process characteristics of a particular site for a given consolidation alternative and, therefore, would not tend to be a significant discriminator among the alternatives. Trauma fatalities to the offsite populations from severe accidents would be almost totally independent of the site consolidation and process characteristics that are driven by alternative selection and would not discriminate among alternatives.

Assuming that the accident occurs, each of the alternatives poses a cancer fatality probability equal to or greater than one in one million for the offsite MEI. Under the No Action Alternative, the cancer fatality probability is estimated to be equal to one in one million for the indicated accident affecting the offsite MEI at SRS. Under Regionalized Alternative 2, an offsite MEI cancer fatality probability of equal to or greater than one in one million is estimated for accidents at five sites (LANL, LLNL, ORR, RFETS and SRS). Centralized Alternative 5 is expected to have an offsite MEI cancer fatality probability of greater than one in one million for accidents at the Hanford Site. However, when the frequencies of the accidents are considered, none of the alternatives pose an offsite MEI cancer risk of greater than one in one million.

Centralized Alternative 5 is estimated to produce the highest number of cancer fatalities resulting from accidents affecting the offsite population (5 individuals at the Hanford Site). Under Regionalized Alternative 2, three cancer fatalities in the offsite population are estimated to result from accidents at LLNL, and one cancer fatality is estimated in the offsite population at LANL. Under the No Action Alternative, no cancer fatalities within the offsite population are estimated. The overall risks from accidents for all the alternatives, derived by multiplying the health risk value by the frequencies of the accidents, are very small.

Only Centralized Alternative 5 is expected to produce a cancer fatality within the WM worker population as a result of radiation exposures from severe accidents. The overall risk from severe accidents, taking into account the very low frequency of these accidents, is much less. It is also important to note that use of the latest safety analysis documentation (described in the preceding section on storage facility accidents) would

reduce all predicted impacts. In addition, the health risks presented in Table 7.4–16 assume no mitigation of the accident and take no credit for emergency response actions. The reduction in impacts due to these mitigation actions would be significant.

7.4.3.3 Disposal Facility Accidents

As discussed in Appendix F, disposal accidents were not evaluated because of the lack of details of ultimate disposal. However, except for dedicated centralized disposal facilities (e.g., Yucca Mountain and WIPP for HLW and TRUW, respectively), disposal sites would generally lack a concentrated volume of material at risk being stored in a configuration susceptible to phenomena such as fires and explosions capable of causing significant releases. These repositories have accident analyses performed as part of their site-specific EISs. Although seismic events could breach in-ground containers, leading to airborne releases, such events would be bounded by accidents breaching the concentrated volumes of waste being held in a treatment or storage facility. The available safety literature does not indicate any credible accident sequence in which the risk from airborne releases in a low-level waste disposal facility would be sufficiently significant to rule out a site from consideration and thereby serve as a discriminator among disposal alternatives.

7.5 Air Quality Impacts

The management of LLW would not appreciably affect the air quality at most sites. However, decentralizing treatment and disposal at BNL, or centralizing at NTS could cause adverse air quality impacts requiring additional emission control measures for criteria pollutants. Emissions of radionuclides were estimated to be below the applicable standards at all sites.

As illustrated in Table 7.5–1, DOE evaluated air quality impacts at each proposed LLW treatment and disposal site based on estimated increases in emissions of the six criteria pollutants and radionuclides. Pollutant emission estimates were made for the construction and O&M activities of LLW facilities.

The Clean Air Act (42 USC 7401 *et seq.)* regulates emissions of air pollutants. In those areas where air pollution standards are not met (known as "nonattainment areas"), activities that introduce new emissions

Table 7.5-1. Air Quality Impacts Evaluated for LLW Alternatives

Impacts Assessed	Period of Analysis	Activities for Which Impacts Are Assessed	Impacts Measure	Location of Impacts Assessment
Criteria air pollutant emissions	Construction	Estimated for construction equipment and worker vehicles	Percent of standard	Table 7.5-2
	Operations	Estimated for thermal treatment units for fuel use by all other LLW facilities, for worker vehicles, and for waste shipment vehicles	Percent of standard	Table 7.5-3
Radionuclide emissions	Operations	For all LLW treatment and disposal facilities	Percent of standard	Text discussion only

from both "stationary" (e.g., treatment and storage facilities) and "mobile" (e.g., vehicles) sources are regulated under the "General Conformity Rule." In this rule, EPA has established limits for each criteria air pollutant for nonattainment areas. An entity which seeks to engage in an activity that will result in emissions that equal or exceed those limits in a nonattainment area must first obtain a permit.

In "attainment areas" (where air pollution standards are met), only new emissions from stationary sources are regulated. In these areas, regulations for the Prevention of Significant Deterioration (PSD) of ambient air quality apply. Allowable emission increases are known as PSD increments. A permit is required for a new stationary source that equal or exceeds the allowable increase. However, a permit is not required for criteria pollutant emissions from mobile sources.

7.5.1 Criteria Air Pollutant Emissions From Construction

Criteria air pollutants can be emitted from construction equipment and from vehicles that workers use to drive to the construction site. Both are considered to be "mobile sources."

For purposes of analysis, DOE identified sites in nonattainment areas where construction activities

Major Types of Air Pollutants

***Criteria Air Pollutants**—carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), lead (Pb), ozone (O_3), and particulate matter less than or equal to 10 micrometers in diameter (PM_{10}).*

***Hazardous Air Pollutants**—189 hazardous substances (including radionuclides) whose emissions are regulated by the Clean Air Act.*

under all the LLW alternatives would result in mobile source emissions that would equal or exceed 10% of the allowable limit of a particular criteria air pollutant. Table 7.5–2 lists those sites. DOE chose the 10% threshold to highlight those sites where criteria air pollutant emissions could result in adverse air quality impacts.

As indicated in Table 7.5-2, six of the 16 major proposed LLW sites are located in nonattainment areas. As a result of LLW construction activities, these sites are predicted to have emissions that equal or exceed 10% of the allowable limit for a particular criteria air pollutant. NTS is predicted to have emissions of 189% of allocated limits under the Centralized Alternative 2 and 128% under Centralized Alternative 4. This analysis may overestimate potential impacts because it assumes that NTS is in a nonattainment region since it is adjacent to the Clark County nonattainment region for CO and PM_{10}. The NTS EIS (DOE, 1996b) does not show any exceedances for criteria air pollutants. For carbon monoxide, BNL is estimated to be at the limit in the Decentralized Alternative. The WM PEIS analysis suggests that NTS and BNL may need to obtain Clean Air Act permits under these alternatives.

7.5.2 Criteria Air Pollutant Emissions From Operations and Maintenance

Criteria air pollutants would also be emitted during operations and maintenance of LLW facilities (stationary sources) and by vehicles driven by workers to the facility or used to transport waste (mobile sources). DOE evaluated air quality impacts for these pollutants at each site by comparing estimated increases in tons per year to the allowable emission limits (General Conformity Rules in nonattainment areas or PSD increments in attainment areas).

Twelve of the 16 major proposed LLW sites are predicted to equal or exceed 10% of applicable air pollutant emission standards (Table 7.5–3). Of these, six sites are located in nonattainment areas; six sites are in attainment areas. As many as seven sites would have pollutant standards that equal or exceed 10% of the levels under an alternative. Only NTS is estimated to exceed the standard; carbon monoxide would be 118 to 183% above the standard in the Centralized 2 and Centralized 4 Alternatives, primarily from worker vehicle emissions. This analysis may overestimate potential impacts because it assumes that NTS is in a nonattainment region since it is adjacent to the Clark County nonattainment region for CO and PM_{10}. The NTS EIS (DOE, 1996b) does not show any exceedances for criteria air pollutants. Based on the

Table 7.5-2. Percent of Sites' Allowable Air Emissions Discharged During Construction—LLW Sites Equaling or Exceeding 10% of Standard in Nonattainment Regions[a]

Alternative	Number of Sites		Criteria Pollutants—Construction[b]										
			ANL-E	BNL		NTS		PGDP		RFETS			SNL-NM
	T[c]	D	NO_2	NO_2	VOC	CO	PM_{10}	NO_2	VOC	CO	NO_2	VOC	CO
No Action	10[d]	6	36 (31/5)	26 (20/6)				13 (11/2)		12 (4/8)	12 (10/2)		
Decentralized		16	58 (52/6)	100 (88/12)	15 (8/7)			88 (85/3)	20 (16/4)	28 (16/12)	45 (43/2)	11 (8/3)	10 (1/9)
Regionalized 1		12	12 (6/6)	26 (20/6)				88 (85/3)	20 (16/4)	28 (16/12)	45 (43/2)	11 (8/3)	10 (1/9)
Regionalized 2	11	12	12 (6/6)	26 (20/6)				81 (74/7)	22 (14/8)	38 (28/10)	76 (74/2)	16 (14/2)	10 (1/9)
Regionalized 3		6	12 (6/6)	26 (20/6)		12 (5/7)				15 (1/14)			10 (1/9)
Regionalized 4	7	6	12 (6/6)	26 (20/6)						26 (21/5)	55 (54/1)	11 (10/1)	10 (1/9)
Regionalized 5	4	6	12 (6/6)	26 (20/6)						15 (1/14)			10 (1/9)
Regionalized 6		2	12 (6/6)	26 (20/6)						15 (1/14)			10 (1/9)
Regionalized 7		2	12 (6/6)	26 (20/6)		64 (20/44)				15 (1/14)			10 (1/9)
Centralized 1		1	12 (6/6)	26 (20/6)						15 (1/14)			10 (1/9)
Centralized 2		1	12 (6/6)	26 (20/6)		189 (79/110)	16 (16/0)			15 (1/14)			10 (1/9)
Centralized 3	7	1	12 (6/6)	26 (20/6)						26 (21/5)	55 (54/1)	11 (10/1)	10 (1/9)
Centralized 4	7	1	12 (6/6)	26 (20/6)		128 (49/79)	10 (10/0)			26 (21/5)	55 (54/1)	11 (10/1)	10 (1/9)
Centralized 5	1	1	12 (6/6)	26 (20/6)						15 (1/14)			10 (1/9)

Notes: T = treat. "Treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. D = dispose. Each of the 6-site disposal alternatives use the same sites; each of the 12-site disposal alternatives use the same 12 sites.

[a] Values less than 10% are shown as blanks. Refer to the *Waste Management Environmental and Socioeconomic Impacts Methods and Results Technical Report* (DOE, 1996a) for complete results. CO = carbon monoxide; SO_2 = sulfur dioxide; PM_{10} = particulate matter equal to or less than 10 micrometers in diameter, NO_2 = nitrogen dioxide; VOC = volatile organic compounds.

[b] Sites that exceed 10% of the standard specified by the General Conformity rule; total % (% equipment /% worker vehicles). Sites that do not exceed 10% are left blank.

[c] All sites perform "minimum treatment" under all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.

[d] Ten sites use existing facilities for Volume Reduction. Three sites (LBL, Mound, and RMI) not listed as major sites above include volume reduction facilities.

analysis performed for the WM PEIS, mitigation measures may be needed at NTS to reduce emissions of carbon monoxide to acceptable levels. These mitigation measures could include ride sharing, transit programs, parking management, compressed work weeks, flextime, and telecommuting. Mitigation could also include reducing emissions from existing activities to compensate for increased emissions from new WM activities. More recent estimates show increased releases of criteria air pollutants at ANL-E (see Appendix I).

The most stringent PSD requirements are for Class I areas. Class I areas are regions of special concern because of national parks, monuments, seashores, wildlife refuges, or wilderness areas. A proposed action may affect air quality in a PSD Class I area if it will emit more than the allowable PSD increment of a criteria air pollutant and will be located within 100 km (62 miles) of a PSD Class I area. Nine sites proposed for LLW activities under the alternatives are located within 100 km of a PSD area: BNL, FEMP, INEL, LANL, LLNL, NTS, ORR, RFETS, and SNL-NM. None of these would have sufficient quantities of emissions to affect a PSD Class I area.

Estimated concentrations resulting from criteria air pollutant emissions from facilities were also compared to the National Ambient Air Quality Standards (NAAQS) (40 CFR 50). No site was estimated to equal or exceed 10% of the standards.

7.5.3 Hazardous Air Pollutant Emissions

Thermal treatment of LLW will result in emission of small quantities of radionuclides. Since by definition LLW does not contain significant quantities of hazardous chemicals, emissions of other hazardous air pollutants were assumed to be negligible. Radionuclides from air emissions were evaluated by comparing the annual radiation dose to a maximally exposed individual (MEI) to the National Emissions Standard for Hazardous Air Pollutants—10 millirems per year (mrem/yr) (40 CFR 61).

Doses from airborne radionuclides were estimated not to equal or exceed 10% of the dose standard at any site except for LLNL (13%) under Regionalized Alternative 2. This exceedance is due to thermal treatment of LLW.

Table 7.5–3. Percent of Sites' Allowable Air Emissions Discharged During Operations—LLW Sites Equaling or Exceeding 10% of Standard[a]

Alternative	Number of Sites		Criteria Pollutants—Operations and Maintenance																		
			PSD or General Conformity																		
			ANL-E	BNL	Hanford		INEL		LANL	NTS	ORR		PORTS		PGDP		RFETS			SNL-NM	SRS
	T[b]	D	NO_2[c]	NO_2[c]	NO_2[d]	PM_{10}[d]	NO_2[d]	PM_{10}[d]	PM_{10}[d]	CO[e]	NO_2[d]	PM_{10}[d]	NO_2[d]	PM_{10}[d]	NO_2[c]	VOC[c]	CO[e]	NO_2[c]	VOC[c]	CO[e]	NO_2[d]
No Action	10[f]	6								67 (0/67)											11
Decentralized		16	17 (2/15)	14 (4/10)							21	10	11		10 (3/7)		39 (0/39)			13 (0/13)	
Regionalized 1		12									21	10	16		10 (3/7)		39 (0/39)				
Regionalized 2	11	12							12				16	10	11 (3/8)	10 (0/10)	55 (0/55)	12 (1/11)	13 (0/13)		
Regionalized 3		6								11 (0/11)	47	21					11 (0/11)				
Regionalized 4	7	6							13		22	12					33 (0/33)				
Regionalized 5	4	6					15	22			27	18					11 (0/11)				
Regionalized 6		2															11 (0/11)				
Regionalized 7		2								67 (0/67)							11 (0/11)				
Centralized 1		1			19												11 (0/11)				
Centralized 2		1								183 (0/183)							11 (0/11)				
Centralized 3	7	1			19				12								33 (0/33)				
Centralized 4	7	1							12	118 (0/118)							33 (0/33)				
Centralized 5	1	1			27	36											11 (0/11)				

Notes: T = treat. "Treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. D = dispose. Each of the 6-site disposal alternatives use the same sites; each of the 12-site disposal alternatives use the same 12 sites. CO = carbon monoxide; SO_2 = sulfur dioxide; PM_{10} = Particulate matter less than or equal to 10 micrometers in diameter; VOC = volatile organic compound.

[a] Blank cells are less than or equal to 10%.

[b] All sites do "minimum treatment" in all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.

[c] Nonattainment area for the pollutant ozone; NO_2 and VOC are ozone precursor emissions; General Conformity regulations applied; total % (% stationary-source / % mobile-source).

[d] Attainment area for this pollutant; PSD regulations applied; total % represents stationary-source emissions only.

[e] Nonattainment area for this pollutant; General Conformity regulations applied; total % (% stationary-source / % mobile-source).

[f] Ten sites use existing facilities for Volume Reduction. Three sites (LBL, Mound, and RMI) not listed as major sites above include volume reduction facilities.

7.6 Water Resources Impacts

Major impacts to water availability from increased water use at the sites are unlikely, although there is the potential for adverse impacts at LLNL Site-300 and the WVDP. Modeling indicates that groundwater concentration reduction measures may be needed for radionuclides when disposal occurs at the Hanford Site, Paducah, SNL-NM, and SRS. Concentration reduction measures would not be needed when disposal occurs at NTS, even under the Centralized 2 and 4 (one disposal site) Alternatives.

As illustrated in Table 7.6-1, DOE analyzed the impacts on water resources of treatment and disposal activities. DOE evaluated the effects on water availability from building and operating treatment and disposal facilities. DOE also examined the effects of migration of radionuclides from disposal facilities on groundwater quality.

In addition, the following impacts were examined for all waste types collectively, and are discussed in Chapter 5, Section 5.4.3:

- Impacts on surface water caused by floodplain encroachment
- Impacts on surface water from runoff and sedimentation
- Impacts on surface water and groundwater quality from effluent discharges
- Impacts on small onsite streams from effluent discharges
- Impacts on existing areas of groundwater contamination from groundwater withdrawal
- Impacts on surface water and groundwater quality from routine transportation and transportation accidents

7.6.1 Water Availability

Impacts on surface water and groundwater availability were assessed by comparing current water use rates from municipal, surface water, or groundwater sources to projected requirements for construction or operation of LLW facilities. In addition, impacts on surface water were further assessed by examining the effect of potential withdrawals from and discharges to the major offsite stream at a given site.

Table 7.6–1. Water Resource Impacts Evaluated for LLW Alternatives

Impacts Assessed	Period of Analysis	Activities for Which Impacts are Assessed	Impacts Measure	Location of Impacts Assessment
Water Availability	Construction	Estimated for water used: • by personnel • for concrete • for dust suppression	Percent increase in current water use	Table 7.6–2
			Percent decrease in stream flow	Text discussion only
	Operations	Estimated for water used: • by personnel • by treatment and disposal processes	Percent increase in current water use	Table 7.6–2
			Percent decrease in stream flow	Text discussion only
		Estimated for effluent discharged from sanitary and process wastewater treatment facilities	Percent increase in stream flow	Text discussion only
Groundwater Quality	Post-Closure	Disposal of LLW	Percent of drinking water quality standard	Table 7.6–3

Table 7.6–2 identifies sites where projected water usage under any alternative would increase by more than 1%. This 1% threshold is based on the assumption that lesser changes are not likely to have significant impacts.

Eleven of the 16 major sites are predicted to exceed the 1% threshold. Most exceedances shown are due largely to water used during the 2- to 3-year period for construction of treatment and disposal facilities. Nine of these sites, ANL-E, FEMP, the Hanford site, INEL, NTS, ORR, Portsmouth, RFETS, and SRS, are not likely to experience adverse impacts because of sufficient capacities and the relatively small amount of additional water needed (DOE, 1996a). Two sites that could experience adverse impacts, LLNL and WVDP, are discussed further.

Water use at LLNL would exceed 1% of current use for all alternatives, and approach 23% under Regionalized Alternative 2. This is based on the conservative assumption that water at Site 300, the assumed location for proposed waste management facilities at LLNL, would be supplied by groundwater. However, most of the water would probably be supplied by the new municipal hook-up to Site 300, or the Livermore Valley municipal system that currently serves LLNL. If the water were supplied by the new 500,000 gallons

Table 7.6–2. Maximum Percent of Current Water Use for Construction or Operations—LLW Sites Predicted to Exceed 1%[a]

Alternative	Number of Sites		ANL-E	FEMP	Hanford	INEL	LLNL	NTS	ORR	PORTS	RFETS	SRS	WVDP
	T[b]	D											
No Action	10[c]	6					1.4					1.4	9.2
Decentralized		16	1.9				8.1		1.4		4.6	6.6	84
Regionalized 1		12					8.1		1.4	1.3	4.6	6.6	9.2
Regionalized 2	11	12		1.3			23			1.1	6.6	6.2	9.2
Regionalized 3		6					4.8		2.9		1.5	6.6	9.2
Regionalized 4	7	6					4.8		1.5		4.2	6.2	9.2
Regionalized 5	4	6				1.1	4.8		1.5		1.5	6.2	9.2
Regionalized 6		2					4.8				1.5	11	9.2
Regionalized 7		2					4.8				1.5	11	9.2
Centralized 1		1					4.8				1.5	1.5	9.2
Centralized 2		1					4.8	4.0			1.5	1.5	9.2
Centralized 3	7	1					4.8				4.2	1.7	9.2
Centralized 4	7	1					4.8	2.5			4.2	1.7	9.2
Centralized 5	1	1			2.1		4.8				1.5	1.5	9.2

Notes: T = treat. "Treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. All sites do "minimum treatment" in all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. D = Dispose. Each of the 6-site disposal alternatives uses the same sites; each of the 12-site disposal alternatives uses the same 12 sites.

[a] Blank cells are less than or equal to 1%. Water sources assumed as follows: Groundwater for ANL-E, FEMP, INEL, LLNL, NTS, Ports, and SRS; Surface water for the Hanford site, ORR and WVDP; and Municipal water for RFETS.

[b] All sites perform "minimum treatment" under all alternatives consisting of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.

[c] Ten sites use existing facilities for volume reduction. Three sites (LBL, Mound, and RMI) not listed as major sites above include volume reduction facilities.

per day municipal hook-up at Site-300, the maximum water use would be 4.1% of the capacity of the system. If the water were supplied by the municipal system in Livermore Valley, it would be 2.8% of the current water use rate of 717,000 gallons per day. If water for LLNL is supplied by an offsite municipal system, onsite water resources would not be affected. Therefore, adverse impacts to onsite water resources are unlikely. Impacts on the source of the municipal supply are not within the scope of this PEIS.

Water use at WVDP would be 84% of current use for the Decentralized Alternative. Water at WVDP would be supplied by surface water from two onsite reservoirs that impound water on tributaries of Buttermilk

Creek. Water use would be 53% of the 110,000-gallons-per-day capacity of the water supply system and less than 1% of the average flow in Buttermilk Creek of 41 million gallons per day. Major impacts to surface water levels and availability would be unlikely.

As shown in the Volume II tables, for DOE sites that withdraw water directly from a surface water source (the Hanford site, ORR, Paducah, and WVDP), water use would be less than 1% of the average flow in the surface water body. In addition, for this analysis, it was assumed that 100% of the water used at the facility during operations would be discharged as effluent from a wastewater treatment plant. For sites that discharge wastewater to natural surface waters (ANL-E, FEMP, ORR, Paducah, Portsmouth, RFETS, SRS, and WVDP), effluent discharges would be less than 1% of the average flow in the principal receiving water body at all sites. These are negligible changes in flow that would not affect surface water levels.

7.6.2 Water Quality

DOE evaluated the impacts to groundwater quality caused by the migration of radionuclides that leach from disposal facilities over time. DOE calculated concentrations of radionuclides at a hypothetical well located 300 meters from the center of the disposal facility, and compared these to DOE or EPA drinking water standards (which have been adopted in DOE's internal orders). For radionuclides, the allowable drinking water concentrations equate to a 4 mrem per year effective dose equivalent.

The drinking water standards are used as comparison criteria for groundwater quality. Although they are not enforceable standards, they are often used as goals for contaminated site cleanup actions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Because EPA established the drinking water standards to protect human health, groundwater concentrations of radionuclides at or below these levels present a low risk.

The discussions of impacts concentrate on contaminants that are near or exceed drinking water standards. Concentrations in the groundwater that equal or exceed 25% of the drinking water standard are presented.

Table 7.6–3 identifies sites where LLW would be disposed and where, under any alternative, the calculated value for any pollutant would exceed 25% of the drinking water standards.

Table 7.6–3. Percent of Drinking Water Standards in Groundwater From Disposal of LLW — Sites Exceeding 25% of Standard [a]

Alternative	Number of Sites		BNL	Hanford			PGDP	SNL-NM					SRS	
	T[b]	D	Tc-99	Tc-99	U-234	U-238	Np-237	Pu-239	Pu-240	Tc-99	U-234	U-238	Np-237	U-238
No Action	10[c]	6				100*	--	--	--	--	--	--		100*
Decentralized		16	30			100*	100	100*	100*	100*	100*	100*		100*
Regionalized 1		12				100*	100	--	--	--	--	--		100*
Regionalized 2	11	12				100*	100*	--	--	--	--	--		100*
Regionalized 3		6				100*	--	--	--	--	--	--		100*
Regionalized 4	7	6		30	30	100*	--	--	--	--	--	--		100*
Regionalized 5	4	6		30	30	100*	--	--	--	--	--	--		100*
Regionalized 6		2			40	100*	--	--	--	--	--	--	60	100*
Regionalized 7		2		--	--	--	--	--	--	--	--	--	60	100*
Centralized 1		1				100*	--	--	--	--	--	--	--	--
Centralized 2		1		--	--	--	--	--	--	--	--	--	--	--
Centralized 3	7	1				100*	--	--	--	--	--	--	--	--
Centralized 4	7	1		--	--	--	--	--	--	--	--	--	--	--
Centralized 5	1	1				100*	--	--	--	--	--	--	--	--

Notes: T = treatment. "Treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. D=disposal. Each of the 6-site disposal alternatives uses the same sites; each of the 12-site disposal alternatives uses the same 12 sites. -- = no disposal at this site under this alternative. * = PEIS modeling indicates that a reduction in the estimated concentration in the groundwater would be necessary to meet drinking water standards. See Volume II tables for the value of the exceedance.

[a] Only radionuclides equal to or above 25% of drinking water standards are listed. Blanks indicate concentrations less than 25% of standards. See Appendix C for a list of the drinking water standards.

[b] All sites do "minimum treatment" in all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.

[c] Ten sites use existing facilities for volume reduction. Three sites (LBL, Mound, and RMI) not listed as major sites above, include volume reduction facilities.

Disposal of LLW at BNL, the Hanford Site, Paducah, SNL-NM, and SRS is predicted to cause 25% of drinking water standards for radionuclides to be exceeded in the groundwater. BNL is located above an EPA-designated sole-source aquifer. Twenty-five percent of standards would not be exceeded when LLW is disposed at ANL-E, INEL, LANL, LLNL, NTS, ORR, the Pantex Plant, Portsmouth, RFETS, or WVDP. Only under the Centralized 2 and 4 Alternatives (disposal of all LLW at NTS) are 25% of drinking water standards not exceeded at any site. More recent estimates show increased releases of uranium-238 at Hanford and SRS (see Appendix I).

Radionuclides that would exceed 25% of the drinking water standards are neptunium-237, plutonium-239, plutonium-240, technetium-99, uranium-234, and uranium-238. These radionuclides all have long half-lives, with the minimum half-life being 6,537 years for plutonium-240. Shorter half-life radionuclides (e.g., cesium-137, strontium-90) tend to decay to acceptable levels before reaching the 300-meter well.

For radionuclides with long half-lives, disposal inventory, infiltration rate, depth to groundwater, and the character of the media through which the water flows are some of the primary factors that determine the concentration in the groundwater. The infiltration rate is related to rainfall; sites in arid regions generally perform better than sites in humid regions because of their smaller infiltration rate. Sites with a large depth to groundwater are generally better because of longer travel times. Sites located over areas with large percentages of materials that retard the movement of radionuclides (e.g., clays, organic materials) generally perform better than sites located over areas devoid of these materials.

Uranium-238 is the most problematic radionuclide, exceeding 100% of the standard at three sites (the Hanford site, SNL-NM, and SRS). In all of these cases, concentrations in the groundwater would have to be reduced to meet drinking water standards. Neptunium-237 (Paducah), plutonium-239 (SNL-NM), plutonium-240 (SNL-NM), technetium-99 (SNL-NM), and uranium-234 (SNL-NM) would also have to be reduced to meet drinking water standards. Measures that could be used to reduce the estimated concentration of radionuclides in the groundwater include:

- Modifying the engineering design of the disposal facility (e.g., addition of a clay liner to increase adsorption or a concrete cap to reduce infiltration)
- Modifying the form of the waste to be disposed to reduce the release rate (e.g., changing to a vitrified waste form)

- Changing the specific location of the disposal facility so it is sited over an area with more favorable hydrologic conditions
- Imposing waste acceptance criteria (i.e., restricting the amount of the radionuclide allowed in the disposal facility)

The performance of disposal facilities at a specific site would also be evaluated in greater detail in DOE's Performance Assessment process under DOE Order 5820.2A (DOE, 1988). This process would help to ensure that all regulatory requirements are met and significant contamination of groundwater would not occur.

7.7 Ecological Resources Impacts

Loss of limited acreages of habitat at some LLW sites during construction site clearing would not affect populations of nonsensitive plant and animal species because these species habitats are well established regionally. Because construction site acreages are small compared to the total acreage at each site suitable for waste operations, DOE would be able to locate new LLW facilities to avoid impacts to nearby wetlands and other sensitive habitats. A screening level risk assessment of LLW facility airborne emissions indicated that terrestrial wildlife species are not likely to be affected. When selecting locations for waste management facilities on sites, DOE will consider the results of relevant existing or required new sitewide or project-level NEPA analyses, which would include analyses of potential impacts to ecological resources, including threatened and endangered species, based on site-specific conditions. Transportation accidents leading to spills of LLW into aquatic environments could have serious short and long term consequences, but would be extremely rare. The Centralized alternatives have the highest probability of accidents because they require the greatest number of shipments; the Decentralized Alternative has the lowest probability.

As illustrated by Table 7.7–1, DOE analyzed the effects of construction site clearing to build LLW treatment and disposal facilities, and the operation of treatment facilities on ecological resources at representative sites. Accidental releases during intersite transportation of LLW, that could affect aquatic resources offsite, were also evaluated.

Although DOE intends to select sites for waste management activities based on the WM PEIS, the PEIS will not be the basis for selecting specific locations for facilities on the sites. When selecting locations for facilities on sites, DOE will consider the results of relevant existing or required new sitewide or project-level NEPA analyses, which would include analyses of potential impacts to sensitive species and habitats

Table 7.7–1. Ecological Resources Impacts Evaluated for the LLW Alternatives

Ecological Impact Analyzed	Affected Ecological Resource	Analysis Method	Presentation of Results
Nonsensitive Habitat Effects	Terrestrial plants and animals	Comparison of habitat loss at LLW construction sites to general habitat range.	Text discussion only
Terrestrial Species Exposures	Terrestrial animal species	Comparison of estimated radiation dose of representative species with toxicity standard.	Text discussion only
Sensitive Habitat Effects	Nearby wetlands and other sensitive habitats	Likelihood of impacts to nearby sensitive habitats by comparing construction acreage to available acreage of nonsensitive habitats.	Text discussion only
Sensitive Species Concerns	Federally- and State-listed endangered and threatened species	Numbers of Federally- and State-listed species displayed by site/alternative.	Table 7.7–2
Effects of Transportation Accidents	Aquatic species in streams crossing transportation corridors	Results of scenario-based modeling analysis of accidental spill effects on fish in various size streams.	Text discussion only

based on site-specific conditions. Should sitewide or project-level NEPA reviews indicate that a site is not suitable for a waste management facility because of adverse impacts to sensitive species or habitats that cannot be avoided or mitigated, then DOE will reconsider its decision to locate a waste management facility at that site.

7.7.1 General Impacts of Site Clearing

None of the alternatives would require extensive site clearing for construction of LLW facilities. No more than 86 acres would be disturbed at any site under any LLW alternative. These acreage requirements are small compared to the available habitat for nonsensitive species represented at the sites. Although site clearing would destroy individual plants and would kill or displace individual animals (particularly small mammals and song birds with limited home ranges), no significant effects to populations of these species are expected from the implementation of the LLW alternatives because nonsensitive species habitats are well established regionally.

7.7.2 Site Clearing Effects on Sensitive Habitats

For those sites that contain sensitive habitats, the degree to which these habitats may be affected by noise or vibration disturbance, human presence, vehicle or equipment emissions, runoff, or encroachment by nearby LLW construction activities depends on DOE's ability to avoid siting near these habitats. A measure of this ability is the percentage of available land required for facility construction under any LLW alternative. Available acreage was estimated from site development plans either using land designated for waste operations or subtracting the acreage of existing structures and sensitive habitats, such as wetlands and wildlife management areas, from the total site acreage. The analysis showed that the percent of available acreage required for LLW facilities ranged from 0.0001% at NTS (under Regionalized Alternative 6 and Centralized Alternatives 1, 3, and 5) to 10.9% at WVDP (under Decentralized Alternative). Considering the available land required for the LLW facilities, DOE should have a great degree of flexibility in their siting and can employ a range of mitigative measures, so that site clearing to implement any of the LLW alternatives should not affect adjacent sensitive habitats.

Aquatic resources may be indirectly affected through increased runoff of water and soil to surface waters from construction sites. However, proper construction practices would minimize these effects. Direct discharges to surface waters from the routine operation of treatment facilities would comply with applicable regulations and would be limited by the use of accepted engineering techniques. Therefore, the impacts to aquatic organisms are expected to be minimal.

7.7.3 Effects of LLW Treatment Facility Emissions

DOE used atmospheric emissions and deposition modeling to estimate the toxicity to terrestrial animals from airborne emissions of radionuclides from treatment facilities. This analysis used the same atmospheric emissions estimates as the human health risk assessment and provided estimates of radionuclides deposited on surface soils.

For this analysis, DOE examined those sites with the highest anticipated emissions. Potential toxicity to terrestrial wildlife was analyzed for selected sites under the No Action, Decentralized Alternative, Regionalized Alternatives 2 and 5, and Centralized Alternative 5. The radionuclides Cs-137, H-3, Ni-63, Co-60, Sr-90, U-238, Pu-238, Pu-239, Pu-241, Y-90, Am-241, Pm-147, Th-234, and Ba-137 were selected for the analysis. These radionuclides comprised 80% of the total activity expected to be emitted. The

remaining activity was contributed by smaller emissions of a large number of radionuclides. The conservative assumptions used to characterize the scenario (e.g., accumulation of contaminants for 10-year period with no loss due to decay or transport) might compensate for limiting the analyses to 80% of the released activity. The concentrations of these radionuclides were used in calculating Hazard Indexes for each selected site/alternative combination as composite ratios between the estimated species exposures to each of the contaminants and estimated, contaminant-specific toxic levels. A Hazard Index greater than one would indicate a potential for the combined exposures to adversely affect the health of terrestrial species. The maximum estimated dose occurred at LLNL under Regionalized Alternative 2 and led to a maximum estimated Hazard Index of 0.09. This value suggests that the maximum total doses should be less than one-tenth of those of potential concern for ecotoxicity. Therefore, impacts to terrestrial receptor populations from radioisotope emissions from LLW treatment facilities are expected to be minimal. Additional information on the methods used to assess potential toxicity to terrestrial animals, as well as the results of the analysis, is presented in Section C.4.4. of Volume III and the impacts technical report (DOE, 1996a).

7.7.4 Consideration of Sensitive Species

For comparison of the LLW management program's potential to affect sensitive species, Table 7.7–2 lists the numbers of Federal- and state-listed sensitive species occurring or potentially occurring at each LLW site under each alternative. Site-specific analysis would be required to assess sensitive species impacts. That analysis would take into account specific locations for the LLW facilities in relation to the location of sensitive habitats and species at each site, including species listed by the U.S. Fish and Wildlife Service as endangered or threatened.

7.7.5 Effects of Low-Level Waste Transportation

The ecological impacts of a transportation accident involving shipment of LLW were analyzed based on an estimate of a waste spill release rate and stream characteristics for a hypothetical aquatic environment. The impacts of waste transportation accidents were evaluated by ORNL (1995d) as consequence assessments that did not include estimates of the probability of occurrence of these events. The transportation accident scenario analyzed spilling the contents of a rail shipment of LLW from INEL (ANL–W) into surface waters of different sizes. As a result of the packaging used in the transportation of LLW, it was assumed that the

Table 7.7–2. Numbers of Federally Listed and State-Listed Endangered and Threatened Species Occurring or Potentially Occurring at the LLW Sites by Alternative (Federal/State)

Alternative	Number of Sites		ANL-E	BNL	FEMP	Hanford	INEL	LANL	LLNL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP
	T[a]	D																
No Action	10[b]	6	--	--	--	3/11	2/2	2/4	--	2/2	1/11	--	--	--	--	--	8/8	--
Decentralized		16	2/5	2/6	--	3/11	2/2	2/4	6/5	--	1/11	9/12	5/8	1/9	2/2	1/8	8/8	1/8
Regionalized 1		12	--	--	--	3/11	2/2	2/4	6/5	--	1/11	9/12	5/8	1/9	2/2	--	8/8	--
Regionalized 2	11	12	--	--	2/10	3/11	2/2	2/4	6/5	--	1/11	9/12	5/8	1/9	2/2	--	8/8	--
Regionalized 3		6	--	--	--	3/11	2/2	2/4	--	2/2	1/11	--	--	--	--	--	8/8	--
Regionalized 4	7	6	--	--	--	3/11	2/2	2/4	--	2/2	1/11	--	--	1/9	2/2	--	8/8	--
Regionalized 5	4	6	--	--	--	3/11	2/2	2/4	--	2/2	1/11	--	--	--	--	--	8/8	--
Regionalized 6		2	--	--	--	3/11	--	--	--	--	--	--	--	--	--	--	8/8	--
Regionalized 7		2	--	--	--	3/11	--	--	--	2/2	--	--	--	--	--	--	8/8	--
Centralized 1		1	--	--	--	3/11	--	--	--	--	--	--	--	--	--	--	8/8	--
Centralized 2		1	--	--	--	3/11	--	--	--	2/2	--	--	--	--	--	--	8/8	--
Centralized 3	7	1	--	--	--	3/11	--	2/4	--	--	1/11	--	--	1/9	2/2	--	8/8	--
Centralized 4	7	1	--	--	--	3/11	--	2/4	--	2/2	1/11	--	--	1/9	2/2	--	8/8	--
Centralized 5	1	1	--	--	--	3/11	--	--	--	--	--	--	--	--	--	--	8/8	--

Notes: T = treat. "Treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. D = dispose. Each of the 6-site disposal alternatives uses the same sites; each of the 12-site disposal alternatives uses the same 12 sites. -- = no major action proposed at the site under the alternative.

[a] All sites do "minimum treatment" in all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are blank.

[b] Ten sites use existing facilities for Volume Reduction. Three sites (LBL, Mound, and RMI) not listed as major sites above include volume reduction facilities.

entire contents of the shipments could be released to surface waters following an accident, but that only a small fraction of the release would be soluble.

According to the results of this analysis, an estimated 30,000 curies of radioactivity, including nearly 15,000 curies of Co-60, would be released into surface waters. Such a release would produce adverse impacts on aquatic populations in 385 meters of a second-order stream and in 1 meter of a fourth-order stream; larger streams are expected to be unaffected. DOE also evaluated the potential impacts of the spill under the assumption that all released material partitioned to sediment. Since LLW typically includes a large fraction of insoluble material, this scenario probably is a more accurate model of the potential consequences of a LLW transportation accident. The results of the sediment deposition scenario analysis suggest that more than 2,000 metric tons of sediment could be contaminated to a level requiring remediation. Additional information on the methods used to assess the potential consequences of LLW transportation accidents on aquatic environments, as well as the results of the analysis, is presented in Section C.4.4 of Volume III and the impacts technical report (DOE, 1996a).

7.8 Economic Impacts

LLW facility construction and operations expenditures would substantially benefit the local economy at 6 of the 16 major LLW sites through job or personal income of 1% or greater of the regional baseline under one or more of the alternatives. None of the LLW alternatives would affect the national economy.

DOE estimated the effects of expenditures for LLW management on the local and national economies (see Table 7.8–1). Local economic effects were based on direct expenditures at each site for construction, operation and maintenance, and decontamination of treatment and disposal facilities. The socioeconomic region-of-influence (ROI) where local effects were evaluated, consists of the counties of residence of site employees. The local economy at each site was represented by employment, personal income, and industry data for the ROI counties. Local jobs and personal income were considered to be substantial benefits where they were 1% or greater than the 1990 baseline. Transportation expenditures were considered at the national level only.

Table 7.8–1. Economic Impacts Analyzed for LLW Alternatives

Economic Impact Analyzed	Affected Aspect of Economy	Analysis Method	Presentation of Results
Increased regional employment	Regional employment for direct, indirect, and induced jobs	Proposed site expenditures multiplied by regional employment multiplier at each LLW site	Table 7.8–2
Increased regional incomes	Regional personal income for direct, indirect, and induced jobs	Proposed site expenditures multiplied by regional income multiplier at each LLW site	Table 7.8–2
National economic effects	National economy	Proposed site expenditures plus total transportation expenditures multiplied by national employment and income multipliers	Text discussion only

Local economic effects were estimated on an annual basis. The impacts resulting from the construction and operation phase expenditures were combined to estimate total project effects at each site. For all alternatives (except No Action), the construction phase at any site was assumed to take 4 years; the operations phase was assumed to take 15 years (a 10-year operations and maintenance period and a 5-year decontamination period). Under the No Action Alternative, in place of distinct construction and operational phases, all costs were assumed to occur in a 20-year workoff of all existing waste (plus 5 years decontamination and decommissioning). Five years were added to both the construction and the operations phases to account for the continued effects on employment and income after each project phase ended. Job and personal income increases are shown for each site in the Volume II site tables.

Across the LLW alternatives, six DOE sites would experience a 1% or greater change in the number of jobs as a result of expenditures (see Table 7.8–2). The Hanford site would experience the greatest increase in the number of direct, indirect, and induced jobs under any of the alternatives, with a maximum increase of 3.3% under the Centralized Alternative 5. Other substantial increases in jobs occur at INEL and LANL under Regionalized Alternative 5, at LANL under Regionalized Alternatives 3 and 4, and at SRS under Regionalized Alternatives 6 and 7. Regionalized Alternative 2 and Centralized Alternative 3 would result in increases of 1% or greater in the number of jobs in five regional economies.

Changes in personal income of 1% or greater occur only at INEL under Regionalized Alternative 5 and at the Hanford site under the Centralized Alternative 5. In general, alternatives that include expenditures for

Table 7.8–2. LLW Jobs and Personal Income (P.I.) as a Percent of Jobs and Personal Income in the Regional Economic Baseline (LLW Sites Where Percentages Are 1% or Greater)[a]

Alternative	Number of Sites		Hanford		INEL		LANL		ORR		PORTS		SRS	
	T[b]	D	Jobs	P.I.	Jobs	P.I.	Jobs	P.I.	Jobs	P.I.	Jobs	P.I.	Jobs	P.I.
No Action	10[c]	6			1.1		1.2		1.1				1.4	
Decentralized		16			1.1		1.3				1.4		1.8	
Regionalized 1		12			1.1		1.6				1.6		1.8	
Regionalized 2	11	12			1.3		1.5		1.4		1.7		1.8	
Regionalized 3		6			1.1		2.1		1.0				1.8	
Regionalized 4	7	6			1.5		2.4		1.6		1.1		1.8	
Regionalized 5	4	6			3.0	1.1	2.2		1.8				1.8	
Regionalized 6		2											2.5	
Regionalized 7		2											2.5	
Centralized 1		[illegible]	1.7											
Centralized 2		[illegible]												
Centralized 3	7	[illegible]	1.5		1.0		1.4		1.3		1.1			
Centralized 4	7	[illegible]			1.0		1.4		1.3		1.1			
Centralized 5	1	[illegible]	3.3	1.2										

Notes: T = treat. "Treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. D = Dispose. Each of the 6-site disposal alternatives uses the same sites; each of the 12-site disposal alternatives uses the same 12 sites. Blank cells equal jobs or personal income growth less than 1%.

[a] Blank cells are less than 1%.

[b] All sites perform "minimum treatment" in all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.

[c] Ten sites use existing facilities for Volume Reduction. Three sites (LBL, Mound, and RMI) not listed as major sites above include volume reduction facilities.

volume reduction at DOE sites would cost more than alternatives that employ only minimum treatment at those same DOE sites. Since economic impacts are linearly proportional to the amount of money spent, the alternatives employing volume reduction treatment would result in larger increases in the number of jobs and personal income.

Comparing the alternatives, the sum of the new direct, indirect, and induced jobs from combined weighted construction and operations and maintenance activities across site ROIs ranges from 9,000 under Centralized Alternative 1 to 18,600 under Regionalized Alternative 2.

In addition to analyzing the impacts on the regional economy, a comparison of these impacts was made on the national economy. None of the LLW alternatives would substantially affect the national economy. The total number of jobs generated in the national economy from combined weighted construction and operations phase activities range from 16,650 under Centralized Alternative 2 to 27,400 jobs under Regionalized Alternative 5. Although the number of jobs appears large in absolute terms, 27,400 jobs represent only 0.02% of the 137 million jobs in the national economy. There are no substantial changes in personal income for the nation as a whole as a result of implementing any of the alternatives. Changes would represent a shift in the source of income from previous employment to employment in LLW projects, rather than a net change in national personal income.

7.9 Population Impacts

Substantial population increases are anticipated at one of five DOE sites under seven of the LLW alternatives, at two sites under Regionalized Alternative 5. These increases could affect community structure and provision of services.

Potential population changes in the ROI at each LLW site were estimated using the direct labor requirement to calculate potential worker in-migration. These estimates were used as an indicator of the likelihood that such population changes would cause effects, such as changes in community size, stability, diversity, and identity, and effects on the provision of necessary services. Sites identified with potential increases greater than or equal to 1% of the total ROI population are presented in Table 7.9–1.

Table 7.9–1. Percentage Population Increase for LLW Alternatives at Sites Identified With Potential Increases Over 1% of the Current ROI Population

Alternative	Number of Sites		Hanford	INEL	LANL	ORR	SRS
	T[b]	D					
No Action	10[c]	6					
Decentralized		16					
Regionalized 1		12			1.0		
Regionalized 2	11	12					
Regionalized 3		6					
Regionalized 4	7	6			1.4		
Regionalized 5	4	6		3.2		1.0	
Regionalized 6		2					1.3
Regionalized 7		2					1.3
Centralized 1		1					
Centralized 2		1					
Centralized 3	7	1			1.0		
Centralized 4	7	1			1.0		
Centralized 5	1	1	1.5				

Notes: T = treat. "Treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. D = dispose. Each of the 6-site disposal alternatives uses the same sites; each of the 12-site disposal alternatives uses the same 12 sites.
[a] Blank cells indicate that potential increases do not exceed 1%.
[b] All sites perform "minimum treatment" in all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.
[c] Ten sites use existing facilities for Volume Reduction. Three sites (LBL, Mound, and RMI) not listed as major sites above include volume reduction facilities.

For No Action and the Regionalized and Centralized minimum treatment alternatives, population in-migrations are not expected to be greater than or equal to 1% at any of the LLW sites, except SRS under Regionalized Alternatives 6 and 7. SRS would experience population increases of 1.3% and thus some impact to community characteristics and the provision of services may be anticipated. Under the Decentralized Alternative, LANL would experience a 1% population increase.

For those alternatives based on treatment by volume reduction, the Hanford site under the Centralized Alternative 5; INEL under Regionalized Alternative 5; LANL under Regionalized Alternative 4 and Centralized Alternatives 3 and 4; and ORR under Regionalized Alternative 5 would have population increases greater than or equal to 1%. Only one volume reduction alternative, Regionalized Alternative 2, has no sites with major population increases. One site is affected by more than one volume reduction alternative—LANL under Regionalized Alternative 4 and Centralized Alternatives 3 and 4. INEL and ORR

are affected only under Regionalized Alternative 5. Some minor impact may also be expected at the Hanford Site and SRS under Regionalized Alternatives 2, 4, and 5 and at ORR and Portsmouth under Regionalized Alternative 2.

All site population increases including those less than 1% are shown in Volume II site data tables.

7.10 Environmental Justice Concerns

Assessment of potential environmental justice impacts from management of LLW indicated that, with the exception of low-income populations at PORTS, minority and low-income populations at the LLW sites would not experience disproportionately high and adverse health risks or environmental impacts under most of the LLW alternatives.

Analysis of environmental justice impacts from management of LLW was based on a review of the impacts reported in this chapter regarding the LLW alternatives. This analysis was performed to identify any disproportionately high and adverse human health or environmental impacts on minority populations or low-income populations surrounding each of the 16 major LLW sites. Chapter 5 summarizes the methods and Appendix C provides the details of how this analysis was done, and the maps illustrating the distribution of minority and low-income populations within 50 miles of each LLW site.

7.10.1 Results

The potential for adverse human health effects from exposures to radionuclide emissions from LLW treatment facility operations is low for most LLW management alternatives. Incident-free LLW treatment facility operations were analyzed (see Section 7.4.1) in terms of risk to workers and the public. Overall, at most sites, incident-free operations present no significant risk and do not constitute a reasonably foreseeable adverse impact to the surrounding populations.

Screening criteria for the nonworker MEI (see Appendix C) indicated a cancer fatality probability of 1.0E-06 or greater for facility operations at FEMP under Regionalized Alternative 2; at Hanford under Regionalized Alternatives 4 and 5 and Centralized Alternatives 4 and 5; at LLNL under Regionalized

Alternative 2; at ORR under Regionalized Alternative 5; and at PORTS under Regionalized Alternative 4 and Centralized Alternative 3. However, demographic analysis of the five ROIs (FEMP, Hanford, LLNL, ORR, PORTS) indicated that only at PORTS would the MEI be located in a minority or low-income census tract. At PORTS (under the Regionalized 4 and Centralized 3 Alternatives), the MEI would be located in a census tract with a low-income proportion (32.7%) that exceeds the national average (13.1%).

A more detailed analysis of environmental justice impacts would be included in NEPA documents that deal with site-specific activities. The number of potential fatalities due to both radiological and nonradiological exposures to truck or rail transportation of LLW is small.

7.10.1.1 Transportation

Because incident-free LLW transportation and reasonably foreseeable transportation accidents are not expected to result in disproportionately high and adverse human health effects to minority or low-income populations, no environmental justice impacts are expected from transportation. As Section 7.4.2 indicates, total fatalities programwide to the collective population (all individuals within 0.5 mile of the transportation corridors) resulting from incident-free transportation range from less than 0.5 fatality to 12 fatalities or approximately 1 fatality for each 47 million shipment miles. This small number of collective population fatalities is spread across a large number of shipments. A disproportionate share of minority and low-income populations reside near interstate highways and railroads; however, the major routine risks to the public from truck transportation are from exposure during rest stops to travelers who are at the same rest stops. Minority and low-income populations are found to be disproportionately lower in representation at highway rest stops (DOT, 1992). For rail shipments, the primary risks to the public are from radiological exposure during railcar classification in railyards, primarily at the start and end of each shipment, and from the emission of diesel exhaust from the trains in urban areas. Even for the individuals expected to be exposed most frequently—residents near a site entrance, individual cancer fatality risk was only minimally elevated. This is true even at sites such as the Hanford Site and NTS, which handle 240,000 to 260,000 shipments (about 100 shipments per operational day) under various Centralized Alternatives during the 10-year operations period. Because the risks to these MEIs were found to be minimal (about 2 in 1 million), no segment of the population anywhere in the transportation corridors is expected to be at high risk. Therefore, no disproportionately high and adverse health effects to minority or low-income populations from incident-free LLW transportation are expected to occur.

The expected number of cancer fatalities due to radiation exposure from transportation accident releases, taking into account both the consequences of such a release and the probability that such a release will occur, is less than 0.5 under all alternatives. Estimated transportation accident fatalities from physical injuries range from less than 0.5 under the No Action Alternative to 35 under the Centralized Alternative 1 (approximately one fatality per 16 million shipment miles).

7.10.1.2 Environmental Impacts

In addition to the above, reviews of other technical disciplines pursuant to the methodology in Section 7.10.1 did not indicate any adverse impacts to water resources, ecology, economics, populations, land use, infrastructure, or cultural resources impacts. Air quality impacts are possible at two sites, but no disproportionately high and adverse impacts are expected for any segment of the population.

None of the LLW management alternatives would have an adverse impact on land use, ecology, or cultural resources because of the limited amount of previously undisturbed land that would be needed for use onsite (no offsite lands are involved) and mitigation programs already in place. Because reasonably foreseen environmental impacts, if any, to land use, ecological resources, or cultural resources are expected to be small under any of the alternatives, DOE expects no disproportionately high and adverse environmental impacts to minority and low-income populations at the LLW sites.

7.11 Land Use Impacts

Land requirements for LLW facility construction are minimal at most sites under the LLW alternatives. However, under several alternatives, land requirements at FEMP, Hanford (under Centralized Alternative 5), ORR, Portsmouth, and WVDP would exceed 1% of land designated or suitable for waste operations. Further evaluation of these sites indicated no impacts are expected to current onsite land uses and no conflicts with offsite uses are expected. Review of site development plans indicated no conflict between proposed treatment or disposal facilities and other plans for the major sites.

DOE evaluated the impacts of the alternatives on land use by comparing the acreage required for new treatment and disposal facilities to the acreage either designated for waste operations or suitable for development (Table 7.11–1). Suitable land is the total site acreage, minus the acreage required for existing

Table 7.11–1. Land Use Impacts Analyzed for the LLW Alternatives

Land Use Impact Analyzed	Affected Land Use	Analysis Method	Presentation of Results
Effect on land use onsite at each LLW site	Land use shown in site development plans	Comparison of required land area with amount designated (or estimated land) for LLW plan—all instances where requirements are 1% or higher are noted.	Table 7.11–2
Conflicts with offsite uses	Adjacent land use	Consideration of conflict between proposed WM uses and nearby land uses.	Text discussion only

structures and roads, known cultural resource areas, sensitive habitats (including wetlands and wildlife management areas), prohibitive topographic features, and surface waters. Available site development plans were also used to identify potential conflicts between the proposed facilities required under each alternative and plans for future site uses.

The land requirements analysis indicated that for the majority of LLW sites under all the LLW alternatives, land required to build treatment, storage, and disposal facilities is less than 1% of designated or suitable site land. Sites where the facility land requirements constituted 1% or more of designated or suitable acreage are listed in Table 7.11–2. The land use requirements exceed 1% of site land at WVDP under all alternatives. With the single exception of WVDP under the Decentralized Alternative, none of the other sites would be expected to exceed 3% of the total available land area. Because the analysis showed that LLW facilities would require only a small portion of the designated or suitable land at these sites, no land impacts onsite are expected. For the same reason, no conflicts with adjacent land uses are expected.

Although DOE intends to select sites for waste management activities based on the WM PEIS, the PEIS will not be the basis for selecting specific locations for facilities on the sites. When selecting locations for facilities on sites, DOE will consider the results of relevant existing or required new sitewide or project-level NEPA analyses, which would include analyses of potential land-use conflicts or restrictions at particular locations within a site. Should a sitewide or project-level NEPA review indicate that a site is not suitable for a waste management facility because of land use considerations that cannot be avoided or mitigated, then DOE will reconsider its decision to locate a waste management facility at that site.

Table 7.11–2. Percent of Waste Management-Designated or Suitable Land Required for LLW Facility Construction at Sites Where the Requirement is 1% or Greater [a]

Alternative	Number of Sites		FEMP	Hanford	ORR	PORTS	SNL-NM	WVDP
	T[b]	D						
No Action	10[c]	6	--		1.5	--	--	2.4
Decentralized		16	--		1.4	--	1	10.9
Regionalized 1		12	--		1.4	1.4	--	2.4
Regionalized 2	11	12	1.4			1.4	--	2.4
Regionalized 3		6	--		2.4	--	--	2.4
Regionalized 4	7	6	--		1.4		--	2.4
Regionalized 5	4	6	--		1.5	--	--	2.4
Regionalized 6		2	--		--	--	--	2.4
Regionalized 7		2	--		--	--	--	2.4
Centralized 1		1	--		--	--	--	2.4
Centralized 2		1	--		--	--	--	2.4
Centralized 3	7	1	--				--	2.4
Centralized 4	7	1	--				--	2.4
Centralized 5	1	1	--	1.4			--	2.4

Notes: T = treat. "Treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. D = dispose. Each of the 6-site disposal alternatives uses the same sites; each of the 12-site disposal alternatives uses the same 12 sites. -- = No major actions are proposed at the site under the alternative.
[a] Blank cells indicate a requirement of less than 1%.
[b] All sites perform "minimum treatment" in all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.
[c] Ten sites use existing facilities for Volume Reduction. Three sites (LBL, Mound, and RMI) not listed as major sites above include volume reduction facilities.

7.12 Infrastructure Impacts

Proposed LLW activities would affect onsite infrastructure at 13 of the major sites, although no offsite infrastructure impacts are expected. New requirements for water, wastewater treatment, or electrical power for proposed LLW facilities equal or exceed 5% of current system capacity at seven sites. Hanford Site and WVDP would approach or exceed the total site wastewater treatment capacity (new requirement plus current treatment load) in the alternatives where Hanford accepts offsite waste for treatment and disposal and in the Decentralized Alternative for WVDP. At WVDP, power and water requirements exceed the total capacity of the current system. Wastewater requirements for all other alternatives for WVDP exceed the current capacity. Twelve sites experience employment increases of 5% or more of current site employment during construction which could lead to traffic increases that would affect onsite transportation infrastructure.

DOE evaluated impacts on site infrastructure by comparing existing onsite capacities to requirements for water, wastewater treatment, and electrical power (See Table 7.12–1). Water and power were evaluated

Table 7.12–1. Infrastructure Impacts Analyzed for the LLW Alternatives

Infrastructure Impact Analyzed	Affected Infrastructure Elements	Analysis Method	Presentation of Results
Onsite capacity to support LLW facilities	Capacity of onsite water, power, and wastewater systems	Add increased LLW facility use to current use and compare to current capacities	Table 7.12–2
	Onsite transportation infrastructure	Compare new site employment with current site employment as an index of increased stress	Table 7.12–3
Capacity of community infrastructure to support increased worker populations and their families	Regional water, power, wastewater, and transportation infrastructure	Compare population increase with current regional population as an index of increased demand	Text discussion only

for both construction and operations; wastewater treatment was evaluated only for operations because wastewater from construction activities was assumed to be negligible. Where onsite maximum capacity information was unavailable, the proposed requirement was evaluated as a percentage of current use. Increased site employment was used as an indicator of potential impacts to the onsite transportation infrastructure. Offsite infrastructure impacts were evaluated using estimates of increased population from the proposed activities as an indicator of increased demand on the community infrastructure.

Table 7.12–2 shows the increase in onsite demand for water, wastewater treatment, and electrical power at sites where the increase exceeds 5%. The potential for a major impact is assumed to exist where an increase of 5% or greater causes total demand to exceed 90% of capacity. A moderate impact is assumed possible where total demand remains below 90% of capacity. Impacts to offsite infrastructure are not expected because population increases do not exceed 5% at any site under any alternative.

As shown in Table 7.12–2, most of the infrastructure impacts relate to demand for wastewater treatment and power. Major wastewater treatment impacts would occur at the Hanford Site under Centralized Alternatives 3 and 5 and at WVDP under the Decentralized Alternative. For the Decentralized Alternative at WVDP, the new demands would exceed 90% of the capacity for all three resources. Because WVDP is currently using full capacity of the wastewater system, all alternatives will impact the treatment system infrastructure.

Table 7.12–2. Increase in Demand for Water, Wastewater, or Power as a Percent of Current Capacity—LLW Sites With Increases Exceeding 5%

Alternative	Number of Sites		ANL-E	Hanford	INEL	NTS	ORR	SRS	WVDP
	T[a]	D							
No Action	10[b]	6		Ww (6.6)					W (5.8) P (10.7)
Decentralized		16	P (7.4)		P (5.8)	--	P (5.6)		W (53.45) Ww (8.03) P (130.63)
Regionalized 1		12			P (5.8)	--	P (5.6)		W (5.8) P (10.7)
Regionalized 2	11	12		Ww (5.5)	P (7.1)	--			W (5.8) P (10.7)
Regionalized 3		6			P (5.8)		P (12.2)		W (5.8) P (10.7)
Regionalized 4	7	6		Ww (5.7)	P (7.2)		P (5.7)		W (5.8) P (10.7)
Regionalized 5	4	6		Ww (5.7)	**P (17.5)**		P (6.0)		W (5.8) P (10.7)
Regionalized 6		2		Ww (6.3)		--		Ww (5.4) P (5.6)	W (5.8) P (10.7)
Regionalized 7		2						Ww (5.4) P (5.6)	W (5.8) P (10.7)
Centralized 1		1		**Ww (8.26)** **P (6)**		--			W (5.8) P (10.7)
Centralized 2		1				P (12.3)			W (5.8) P (10.7)
Centralized 3	7	1		**Ww (15.9)** **P (6.3)**	P (7.2)	--			W (5.8) P (10.7)
Centralized 4	7	1			P (7.2)	P (7.6)			W (5.8) P (10.7)
Centralized 5	1	1		**Ww (50.8)**		--			W (5.8) P (10.7)

Notes: T = treat. "Treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. D = dispose. Each of the 6-site disposal alternatives uses the same sites; each of the 12-site disposal alternatives uses the same 12 sites. -- = No major actions are proposed at the site under the alternative. Bold indicates major impact; all others are moderate. W = water; Ww = wastewater; P = power. Blank cells indicate an increase of 5% or less of current capacity.

[a] All sites perform "minimum treatment" in all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.

[b] Ten sites use existing facilities for volume reduction. Three sites (LBL, Mound, and RMI) not listed as major sites above include volume reduction facilities.

Table 7.12–3 identifies sites where the increase in site employment from construction activities exceeds 5%. These sites could experience impacts to the onsite transportation infrastructure from increased worker traffic. The Decentralized Alternative at WVDP would have an increase of approximately 41% for the site employment due to construction activities, which is the largest increase in site employment for the LLW waste management activities.

Table 7.12–3. Percent Increase in Site Employment From Construction—LLW Sites With Employment Increases Equal to or Greater Than 5%

Alternative	Number of Sites		FEMP	Hanford	INEL	LANL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SRS	WVDP
	T[a]	D												
No Action	10[b]	6	--						5	--	7	--	--	13
Decentralized		16	--			24	--	10	**16**		**16**		**22**	41
Regionalized 1		12	--			7	--		16		16		**22**	13
Regionalized 2	11	12	11		5	10	--	8	**24**		**29**	8	19	13
Regionalized 3		6	--			8	--	5	7	5		--	**22**	13
Regionalized 4	7	6	--		5	17		9	7	5	20	6	19	13
Regionalized 5	4	6	--		23	5		10	7	5		--	19	13
Regionalized 6		2	--	**5**	--	--			7	5		--	**36**	13
Regionalized 7		2	--		--	--	14		7	5		--	**36**	13
Centralized 1		1	--	**9**	--	--	--	--	7	5		--		13
Centralized 2		1	--		--	--	**26**	--	7	5		--		13
Centralized 3	7	1	--	**9**		13	--	7	7	5	20	7		13
Centralized 4	7	1	--			13	**8.6**	7	7	5	20	7		13
Centralized 5	1	1	--	**20**	--	--	--	--	7	5		--		13

Notes: T = treat. "Treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. D = Dispose. Each of the 6-site disposal alternatives uses the same sites; each of the 12-site disposal alternatives uses the same 12 sites. -- = No major action proposed for the site under the alternative. Bold indicates major impact; all others are moderate. Blank cells indicate site employment increases of less than 5%.

[a] All sites perform "minimum treatment" in all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.

[b] Ten sites use existing facilities for volume reduction. Three sites (LBL, Mound, and RMI) not listed as major sites above include volume reduction facilities.

7.13 Cultural Resources Impacts

Construction and operation of LLW facilities could adversely affect cultural resources. When selecting locations for waste management facilities on sites, DOE will consider the results of relevant existing or required new sitewide or project-level NEPA analyses, which would include analyses of potential impacts to cultural resources based on site-specific conditions.

Cultural and paleontological resources, including prehistoric, historic, fossil, and Native American sacred sites (Executive Order 13007), may be affected at sites where LLW treatment and disposal facilities are proposed to be built. Table 4.3–8 in Chapter 4 describes the status of cultural resources surveys at the 16 major proposed LLW sites and lists the reported cultural resources at those sites. However, the impacts of the construction of LLW facilities on cultural resources cannot be effectively analyzed at the programmatic level because the extent of those impacts depends upon their specific location at a site.

Although DOE intends to select sites for waste management activities based on the WM PEIS, the PEIS will not be the basis for selecting specific locations for facilities on the sites. When selecting locations for facilities on sites, DOE will consider the results of relevant existing or required new sitewide or project-level NEPA analyses, which would include analyses of potential impacts to cultural resources based on site-specific conditions.

Land requirements for the construction of LLW waste management facilities are sufficiently small under all alternatives so that DOE would probably have enough flexibility in siting LLW facilities to avoid impacts on cultural resources. If not, measures would be taken to mitigate negative effects on these resources.

7.14 Costs

Costs decrease as the number of treatment and disposal sites decrease, ranging from $17 to $11 billion for minimum treatment, and from $20 to $15 billion for volume reduction treatment. At the alternative level, the increased cost of volume reduction treatment more than offsets the disposal savings achieved from reduced volume. Transportation costs are lower than facility costs, making shipment to available facilities at another site generally less expensive than building new onsite facilities.

Table 7.14–1 outlines the cost-analysis components that DOE used to estimate costs for building and operating LLW treatment and disposal facilities and for transporting LLW (INEL, 1995a,b). DOE evaluated costs associated with LLW management from both a life-cycle and process perspective, using 1994 dollars.

7.14.1 LIFE-CYCLE COST

DOE evaluated facility costs for four phases representing the life-cycle of the facilities and their operations: preoperations, construction, O&M, and decontamination and decommissioning. Life-cycle costs do not include speculative factors, such as impacts on the long-term value of land.

Costs for preoperation activities consist of technology and site adaptation, including bench-scale tests and demonstrations; permitting; plant startup and cold run costs; and related conceptual design, safety analysis, project management, and contingencies.

Facility construction costs consist of building construction, equipment purchase and installation, contractor overhead, and related design, construction management, project management, and contingencies. Mobilization and demobilization costs are included for portable treatment units.

Table 7.14–1. Components of Cost Analysis

Impacts Assessed	Functions Analyzed	Activities for Which Impacts Were Assessed	Location of Impacts Assessment
Process Costs	Treatment[a]	Life-cycle costs for treatment including support facilities; estimated for minimum treatment and volume reduction	Table 7.14–2
	Storage	No life-cycle costs for storage facilities were estimated; on-site storage was assumed to be adequate	Not applicable
	Disposal[b]	Life-cycle costs for disposal facilities	Table 7.14–2
Transportation Cost	Truck	Inter-site common carrier costs for transportation from generating sites to treating sites, and to disposal sites	Table 7.14–2
	Rail	See above	Table 7.14–2

[a] No Action Alternative includes 20 years of treatment at the current mix of minimum treatment and volume reduction per site capabilities.
[b] Disposal includes closure and 300 years of postclosure custodial support.

Operations and maintenance costs consist of annual operations labor and material, maintenance labor and equipment, utilities, contractor supervision and overhead, and related project management and contingencies.

Decontamination and decommissioning costs consist of facility decontamination and demolition, closure, post-closure, and environmental monitoring activities.

7.14.2 Process Cost

DOE also analyzed costs for treatment, storage, and disposal activities. Treatment costs include costs to build and operate treatment facilities (such as incineration) and common support facilities (such as maintenance and certification/shipping facilities). For the No Action Alternative, DOE estimated the costs of a mix of minimum treatment and volume reduction, as accomplished currently by the sites. For the Decentralized Alternative, Regionalized Alternatives 1, 3, 6, and 7, and Centralized Alternatives 1 and 2, DOE estimated the costs of minimum treatment (solidification of liquids and fines as required to transport or for disposal). For Regionalized Alternatives 2, 4, and 5, and for Centralized Alternatives 3, 4, and 5, DOE estimated the cost of volume reduction (incineration, shredding, supercompaction, and follow-on solidification) at various combinations of regional treatment sites.

For the purpose of the WM PEIS analysis, existing LLW storage capacity is assumed to be sufficient for all alternatives. DOE assumed that after being treated, the waste would be disposed of in a timely manner. The minimal costs for storage were not estimated separately.

Disposal costs include costs to build and operate front-end administration and receiving facilities for disposal as well as the actual disposal units.

Transportation costs include the costs associated with the physical movement of the waste from one site to another, for either treatment or disposal. Transportation costs are evaluated for both truck transportation and rail shipments (INEL, 1995a).

Support facilities were assumed to be available for the No Action Alternative but were assumed to require construction for the other alternatives. Packaging and certification/shipping facilities were assumed to

require construction in each alternative because of their critical role in the proper control and tracking of waste, and because an inventory of existing support facilities was not available.

The summary of costs is shown in Table 7.14–2 (INEL, 1996). Construction accounts for 15% to 33% of the total costs, and O&M accounts for 49% to 72% of those costs. As waste is consolidated at fewer sites, costs for treatment and disposal facilities decrease, reflecting the economy of scale of using larger and fewer facilities. In considering minimum treatment, the reduction in cost between the Decentralized Alternative and Centralized Alternative 2 is $5.7 billion; the reduction is in disposal costs, partially offset by $2.2 billion of increased transportation costs. For volume reduction, the decrease in cost between Regionalized Alternative 2 and Centralized Alternative 5 is $4.2 billion. This is potentially offset by increased transportation costs of approximately $2.4 billion. Volume reduction treatment costs are twice as high as minimum treatment costs, and more than offset savings achieved in lowered disposal costs from less waste being disposed.

Although the quantity of waste requiring transport is at its maximum in the alternatives that centralize functions at NTS or the Hanford Site, the relative proportion of transportation costs remains relatively small, less than 21% of total costs. For the decentralized and regionalized alternatives, transportation costs are less, ranging from 0.1% to 5% of total costs.

7.15 Environmental-Restoration-Transferred Waste

The volume of LLW generated by environmental restoration activities that would be transferred to the waste management program is currently estimated to be about 140% of the volume of waste management LLW requiring treatment. The radiological profiles and physical characteristics of the environmental restoration (ER) transferred LLW have not yet been determined to the extent necessary to allow a meaningful evaluation of the potential environmental and human health impacts. The potential effects resulting from the treatment of the ER transferred LLW within the waste management program are discussed separately in the WM PEIS. When the radiological and physical characteristics of the ER transferred waste are better known, DOE may be required to assess the impacts of managing the ER transferred LLW on a site-specific basis.

Table 7.14–2. Life-Cycle Costs (billions of 1994 dollars)

Alternatives	Number of Sites		Total Costs[a] (Including Truck Transportation)	Life-Cycle Costs				Process Costs[b]		Transport Costs	
	T[c]	D		Preops	Const	O&M	D&D	T	D	Truck	Rail
No Action	10[d]	6	18.1	0.32	3.54	13.11	1.08	7.06	11.1	0.07	0.14
Decentralized		16	16.8	1.24	4.66	9.47	1.42	5.85	10.95	0.05	0.02
Regionalized 1		12	16.4	1.24	4.43	9.32	1.34	5.89	10.43	0.06	0.02
Regionalized 2	11	12	19.5	1.65	4.75	11.92	1.16	12.73	6.78	0.06	0.02
Regionalized 3		6	14.9	1.02	4.91	7.73	1.00	5.96	8.71	0.23	0.07
Regionalized 4	7	6	19.8	1.6	4.77	12.04	1.14	13.4	6.2	0.22	0.07
Regionalized 5	4	6	19.7	1.48	4.87	11.94	1.08	12.8	6.57	0.34	0.08
Regionalized 6		2	13.0	0.99	4.08	6.50	0.77	6.31	6.03	0.65	0.17
Regionalized 7		2	13.9	0.98	4.08	7.60	0.61	6.31	6.95	0.67	0.18
Centralized 1		1	12.2	0.77	1.89	6.02	1.09	6.47	3.3	2.46	0.44
Centralized 2		1	11.1	0.70	1.88	5.50	0.79	6.45	2.42	2.25	0.43
Centralized 3	7	1	18.2	1.39	3.14	10.47	0.94	13.3	2.57	2.34	0.43
Centralized 4	7	1	17.3	1.33	3.14	9.74	0.94	13.3	1.82	2.15	0.43
Centralized 5	1	1	15.3	1.08	2.59	8.17	0.98	10.23	2.57	2.45	0.43

Notes: Preops = preoperations; Const = construction; O&M = operations and maintenance; D&D = decontamination and decommissioning. T = treat; "treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. D = dispose; each of the 6-site disposal alternatives uses the same sites; each of the 12-site disposal alternatives uses the same 12 sites.

[a] Total Facility Costs are presented twice in this table: as life-cycle costs and as process costs. The sum of life-cycle costs is equal to the sum of process costs. Total Costs, also in the table, add truck costs to the facility costs. Therefore, Total Costs equals the sum of life-cycle costs and truck costs and also equals the sum of process costs and truck costs.

[b] Since sites are routinely treating/packaging and shipping to disposal sites, the current storage is included in the site infrastructure accounts which are not included in this PEIS.

[c] All sites do "minimum treatment" in all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.

[d] Ten sites use existing facilities for volume reduction. Three sites (LBL, Mound, and RMI) not listed as major sites above include volume reduction facilities.

DOE is responsible for the management of wastes currently in inventory and those generated by future operations (referred to as "waste management" wastes). As discussed in Chapter 1, DOE is also responsible for the management and remediation of contaminated media including soils, groundwater, and buildings. DOE expects that most of the contaminated media at its DOE sites will be remediated under the Environmental Restoration Program. The extent to which media are "cleaned up" is site specific and will depend largely on regulatory requirements and decisions regarding future land use. For analytical purposes, a standard "base case" scenario has been developed that estimates remediation costs across the DOE complex (DOE, 1996c). Although most waste generated by cleanup activities will be managed within the Environmental Restoration Program, a certain subset of the waste generated by these remediation activities will be transferred to waste management facilities. In the WM PEIS, these wastes are referred to as "environmental restoration (ER) transferred wastes." At present, only estimates of the volumes of ER transferred waste are available. These estimates were used to provide a qualitative assessment about how the addition of ER transferred waste may affect LLW alternatives.

Appendix B provides more detail on how certain wastes generated during environmental restoration will be transferred to the waste management program for final disposition and provides estimates of the volumes of ER transferred LLW. Appendix B also discusses the assumptions and uncertainties involved in assessing how ER transferred LLW may affect waste management alternatives.

To conduct an impact analysis for the additional ER transferred LLW similar to that conducted for waste management LLW, additional information is needed on the ER transferred waste streams. In addition to the volume of ER transferred waste, information is needed on the treatability characterization of the individual transferred LLW streams, including data about the radiological profile, chemical constituents, and physical form of the ER transferred waste. The wastes would also have to be categorized according to alpha and non-alpha radionuclide composition. Physical characterization of the ER transferred wastes into one of the treatment categories identified for TRUW is needed to estimate management costs. Information about the timing for the transfer of ER wastes to the waste management program is needed to determine the capacities of treatment or disposal facilities. This information is also crucial to conduct transportation and socioeconomic analyses. However, in many cases, this information will not be available until site-specific cleanup is conducted.

To identify how the addition of ER transferred LLW could affect the comparison among waste management alternatives made in the WM PEIS, DOE compared the volumes of waste management LLW with the

expected volumes of ER transferred LLW. This analysis reveals the potential for overloading treatment facilities for those sites and alternatives where the volumes of ER transferred LLW are projected to equal or exceed the volumes of waste management LLW. Strategies that can be used to manage the additional loading of ER transferred LLW in order to avoid overloading facilities include increasing facility operational capacity and operating a facility longer to "work off" the increased waste load. The WM PEIS treatment facilities are assumed to have an effective operational life of at least 30 years, which allows for an additional 20 years of operational capacity beyond the 10 years needed to work off the waste management wastes.

Increased radiation and chemical exposure risks to site workers, offsite populations, and the environment are related to the radiological activity in the ER transferred wastes, which at present cannot be reliably predicted. However, because radiological activities and chemical concentrations in ER transferred waste are, in general, expected to be lower than those for comparable waste management waste, risks from the addition of ER transferred wastes are expected to be lower than the risks resulting from the treatment of equivalent volumes of waste management wastes. In addition, because most ER transferred LLW (e.g., soils and debris) is expected to be amenable to the minimal treatment (e.g., packaging or solidification) criteria to meet LLW disposal requirements rather than to the full volume reduction treatment, risks and impacts to offsite populations are expected to be comparable or lower than those for similar types of waste management LLW. Site-specific performance assessments would be conducted, and appropriate disposal restrictions would be imposed to manage any potential increased risks. The risks from physical hazards associated with operating facilities to manage the ER transferred waste are related to the volume relationship between the ER transferred and waste management wastes. Transportation risks and costs are also dependent on waste volumes rather than the composition of the waste.

Overall, the volume of ER transferred LLW is expected to be about 127% of the waste management LLW load (1,900,000 cubic meters compared with 1,500,000 cubic meters, respectively; see Table B.6-1). The additional ER transferred LLW would exceed the waste management LLW load at five sites (ANL-E, FEMP, INEL, NTS, and SNL-NM) under the Decentralized Alternative (see Table B.7-1). The additional ER transferred LLW would be 130% of the waste management load at ANL-E and would represent a 130% increase to the INEL LLW load. The large increase in ER transferred LLW at NTS and SNL-NM (650× and 14× the respective WM LLW loads) would require increased capacity for the minimal LLW treatment facility, along with a longer period of operation. Because the bulk of the ER transferred LLW would require minimal treatment at most sites, the effects of the additional ER transferred waste loads at

NTS and SNL-NM in the Regionalized Alternatives would be small. Using the minimal treatment option, the additional ER transferred LLW would also be expected to influence the Centralized Alternative. The large input of ER transferred LLW at FEMP (180,000 cubic meters compared to 0 for waste management LLW) is due to the fact that FEMP is considered an ER site, and thus all waste at the site is, by definition, ER waste. The ER transferred LLW at FEMP is designated for offsite disposal.

7.16 Comparison of Alternatives Summary

The LLW impacts were evaluated across all the LLW alternatives to identify trends and ultimately the preferred alternative. The following discussion focuses on each impact area, identifying alternative trends when appropriate, and highlighting noteworthy findings at particular sites.

Health Risks. For routine treatment, radiation exposure risks to offsite and noninvolved worker populations correlate most closely to the choice of treatment technology (volume reduction risks are 4-20 times higher than those for minimum treatment). Secondarily, the presence of particular sites and waste characteristics in the alternative influences risks. FEMP, Hanford, LLNL, ORR, and Portsmouth experience the highest offsite risk under volume reduction alternatives that consider thermal treatment of tritium-contaminated waste. The number of worker fatalities is about one order of magnitude higher than for other receptors, driven by physical hazards. The increase in treatment worker fatalities as a result of volume reduction treatment operations exceeds the decrease in disposal worker fatalities from handling smaller disposal volumes. Concentrations of radionuclides in groundwater exceed applicable standards at several sites, demonstrating the need for upgraded waste acceptance criteria and other site-specific considerations. Management of radionuclide concentrations and waste forms would be required to assure acceptable water quality and human health risks. One of the most prevalent causes of these exceedances was unconstrained disposal of uranium-238-containing wastes at Hanford and SRS, which was evaluated under most of the alternatives. Disposal of LLW containing uranium-238 must be carefully managed at these sites. In addition, radionuclide exceedances in groundwater were recorded for unconstrained disposal at SNL-NM in the Decentralized Alternative and at Paducah in Regionalized Alternative 2. All other sites meet groundwater standards based on the technical and wasteload assumptions used for the WM PEIS analysis.

The greatest potential consequences for facility accidents occur at sites treating wastes with high concentrations of radioactivity. Only three sites, LLNL, LANL, and Hanford, experience one or more fatalities for accidents evaluated in the WM PEIS.

Transportation risks are proportional to vehicle-miles traveled; consequently, the large volumes of LLW transported in the centralized alternatives lead to relatively high numbers of expected fatalities from both traffic accidents and radiation exposure. Rail accident nonradiological risks are lower than those for truck.

Air Quality Impacts. The management of LLW does not affect the air quality at most sites. However, decentralized treatment and disposal at BNL or centralized disposal at NTS could cause adverse air quality impacts requiring additional emission control measures for criteria pollutants. Emissions of radionuclides were estimated to be below the applicable standards at any site.

Water Resources Impacts. Major impacts to water availability from increased water use at the sites are unlikely, although there is the potential for adverse impacts at LLNL Site-300 and WVDP. As discussed in Section 7.4.1.7, management of radionuclide concentrations from disposal at the Hanford Site, SRS, SNL-NM, and Paducah may be necessary to protect groundwater resources.

Ecological Resources, Cultural Resources, Environmental Justice Concerns, and Land Use. The WM PEIS analysis did not provide discriminators among the alternatives in these four impact areas. The programmatic analysis that was conducted did not reveal any major impacts in any alternative. However, impacts to ecological and cultural resources are dependent to some degree on specific technologies and their location at each site. These were not determined at the programmatic level of the WM PEIS, and these impact areas would be evaluated in more detail when such site-level details are evaluated. Land use is not a discriminator because the LLW alternatives do not use much land compared to the amount available at every site. Assessment of potential environmental justice impacts indicated that with the exception of low-income populations at PORTS, minority and low-income populations at the LLW sites would not experience disproportionately high and adverse health risks or environmental impacts under any of the LLW alternatives.

Economic Impacts. Regional economies at six of the 16 major sites would benefit more substantially in jobs expected, in addition to the increased employment at the Hanford Site expected under all the LLW alternatives. None of the LLW alternatives would affect the national economy.

Population Impacts. Generally, the more sites considered in an alternative, the lower the level of impacts at the most affected sites. As waste is consolidated at fewer sites, effects at the shipping sites diminish but effects at the receiving sites and in the transportation corridors increase. The largest increases are evident at INEL under Regionalized Alternative 5 for treatment and disposal.

Infrastructure Impacts. Proposed LLW activities would affect onsite infrastructure at 13 of the major sites, although no offsite impacts are expected. New requirements for wastewater treatment or electrical power for proposed LLW facilities equal or exceed 5% of current system capacity at seven sites. The most significant increases are at INEL in Regionalized Alternative 5 (when volume reduction and disposal are regionalized at the site), at the Hanford Site (Centralized Alternatives 1, 3, and 5) when disposal is consolidated at these sites, and at WVDP (all alternatives). Increased wastewater inputs at Hanford could cause wastewater treatment capacity to be exceeded. For the Decentralized Alternative at WVDP, water, wastewater, and power requirements would exceed the current capacity. Because WVDP is already operating at capacity for wastewater, requirements for all the alternatives will impact the site's wastewater system. Twelve sites would experience employment increases of 5% or more of current site employment during construction, which could lead to traffic increases that would affect the onsite transportation infrastructure.

Costs. Costs decrease as the number of treatment and disposal sites decrease, ranging from $17 to $11 billion for minimum treatment, and $20 to $15 billion for volume reduction treatment. At the national level, the increased cost of volume reduction treatment more than offsets the disposal savings achieved from reduced volume. Transportation costs are lower than facility costs, making shipment to available facilities at another site generally less expensive than building new onsite facilities. The reason for pursuing both privatization and commercialization is the belief that private vendors may be able to perform the same tasks faster and at a lower cost than DOE, through innovative technology, efficient oversight, and application of other streamlined business practices. In the experience of other institutions that have attempted privatization, savings are more common than increased costs. Actual cost differences have not been calculated for this document for the privatization of DOE waste management activities. The details of cost estimating are covered in Section 5.3.3 in Volume I.

Summary of Impacts by Alternative. Tables 7.16–1 and 7.16–2 summarize key impacts for each alternative.

The Preferred Alternative for Treatment. Each site with LLW would treat its waste onsite. Each site would perform minimum treatment on its wastes to prepare them for disposal, although DOE would allow each of its sites the flexibility to perform additional treatment if it would decrease costs and requirements for transportation by significantly reducing the volume of LLW requiring disposal. The potential environmental impacts of all alternatives for treatment of LLW evaluated in the WM PEIS are small. The impacts of DOE's preferred alternative for LLW are identified in Regionalized Alternative 3 as shown in Table 3.7–1 in Chapter 3, under which the potential impacts associated with minimum treatment of LLW at each site were analyzed, assuming regionalized disposal, as discussed below.

The Preferred Alternative for Disposal. The Department's preferred alternative at this time is to send its LLW to regional disposal sites after it is treated. After consultations with stakeholders, the Department intends to select two or three sites from the following six: Hanford, INEL, LANL, NTS, ORR, and SRS.

The six sites named above are those at which DOE already has established LLW disposal operations and, except for NTS, each has large waste volumes for disposal. Because these six sites would have more than adequate capacity for the amounts of LLW the Department will need to dispose of, there is no need to establish additional sites. Fewer than the six sites would provide adequate capacity at a substantially lower overall cost. Relying on only one disposal site, however, would require the most transportation of the waste, with correspondingly higher traffic accident fatalities, and would be operationally inflexible if disposal activities were interrupted.

While all six current disposal sites remain candidates for future disposal operations and the potential health and environmental impacts of regionalized disposal are small, further consideration of various factors may affect the DOE's site preferences. For example, hydrological characteristics indicate that disposal at sites with high rainfall, such as ORR and SRS, would require mitigation costs that would not be needed at more arid sites. However, a disposal configuration that included at least one eastern site and one western site would require less transportation and produce fewer fatalities from traffic accidents than an eastern-only or western-only configuration. Preliminary cost analyses indicate that regional disposal at ORR, LANL, and INEL may not be as cost effective as disposal at SRS, NTS, and Hanford.

Table 7.16–1. Comparison of LLW Alternatives—Projected Risks Results

Alternative	Number of Sites		Treatment Worker Physical Hazard Fatalities	Treatment Worker Cancer Fatalities	Offsite Population Cancer Fatalities	Disposal Worker Physical Hazard Fatalities	Disposal Worker Cancer Fatalities	Groundwater Impacts from Disposal			Truck Radiation Fatalities	Truck Non-Radiation Fatalities
	T[a]	D						Number of Sites That Meet Standards Without Additional Constraints	Number of Sites That Require Additional Constraints to Meet Standards	Radionuclides That Must Be Constrained for Sites to Meet Standards		
No Action	10[b]	6	3	1	*	4	3	4	2	U-238	5	12
Decentralized		16	2	1	*	6	2	12	3	Pu-239, Pu-240, Tc-99, U-234, U-238	*	1
Regionalized 1		12	2	1	*	6	3	9	2	U-238	*	1
Regionalized 2	11	12	4	1	1	4	2	8	3	U-238, Np-237	*	1
Regionalized 3		6	2	1	*	5	3	4	2	U-238	2	3
Regionalized 4	7	6	4	2	*	4	2	4	2	U-238	2	3
Regionalized 5	4	6	4	2	*	4	2	4	2	U-238	2	4
Regionalized 6		2	2	1	*	6	2	0	2	U-238	4	10
Regionalized 7		2	2	1	*	6	1	1	1	U-238	4	10
Centralized 1		1	2	1	*	1	3	0	1	U-238	16	37
Centralized 2		1	2	1	*	1	2	1	0	--	15	38
Centralized 3	7	1	4	1	*	1	2	0	1	U-238	15	35
Centralized 4	7	1	4	1	*	*	2	1	0	--	14	37
Centralized 5	1	1	4	2	*	1	2	0	1	U-238	15	37

Notes: T = treat; D = dispose. "Treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. * = greater than 0 but less than 1.

[a] All sites perform "minimum treatment" in all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.

[b] Ten sites use existing facilities for volume reduction. Three sites (LBL, Mound, and RMI) not listed as major sites include volume reduction facilities.

Table 7.16–2. Comparison of LLW Alternatives—Selected Impacts

Alternative	Number of Sites		Number of Sites With Air Pollutants That Exceed Standards	Highest Air Pollutant Percentages at Any Site	Cost ($Billions)	Truck Shipments	Comment
	T[a]	D					
No Action	10[b]	6	0	67 (CO-NTS)	18.1	87,000	Current Program
Decentralized		16	1	100 (NO_2-BNL)	16.8	24,000	Expand from 6 current disposal sites to 16
Regionalized 1		12	0	88 (NO_2-PGDP)	16.4	26,000	Expand from 6 current disposal sites to 12
Regionalized 2	11	12	0	81 (NO_2-PGDP)	19.5	26,000	Volume reduce at 6 western, 5 eastern sites; expand from 6 current disposal sites to 12
Regionalized 3		6	0	47 (NO_2-ORR)	14.9	84,000	Disposal at 6 current sites, but ship based on proximity
Regionalized 4	7	6	0	55 (NO_2-RFETS)	19.8	87,000	Volume reduce at 4 western, 3 eastern sites; disposal at 6 current disposal sites
Regionalized 5	4	6	0	23 (NO_2-ORR)	19.7	92,000	Volume reduce at 2 western, 2 eastern sites; disposal at 6 current disposal sites
Regionalized 6		2	0	16 (CO-LLNL)	13.0	174,000	Disposal at SRS and Hanford
Regionalized 7		2	0	67 (CO-NTS)	13.9	189,000	Disposal at SRS and NTS
Centralized 1		1	0	19 (NO_2-HS)	12.2	243,000	Centralized disposal at Hanford
Centralized 2		1	1	189 (CO-NTS)	11.1	257,000	Centralized disposal at NTS
Centralized 3	7	1	0	55 (NO_2-RFETS)	18.2	250,000	Volume reduce at 4 western, 3 eastern sites; disposal at Hanford
Centralized 4	7	1	1	128 (CO-NTS)	17.3	264,000	Volume reduce at 4 western, 3 eastern sites; disposal at NTS
Centralized 5	1	1	0	36 (PM_{10}-HS)	15.3	242,000	Volume reduce and dispose at Hanford

Notes: T = treat; "Treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. D = dispose. Each of the 6-site disposal alternatives uses the same sites; each of the 12-site disposal alternatives uses the same 12 sites.

[a] All sites perform "minimum treatment" in all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. For those alternatives where only minimum treatment occurs, the cells are left blank.

[b] Ten sites use existing facilities for volume reduction. Three sites (LBL, Mound, and RMI) not listed as major sites include volume reduction facilities.

Because of these sometimes contravening factors and the permanence associated with disposal decisions, it is prudent to further evaluate costs and discuss all pertinent aspects of potential configurations with stakeholders before identifying two or three preferred sites for disposal. The Department will notify the public which specific sites it prefers for disposal of LLW by publishing a notice in the *Federal Register* and by other means. DOE will not issue a Record of Decision selecting any regional disposal sites for LLW sooner than 30 days after publication of its preferred sites in the *Federal Register*.

Table 7.16–3 provides potential impacts for the preferred alternative by combining the impacts evaluated in the WM PEIS for the preferred alternative at each site. Although it is not possible to estimate disposal impacts with precision until the disposal sites have been selected, the table provides approximate values and ranges expected for the preferred LLW alternatives. Treatment and disposal impacts are taken from Volume II site data tables for the preferred alternatives specified in the second and third rows of Table 7.16–3. Values presented in the table for regionalized disposal use impacts estimated at Hanford, INEL, LANL, NTS, ORR, and SRS for Regionalized Alternative 3 (six disposal sites), Centralized Alternative 1 (one disposal site—Hanford), and Centralized Alternative 2 (one disposal site—NTS) to provide a range of potential impacts. Impact estimates under Centralized Alternative 1 at Hanford and Centralized Alternative 2 at NTS are greater than expected at either site. They provide an upper limit for the range of impacts at these sites, using impacts that result when all LLW is disposed of at one site—Hanford or NTS. The preferred disposal alternative would distribute disposal impacts over two to three sites, lowering values shown for Hanford or NTS.

Table 7.16–3. The Preferred LLW Alternative — Selected Impacts

Impact Area	Decision	ANL	BNL	FEMP	Hanford	INEL	LLNL	LANL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP	Total
Preferred alternative	T	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	
	D[a]	—	—	—	R	R	—	R	R	R	—	—	—	—	—	R	—	
Worker physical hazard fatalities	T	5.1E-02	4.3E-02	—	1.2E-01	1.5E-01	5.7E-02	1.4E-01	6.2E-03	2.8E-02	1.1E-01	2.5E-02	2.3E-01	8.0E-02	5.1E-02	4.4E-01	5.3E-02	1.6E+00
	D	—	—	—	0.0E+00–<1.4E+00	0.0E+00–2.5E-01	—	0.0E+00–4.1E-01	0.0E+00–<6.1E-01	0.0E+00–4.0E-01	—	—	—	—	—	0.0E+00–3.5E+00	—	6.1E-01–4.8E+00
	Total	5.1E-02	4.3E-02	—	1.2E-01–<1.5E+00	1.5E-01–4.0E-01	5.7E-02	1.4E-01–5.5E-01	6.2E-03–<6.2E-01	2.8E-02–4.3E-01	1.1E-01	2.5E-02	2.3E-01	8.0E-02	5.1E-02	4.4E-01–3.9E+00	5.3E-02	2.2E+00–6.4E+00
Worker cancer fatalities	T	3.2E-02	3.9E-02	—	9.9E-02	1.7E-01	2.5E-03	1.4E-01	3.0E-04	6.1E-02	1.5E-03	7.8E-04	4.6E-03	1.2E-03	4.1E-04	2.3E-01	1.3E-02	8.0E-01
	D	—	—	—	0.0E+00–<2.8E+00	0.0E+00–4.2E-01	—	0.0E+00–7.8E-01	0.0E+00–<2.2E+00	0.0E+00–5.5E-01	—	—	—	—	—	0.0E+00–5.8E-01	—	2.2E+00–2.8E+00
	Total	3.2E-02	3.9E-02	—	9.9E-02–<2.9E+00	1.7E-01–5.9E-01	2.5E-03	1.4E-01–9.2E-01	3.4E-04–<2.2E+00	6.1E-02–6.1E-01	1.5E-03	7.8E-04	4.6E-03	1.2E-03	4.2E-04	2.3E-01–8.1E-01	1.3E-02	3.0E+00–3.6E+00
Offsite population cancer fatalities	T	2.5E-06	2.3E-06	—	2.7E-06	8.0E-07	1.0E-02	2.1E-04	1.4E-12	5.0E-06	2.1E-08	4.4E-07	1.8E-09	4.0E-07	1.8E-06	1.9E-05	2.1E-06	1.0E-02
Radionuclides requiring constraints to meet groundwater standards	D	—	—	—	None or U-238	None	—	None	None	None	—	—	—	—	—	None or U-238	—	0-2 sites exceed

Table 7.16-3. The Preferred LLW Alternative — Selected Impacts—Continued

Impact Area	Decision	ANL	BNL	FEMP	Hanford	INEL	LLNL	LANL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP	Total
Preferred alternative	T	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	R3	
	D[a]	—	—	—	R	R	—	R	R	R	—	—	—	—	—	R	—	
Truck radiation fatalities		These numbers reflect intersite transportation results and are not attributable to individual sites																2-16
Truck nonradiation fatalities																		3-38
Highest air pollutant percentage	T	12% NO_2	26% NO_2	—	0%	1% NO_2/PM_{10}	0%	1% NO_2/PM_{10}	5% CO	47% NO_2	7% NO_2	0%	0%	15% CO	0%	3% NO_2	0%	no sites exceed
	D	—	—	—	0% - 19% NO_2	—	—	—	0% - 183% CO	—	—	—	—	—	—	—	—	0-1 sites exceed
Cost $ billions	T	.11	.11	—	.24	.66	.21	.29	.04	.71	.28	.14	.17	.23	.11	.90	.33	4.53
	D	0	0	—	.0–3.8	0-.61	0	0–1.72	0–<2.95	0–2.16	0	0	0	0	0	0-4.04	0	3.0-9.3
	Total[b]	.11	.11	—	.24–<4.05	.66–1.27	.21	.29–2.0	.04–<3.0	.71–2.87	.28	.14	.17	.23	.11	.90–4.95	.35	7.5E-0–13.8E-0
Truck shipments		1,050	1,350	0	0–243,000	0–8,520	620	11,420-18,400	120-257,000	55,000–65,000	6,270	420	33,000	3,570	330	20–68,000	6,620	84,000–257,000[c]

[a] DOE prefers to further narrow its configuration of disposing sites to 2-3 sites from these 6 sites. DOE has no site preferences pending further deliberations with regulators and stakeholders.
[b] Total costs for the alternative as presented in Table 7.16-2 are calculated by adding additional treatment costs for non-major DOE sites (estimated at $1.4 billion) and truck transportation costs (which vary from $0.2 billion for R3 to $2.5 billion for C1) to the costs presented here. The total cost for the alternative could therefore vary between $11.4 billion and $15.4 billion. For the preferred disposal alternative, disposal volumes would range between zero and those quantities disposed of in the Regionalized Alternative 3, at INEL, LANL, ORR, and SRS. At Hanford volumes would range between zero and those evaluated for Centralized Alternative 1. At NTS volumes would range between zero and those evaluated for Centralized Alternative 2.
[c] Total one-way shipments between two sites, as defined for shipments in Table 7.16-2, range between values for Regionalized Alternative 3 and Centralized Alternative 2.

Chapter 7
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Low-Level Waste Alternatives

Alternatives	Number of Sites		ANL-E	BNL	FEMP	Hanford	INEL	LANL	LLNL	NTS	ORR	PGDP	Pantex	PORTS	RFETS	SNL-NM	SRS	WVDP
	T	D																
No Action	10[a]	6				TD	TD	D	T	D	TD	T			T		TD	
Decentralized		16	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Regionalized 1		12			D	D	D	D	D	D	D	D	D	D	D		D	
Regionalized 2	11	12			TD	TD	TD	TD	TD	D	TD	TD	TD	TD	TD		TD	
Regionalized 3		6				D	D	D		D	D						D	
Regionalized 4	7	6				TD	TD	TD		D	TD			T	T		TD	
Regionalized 5	4	6				TD	TD	D		D	TD						TD	
Regionalized 6		2				D											D	
Regionalized 7		2								D							D	
Centralized 1		1				D												
Centralized 2		1								D								
Centralized 3	7	1				TD	T	T			T			T	T		T	
Centralized 4	7	1				T	T	T		D	T			T	T		T	
Centralized 5	1	1				TD												

Notes: T = treat. "Treat" in the context of LLW means volume reduction using thermal organic destruction, size reduction, and compaction followed by solidification. All sites perform "minimum treatment" in all alternatives, which consists of solidification of liquids and "fines" (powdered material), packaging, and shipment. D = dispose. Each of the 6-site disposal cases uses the same sites; each of the 12-site disposal cases uses the same 12 sites. Blanks indicate that no treatment or disposal takes place at these sites under the specified alternative.

[a] Ten sites use existing facilities for volume reduction. Three sites not listed as major sites above (LBL, RMI, and Mound) include volume reduction facilities.

CHAPTER 8
Impacts of the Management of Transuranic Waste

Chapter 8 describes the environmental consequences associated with the No Action, Decentralized, Regionalized, and Centralized Alternatives for transuranic waste (TRUW). This chapter provides information on existing and anticipated TRUW volumes, and existing and planned facilities available at DOE sites. This is followed by an overview of the analysis and assumptions relating to TRUW characteristics, the treatment and technologies considered, and the rationale for selecting the specific sites analyzed under each alternative. This chapter discusses the health risk, environmental impacts, and costs of the alternatives and provides a comparison of the alternatives.

The methods used to evaluate impacts are outlined in Chapter 5. Impacts tables for each major DOE site are contained in Volume II. Details of the TRUW analysis are contained in the technical report entitled "Transuranic Waste Inventory, Characteristics, Generation, and Facility Assessment for Treatment, Storage, and Disposal Alternatives Considered in the U.S. Department of Energy Waste Management Programmatic Environmental Impact Statement" (ANL, 1996). Additional information can be found in the complete list of appendices and technical reports provided in Chapter 15.

8.1 Background

- *TRUW is material produced during research and development, nuclear weapons production and dismantlement, and fuel reprocessing. It contains elements with atomic numbers greater than that of uranium, which has an atomic number of 92.*
- *TRUW is managed, or may be managed in the future, at 16 waste generator/storage sites, a number of other small generator sites, and a planned disposal site, the Waste Isolation Pilot Plant (WIPP).*
- *DOE's Waste Management Program will manage approximately 132,000 cubic meters of TRUW over the next 20 years.*
- *Although approximately 60% of TRUW contains both radioactive and hazardous components, DOE assumes that all TRUW is mixed waste for purposes of the WM PEIS analysis.*
- *DOE must select sites for the treatment and storage of TRUW.*

8.1.1 DEFINITION AND ORIGIN

Transuranic waste is waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for (a) high-level radioactive waste, (b) waste that the Secretary has determined, with the concurrence of the Administrator, does not need the degree of isolation required by the disposal regulations, or (c) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by case basis in accordance with Part 61 of Title 10, Code of Federal Regulations (10 CFR 61) (WIPP Land Withdrawal Act, Public Law

102-579).[1] The radioactive nuclides in transuranic waste emit alpha radiation, which requires minimal shielding when outside the body but can severely damage human tissue if taken into the body by inhalation, ingestion, or other means (such as through cuts). Transuranic waste requires long-term isolation from the environment. It is produced during reactor fuel assembly, research and development, nuclear weapons production, and spent nuclear fuel reprocessing. Transuranic waste contains traces of plutonium, with lesser amounts of neptunium, americium, curium, and californium. Other alpha-contaminated waste peculiar to a specific site may be managed as TRUW. For example, waste managed as TRUW at WVDP includes radioactive waste with concentrations of transuranic radionuclides as low as 10 nanocuries per gram, pursuant to the West Valley Demonstration Project Act.

Approximately 60% of TRUW is mixed waste, with both radioactive and hazardous components. However, for purposes of the WM PEIS analysis, DOE analyzes all TRUW as if it were mixed waste.

Because of its radioactive characteristics, TRUW falls under the jurisdiction of the Atomic Energy Act. In addition, TRUW's hazardous constituents are regulated under the Resource Conservation and Recovery Act (RCRA) (42 USC 6901 *et seq.*). The hazardous components, such as solvents and heavy metals, can be subject to RCRA land disposal restrictions (LDRs) (40 CFR 268) promulgated by the U.S. Environmental Protection Agency (EPA). The amendments to the Waste Isolation Pilot Plant Land Withdrawal Act contained in the 1997 Defense Authorization Act, however, exempt waste to be disposed of at WIPP from RCRA's provisions regarding LDRs.[2]

DOE plans to dispose of TRUW generated from defense activities and retrievably stored since 1970 at a geologic repository called the Waste Isolation Pilot Plant (WIPP), located near Carlsbad, New Mexico. In 1980, DOE issued a final environmental impact statement (EIS) on the proposed development of WIPP (DOE, 1980). DOE's record of decision (ROD), issued in 1981, called for the phased development of the repository. DOE prepared a Supplemental EIS (WIPP SEIS-I) in 1990 to analyze changes in environmental impacts since the 1980 EIS (DOE, 1990). In a 1990 ROD, DOE decided to continue with phased

[1]LLW and LLMW may also contain these transuranic isotopes, but with concentrations less than 100 nanocuries per gram of waste.

[2]The Waste Isolation Pilot Plant Land Withdrawal Act of 1992 provides for the disposal of 175,600 cubic meters (6.2 million cubic feet) of "defense TRUW" at WIPP provided all regulatory requirements are met. WVDP and other DOE sites have small amounts of "nondefense" TRUW. For purposes of analysis in this WM PEIS, DOE has assumed that all TRUW is defense TRUW and will be disposed of at WIPP. The impacts of treating and disposing of nondefense TRUW are evaluated in some of the alternatives analyzed in the second supplemental EIS for WIPP (WIPP SEIS-II) (DOE 1996e).

development of the WIPP. DOE is examining whether or not to dispose of TRUW in WIPP in a second supplemental EIS (WIPP SEIS-II) (DOE, 1996e).

However, disposal of TRUW cannot begin until DOE meets a series of regulatory requirements imposed under the Waste Isolation Pilot Plant Land Withdrawal Act, as well as other applicable regulatory and permitting requirements. Before shipment for disposal, all TRUW will be required to meet the Waste Isolation Pilot Plant Waste Acceptance Criteria (WIPP-WAC) that will be established by DOE in consultation with EPA and the State of New Mexico (DOE, 1991). However, this consultation process has not been completed yet, and additional treatment could be required to reduce the potential for gas generation at WIPP.[3] Since the Draft WM PEIS was prepared, DOE has revised the WIPP-WAC that it uses for planning purposes (DOE, 1996a). Revision 5 eliminated WAC that applied only to waste that would have been used in underground-test-phase experiments at WIPP, which were canceled, and revised the remaining requirements to make the document easier to use. Some additional requirements were added, including limits on volatile organic compounds and polychlorinated biphenyls. In general, the changes to the WIPP-WAC were minor, and the revised WIPP-WAC are slightly more restrictive than the previous version. Under the circumstances, the analysis in the Draft WM PEIS, which was based on Revision 4 of WIPP-WAC, is assumed to be adequate for the purposes of bounding the impacts that might be expected from packaging and treating waste to meet Revision 5 of WIPP-WAC.[4]

8.1.2 Volumes and Locations

Table 8.1–1 presents the estimated total volume of TRUW from waste management activities at the 16 sites where the largest amounts of TRUW are currently present or projected. (Details on the amounts and characteristics of TRUW are provided in ANL [1996].) Of these 16 sites, 10 (ANL-E, Hanford, INEL, LANL, LLNL, NTS, ORR, PGDP, RFETS, and SRS) and the WIPP site, which currently does not contain TRUW, were fully evaluated for environmental impacts and costs for each alternative considered in the WM PEIS. For the remaining six (ETEC, LBL, Mound, SNL-NM, UofMO, and WVDP) and for Pantex, the

[3] Treatment to reduce gas generation is considered in this PEIS. For TRUW, gas could be generated by the corrosion of metals in the waste, the metal containers themselves, and by microbial decomposition of the waste. DOE is evaluating in the WIPP SEIS-II (DOE, 1996e) an alternative for disposal of TRUW after treatment to reduce gas generation. Recent studies suggest that gas generation will not affect WIPP's ability to contain hazardous and radioactive constituents of TRUW.

[4] The WIPP SEIS-II (DOE, 1996e) evaluated Revision 5 of the WIPP-WAC.

Table 8.1–1. Transuranic Waste Volumes (cubic meters)

Site[a]	Contact-Handled TRUW			Remote-Handled TRUW			
	Inventory[b]	20-Year Projected Generation	Estimated Inventory + 20 Year Generation	Inventory[b]	20-Year Projected Generation	Estimated Inventory + 20 Year Generation	Total
ANL-E	15 (25)	940	960	0	340	340	1,300
ETEC	0.02 (2)	0	0.02	0 (6)	0	0	0.02
Hanford	12,000 (12,000)	24,000	36,000	200 (200)	15,400	16,000	52,000
INEL	38,000 (28,000)	280	38,000	110 (220)	500	610	39,000
LANL	8,200 (11,000)	2,500	11,000	79 (94)	10	89	11,000
LBL	0.8 (0)	0.2	1	0 (0)	0	0	1
LLNL	200 (230)	1,500	1,700	0 (0)	0	0	1,700
Mound	274 (300)	1,200	1,500	0 (0)	0	0	1,500
NTS	610 (620)	0	610	0 (0)	0	0	610
ORR	670 (1,300)	360	1,000	1,300 (2,500)	360	1,700	2,700
PGDP	14 (0)	0	14	0 (0)	0	0	14
RFETS[c]	1,500 (4,900)	4,800	6,200	0 (0)	0	0	6,200
SNL-NM	1 (7)	0	1	0 (0)	0	0	1
SRS	5,100 (2,900)	11,500	16,600	1 (0)	20	21	16,600
UofMO	0 (1)	2	2	0 (0)	0	0	2
WVDP	0.5 (0)	0	0.5	0 (0)	0	0	1
Total[d]	**67,000 (61,000)**	47,000	**114,000**	**1,700 (3,000)**	**17,000**	**18,000**	**132,000**
Other Sites Reporting TRUW Inventories:[e]							
Ames	(0)			(0)			
BCL	(0)			(580)			
Bettis	(0)			(0)			
Pantex	(1)			(0)			
TBE[f]	(1)			(0)			
USAMC[f]	(3)			(0)			

[a] WIPP, the seventeenth site, does not currently have any TRUW.
[b] Amount shown parenthetically indicates volume reported in BIR-2 (DOE, 1995c) and the WIPP SEIS-II (DOE, 1996e). Comparison of values is not necessarily appropriate because the BIR-2 estimates of volume reflect some level of treatment.
[c] Includes volume estimate of plutonium process residues.
[d] Volume data are rounded from field estimates and columns and rows do not add. Waste volume projections contained in this and other WM PEIS tables were based on 1993 or earlier data and may vary from the latest site estimates at the time of publication. Updated inventories and waste generation rates are summarized in Appendix I, "Update of Site-Specific Waste Volumes for LLW, LLMW, and TRUW."
[e] These sites are additional small quantity generators reported in the BIR-2 (DOE, 1995c) and the WIPP SEIS-II (DOE, 1996e) that constitute less than 1% of the total TRUW inventory.
[f] TBE = Teledyne Brown Engineering; USAMC = U.S. Army Material Command.

Sources: DOE (1992, 1993, 1995b,c).

TRUW volumes were very low (2 cubic meters or less) and did not warrant analysis of impacts because of the minimal amount of handling and packaging that would be required. However, the volumes for these six sites were included with waste that would be treated or stored at Regionalized or Centralized facilities. Waste volume managed at the 16 TRUW sites considered in the WM PEIS accounts for more than 99% of the Department's current and projected TRUW inventory.

TRUW is categorized as either contact-handled (CH) or remote-handled (RH) based on the level and type of radioactivity emitted. CH-TRUW consists primarily of alpha particles and low energy radionuclides with little penetrating power. CH waste containers can be handled directly by humans. As illustrated in Table 8.1–1, more than 85% of the total volume of TRUW is CH-TRUW. RH-TRUW typically contains a greater proportion of radionuclides that produce highly penetrating radiation (gamma radiation) and thus must receive special shielding in treatment, storage, and disposal facilities.

Since the initial preparation of the WM PEIS, DOE has issued updated information on TRUW volumes in the *Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report*, Revision 2 [WIPP BIR-2] (DOE, 1995c) and the *Mixed Waste Inventory Summary Report* [MWIR 95] (DOE, 1995b). Appendix I discusses how newly available data on TRUW may impact the analyses of alternatives in the WM PEIS. This more recent information revealed additional "small-quantity" generator or storage sites, which have or are expected to manage TRUW. The TRUW volumes at these small-quantity sites constitute less than 1% of the total TRUW inventory and are not expected to affect the TRUW analysis in the WM PEIS because sites with small amounts of TRUW are not well-suited for treatment facilities, as quantities of offsite TRUW greater than that stored onsite would have to be transported to such sites if they were proposed for treating TRUW in the various alternatives. Table 8.1–1 has been updated to identify these sites. Waste inventories from the BIR-2 for these sites, as well as for other sites, are expressed parenthetically because most of these data were not analyzed in the WM PEIS. The WIPP SEIS-II inventory is based on BIR-2.

Table 8.1–1 provides estimates of volumes of TRUW currently in inventory and estimates of the volumes DOE anticipates generating during the next 20 years; these estimates do not include wastes that may be generated as a result of environmental restoration activities.[5] The largest volumes of TRUW are located at

[5] The waste volumes also do not include TRUW generated before 1970. TRUW generated before 1970 is known as "buried TRUW." This waste is considered environmental restoration waste and will be managed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Section 8.15 of this chapter contains information regarding TRUW generated as a result of environmental restoration activities

10 sites, with 95% of the waste located at six of these sites: Hanford, INEL, LANL, ORR, RFETS, and SRS. Figure 8.1–1 presents the total TRUW volumes at the major sites. The data shown in Table 8.1–1 were obtained primarily from the *Interim Mixed Waste Inventory Report* (DOE, 1993) and *Integrated Data Base for 1992* (DOE, 1992),[6] with updated information on waste volumes used for two sites. As described in Appendix I, more recent data for TRUW were taken primarily from two sources: the *Mixed Waste Inventory Summary Report* [MWIR 95] (DOE, 1995b) and the *Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report, Revision 2* [WIPP BIR-2] (DOE, 1995c), with most of the new information taken from MWIR 95. MWIR 95 contains information on waste as it currently exists, and specifies treatability groups, and therefore is used in the WM PEIS analyses for calculating impacts from consolidating or decentralizing the treatment of TRUW throughout the DOE complex. Such information on as-generated waste forms is readily available from MWIR 95 but is not readily extracted from the WIPP BIR-2 data. A portion of the WIPP BIR-2 waste loads reflect some level of treatment because they are intended to represent the volume of wastes in the forms they might be disposed of at WIPP. The WIPP BIR-2 was also used for its radiological profiles and for more definitive waste volumes estimates for the years that are not covered by MWIR 95.[7]

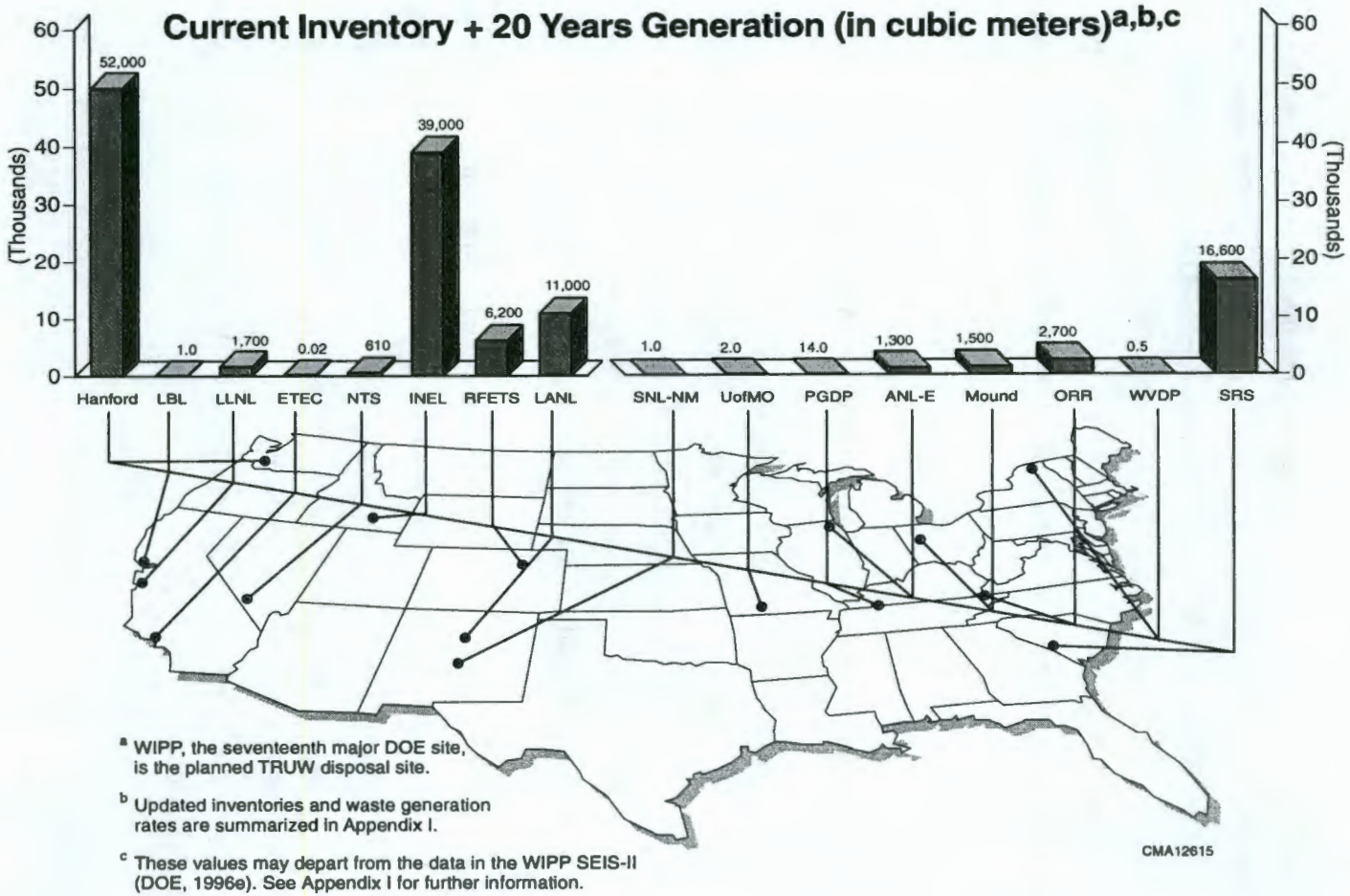
DOE also reviewed a third version of the *Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report* [WIPP BIR-3] (DOE, 1996d), which was published in June 1996, and the *Integrated Data Base Report–1994* (DOE, 1995d), published September 1995. Although the radionuclide inventories at some sites are changed slightly, the waste volumes and hazardous constituent inventories in WIPP BIR-3 are unchanged from WIPP BIR-2. The WIPP BIR-3 and IDB Report–1994 databases were not available at the time of the WM PEIS analysis; however, the changes in WIPP BIR-3 and IDB Report–1994 are minor, and, therefore, WIPP BIR-2 data were considered to be sufficient for analytical purposes.

A comparison of MWIR 95 with more recent site information at Hanford (22,000 m^3 in WIPP BIR-2 as compared to 160 m^3 in MWIR 95) showed that it would be more appropriate to use data in the WIPP BIR-2

(including retrieval of buried TRUW) and the extent to which these waste volumes may affect the analyses in the WM PEIS.

[6] These data were modified slightly because the TRUW reported at LLNL as remote-handled (RH) is actually contact-handled (CH) on the basis of information included in the 1994 Mixed Waste Inventory Report (DOE, 1994). For the rest of the sites, the waste volumes reported in the 1994 report do not vary significantly from the waste volumes reported in the 1993 interim report.

[7] For impacts at potential treatment site, the Draft WIPP SEIS-II (DOE, 1996e) scaled or adjusted the analysis in the Draft WM PEIS to reflect BIR-2 and other updated information as explained in the Draft WIPP SEIS-II. (See Section 8.2.5.)



[a] WIPP, the seventeenth major DOE site, is the planned TRUW disposal site.

[b] Updated inventories and waste generation rates are summarized in Appendix I.

[c] These values may depart from the data in the WIPP SEIS-II (DOE, 1996e). See Appendix I for further information.

Figure 8.1–1. TRUW Total Inventory and Generation.

for Hanford, as the largest waste streams at Hanford would not be generated until after the 5-year period covered by MWIR 95 and thus do not appear in MWIR 95.

The analysis presented in the WM PEIS has been updated based on this newer information for Hanford and SRS in alternatives where these sites treat their own wastes. Additionally, WIPP waste loads have been updated in the Centralized Alternative. A more complete discussion of the criteria for selecting sites for reanalysis using the newer information is presented in Appendix I. This appendix also identifies the criteria for reanalyzing using the more recent data, compares the waste load data used in the Draft WM PEIS with the more recent data, and describes DOE's conclusions about the need to analyze the more recent data for specified sites.

8.1.3 Existing and Planned Facilities Available at DOE Sites

To establish the baseline capacities for TRUW treatment and to identify the need for new or expanded facilities, DOE compiled a list of existing and planned TRUW facilities. Total capacities of these identified facilities are presented in Table 8.1–2. Some facilities that are not currently operating were considered to be in existence for the analysis, based on the assumption that they could become operational if required. Planned facilities include only those facilities for which a Title II design has been initiated.

Analysis in the PEIS assumes use of existing and planned facilities until their capacities are met. If additional capacity is needed, use of new conceptual facilities is assumed. These conceptual facilities constitute the difference in treatment and storage capacity between the baseline reported in Table 8.1–2 and what is necessary to manage the waste that a given site would receive under an alternative. Conceptual facilities are based on generic designs with specified impacts (e.g., cost, performance, and efficiency). Where necessary for analysis, an assumption was made that the impact of existing facilities essentially reflects the impact of conceptual facilities.

Six sites have either existing or planned treatment facilities: Hanford, INEL, LANL, ORR, RFETS, and SRS (see Table 8.1–2). These facilities are each capable of performing different aspects of treatment including aqueous treatment, shredding, solidification, thermal treatment, and repackaging. DOE also assumed that the basic capabilities to package and store TRUW are available at every site that would

Table 8.1–2. Capacities of Existing and Planned TRUW Facilities

Site	Treatment (m^3/yr)					Storage (m^3)
	Aqueous Treatment	Shredding	Solidification	Thermal Treatment	Repackaging	
Hanford					1,400	
INEL					200	20,000
LANL	200		7.7	680[a]		
ORR			189			
RFETS	149,000	3,683	497		949	
SRS					200	15,300

Note: Blanks indicate that the treatment process or storage does not take place at the site.
[a] Thermal treatment unit at LANL is currently shut down and is being dismantled.

Source: DOE (1996b).

generate TRUW in the future. This includes 11 sites projected to generate CH TRUW and 5 sites with projected RH TRUW, as shown in Table 8.1–1.

8.2 Analytical Methods and Assumptions

To evaluate the TRUW alternatives, DOE first examined total waste volumes and the capability of existing or planned facilities. DOE then identified the chemical and radiological characteristics of TRUW in order to evaluate the effects of treatment. The specific assumptions used in the analysis related to TRUW facilities, treatment technologies, and transportation are discussed below.

8.2.1 CHARACTERISTICS

8.2.1.1 Physical/Chemical

Although TRUW contains hundreds of waste streams, these streams can be grouped by physical and chemical properties into a limited number of waste treatment categories. In doing this, DOE was able to analyze a relatively broad range of TRUW by applying appropriate technologies dictated by the common

physical and chemical treatment categories. Similar to low-level mixed waste (LLMW), the WM PEIS analysis of TRUW evaluated five treatment categories (or groupings): aqueous liquids, solid process residues, soils, organic liquids, and debris.

For the evaluation of impacts in the WM PEIS, DOE assumed that all TRUW is mixed waste. This assumption is conservative and consistent with practice in the field, where TRUW is managed as mixed waste unless definitive characterization has been performed to establish that there are no hazardous constituents present. The assumption that all TRUW contains hazardous constituents is conservative because it tends to overestimate the impacts of treating TRUW. DOE estimated the hazardous constituents in TRUW based on the TRUW present at RFETS, which has the most detailed process knowledge information on hazardous constituents available in the DOE system.

8.2.1.2 Radiological Profiles

Radionuclide concentrations for the 10 largest generators of TRUW were obtained from process knowledge, supplemented by limited sampling and analysis of stored TRUW. The radiological profiles at each site were derived from the estimated radionuclide concentrations in TRUW at the site. Insufficient data exist to assign unique radiological profiles to each individual waste stream at each site. Thus, a uniform radiological profile was assigned to all waste streams of a similar treatment category at each site (ANL, 1996). Updated information on radiological profiles was used in the Final WM PEIS for Hanford and SRS (DOE 1995b,c). Smaller generators were assumed to have the same concentrations as LLNL's TRUW (DOE, 1991). These radiological profiles identify the radionuclides likely to be encountered in TRUW and ultimately determine risk and impacts. DOE analyzed CH and RH TRUW separately in the WM PEIS to account for their different handling and treatment requirements.

8.2.2 Technologies and Treatment Processes

TRUW is treated by one or more treatment processes (or "modules"). Individual modules were linked together to form a complete treatment process for each treatability group. The emissions and impacts were calculated for each module and then added to determine the overall impacts from each treatment process at a site. Figures 8.2–1 through 8.2–3 represent simplified TRUW "treatment trains." These treatment trains are based on more detailed diagrams contained in the report, "Analysis of Waste Treatment

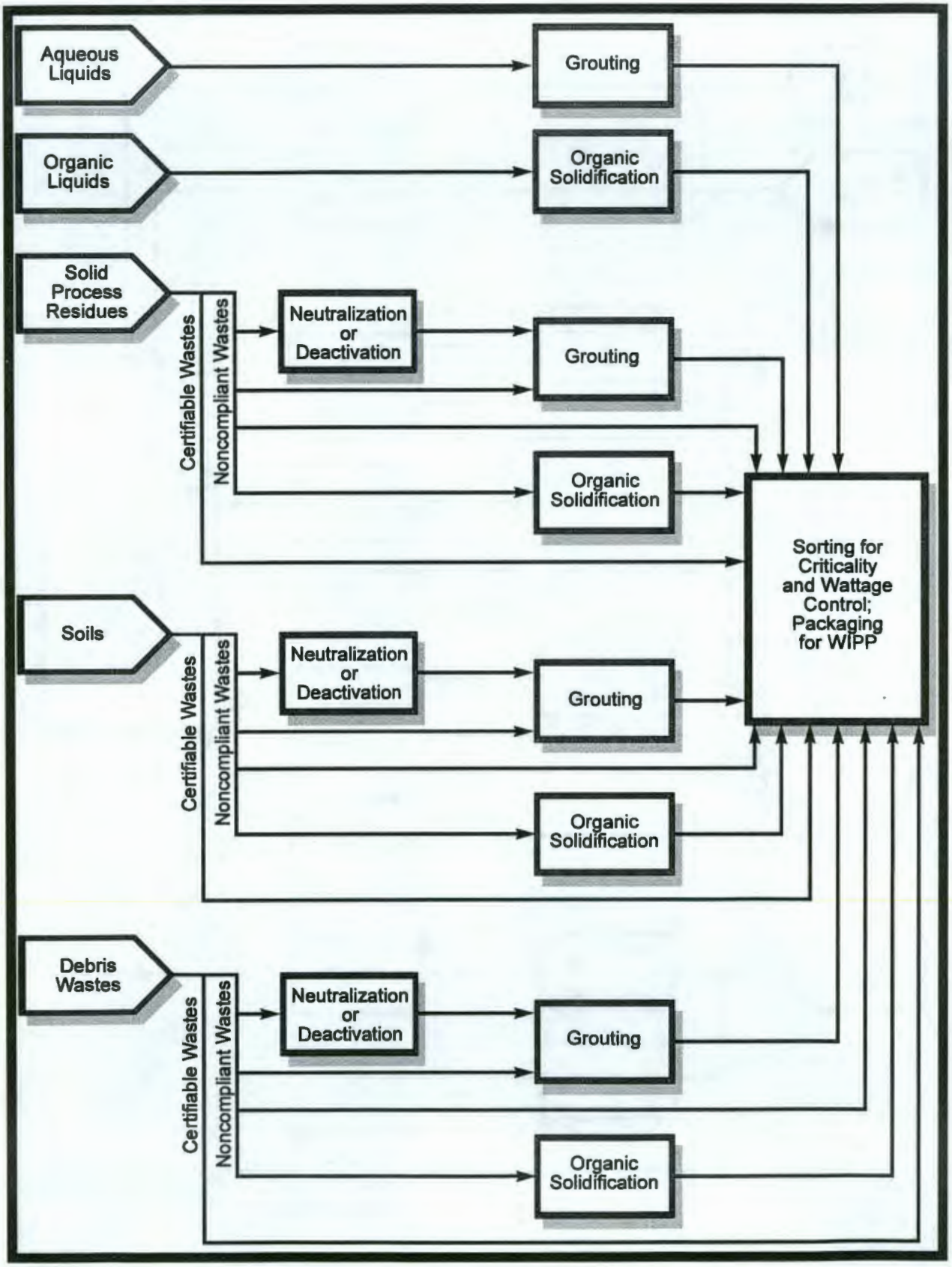


Figure 8.2–1. Treatment Trains for Meeting Current WIPP Waste Acceptance Criteria.

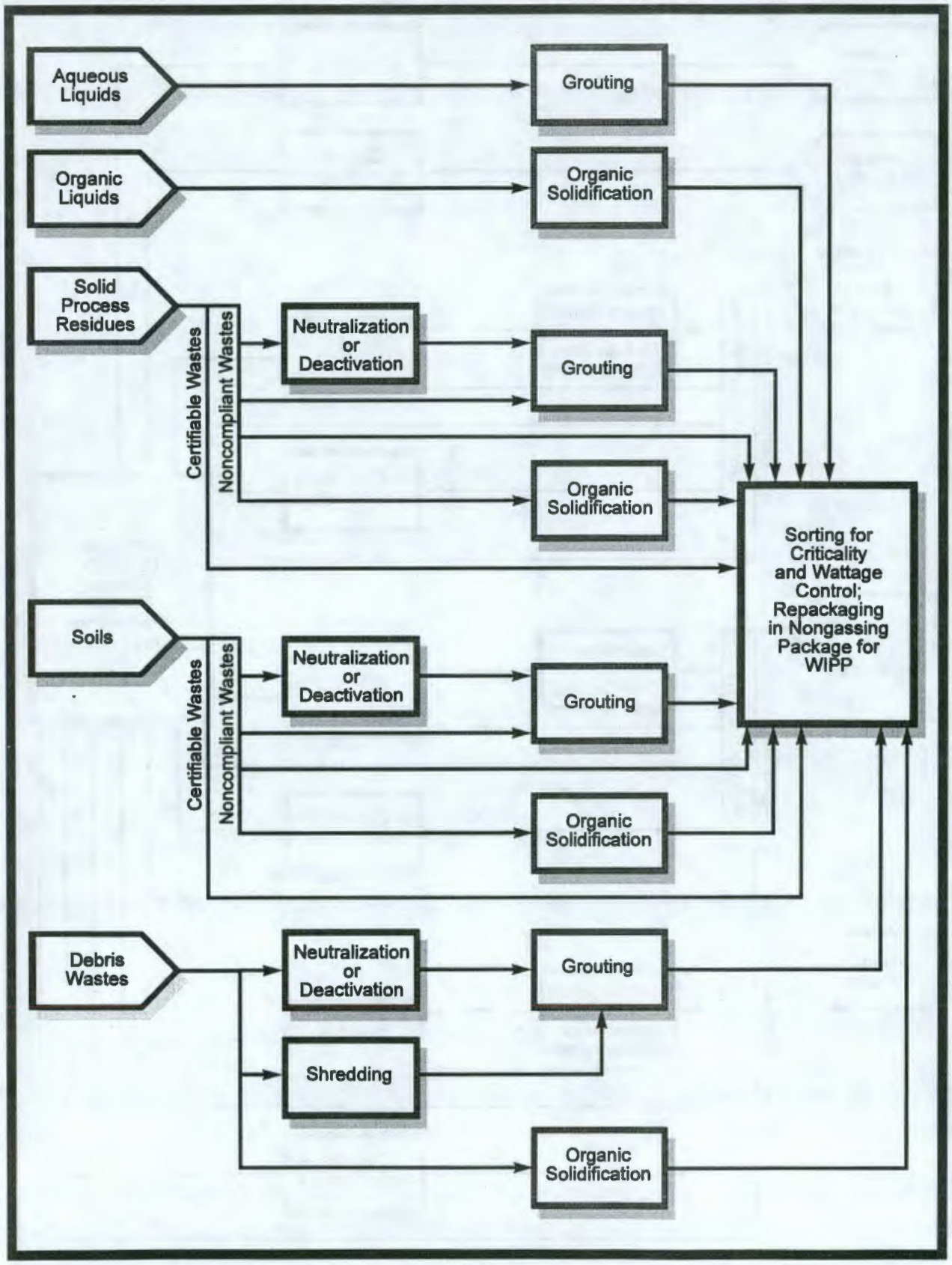


Figure 8.2–2. Treatment Trains for Reducing the Potential for Gas Generation in the WIPP.

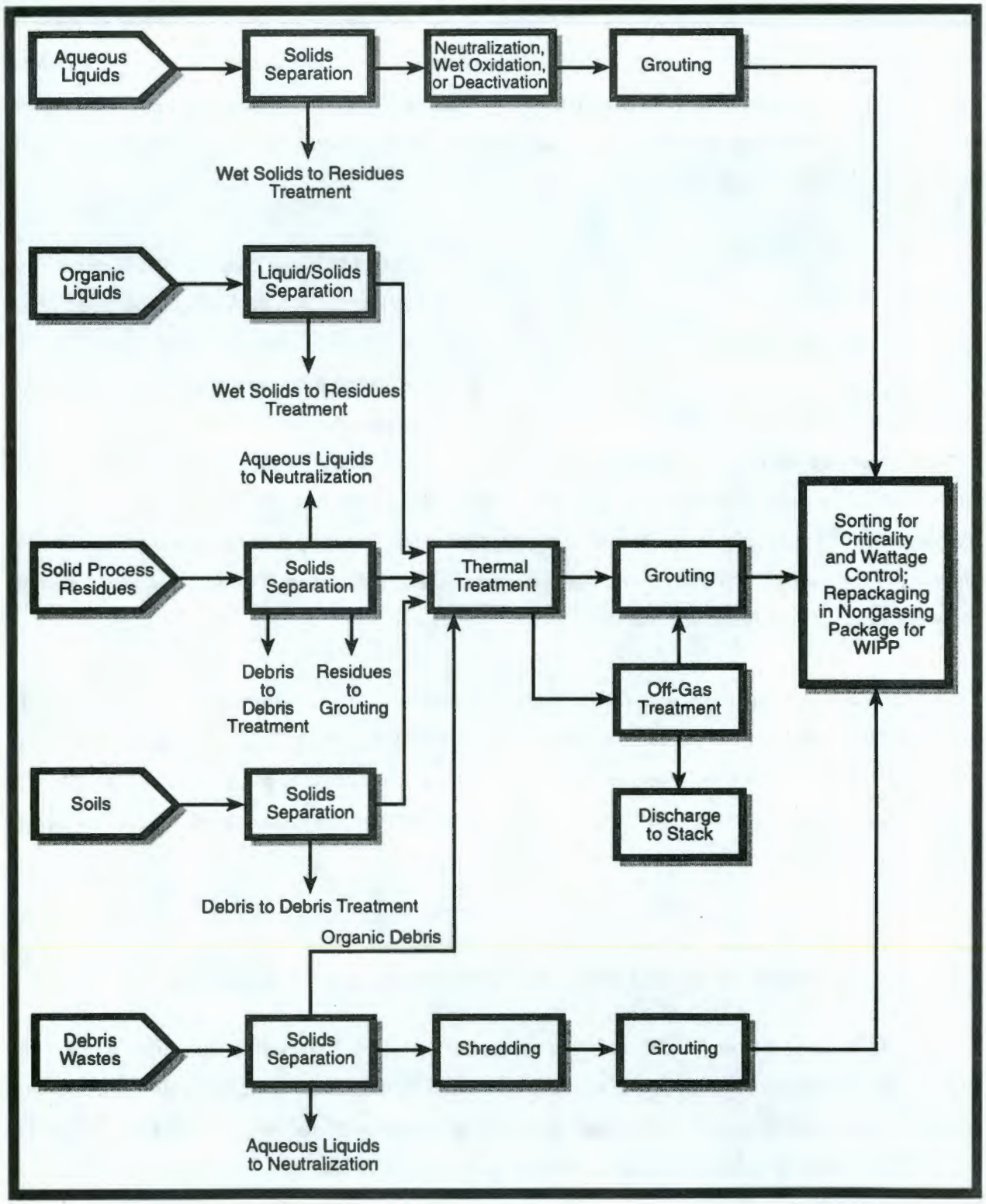


Figure 8.2–3. Treatment Trains for Meeting RCRA Land Disposal Restrictions.

Requirements for DOE Mixed Wastes: Technical Basis" (Musgrave, 1995). The waste volumes in Table 8.1–1 contain a small amount of TRUW (<1% of the total) that requires extensive characterization prior to treatment. Such TRUW is not evaluated in the WM PEIS since its characteristics are unknown and therefore impacts cannot be quantified. This small amount of TRUW would not affect comparisons among TRUW alternatives evaluated in the WM PEIS.

The conceptual process for managing TRUW is similar to that for LLMW and includes (1) retrieving from storage and transporting; (2) sorting, characterizing, treating as appropriate, packaging, and certifying as acceptable under WIPP-WAC; (3) storing certified waste; and (4) transporting to WIPP for disposal. To ensure that the full range of impacts were assessed, DOE considered minimal treatment to meet current WIPP-WAC, intermediate treatment to reduce gas generation potential, and a more extensive treatment process including thermal treatment to meet LDRs. The estimated risks, impacts, and costs of characterization are also included in the WM PEIS analysis. When selecting specific technologies for waste treatment facilities at specific sites, DOE will consider the results of existing sitewide or project-level NEPA analyses, as there are several different technologies that could be used to treat TRUW to the levels required for WIPP or other disposition alternatives.

DOE's current strategy is to process TRUW when it is necessary to meet safety and health requirements for transport and handling and to meet Revision 5 of the WIPP-WAC. Minimum processing to meet current (but not yet final) WIPP-WAC was the least stringent treatment analyzed. More extensive treatment to reduce gas generation or to meet LDRs was analyzed as an intermediate and an upper range of treatment should more extensive treatment become necessary.

8.2.3 WM PEIS Assumptions: Facilities, Treatment, and Storage

Although DOE used data on TRUW volumes and existing facilities from well-documented sources, the analysis of alternatives required DOE to make additional assumptions. In addition to estimating and extrapolating techniques used to identify the radiological and chemical characteristics of TRUW, DOE made additional general assumptions related to facilities, treatment, storage, and special requirements, to further define specific actions and operating parameters for each alternative.

Facilities

- Any new treatment facilities required for an alternative would be in operation after a 10-year design and construction period.
- TRUW currently in inventory (sometimes referred to as "legacy waste") plus 20 years of newly generated waste would be treated during the 10-year period after construction (called a "work-off" period). After the designated work-off period, TRUW is assumed to be treated as it is generated on an annual basis; although it was not analyzed, the amount of waste annually generated after the work-off period is expected to be small, and the impacts from treatment and storage are expected to be bounded by those analyzed in the WM PEIS.
- In the TRUW analysis, each site was assumed to build and operate facilities with capacities sufficient to handle only TRUW. This avoids linking the results of one waste type to decisions not yet made in another and results in conservative estimates of risk, impacts, and cost. Chapter 11 discusses the cumulative effects for sites hosting more than one waste-type facility.
- DOE assumed that either fixed or mobile characterization facilities would be operated at sites that would need to retrieve, treat, repackage, and ship TRUW. Characterization and repackaging of TRUW is often necessary to meet Department of Transportation (DOT) or RCRA regulations for transport, and to meet State shipping and receiving requirements.

Treatment and Storage

- Processing to meet current WIPP-WAC is practical at all sites with TRUW.
- More extensive treatment to reduce gas generation is practical at only the six sites with the largest volumes of TRUW because of the economies of scale associated with larger facilities. Treatment to meet LDRs is only practical at the same six sites or at a central location. In this analysis, WIPP was evaluated as the central treatment location.
- Impacts and costs were evaluated for retrieval of stored TRUW and for characterization and are included in the analysis results as a component of treatment.

8.2.4 Transportation Analysis and Assumptions

DOE analyzed transportation impacts associated with each TRUW alternative. In general, offsite transportation for treatment was minimized. Both truck and rail transportation were analyzed using computerized routing models following the general principle of minimizing distance and transportation time. The routes were selected to be consistent with existing practices and with all applicable regulations and

guidelines; however, because the routes were developed for the purpose of risk assessment, they do not necessarily represent actual routes that would be used to transport waste in the future.

In general, the radiological risks from routine transportation of radioactive materials are directly proportional to the external dose rate, which is a measure of the external radiation (principally gamma radiation) from the shipment. The average external dose rates were assumed to be 3 millirem per hour for CH-TRUW and 7 millirem per hour for RH-TRUW at 1 meter from the shipping container. These values were derived from site-specific information contained in the WIPP SEIS-I (DOE, 1990) and are less than the DOT regulatory limit of 10 millirem per hour at 2 meters from the container.[8]

The following assumptions were used in the analysis:

- For purpose of analysis, this PEIS assumed that all CH-TRUW would be shipped in the TRUPACT-II Type B container.
- Waste package requirements for transportation of RH-TRUW would be based on the RH-72B cask described in a Safety Analysis Report for Packaging, which is being reviewed by the Nuclear Regulatory Commission (NRC) prior to issuance of a Certificate of Approval.

Transportation of hazardous and radioactive materials, substances, and wastes is governed by the U.S. Department of Transportation, NRC, and EPA regulations, and by the Hazardous Materials Transportation Act. These regulations may be found in 49 CFR Parts 171-178, 49 CFR Parts 383-397, 10 CFR Part 71, and 40 CFR Parts 262 and 265, respectively.

8.2.5 Comparison of Treatment Impacts with the WIPP SEIS-II

Both the WIPP SEIS-II (DOE, 1996e) and WM PEIS consider TRUW treatment. In addition to exploring TRUW disposal impacts, the WIPP SEIS-II will lead to a determination of minimum levels of TRUW treatment preparatory to final disposition; the WM PEIS will lead to a decision *where* to treat TRUW. Both the WM PEIS and the WIPP SEIS-II report the human health impacts from treatment of TRUW. The WIPP SEIS-II recognizes that treatment may be a major contributor to the overall impacts of disposing of TRUW and preparing TRUW for disposal, while the WM PEIS presents treatment impacts in order to assist decision makers in determining whether to centralize, regionalize, or decentralize actual treatment activities.

[8] The WIPP SEIS-II (DOE, 1996e) assumes an average extreme dose rate of 4 millirem per hour for CH-TRUW, and 10 millirem per hour for RH-TRUW at 1 meter from the shipping container.

The approaches applied in the Final WM PEIS and the WIPP SEIS-II for estimating human health impacts from TRUW treatment are in general the same. The Draft WM PEIS analyses formed the basis of the WIPP SEIS-II analysis of treatment impacts. The impacts as a result of routine operations from the Draft WM PEIS were adjusted in the WIPP SEIS-II to account for the differences between the two documents in TRUW waste volumes and radionuclide inventories due to different periods of TRUW generation and site operation (28 years in the WIPP SEIS-II versus 20 years in the WM PEIS) and the addition of commercial and buried waste in the WIPP SEIS-II, number of sites producing waste, and the manner of waste consolidation as defined in the WIPP SEIS-II alternatives.

It should be noted that the Final WM PEIS provides updates and makes corrections to the analysis presented in the Draft WM PEIS. The preparers of the Final WIPP SEIS-II will review these WM PEIS changes to determine whether the Final WIPP SEIS-II should be similarly modified.

Comparison between the Final WM PEIS and the WIPP SEIS-II analyses of human health impacts from postulated accident scenarios is provided in Section 8.4.3.2.

8.3 Transuranic Waste Alternatives

The WM PEIS considered six alternatives for both CH-TRUW and RH-TRUW. Treatment and storage activities vary by alternative and by site. The foldout table at the end of this chapter shows the major sites at which TRUW would be treated and stored under each alternative. This table is designed to be used as a quick reference when reading the sections on TRUW impacts.

Each alternative was developed to evaluate the human health risk, environmental impacts, and costs associated with the range of treatment and storage activities available to DOE and to inform decisions about where to locate TRUW treatment and storage facilities.

The analysis includes alternatives in which TRUW would be treated to LDR levels. Although the WIPP LWA amendments contained in the 1997 Defense Authorization Act exempt waste destined for WIPP from the provisions in RCRA regarding LDRs, LDR treatment is a reasonable alternative for management activities and practices other than disposal at WIPP.

8.3.1 No Action Alternative

Under the No Action Alternative, DOE would continue to characterize, process, and package newly generated TRUW to meet current WIPP-WAC for storage at sites where existing or planned facilities are available. DOE would continue to store TRUW in existing storage facilities indefinitely. The impacts of these storage activities are analyzed for 20 years based on the scope of this PEIS. The impacts of storage beyond 20 years are analyzed as part of the No Action Alternatives in the WIPP SEIS-II (DOE, 1996e). As analyzed in the WIPP SEIS-II, if DOE continues to provide effective monitoring and maintenance of storage facilities, adverse health effects for the general public would be quite small, and the principal adverse effects, also small, would be related to occupational activity at the facilities. These health effects would continue at such levels for the indefinite future under the hypothesis of DOE control.

The analysis in the WIPP SEIS-II also considered, however, impacts if DOE were to lose institutional control of storage facilities. Considering the long-lived nature of the radionuclides in TRUW, this analysis was conducted for timeframes ranging up to 10,000 years after loss of institutional control. The WIPP SEIS-II analysis of intrusion for waste stored underground considered impacts of directly drilling into the wastes and gardening over the exhumed waste cuttings. Analysis of intrusion for waste stored above-ground considered impacts of an individual scavenging into the wastes and a farm family living over the wastes. The analyses showed that intruders could receive substantial radiation doses and that a potentially large number of non-intruders could die from exposure to stored waste that may be dispersed into the general environment.

Under the No Action Alternative, DOE would not ship TRUW for offsite, long-term storage or disposal. All sites are assumed to have adequate capabilities to package and store TRUW generated in the future. Eleven sites anticipate TRUW generation, including six sites that will generate both CH and RH TRUW. The potential impacts of TRUW management under the No Action Alternative are smaller than under the other alternatives because the No Action Alternative (1) evaluates treatment to WIPP-WAC only for future TRUW (existing retrievably stored TRUW would not be processed to meet current WIPP-WAC), (2) does not assess the impacts of removing TRUW from retrievable storage, and (3) does not include shipment of TRUW.

Figure 8.3–1 and Table 8.3–1 illustrate the sites at which TRUW would be processed and stored under the No Action Alternative.

TRUW No Action Alternative—(11 Sites Process to Current WIPP Criteria; Storage at Existing Facilities at 16 Sites)

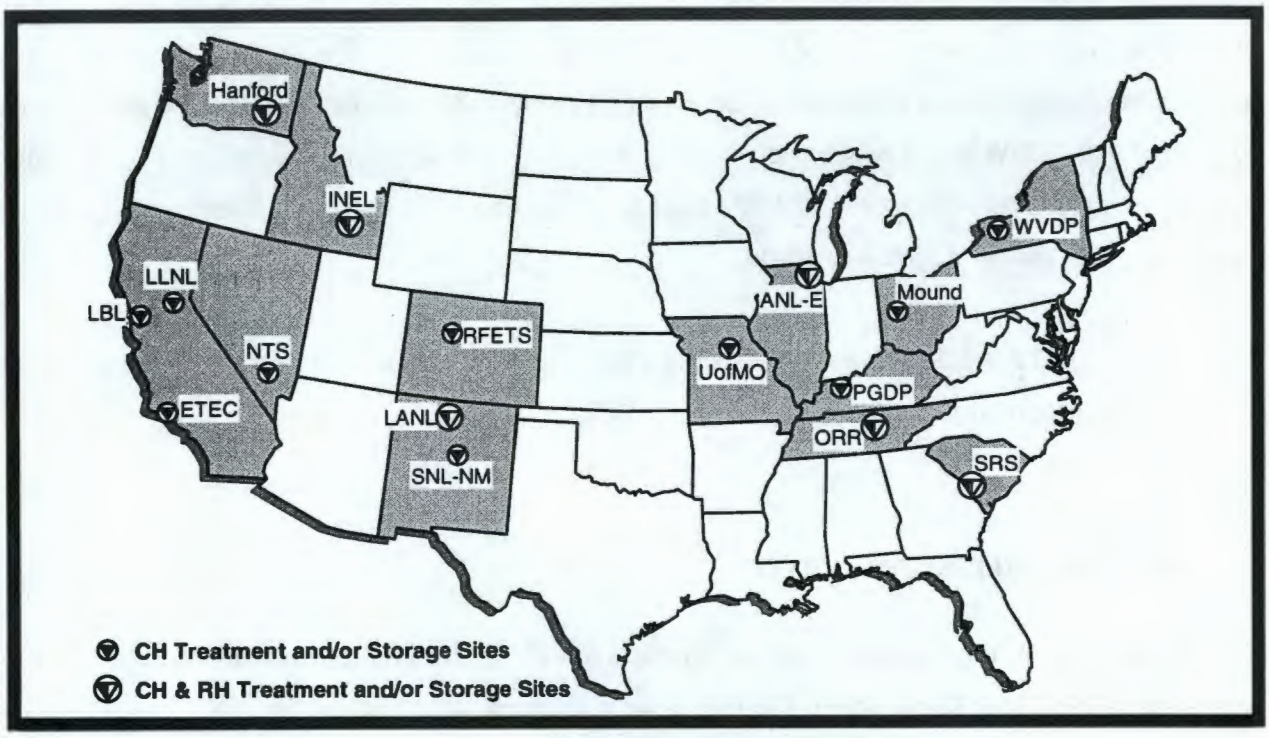


Figure 8.3–1. TRUW No Action Alternative.

	Generating Sites								
	ANL–E ANL-E^{RH}	ETEC	Hanford Hanford^{RH}	INEL INEL^{RH}	LANL LANL^{RH}	LBL	LLNL	Mound	NTS
Treat/Package (% Rec'd from Offsite)	ANL–E (0)		Hanford (0)	INEL (0)	LANL (0)	LBL (0)	LLNL (0)	Mound (0)	
Store	Store Onsite								

	Generating Sites						
	ORR ORR^{RH}	PGDP	RFETS	SNL–NM	SRS SRS^{RH}	UofMO	WVDP
Treat/Package (% Rec'd from Offsite)	ORR (0)		RFETS (0)		SRS (0)	UofMO (0)	
Store	Store Onsite						

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; percentage of waste a site would receive from offsite is indicated in parentheses; blank cells indicate sites store TRUW only.

Table 8.3–1. TRUW No Action Alternative

8.3.2 DECENTRALIZED ALTERNATIVE

Under the Decentralized Alternative, DOE would process and package TRUW to meet the current WIPP-WAC at 16 sites where TRUW is currently located. The CH-TRUW would then be shipped from sites with smaller amounts to the nearest of the 10 sites with the largest amount of TRUW for storage prior to disposal. All TRUW would be shipped to WIPP for disposal.[9] An important change from the No Action Alternative is that retrievably stored TRUW would be treated under this alternative, whereas it would not be treated under the No Action Alternative.

Figure 8.3–2 and Table 8.3–2 illustrate the sites at which TRUW would be processed and stored under the Decentralized Alternative.

8.3.3 REGIONALIZED ALTERNATIVES

The Regionalized Alternatives consider the consolidation of TRUW for treatment and storage prior to disposal at WIPP. Three Regionalized Alternatives were analyzed, with treatment (to reduce gas generation potential or to meet LDRs) at six and four sites, and storage at those sites prior to disposal at WIPP.

Under Regionalized Alternative 1, CH-TRUW would be shipped from the smallest generators to the four sites with the largest volumes of CH-TRUW (the Hanford Site, INEL, LANL, and SRS). In addition, RFETS would continue to treat its own waste, but would not receive waste from offsite. RH-TRUW would be shipped from ANL-E, INEL, and LANL to Hanford or ORR for treatment. At all six treatment sites, TRUW would be treated to reduce gas generation potential (referred to as intermediate treatment) and shipped from those sites to WIPP for disposal. The six treatment sites proposed under this alternative have 95% of current and anticipated TRUW inventories. Figure 8.3–3 shows the sites at which TRUW would be treated and stored under Regionalized Alternative 1. Table 8.3–3 lists the sites from which TRUW would be shipped and the six sites at which TRUW would be consolidated and treated.

[9] The Waste Isolation Pilot Plant Land Withdrawal Act of 1992 provides for the disposal of 175,600 cubic meters (6.2 million cubic feet) of "defense TRUW" at WIPP provided all regulatory requirements are met. WVDP and other DOE sites have small amounts of "nondefense" TRUW. For purposes of analysis in this WM PEIS, DOE has assumed that all TRUW is defense TRUW and will be disposed of at WIPP. The impacts of treating and disposing of nondefense TRUW are evaluated in some of the alternatives analyzed in the second supplemental EIS for WIPP (WIPP SEIS-II) (DOE 1996e).

TRUW Decentralized Alternative—(16 Sites Process to Current WIPP Criteria; Interim Storage at 10; Disposal at WIPP)

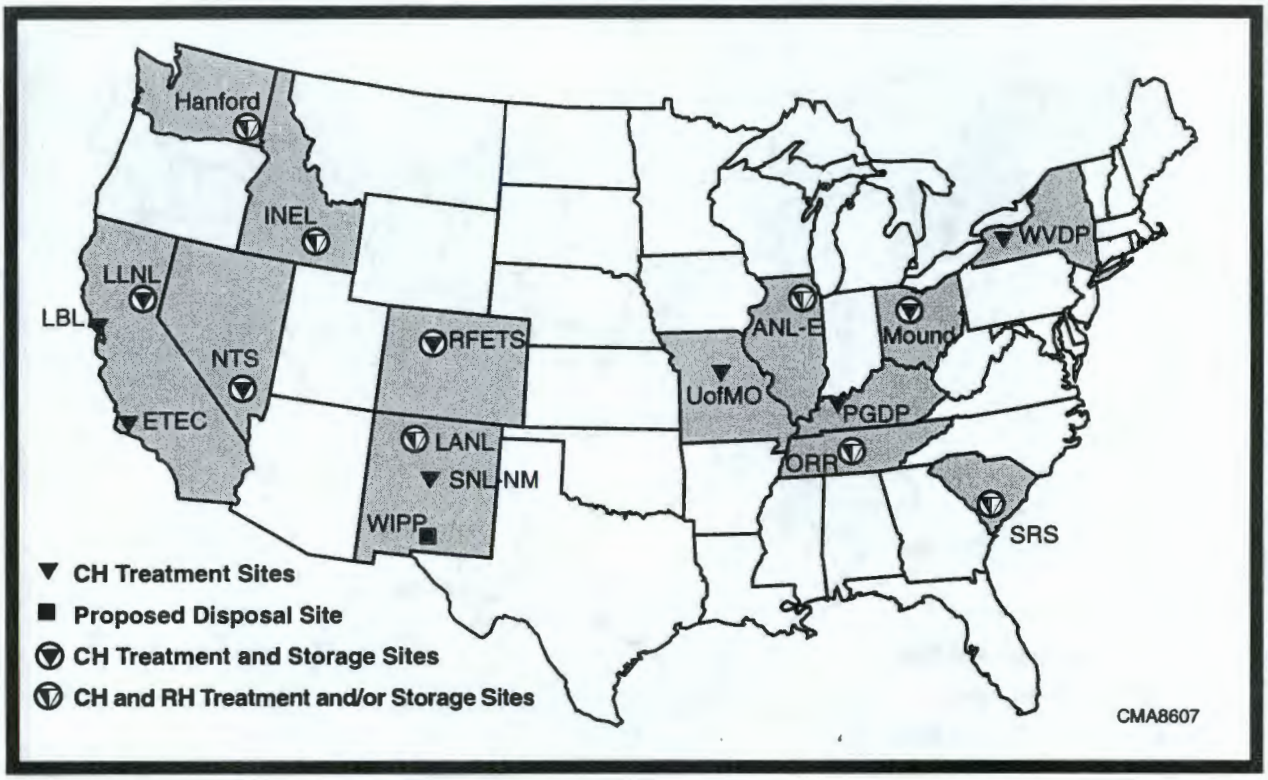


Figure 8.3–2. TRUW Decentralized Alternative.

	Generating Sites								
	ANL-E ANL-E^{RH}	ETEC	Hanford Hanford^{RH}	INEL INEL^{RH}	LANL LANL^{RH}	LBL	LLNL	Mound	NTS
Treat (% Rec'd from Offsite)	ANL-E (0)	ETEC (0)	Hanford (0)	INEL (0)	LANL (0)	LBL (0)	LLNL (0)	Mound (0)	NTS (0)
Store	ANL-E	NTS	Hanford	INEL	LANL	Hanford	LLNL	Mound	NTS
Dispose	All Sites Ship to WIPP								

	Generating Sites						
	ORR ORR^{RH}	PGDP	RFETS	SNL-NM	SRS SRS^{RH}	UofMO	WVDP
Treat (% Rec'd from Offsite)	ORR (0)	PGDP (0)	RFETS (0)	SNL-NM (0)	SRS (0)	UofMO (0)	WVDP (0)
Store	ORR	ORR	RFETS	LANL	SRS	ORR	Mound
Dispose	All Sites Ship to WIPP						

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; percentage of waste a site would receive from offsite is indicated in parentheses.

Table 8.3–2. TRUW Decentralized Alternative

Regionalized Alternative 1—(Treatment to Reduce Gas at 6 Sites; Disposal at WIPP)

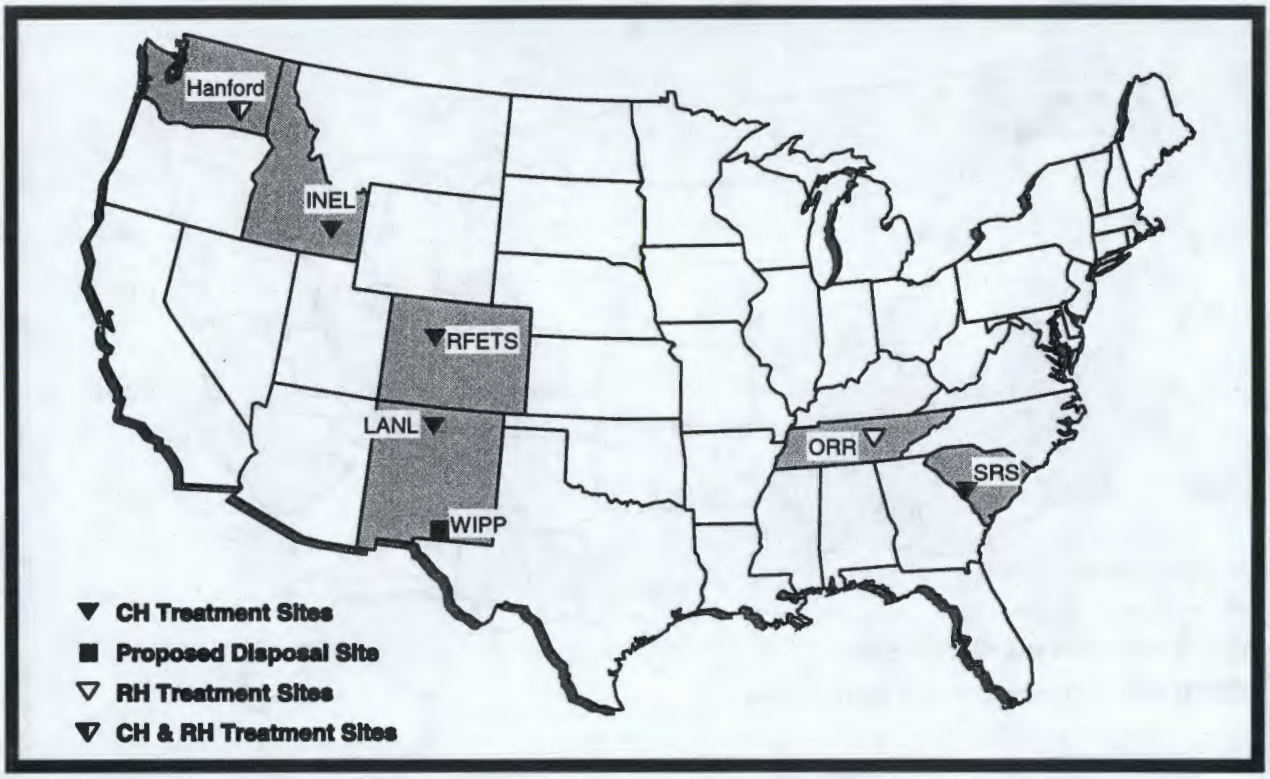


Figure 8.3–3. TRUW Regionalized Alternative 1.

	Generating Sites					
	Hanford Hanford^{RH} LBL LLNL INEL^{RH} LANL^{RH}	ETEC INEL NTS	LANL SNL-NM	SRS^{RH} ANL–E^{RH} ORR^{RH}	RFETS	ANL-E Mound ORR PGDP SRS UofMO WVDP
Treat (% Rec'd from Offsite)	Hanford (5)	INEL (1.5)	LANL (<1)	ORR (18)	RFETS (0)	SRS (17)
Dispose	All Sites Ship to WIPP					

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; percentage of waste a site would receive from offsite is indicated in parentheses.

Table 8.3–3. TRUW Regionalized Alternative 1

Under Regionalized Alternative 2, DOE would use the same configuration as in Regionalized Alternative 1, except that TRUW would be treated to meet LDRs and then shipped to WIPP for disposal. With this alternative, DOE can compare the impacts of intermediate treatment in Regionalized Alternative 1 to the impacts of LDR treatment in Regionalized Alternative 2; the impacts of both Regionalized Alternatives 1 and 2 can be compared to the impacts of meeting current WIPP-WAC in the Decentralized Alternative (where 98% of the waste would be processed at the same six sites). Figure 8.3–4 shows the sites at which TRUW would be processed and stored under Regionalized Alternative 2; Table 8.3–4 lists the sites from which TRUW would be shipped and the six sites at which TRUW would be consolidated and treated.

Regionalized Alternative 3 considers the consolidation of waste for treatment at four sites (Hanford, INEL, ORR, and SRS) where approximately 80% of TRUW is already located or is expected to be generated. CH-TRUW would be treated at Hanford, INEL, and SRS; RH-TRUW would be treated at Hanford and ORR. Under this alternative, TRUW would be treated to meet LDRs and shipped to WIPP for disposal. Figure 8.3–5 shows the four sites at which TRUW would be treated and stored under Regionalized Alternative 3; Table 8.3–5 lists the sites from which TRUW would be shipped and the four sites at which TRUW would be consolidated and treated.

8.3.4 Centralized Alternative

Under the Centralized Alternative, DOE would ship all CH-TRUW to WIPP for treatment to meet LDRs and for disposal. RH-TRUW would be shipped to the Hanford Site and ORR for treatment to meet LDRs and then shipped to WIPP for disposal. Figure 8.3–6 illustrates the Centralized Alternative. Table 8.3–6 shows the sites from which all TRUW would be shipped and the two sites at which RH-TRUW would be consolidated and treated.

8.3.5 Rationale for Selecting Treatment Sites

Treatment configurations for TRUW were developed to cover the range of reasonable alternatives. Thus, the Decentralized Alternative considers treatment of TRUW at 16 sites where TRUW is currently located, and the Centralized Alternative considers treatment of all CH-TRUW at one site and all RH-TRUW (which needs special handling) at two sites. For the regionalized alternatives, which are intermediate between the Decentralized and Centralized Alternatives, DOE focused on the six sites where 95% of the waste is located

Regionalized Alternative 2—(Treatment to LDRs at 6 Sites; Disposal at WIPP)

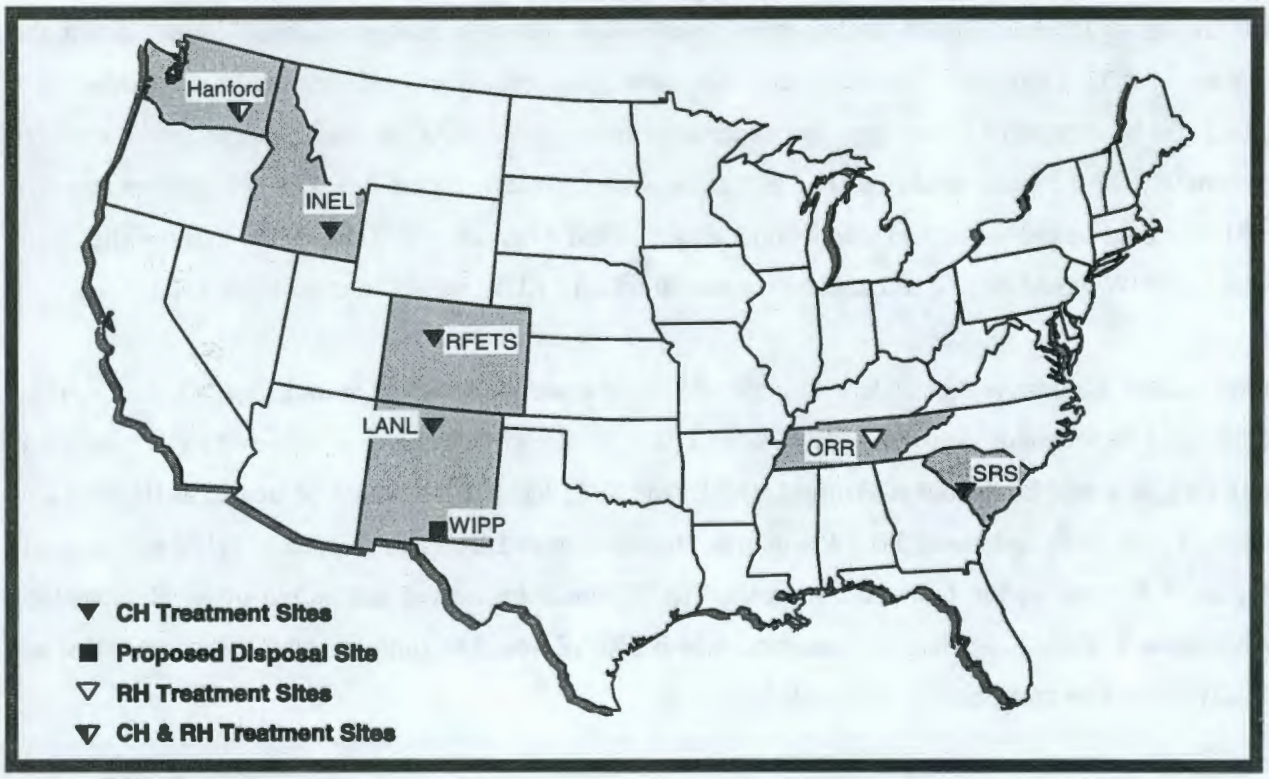


Figure 8.3–4. TRUW Regionalized Alternative 2.

	Generating Sites					
	Hanford Hanford^{RH} INEL^{RH} LANL^{RH} LBL LLNL	ETEC INEL NTS	LANL SNL-NM	SRS^{RH} ANL-E^{RH} ORR^{RH}	RFETS	ANL-E Mound ORR PGDP SRS UofMO WVDP
Treat (% Rec'd From Offsite)	Hanford (5)	INEL (1.5)	LANL (<1)	ORR (18)	RFETS (0)	SRS (17)
Dispose	All Sites Ship to WIPP					

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; percentage of waste a site would receive from offsite is indicated in parentheses.

Table 8.3–4. TRUW Regionalized Alternative 2

Regionalized Alternative 3—(4 Sites to Meet Treatment LDRs; Disposal at WIPP)

Figure 8.3–5. TRUW Regionalized Alternative 3.

	Generating Sites			
	Hanford Hanford^{RH} INEL^{RH} LANL^{RH} LBL LLNL	ETEC INEL LANL NTS RFETS SNL–NM	SRS^{RH} ANL–E^{RH} ORR^{RH}	ANL-E Mound ORR PGDP SRS UofMO WVDP
Treat (% Rec'd From Offsite)	Hanford (5)	INEL (31)	ORR (18)	SRS (17)
Dispose	All Sites Ship to WIPP			

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; percentage of waste a site would receive from offsite is indicated in parentheses.

Table 8.3–5. TRUW Regionalized Alternative 3

Centralized Alternative—(Treatment of CH at 1 Site and RH at 2 Sites to Meet LDRs; Disposal at WIPP)

Figure 8.3–6. TRUW Centralized Alternative.

	Generating Sites			
	Hanford^{RH} INEL^{RH} LANL^{RH}	SRS^{RH} ANL-E^{RH} ORR^{RH}	ANL-E ETEC Hanford INEL LANL LBL LLNL Mound	NTS ORR PGDP RFETS SNL-NM SRS UofMO WVDP
Treat (% Rec'd From Offsite)	Hanford (5)	ORR (18)	WIPP (100)	
Dispose	All Sites Ship to WIPP			

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; percentage of waste a site would receive from offsite is indicated in parentheses.

Table 8.3–6. TRUW Centralized Alternative

or expected to be generated, and on the four sites where approximately 80% of the waste is located or expected. Under these regionalized alternatives, DOE assumed that the waste from other sites with TRUW would be shipped to the closest site for treatment and storage.

In addition, DOE assumed that it would not be practical or reasonable for sites with small volumes of TRUW (less than 15 cubic meters) to treat TRUW onsite to either reduce gas generation potential or to meet LDRs. Thus, waste at the small-volume sites (e.g., ETEC, LBL, PGDP, SNL-NM, UofMo, and WVDP) was shipped to another site for treatment to either of these levels under the Regionalized and Centralized Alternatives. Onsite processing to meet current WIPP-WAC was considered for all 16 sites, including the small-volume sites, under the Decentralized Alternative.

Consolidation of RH-TRUW at one site for treatment was not considered because a large number of cross-country trips would be required, and because most RH-TRUW requires extensive treatment (not necessarily to meet LDRs) before it can be shipped. Thus, under the Centralized Alternative, DOE would treat RH-TRUW at the two sites—the Hanford Site and ORR—where approximately 90% of current and projected inventory would be located.

8.4 Health Risks

The most adverse health risks occur under alternatives where TRUW is treated to meet LDRs—in Regionalized Alternatives 2 and 3 and the Centralized Alternative. These alternatives require the thermal treatment of organic wastes, which results in emissions of radionuclides (Pu-238, Am-241) that have the greatest contribution to offsite cancer risks and increase the probability of cancer to the maximally exposed individual (MEI). Fatalities among workers result primarily from physical trauma and are lower when TRUW is processed to WIPP-WAC or treated to reduce gas generation potential rather than treated to meet LDRs. Estimated transportation fatalities are low in all alternatives.

Health risk impacts result from exposure to radiation and chemicals and from physical trauma during the construction and operation of TRUW treatment facilities and transportation of waste. Health effects resulting from radiation and chemical exposure, whether from sources external or internal to the body, can affect either the exposed individual's body (known as a "somatic" effect, i.e., cancer) or descendants of the exposed individual (known as a "genetic" effect). This section discusses the estimated adverse health impacts resulting from radiation and chemical exposures as well as the physical hazards for each TRUW

treatment alternative. Details of the TRUW results are contained in Appendices D, E, and F. Methodology details are contained in Section 5.4.1 of Chapter 5 and in ORNL technical reports (ORNL, 1995a-d).

Potential health risks to a number of receptor populations and individuals are presented including:

- The offsite population—individuals living within a 50-mile radius of the site as well as along transportation routes.
- Noninvolved worker population—workers at DOE sites who are not involved directly in waste management.
- Waste management worker population (or "waste management workers")—employees working at a site's waste management facilities, including workers who manage waste, construction workers who build the waste management facilities, and workers who operate the trucks and trains that transport the waste.
- MEIs for the offsite population—hypothetical individuals in the offsite population who are assumed to receive the highest total lifetime dose from all media.
- MEIs for the noninvolved worker population— hypothetical individuals in the noninvolved worker population who are assumed to receive the highest total lifetime dose from all media.

The following sections present the impacts for the TRUW Alternatives:

8.4 Health Risks
8.5 Air Quality Impacts
8.6 Water Resources Impacts
8.7 Ecological Resources Impacts
8.8 Economic Impacts
8.9 Population Impacts
8.10 Environmental Justice Concerns
8.11 Land Use Impacts
8.12 Infrastructure Impacts
8.13 Cultural Resources Impacts
8.14 Costs
8.15 Environmental Restoration Analysis
8.16 Comparison of Alternatives Summary

The impacts evaluated were:

- Fatalities from physical hazards (e.g., vehicle accidents)
- Cancer fatalities from radiation exposure
- Cancer incidences from radiation or chemical exposure
- Genetic effects from radiation exposure
- Noncancer effects from chemical exposure (e.g., headaches, nasal irritation, liver or kidney toxicity, neurotoxicity, immunotoxicity, and reproductive and developmental toxicity)

Maximally Exposed Individual

In keeping with standard risk assessment methodology, DOE analyzed the impacts to a "maximally exposed individual" (MEI). The MEI is the hypothetical person within the receptor group who has the highest exposure. This individual is assumed to be located at the point of maximum concentration of contaminants 24 hours a day, 7 days a week, for the 10-year period of treatment operations analyzed in the PEIS.

Interpreting the results of health risk analyses involves consideration of both uncertainties and appropriate standards. See Section 5.4.1 and Appendix D for a further discussion of these issues.

8.4.1 Routine Operation Impacts

For operations involving TRUW treatment, health effects were evaluated for the offsite population, the onsite worker population not involved in TRUW treatment ("noninvolved workers"), and waste management workers directly involved in TRUW treatment. Impacts were quantified using two approaches: analysis of *population* health risk impacts and analysis of *individual* health risk impacts.

Population impacts focus on the *total number* of people in each receptor population who would experience adverse health impacts if a particular alternative were implemented. Table 8.4-1 provides the estimated number of individuals in the offsite populations at the proposed TRUW treatment and storage sites and the number of waste management workers for each alternative. The numbers of waste management workers are derived from generic baselines that established the number of personnel required to operate treatment facilities needed to manage a given amount of waste (INEL, 1995b).

Individual impacts focus on the *probability* that the MEI within each receptor population would experience an adverse health impact. Because the focus is on the MEI, the risk is presented as a probability (e.g., one-in-one million, or 1E–06) of that individual experiencing an adverse health impact, rather than a total number of impacts for a selected population.

DOE analyzed effects of both radionuclides and chemicals on individuals and populations. The pathways of exposure analyzed were inhalation, ingestion of plants and animals, direct gamma radiation, and absorption of tritium through the skin.

Worker risks associated with physical hazards were evaluated for 20 years: a 10-year period of construction of treatment facilities, and a subsequent 10-year period of operation. However, worker and public risks from radionuclide or chemical exposure (received during the 10-year operation period) were evaluated for an entire lifetime (70 years), because health impacts from airborne contaminants or direct radiation could occur throughout the lifetime of the exposed individual.

Table 8.4–1. Offsite Populations and Waste Management Treatment Worker Populations

Site	Offsite Population*	WM Treatment Worker Population by Alternative[a]					
		No Action	Decentralized	Regionalized 1	Regionalized 2	Regionalized 3	Centralized
ANL-E	7,939,785	136	337	150	150	150	150
Hanford	377,645	899	1,519	2,312	3,621	3,621	1,993
INEL	153,061	132	2,471	3,205	5,469	6,382	1,691
LANL	159,152	262	1,115	1,537	2,807	748	748
LLNL	6,324,234	148	354	186	186	186	186
NTS	14,266	0[b]	204	137	137	137	137
ORR	881,652	41	272	314	682	682	682
PGDP	500,502	0[b]	15	8	8	8	8
RFETS	2,171,877	353	664	989	1,852	420	420
SRS	620,618	324	556	948	1,412	1,412	368
WIPP	99,889	--	--	--	--	--	4,132

Notes: -- = no waste treatment occurs at the site under this alternative; * = within 50 mile radius of sites. Waste management worker population estimates represent full-time equivalents (FTEs) over the entire construction and operation periods.
[a] Because ETEC, LBL, Mound, and UofMo are not "major" waste management sites analyzed in the WM PEIS (see Section 1.6) and because it was assumed that it would not be practical or reasonable to treat the small volume of TRUW at SNL-NM or WVDP, values are not provided for these sites.
[b] Sites reporting zero workers are sites where no TRUW was generated as reported in the 1992 Integrated Data Base (DOE, 1992). There would be no treatment of newly generated TRUW under the No Action Alternative.

Table 8.4–2 provides an overview of the health risk endpoints, receptor groups, hazard sources, pathways, and exposure periods evaluated for TRUW treatment.

This human health risk analysis includes evaluation of both the potential numbers of fatal cancers as well as the numbers of total cancer incidences induced by exposure to radionuclides and direct radiation. The numbers of nonfatal cancers can be derived from the cancer incidence values by subtracting the estimated number of fatal cancer cases. Note that both the *total cancer incidence* and the *nonfatal cancer incidence* values are overestimated by a factor of about two because the estimates contain a relatively large component of skin cancers. The internal exposure pathways evaluated in the WM PEIS (e.g., inhalation or ingestion of radionuclides) are not likely to induce large numbers of skin cancer cases. However, the International Commission on Radiological Protection (ICRP) dose conversion factors used in the WM PEIS to estimate total cancer incidence includes incidences of skin cancer (ICRP, 1990).

Table 8.4–2. TRUW Health Risk Analysis Components

TRUW Treatment					
Endpoints	**Receptor**	**Source**	**Pathways**	**Exposure Period**	**Table Reference**
Number of trauma fatalities	WM workers	Physical hazards	Physical hazards	20 years	8.4–3
Number of cancer fatalities	Offsite population	Radionuclides	Inhalation, ingestion, direct radiation	10 years	8.4–3
	Noninvolved workers		Inhalation, direct radiation		
	WM workers		Inhalation, direct radiation		
Number of cancer incidences	Offsite population	Radionuclides	Inhalation, ingestion, direct radiation	10 years	8.4–4
		Chemicals	Inhalation, ingestion		
	Noninvolved workers	Radionuclides	Inhalation, direct radiation		
		Chemicals	Inhalation		
	WM workers	Radionuclides	Inhalation, direct radiation		
		Chemicals	Inhalation		
Number of genetic effects	Offsite population	Radionuclides	Inhalation, ingestion, direct radiation	10 years	8.4–4
	Noninvolved workers		Inhalation, direct radiation		
	WM workers		Inhalation, direct radiation		
Probability of cancer fatality	Offsite MEI	Radionuclides	Inhalation, ingestion, direct radiation	10 years	8.4–5 8.4-6
	Noninvolved worker MEI		Inhalation, direct radiation		
Probability of cancer incidence	Offsite MEI	Radionuclides	Inhalation, ingestion, direct radiation	10 years	8.4–7
		Chemicals	Inhalation, ingestion		
	Noninvolved worker MEI	Radionuclides	Inhalation, direct radiation		
		Chemicals	Inhalation		
Probability of genetic effects	Offsite MEI	Radionuclides	Inhalation, ingestion, direct radiation	10 years	8.4–7
	Noninvolved worker MEI		Inhalation, direct radiation		

Understanding Scientific Notation

Scientific notation is used in the WM PEIS to express numbers that are so large or so small that they can be difficult to read or write. Scientific notation is based on the use of positive and negative powers (or exponents) of 10. A number written in scientific notation is expressed as the product of a number between 1 and 10 times a positive or negative power of 10. Some positive and negative powers of 10 include:

Positive Powers of 10	***Negative Powers of 10***
$10^1 = 10 \times 1 = 10$	$10^{-1} = 1/10 = 0.1$
$10^2 = 10 \times 10 = 100$	$10^{-2} = 1/100 = 0.01$
and so on; therefore,	*and so on; therefore,*
$10^6 = 1{,}000{,}000$ *(or 1 million)*	$10^{-6} = 0.000001$ *(or 1 in 1 million)*
etc.	*etc.*

A power of 10 is also commonly expressed as "E," where "E" means "× 10." For example, 3×10^5 *can also be written as 3E+05, and* 3×10^{-5} *is equivalent to 3E-05. Therefore, 3E+05 = 300,000 and 3E-05 = 0.00003.*

The health risk data tables in this section use "E" notation with negative exponents.

Probability is expressed as a number between 0 and 1. The notation 3E-06 can be read 0.000003, which means that there are three chances in 1,000,000 that the associated results (e.g., fatal cancer) will occur in the period covered by the analysis.

8.4.1.1 Estimated Number of Fatalities

Table 8.4–3 presents an overview, by alternative, of the total estimated programwide fatalities associated with TRUW treatment. This table presents the estimated number of fatalities to the offsite population, noninvolved workers, and waste management workers caused by radiological exposure. In addition, the table shows the estimated number of waste management worker deaths resulting from physical hazards during facility construction and operation.

For each alternative except No Action, there is at least one estimated fatality associated with treatment operations. Most of these fatalities occur within the waste management worker population, and result from physical hazards involved in construction and operation of TRUW treatment facilities. Only waste management workers are exposed to these physical hazards, and therefore, have more estimated fatalities than other receptor groups. Overall the estimated number of waste management worker fatalities due to

Table 8.4–3. TRUW Treatment: Estimated Number of Fatalities Programwide[c]

Alternative	Number of Sites		Treatment Standard	WM Worker		Offsite Population Radiation Exposure	Noninvolved Worker Radiation Exposure
	CH Treat	RH Treat		Physical Hazards	Radiation Exposure		
No Action[a]	11	5	WIPP-WAC	*	*	*	*
Decentralized[b]	16	5	WIPP-WAC	2	1	*	*
Regionalized 1	5	2	Reduce gas	3	1	*	*
Regionalized 2	5	2	LDRs	4	1	1	*
Regionalized 3	3	2	LDRs	3	1	*	*
Centralized	WIPP	2	LDRs	2	1	*	*

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; LDRs = Land Disposal Restrictions; WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria; * = greater than 0 but less than 0.5.
[a] For No Action Alternative, storage is indefinite, no disposal at WIPP is assumed; however, risks are provided for only the first 20 years of indefinite storage (see Section 8.3.1). For all other alternatives, disposal at WIPP is assumed.
[b] In Decentralized Alternative, TRUW is processed at all 16 sites, then transferred to interim storage at 10 sites, then to WIPP.
[c] These values may differ from the WIPP SEIS-II (DOE, 1996e); refer to Section 8.2.5 for discussion.

physical hazards exceeds the number of estimated fatalities to the offsite and the noninvolved worker populations for all alternatives. In general, risk to waste management workers appears to decrease when TRUW is treated to less stringent standards. That is, estimated fatalities are less when TRUW is processed to meet current waste acceptance criteria or to reduce gas generation potential than when it is treated to meet LDRs. A single latent cancer fatality is estimated for the waste management worker population under each alternative except No Action. It should, however, be noted that potential radiological impacts provided in the WM PEIS are based on analyses that include prudently conservative release, exposure, and risk factor estimates. DOE would use ALARA ("As Low As Reasonably Achievable") procedures and monitoring to reduce the actual doses received by the workforce.

Regionalized Alternative 2 also produces an estimated single latent cancer fatality in the offsite population at LANL from the thermal treatment of waste that contains americium-241. DOE may mitigate this potential effect by reducing emissions by means of special oxidation or other treatment or offgas control techniques that would be examined in sitewide or project-specific NEPA reviews. Site-specific estimated latent cancer fatalities for TRUW can be found in the site data tables in Volume II.

8.4.1.2 Estimated Number of Cancer Incidences and Genetic Effects

Table 8.4–4 presents an overview, by alternative, of the total programwide incidences of cancer and genetic effects associated with treatment of TRUW. These impacts result from exposures of the offsite, noninvolved worker, and waste management worker populations to chemicals and radiation. In addition, dose estimates are included for the offsite, noninvolved worker, and waste management worker populations.

Each of the alternatives has estimates of one or more cancer incidences resulting from radiation exposure. The greatest numbers of estimated cancer incidences resulting from treatment of TRUW to meet LDRs occur in the offsite populations at LANL and Hanford under Regionalized Alternative 2 and Hanford under Regionalized Alternative 3. This result reflects thermal treatment of waste that contains americium-241 at LANL and plutonium-238 at Hanford, which, as previously mentioned, would require special mitigation measures. There is a reduction in offsite population cancer incidences from treatment to meet LDRs under the Regionalized 3 and Centralized Alternatives. Estimated cancer incidences and genetic effects for TRUW can be found in the site data tables in Volume II.

LANL, Hanford, and WIPP are the only sites that have an estimated incidence of at least one cancer in the offsite population as a result of radiation exposure. Treatment to meet LDRs is forecast to cause this at Hanford and WIPP predominantly because of plutonium-238, whereas americium-241 accounts for most of the risk at LANL. Mitigation of the emissions from thermal treatment of these radionuclides may be accomplished through application of alternative treatment concepts when these become available, or by enhancing off-gas treatment systems, if these alternatives are selected. Specific mitigation measures would be evaluated in sitewide or project-specific NEPA reviews. Cancer incidences resulting from chemical exposure and genetic effects resulting from radionuclide and radiation exposure were not estimated to exceed one for any receptor group under any alternative.

8.4.1.3 Probability of MEI Cancer Fatalities

Table 8.4–5 summarizes, by alternative, the highest estimated *probability* at any site of latent fatal cancer from radiation exposure. This table presents the risk of cancer fatality to the MEI within the offsite and noninvolved worker populations. The numbers in this table are the estimated *probabilities* that the MEI will die of cancer from radiation exposure.

Table 8.4–4. TRUW Treatment: Estimated Number of Cancer Incidences and Genetic Effects Programwide[c]

Alternative	Number of Sites		Treatment Standard	Offsite Population				Noninvolved Workers				WM Workers			
	CH Treat	RH Treat		Radiation Dose (person-rem)	Radiation Cancer Incidence	Chemical Cancer Incidence	Radiation Genetic Effects	Radiation Dose (person-rem)	Radiation Cancer Incidence	Chemical Cancer Incidence	Radiation Genetic Effects	Radiation Dose (person-rem)	Radiation Cancer Incidence	Chemical Cancer Incidence	Radiation Genetic Effects
No Action [a]	11	5	WIPP-WAC	0.08	*	*	*	0.007	*	*	*	400	1	*	*
Decentralized [b]	16	5	WIPP-WAC	0.3	*	*	*	0.03	*	*	*	1,510	2	*	*
Regionalized 1	5	2	Reduce gas	0.5	*	*	*	0.05	*	*	*	1,620	2	*	*
Regionalized 2	5	2	LDRs	1,990	3	*	*	3	*	*	*	1,640	2	*	*
Regionalized 3	3	2	LDRs	469	1	*	*	40	*	*	*	1,740	3	*	*
Centralized	WIPP	2	LDRs	609	1	*	*	4	*	*	*	2,040	3	*	*

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; LDRs = Land Disposal Restrictions; WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria; * = values greater than 0 but less than 0.5.

[a] For No Action Alternative, storage is indefinite, no disposal at WIPP is assumed; however, risks are provided for only the first 20 years of indefinite storage (see Section 8.3.1). For all other alternatives, disposal at WIPP is assumed.

[b] In Decentralized Alternative, TRUW is processed at all 16 sites, then transferred to interim storage at 10 sites, then to WIPP.

[c] These values may differ from the WIPP SEIS-II (DOE, 1996e); refer to Section 8.2.5 for discussion.

Table 8.4–5. TRUW Treatment: Greatest Probability of Cancer Fatality at Any TRUW Site[c]

Alternative	Number of Sites		Treatment Standard	Offsite MEI Cancer Fatality Probability	Noninvolved Worker MEI Cancer Fatality Probability
	CH Treat	RH Treat			
No Action [a]	11	5	WIPP-WAC	4E–10	2E–09
Decentralized [b]	16	5	WIPP-WAC	6E–09	7E–09
Regionalized 1	5	2	Reduce gas	7E–09	1E–08
Regionalized 2	5	2	LDRs	7E–05	5E–05
Regionalized 3	3	2	LDRs	5E–06	2E–05
Centralized	WIPP	2	LDRs	7E–05	9E–05

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; LDRs = Land Disposal Restrictions; WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.
[a] For No Action Alternative, storage is indefinite, no disposal at WIPP is assumed; however, risks are provided for only the first 20 years of indefinite storage (see Section 8.3.1). For all other alternatives, disposal at WIPP is assumed.
[b] In Decentralized Alternative, TRUW is processed at all 16 sites, then transferred to interim storage at 10 sites, then to WIPP.
[c] These values may differ from the WIPP SEIS-II (DOE, 1996e); refer to Section 8.2.5 for discussion.

The probability of a cancer fatality to the MEI was calculated for each site, and the highest values under each alternative are presented in Table 8.4–5. The MEI risk is not a combined total of risks across all of the sites in an alternative. This table indicates that the TRUW alternatives with treatment to meet LDRs have the highest cancer fatality probabilities for the MEI of the offsite and noninvolved worker populations. The other alternatives, which process TRUW to WIPP-WAC or treat it to reduce the potential of gas generation, have probabilities of cancer fatalities that are less by three orders of magnitude or more.

Table 8.4–6 presents the probability of a fatal cancer from radiological exposure for the offsite MEIs for all sites by treatment alternative. The data in Table 8.4–6 are graphically presented in Figure 8.4–1. Essentially, all sites that conduct treatment to meet LDRs have relatively higher cancer fatality probabilities than those that do not treat to meet LDRs. Air emissions of plutonium-238 are responsible for the relatively higher risk estimates at Hanford and WIPP, whereas americium-241 accounts for most of the risk at INEL, LANL, and RFETS.

Estimates of the potential release of alpha radionuclides to the air based on more recent waste loads at INEL and RFETS result in increases in the offsite MEI cancer fatality probabilities, and produce risk estimates in excess of one in one million for these sites for the Regionalized Alternative 2. Other risks (e.g., noninvolved worker MEI cancer fatality probability, offsite MEI cancer incidence probability) posed by the release of alpha radionuclides could increase as well (see Appendix I).

Table 8.4–6. TRUW Treatment: Offsite MEI Cancer Fatality Probabilities[c]

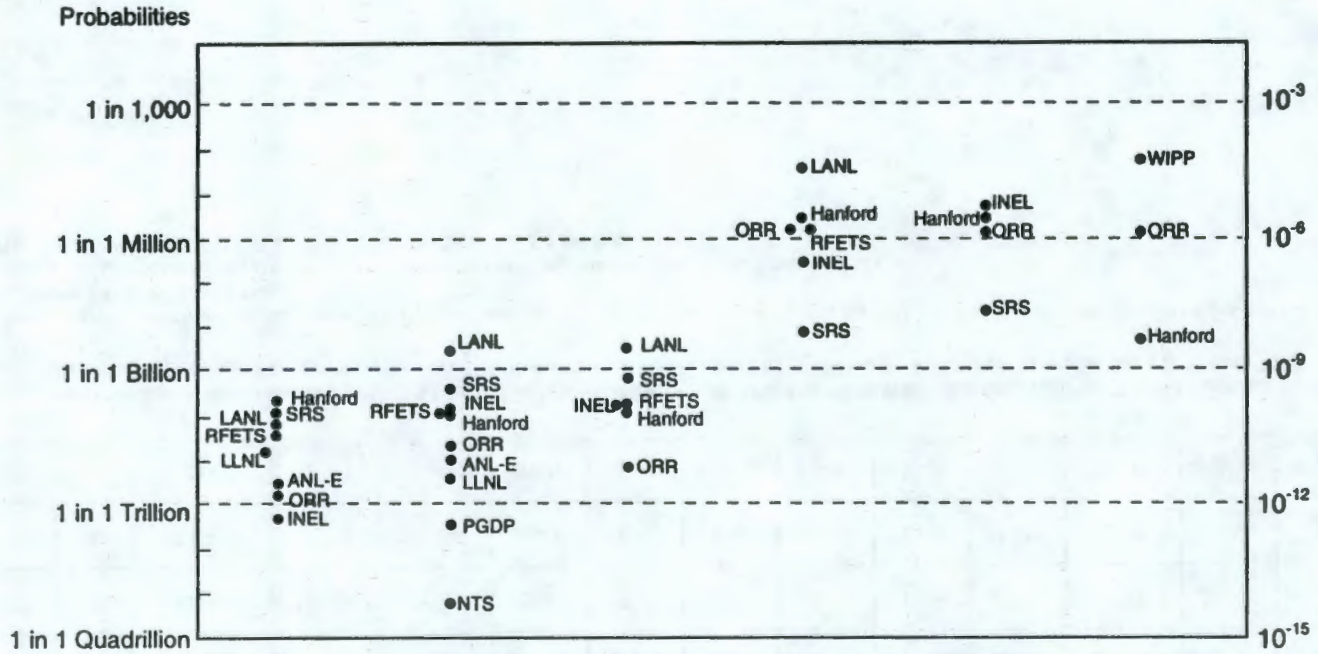
Alternative	Number of Sites		Treatment Standard	ANL-E	Hanford	INEL	LANL	LLNL	NTS	ORR	PGDP	RFETS	SRS	WIPP
	CH Treat	RH Treat												
No Action [a]	11	5	WIPP-WAC	3E–12	2E–10	8E–13	4E–10	2E–11	--	2E–12	--	4E–11	2E–10	--
Decentralized [b]	16	5	WIPP-WAC	1E–11	5E–10	1E–10	6E–09	6E–11	3E–14	2E–11	4E–13	1E–10	7E–10	--
Regionalized 1	5	2	Reduce gas	1E–11	9E–10	2E–10	7E–09	6E–11	4E–14	3E–11	6E–13	2E–10	1E–09	--
Regionalized 2	5	2	LDRs	1E–11	3E–06	9E–07	7E–05	6E–11	4E–14	1E–06	6E–13	1E–06	2E–08	--
Regionalized 3	3	2	LDRs	1E–11	3E–06	5E–06	7E–09	6E–11	4E–14	1E–06	6E–13	2E–10	2E–08	--
Centralized	WIPP	2	LDRs	1E–11	1E–08	2E–10	7E–09	6E–11	4E–14	1E–06	6E–13	2E–10	3E–10	7E–05

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; LDRs = Land Disposal Restrictions; WIPP-WAC = Waste Isolation Pilot Plant Waste Acceptance Criteria. Analysis was not conducted for Offsite MEI Cancer Fatality Probabilities at SNL-NM and WVDP due to low TRUW inventory. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.

[a] For No Action Alternative, storage is indefinite, no disposal at WIPP is assumed; however, risks are provided for only the first 20 years of indefinite storage (see Section 8.3.1). For all other alternatives, disposal at WIPP is assumed.

[b] In Decentralized Alternative, TRUW is processed at all 16 sites, then transferred to interim storage at 10 sites, then to WIPP.

[c] These values may differ from the WIPP SEIS-II (DOE, 1996e); refer to Section 8.2.5 for discussion.



	NA	D	R1	R2	R3	C
CH Treat At	11 Sites	16 Sites	5 Sites	5 Sites	3 Sites	WIPP
RH Treat At	6 Sites	6 Sites	2 Sites	2 Sites	2 Sites	2 Sites
Treat STD	WIPP-WAC	WIPP-WAC	Reduce Gas	LDRs	LDRs	LDRs

note: chart in logarithmic scale

CH = Contact-Handled TRUW
RH = Remote-Handled TRUW
LDRs = Land Disposal Restrictions
WIPP-WAC = Waste Isolation Pilot Plant Waste Acceptance Criteria

Figure 8.4–1. Probability of Cancer Fatality to Offsite MEI—TRUW.

8.4.1.4 Probability of MEI Cancer Incidence and Genetic Effects

Table 8.4–7 summarizes, by alternative, the highest estimated *probability* at any site of cancer incidence and genetic effects resulting from chemical and radiation exposure. This table presents these estimated risks for the MEI within the offsite and noninvolved worker populations.

Each of the TRUW alternatives involving treatment to meet LDRs has estimated probabilities of cancer incidence and genetic effects relatively greater than alternatives that do not involve treatment to meet LDRs. This includes the MEI in both the offsite and noninvolved worker populations.

All seven sites that would conduct treatment to meet LDRs (the Hanford Site, INEL, LANL, ORR, RFETS, SRS, WIPP) have relatively higher estimated probabilities of cancer or genetic effects than sites that would not treat to LDRs. Probabilities of cancer from chemical exposure were lower than probabilities of cancer from exposure to radiation. Estimated cancer incidences and genetic effects for TRUW can be found in Volume II in the site data tables.

8.4.1.5 MEI Noncancer Risks

The "Hazard Index" is the EPA's standard indicator of potential noncancer toxicity caused by exposure to hazardous chemicals. It is derived by comparing estimated exposure to concentrations of noncarcinogenic chemicals to concentrations presumed to be protective of human health over an entire lifetime, assuming continuous low-level exposure. If the Hazard Index exceeds one, the estimated exposure concentrations exceed the concentrations presumed to be without adverse health effects. In the WM PEIS, the Hazard Index was estimated for the offsite population MEI and noninvolved worker MEI.

For waste management workers, an "Exposure Index" rather than a Hazard Index was estimated. The Exposure Index is derived by comparing the estimated exposure concentrations to appropriate occupational exposure limits. The Exposure Index was considered to be a better measure for waste management workers because the Hazard Index uses standards designed to protect the health of the general population, including sensitive subgroups, such as children. Workers are generally assumed to be healthier than the general population, and worker populations contain fewer sensitive subgroups. Therefore, the concentrations of noncarcinogenic chemicals presumed to be protective of human health are different for these two groups

Table 8.4–7. TRUW Treatment: Estimated Greatest Probability of Cancer Incidence and Genetic Effects at Any Site[c]

Alternative	Number of Sites		Treatment Standard	Offsite MEI				Noninvolved Worker MEI			
	CH Treat	RH Treat		Radiation Dose (rem)	Radiation Cancer Incidence	Chemical Cancer Incidence	Radiation Genetic Effects	Radiation Dose (rem)	Radiation Cancer Incidence	Chemical Cancer Incidence	Radiation Genetic Effects
No Action [a]	11	5	WIPP-WAC	0.000001	2E–09	7E–13	1E–10	0.000005	8E–09	3E–10	5E–10
Decentralized [b]	16	5	WIPP-WAC	0.00001	2E–08	1E–11	1E–09	0.00002	6E–08	6E–11	2E–09
Regionalized 1	5	2	Reduce gas	0.00001	2E–08	1E–11	1E–09	0.00003	5E–08	7E–11	3E–09
Regionalized 2	5	2	LDRs	0.1	2E–04	1E–11	1E–05	0.03	2E–04	5E–11	9E–06
Regionalized 3	3	2	LDRs	0.01	2E–05	1E–11	1E–06	0.03	5E–05	5E–11	3E–06
Centralized	WIPP	2	LDRs	0.1	2E–04	6E–12	1E–05	0.2	3E–04	4E–11	2E–05

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; LDRs = Land Disposal Restrictions; WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria;
* = greater than 0 but less than 0.0005 rem. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.
[a] For No Action Alternative, storage is indefinite, no disposal at WIPP is assumed; however, risks are provided for only the first 20 years of indefinite storage (see Section 8.3.1). For all other alternatives, disposal at WIPP is assumed.
[b] In Decentralized Alternative, TRUW is processed at all 16 sites, then transferred to interim storage at 10 sites, then to WIPP.
[c] These values may differ from the WIPP SEIS-II (DOE, 1996e); refer to Section 8.2.5 for discussion.

of receptors. If the Exposure Index exceeds one, the estimated concentrations exceed the concentrations presumed to be without adverse health effects.

None of the Hazard or Exposure Indices estimated for the alternatives evaluated exceeded one; therefore, no noncancer risks are expected as a result of TRUW treatment.

8.4.2 TRANSPORTATION-RELATED IMPACTS

Transporting TRUW for treatment and storage may affect the health of the truck drivers, rail crew, and the public along the transportation route. These impacts are the result of physical injury from vehicle accidents, radiation-induced latent cancers from normal operations, accidents where the waste containers are assumed to open, chemical exposure during accidents, and exposure to vehicle exhaust. For all alternatives except No Action, shipments were assumed to occur uniformly over a 10-year period, assuming a 10-year period to build treatment and storage facilities. There would be no transportation in the No Action Alternative.

The methods used to estimate transportation risks as well as relevant information concerning the types of shipping casks assumed are described in Appendix E. Tables 8.4–8 and 8.4–9 present the total number of estimated fatalities associated with truck and rail transportation of TRUW, respectively. Table 8.4–8 shows that if DOE shipped TRUW by truck, there is one additional fatality estimated for truck drivers under the Decentralized Alternative than under the other alternatives. Otherwise, the estimated number of latent cancer and traffic accident fatalities are approximately the same for all alternatives. Risks from rail transport are estimated to be slightly less than risks estimated for truck transport (Table 8.4–9).

The health impacts associated with exposure to the hazardous chemical components of TRUW that might be released during accidents are presented in Appendix E. No incidences of cancer or noncancer health effects associated with transportation were estimated for any alternative.

Table 8.4–8. Estimated Fatalities for TRUW Truck Transportation From Vehicular Accidents and Exposure to Radiation and Fuel Emissions

Alternative	Number of Sites		Treatment Standard	Estimated Number of Radiological Fatalities[a]		Estimated Number of Nonradiological Fatalities	
	CH Treat	RH Treat		Normal Operations Public	Normal Operations Crew	Fuel Emissions	Injury From Traffic Accidents
No Action [b]	11	5	WIPP-WAC	0	0	0	0
Decentralized [c]	16	5	WIPP-WAC	2	2	*	3
Regionalized 1	5	2	Reduce gas	2	1	*	3
Regionalized 2	5	2	LDRs	2	1	*	2
Regionalized 3	3	2	LDRs	2	1	*	3
Centralized	WIPP	2	LDRs	2	1	*	3

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; LDRs = Land Disposal Restrictions; WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria.
* Greater than 0 but less than 0.5.
[a] Fatalities are from radiation-induced cancer.
[b] For No Action Alternative, storage is indefinite, no disposal at WIPP is assumed; for all other alternatives, disposal at WIPP is assumed.
[c] In Decentralized Alternative, TRUW is processed at all 16 sites, then transferred to interim storage at 10 sites, then to WIPP.

Table 8.4–9. Estimated Fatalities for TRUW Rail Transportation From Rail Accidents and Exposure to Radiation and Fuel Emissions

Alternative	Number of Sites		Treatment Standard	Estimated Number of Radiological Fatalities[a]		Estimated Number of Nonradiological Fatalities	
	CH Treat	RH Treat		Normal Operations Public	Normal Operations Crew	Fuel Emissions	Injury From Traffic Accidents
No Action [b]	11	5	WIPP-WAC	0	0	0	0
Decentralized [c]	16	5	WIPP-WAC	1	*	*	*
Regionalized 1	5	2	Reduce gas	*	*	*	*
Regionalized 2	5	2	LDRs	*	*	*	*
Regionalized 3	3	2	LDRs	*	*	*	*
Centralized	WIPP	2	LDRs	1	*	*	*

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; LDRs = Land Disposal Restrictions; WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria.
* Greater than 0 but less than 0.5.
[a] Fatalities are from radiation-induced latent cancer.
[b] For No Action Alternative, storage is indefinite, no disposal at WIPP is assumed; for all other alternatives, disposal at WIPP is assumed.
[c] In Decentralized Alternative, TRUW is processed at all 16 sites, then transferred to interim storage at 10 sites, then to WIPP.

8.4.3 FACILITY ACCIDENT IMPACTS

8.4.3.1 Storage Facility Accidents

Accidents and source terms for current storage were not analyzed explicitly. Unlike treatment, which will chiefly use new facilities that have common characteristics, current (pretreatment) storage uses a variety of preexisting facilities that vary greatly with regard to the amounts and types of waste inventories they store, the arrangements in which the inventories are stored, and the containment characteristics of the storage enclosures. However, recent DOE safety analysis reports (SARs) and NEPA reviews provide guidance on the potential impacts of accidents in existing LLMW and TRUW storage facilities.

These current SARs and EISs are valid indicators of the potential consequences of a range of storage accidents with various probabilities of occurring. A brief summary of some of the accidents and assumptions used by sites in preparing the analyses, and the related release or health effects-related results, are shown in Appendix F. Examples of existing analyses applicable to TRUW storage accidents include accidents ranging from breaches of single drums due to drum rupture and lid failure to the total collapse of a storage facility due to a beyond-design-basis earthquake.

The most relevant recent analyses dealing with postulated accidents for TRUW waste storage facilities were reviewed, including the *Waste Isolation Pilot Plant Disposal Phase Draft Supplemental Environmental Impact Statement* (WIPP SEIS-II) (DOE, 1996e). The WIPP SEIS-II considers accidents associated with storage of TRUW after treatment and before further disposition. Accidents during current storage of TRUW are not considered in the WIPP SEIS-II. To allow comparison with other safety analysis of current TRUW storage, it was assumed that the TRUW treated to the planning-basis WAC in the WIPP SEIS-II would be similar in form to that currently stored at the generator sites. The accident scenarios considered in the WIPP SEIS-II include a multiple drum spill, an internally induced drum rupture and fire, and a beyond-design-basis earthquake that results in collapse of the storage facility. Accident consequences were calculated for six sites (Hanford, INEL, LANL, RFETS, ORNL, and SRS). The radionuclide content of each TRUW drum for the first two postulated accidents was assumed to be at the WIPP WAC limit of 80 plutonium equivalent curies (PE-Ci), while the average radionuclide content was applied to the accident involving a beyond-design-basis earthquake.

For the multiple drum spill accident (annual frequency of occurrence of about 0.01) considered in the WIPP SEIS-II, the probability of a latent cancer fatality (LCF) to the offsite MEI ranged from 2E-09 at SRS to 3E-07 at ORNL, with offsite population impacts estimated at less than 1E-03 fatalities. Similarly, the internally induced drum rupture and fire accident considered in the WIPP SEIS-II (annual frequency of occurrence of about 1E-04) also resulted in offsite population impacts of less than 1E-02 fatalities and probabilities of a LCF to the offsite MEI of from 8E-09 at SRS to 1E-06 at ORNL.

Much higher consequences were predicted for the earthquake accident (annual frequency of occurrence of less than 1E-05) considered in the WIPP SEIS-II. The probability of a LCF to the offsite MEI ranged from 2E-03 at SRS to 7E-02 at LANL. The number of latent cancer fatalities in the offsite population ranged from 6 at ORNL and INEL to 200 at Hanford and 300 at RFETS. The high number of fatalities may be attributable to the assumption of a beyond-design-basis earthquake that results in total collapse of the storage structure upon the site's entire inventory of TRUW treated to WIPP-WAC, which produces a significant airborne release of TRUW. In light of the stable nature of treated TRUW, this set of assumptions may be conservative. Consideration of the probability of such an accident results in an offsite MEI cancer risk of less than one in one million.

It should be noted that explicitly analyzing risks from storage would not help to discriminate among most alternatives because of the assumptions used in the WM PEIS. Except for the No-Action Alternative, the WM PEIS assumes that all sites will increase (or at least maintain) their inventories of TRUW for 10 years, until treatment begins. Thus, all sites will have their largest inventories (leading to maximum potential releases during a storage facility accident) regardless of the alternative, with the exception of the No Action Alternative. In that alternative, inventories of TRUW would continue to increase indefinitely.

8.4.3.2 Treatment Facility Accidents

Although there are many possible ways to treat TRUW, technologies using thermal treatment have been the most effective to date (in terms of volume reduction and destruction of organic hazardous constituents). A significant amount of incineration data are available and incineration represents and bounds other thermal

treatment processes. Thus, this risk analysis focuses on incineration.[10] Like other TRUW treatment processes, incineration operations and accidents can result in airborne releases of radionuclides. Potential treatment facility accidents identified for all TRUW alternatives include: (1) incineration facility fires or explosions initiated by internal causes; (2) an earthquake or tornado that causes damage and fires in the facility; and (3) the crash of a large or small aircraft into the facility, resulting in fire and explosion. All of these types of accidents can release the radioactive contents from the kiln of the incinerator, the stored ash byproduct from the incineration process, or the trapped contents of the filtration systems in the facility. The accident with the highest potential consequence at each site was evaluated.

The radiological health effects from treatment facility accidents were calculated on the basis of conservative assumptions. Table 8.4–10 summarizes the estimated cancer fatalities resulting from radiation exposures produced by potential treatment facility accidents. This table contains estimates of the cancer fatalities for maximum consequence accidents at each site and of the annual frequency of those accidents. The doses indicated are a function of the severity of the accident and the size of the population affected. The indicated probabilities of an excess cancer are calculated on the basis of the assumption that the accident occurs. Consistent with standard practice in radiological safety analysis, the fatalities are derived only from the cancers associated with radiation. In general, local worker fatalities from trauma in severe accidents would primarily result from the physical effects of the accident (e.g., the initial impact and fire of an airplane crash). These trauma fatalities would tend to be independent of the inventory or process used at a particular site under a given alternative and, therefore, would not tend to be a significant discriminator among the alternatives. Trauma fatalities to the offsite populations from severe accidents would be almost totally independent of the alternative, and therefore would not vary among alternatives.

Assuming that the accident occurs, each of the alternatives poses a cancer fatality probability equal to or greater than one in one million for the offsite MEI at most sites. However, when the frequencies of the accidents are considered, none of the alternatives pose an offsite MEI cancer risk greater than one in one million.

The Centralized Alternative is estimated to produce the highest number of cancer fatalities if an accident occurs affecting the offsite population (seven individuals at the WIPP site). Under Regionalized

[10] This focus gives DOE sufficient information to decide on the location of proposed TRUW treatment and storage facilities. Accident scenarios for all three TRUW treatment trains are assessed in the WIPP SEIS-II (DOE, 1996e). DOE will base its decision on which treatment process it will use to meet the performance standards for WIPP or storage requirements on the analysis in the WIPP SEIS-II.

Table 8.4–10. TRUW Facility Accidents—Radiation-Induced Cancer Fatalities From Maximum Reasonably Foreseeable Potential Treatment Facility Accidents

Site	Accident Type	Estimated Annual Accident Frequency	Offsite MEI Radiation Dose (rem)	Offsite MEI Cancer Fatality Probability	Offsite Population Radiation Dose (person-rem)	Offsite Population Number of Cancer Fatalities	Worker Radiation Dose (person-rem	WM Workers Number of Cancer Fatalities
Regionalized 2								
Hanford	Incineration, natural phenomena	1.0E–06 to 1.0E–04	2E–03	9E–07	8E+01	*	1E+04	5
Hanford	Incineration explosion	1.0E–06 to 1.0E–04	1E–02	5E–05	4E+03	2	8E+02	*
INEL	Incineration, natural phenomena	1.0E–06 to 1.0E–04	9E–03	5E–06	8E+01	*	4E+02	*
LANL	Incineration, natural phenomena	1.0E–06 to 1.0E–04	1E+00	7E–04	3E+03	1	2E+03	1
RFETS	Incineration, natural phenomena	1.0E–06 to 1.0E–04	2E–02	1E–05	6E+02	*	5E+01	*
SRS	Incineration, natural phenomena	1.0E–06 to 1.0E–04	9E–06	5E–09	3E–01	*	4E+01	*
SRS	Incineration explosion	1.0E–06 to 1.0E–04	5E–04	2E–07	2E+01	*	2E+00	*
Regionalized 3								
Hanford	Incineration, natural phenomena	1.0E–06 to 1.0E–04	2E–03	9E–07	8E+01	*	1E+04	5
Hanford	Incineration explosion	1.0E–06 to 1.0E–04	1E–01	5E–05	4E+03	2	8E+02	*
INEL	Incineration, natural phenomena	1.0E–06 to 1.0E–04	5E–02	3E–05	4E+02	*	2E+03	1
SRS	Incineration, natural phenomena	1.0E–06 to 1.0E–04	9E–06	5E–09	3E–01	*	4E+01	*
SRS	Incineration explosion	1.0E–06 to 1.0E–04	5E–04	3E–07	2E+01	*	2	*
Centralized								
WIPP	Incineration, natural phenomena	1.0E–06 to 1.0E–04	2E+00	1E–03	3E+02	*	2E+05	14
WIPP	Incineration explosion	1.0E–06 to 1.0E–04	1E+02	6E–02	1E+04	7	1E+04	4
Centralized (RH)								
Hanford	Incineration, natural phenomena	1.0E–06 to 1.0E–04	8E–06	4E–09	4E–01	*	6E+00	*
ORNL	Incineration, natural phenomena	1.0E–06 to 1.0E–04	7E–02	3E–05	8E+02	*	3E+01	*

Notes: Natural phenomena refer to accidents initiated either by earthquake or by high wind or tornado, depending on the site and the associated recurrence frequencies. Incineration was the thermal treatment analyzed. * = greater than 0 but less than 0.5. Please refer to Section 5.4.1 of Volume I for guidance in interpreting MEI risks.

Alternative 2, treatment accidents would result in two cancer fatalities in the offsite population at Hanford and one cancer fatality in the offsite population at LANL if the accidents were to occur. Under Regionalized Alternative 3, treatment accidents are estimated to result in two cancer fatalities in the offsite population at Hanford, assuming they occur. No cancer risk fatalities exceeding one within the offsite population would result from accidents under the Centralized Alternative for RH TRUW. The overall risks from accidents for all alternatives, derived by multiplying the health risk value by the frequencies of the accidents, are small.

The highest estimate of cancer fatalities resulting from the maximum reasonably foreseeable accidents affecting waste management workers is 14 at the WIPP site under the Centralized Alternative. Under Regionalized Alternative 2, five cancer fatalities are estimated in the WM worker population at Hanford, and one cancer fatality is estimated at LANL. Under Regionalized Alternative 3, five cancer fatalities are estimated in the WM worker population at Hanford, and one cancer fatality is estimated at INEL. No cancer fatalities within the WM worker population are estimated to result from accidents under the Centralized Alternative for RH TRUW. The overall risks from accidents, taking into account the probability of these accidents, are small.

The results of the WM PEIS analysis are consistent with those in the WIPP SEIS-II (DOE, 1996e). The WIPP SEIS-II examines three levels of treatment: treating to WIPP WAC, thermal treatment using vitrification, and shred and grout. Although the generic treatment train evaluated in the WM PEIS for meeting RCRA land disposal restrictions (Figure 8.2-3) does not include vitrification as a treatment technology, comparison of the accident analyses impacts in the WM PEIS with those estimated in the WIPP SEIS-II indicates that the largest potential impacts from accidents are associated with thermal treatment. The accident analysis for thermal treatment to LDRs in the WIPP SEIS-II considers three scenarios: failure of a drum containing vitrified treated waste, a steam explosion in a vitrification glass melter, and a beyond-design-basis earthquake with resultant collapse of the waste treatment facility. The accident associated with TRUW treatment with the highest potential consequence to the offsite population for both the WM PEIS and WIPP SEIS-II is a seismic event. For this event, the WM PEIS predicts up to 7 latent cancer fatalities in the offsite public, depending upon the alternative and site; the WIPP SEIS-II predicts up to 30 LCFs in the offsite population. The difference in consequences for this seismic event between the WIPP SEIS-II and the WM PEIS can be attributed to the use of different analytical methods and assumptions and their attendant uncertainties. As an example, the WIPP SEIS-II very conservatively assumes that the entire process inventory would be affected by this accident, while the WM PEIS assumes 24% of the process

inventory, based upon recent safety literature. Therefore it may be expected that the WIPP SEIS-II would predict generally higher consequences for a seismic-initiated treatment facility accident. The maximum probability of a LCF to the offsite MEI is on the order of 0.06 for the Centralized Alternative at WIPP in the WM PEIS and 0.02 for ORNL in the WIPP SEIS-II.

The health risk consequences presented in Table 8.4–10 are conservative. They assume no mitigation of the accidents and take no credit for emergency response actions. The reduction in impacts due to these mitigation actions would be significant.

8.5 Air Quality Impacts

The management of TRUW would not appreciably affect the air quality at most sites. No criteria air pollutant emissions would exceed standards at any site. Emissions of radionuclides were estimated to be below the applicable standards at all sites, except for LANL and WIPP when these sites treat TRUW to meet LDRs. The exceedances at these sites would require mitigation measures to reduce emissions to acceptable levels. Emissions of other hazardous air pollutants were estimated to be below the applicable standards at all sites.

As illustrated in Table 8.5–1, DOE evaluated air quality impacts at each proposed TRUW treatment site on the basis of estimated increases in emissions of the six criteria air pollutants, hazardous air pollutants (which include radionuclides), and toxic air pollutants. Emissions from TRUW facility construction and operation and maintenance activities were estimated.

The Clean Air Act (42 USC 7401 *et seq.*) regulates emissions of air pollutants. In those areas where air pollution standards are not met (known as "nonattainment areas"), activities that introduce new emissions from both "stationary" (e.g., treatment and storage facilities) and "mobile" (e.g., vehicles and construction equipment) sources are regulated under the "General Conformity Rule" (GCR). In this rule, EPA has established limits for each criteria air pollutant in nonattainment areas. An entity which would engage in an activity that would result in emissions that equals or exceeds those limits in a nonattainment area must first obtain a permit.

Table 8.5-1. Air Quality Impacts Evaluated for TRUW Alternatives

Impacts Assessed	Period of Analysis	Activities for Which Impacts Were Assessed	Impacts Measure	Location of Impacts Assessment
Criteria air pollutant emissions	Construction	Estimated for construction equipment and worker vehicles	Percent of standard	Table 8.5-2
	Operations	Estimated for thermal treatment units, for fuel use by all other TRUW facilities, for worker vehicles, and for waste shipment vehicles	Percent of standard	Table 8.5-3
Radionuclide emissions	Operations	For all TRUW treatment facilities	Percent of standard	Table 8.5-4
Hazardous and toxic air pollutant emissions	Operations	For all TRUW treatment facilities	Percent of standard	Text discussion only

In "attainment areas" (where air pollution standards are met), only new emissions from stationary sources are regulated. In these areas, regulations for the Prevention of Significant Deterioration (PSD) of ambient air quality apply. Allowable emission increases are known as PSD increments. However, a permit is required for a new stationary source if it equals or exceeds the allowable increase. Permits are not required for criteria pollutant emissions from mobile sources.

8.5.1 Criteria Air Pollutant Emissions From Construction

Criteria air pollutants can be emitted from construction equipment and from vehicles that workers drive to the construction site—"mobile sources."

For purposes of analysis, DOE identified sites in nonattainment areas where construction activities under the TRUW alternatives would result in emissions that would equal or exceed 10% of the allowable limit of a particular criteria air pollutant. Table 8.5-2 lists those sites. DOE chose the 10%

Major Types of Air Pollutants

- ***Criteria Air Pollutants**: carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), lead (Pb), ozone (O_3), and particulate matter less than or equal to 10 micrometers in diameter (PM_{10})*
- ***Hazardous Air Pollutants:** 189 hazardous substances (including radionuclides) whose emissions are regulated by the Clean Air Act*
- ***Toxic Air Pollutants**: Other toxic compounds regulated by EPA and state or local governments*

Table 8.5–2. TRUW Sites Equaling or Exceeding 10% of Standard for Criteria Air Pollutants During Construction[a]

Alternative	Number of Sites		Treatment Standard[b]	ANL-E		RFETS	
	CH Treat	RH Treat		NO_2	VOC	CO	NO_2
No Action[c]	11	5	WIPP-WAC				
Decentralized[d]	16	5	WIPP-WAC	49(23/26)	17(2/15)	19(3/16)	11(8/3)
Regionalized 1	5	2	Reduce gas	40(16/24)	16(2/14)	20(3/17)	11(8/3)
Regionalized 2	5	2	LDRs	34(25/9)		29(4/25)	15(10/5)
Regionalized 3	3	2	LDRs	34(25/9)			
Centralized	WIPP	2	LDRs	34(25/9)			

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; NO_2 = nitrogen dioxide; VOC = volatile organic compounds; CO = carbon monoxide.
[a] Sites that exceed 10% of the limit specified by the GCR; total % of limit (% equipment/% worker vehicles). Blanks indicate that a site does not exceed 10% of the standard under the specified alternative.
[b] Treatment standards include WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria; Reduce gas = intermediate TRUW treatment to reduce volatile gas generation; LDRs = Land Disposal Restrictions criteria.
[c] For the No Action Alternative, storage is indefinite; no disposal at WIPP is assumed. However, risks are provided for only the first 20 years of indefinite storage (see Section 8.3.1). For all other alternatives, disposal at WIPP is assumed.
[d] In the Decentralized Alternative, TRUW is processed at all 16 sites then transferred to 10 sites for interim storage, and then to WIPP for disposal.

threshold to identify those sites where criteria air pollutant emissions could result in adverse air quality impacts.

As indicated in Table 8.5–2, two of the 13 major TRUW sites are located in nonattainment areas and, as a result of construction of TRUW facilities, would release emissions that exceed 10% of the allowable limit for a particular criteria air pollutant. Both sites would exceed the 10% threshold in the Decentralized and Regionalized Alternatives 1 and 2. However, DOE estimates that emissions from construction activities would not exceed the allowable levels at any site under any alternative.

8.5.2 Criteria Air Pollutant Emissions From Operations and Maintenance

Criteria air pollutants are also emitted during operations and maintenance (O&M) of TRUW facilities (stationary sources) and by vehicles driven by workers to the facility or used to transport waste (mobile sources). DOE evaluated air quality impacts for these pollutants at each site by comparing estimated increases in tons per year to the allowable emission limits (General Conformity Rule in nonattainment areas or PSD increments in attainment areas).

As shown in Table 8.5–3, three of the 13 major TRUW sites would exceed 10% of applicable air pollutant emission standards. Of these, one site is located in a nonattainment area, and two sites are in attainment areas. Two sites would have pollutant emissions that exceed 10% of the levels under any alternative. No site is estimated to exceed applicable standards, and therefore, no site would need to obtain a Clean Air Act permit.

Estimated concentrations resulting from criteria air pollutant emissions from facilities were also compared to the National Ambient Air Quality Standards (NAAQS) (40 CFR 50). No site was estimated to equal or exceed 10% of the standards.

The most stringent PSD requirements are for Class I areas. Class I areas are regions of special concern because they include national parks, monuments, seashores, wildlife refuges, or wilderness areas. A proposed action may affect air quality in a PSD Class I area if it will emit more than the allowable PSD increment of a criteria air pollutant and will be located within 100 kilometers of a PSD Class I area. Eight

Table 8.5–3. Percent of Sites' Allowable Air Emissions Discharged During Operations—TRUW Sites Equaling or Exceeding 10% of Standard [a]

Alternative	Number of Sites		Treatment Standard [b]	Criteria Pollutants			
				Operation and Maintenance			
				INEL	RFETS	WIPP	
	CH Treat	RH Treat		PM_{10}[c]	CO[d]	NO_2[c]	PM_{10}[c]
No Action[e]	11	5	WIPP-WAC				
Decentralized[f]	16	5	WIPP-WAC		17(0/17)		
Regionalized 1	5	2	Reduce gas		20(0/20)		
Regionalized 2	5	2	LDRs	10	24(0/24)		
Regionalized 3	3	2	LDRs	17			
Centralized	WIPP	2	LDRs			15	25

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW; CO = carbon monoxide; NO_2 = nitrogen dioxide; PM_{10} = particulate matter less than or equal to 10 micrometers in diameter. Blanks indicate that a site does not exceed 10% of the standard under the specified alternative.

[a] Sites equaling or exceeding 10% of the PSD increment or the standard specified by the General Conformity Rule, as indicated.

[b] Treatment standards include WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria; Reduce gas = intermediate TRUW treatment to reduce gas generation potential; LDRs = Land Disposal Restrictions criteria.

[c] Attainment area for this pollutant; PSD regulations are applied; total % represents stationary-source emissions only.

[d] Nonattainment area for this pollutant; General Conformity regulations are applied; total % (% stationary-source/% mobile-source).

[e] For No Action Alternative, storage is indefinite; no disposal at WIPP is assumed. However, risks are provided for only the first 20 years of indefinite storage (see Section 8.3.1). For all other alternatives, disposal at WIPP is assumed.

[f] In the Decentralized Alternative, TRUW is processed at all 16 sites then transferred to 10 sites for interim storage, and then to WIPP for disposal.

sites proposed for TRUW activities under various alternatives are located within 100 km of a PSD area: INEL, LANL, LLNL, NTS, ORR, RFETS, SNL–NM, and WIPP. None of the proposed TRUW activities would emit enough criteria pollutants to affect a PSD Class I area.

8.5.3 Hazardous and Toxic Air Pollutant Emissions

Thermal treatment of TRUW will result in emission of small quantities of hazardous (including radionuclides) and toxic air pollutants. Nonradiological hazardous air pollutants and toxic air pollutants were evaluated by comparing estimated ambient concentrations to EPA guidelines and State Ambient Allowable Limits (AALs) for each site. Radionuclides were evaluated by comparing the annual MEI radiation dose to the National Emissions Standards for Hazardous Air Pollutants (NESHAP)—10 millirem per year (40 CFR 61).

As shown in Table 8.5–4, doses from airborne radionuclides were estimated not to equal or exceed 10% of the dose standard at any site, except at INEL, LANL, and WIPP. The dose standard was exceeded at LANL and WIPP. These results are from the assumed thermal treatment with generic technology of waste containing plutonium-238 at WIPP and americium-241 at INEL and LANL. The treatment of TRUW with these radionuclides would require special design and other considerations, including additional control measures to reduce emissions to acceptable levels. Nonradiological hazardous or toxic air pollutant concentrations at the proposed treatment sites were not estimated to equal or exceed 10% of the applicable guidelines or standards.

8.6 Water Resources Impacts

Major impacts to water resources at the sites are unlikely for treatment of TRUW under any of the alternatives.

As illustrated in Table 8.6–1, DOE analyzed the impacts on water resources of treatment activities. DOE evaluated the effects on water availability from building and operating treatment facilities.

Table 8.5–4. TRUW Sites Equaling or Exceeding 10% of Standard for Radionuclides During Operation

Alternative	Number of Sites		Treatment Standard[a]	Radionuclides		
	CH Treat	RH Treat		INEL	LANL	WIPP
No Action[b]	11	5	WIPP-WAC			
Decentralized[c]	16	5	WIPP-WAC			
Regionalized 1	5	2	Reduce gas			
Regionalized 2	5	2	LDRs		134	
Regionalized 3	3	2	LDRs	10		
Centralized	WIPP	2	LDRs			137

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW. Blanks indicate that a site does not exceed 10% of the standard under the specified alternative.
[a] Treatment standards include WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria; Reduce gas = intermediate TRUW treatment to reduce gas generation potential; and LDRs = Land Disposal Restrictions criteria.
[b] For the No Action Alternative, storage is indefinite; no disposal at WIPP is assumed. However, risks are provided for only the first 20 years of indefinite storage (see Section 8.3.1). For all other alternatives, disposal at WIPP is assumed.
[c] In the Decentralized Alternative, TRUW is processed at all 16 sites then transferred to 10 sites for interim storage, and then to WIPP for disposal.

Table 8.6–1. Water Resource Impacts Evaluated for TRUW Alternatives

Impacts Assessed	Period of Analysis	Activities for Which Impacts Are Assessed	Impacts Measure	Location of Impacts Assessment
Water availability	Construction	Estimated for water used: • by personnel • for concrete • for dust suppression	Percent increase in current water use	Table 8.6–2
			Percent decrease in stream flow	Text discussion only
	Operations	Estimated for water used: • by personnel • by treatment processes	Percent increase in current water use	Table 8.6–2
			Percent decrease in stream flow	Text discussion only
		Estimated for effluent discharged from sanitary and process wastewater treatment facilities	Percent increase in stream flow	Text discussion only

In addition, the following impacts were examined for all waste types collectively, and are discussed in Chapter 5, Section 5.4.3:

- Impacts on surface water caused by floodplain encroachment
- Impacts on surface water from runoff and sedimentation
- Impacts on surface water and groundwater quality from wastewater discharges
- Impacts on small onsite streams from wastewater discharges
- Impacts on existing areas of groundwater contamination from groundwater withdrawal
- Impacts on surface and groundwater water quality from routine transportation and transportation accidents

8.6.1 WATER AVAILABILITY

Impacts on surface water and groundwater availability were assessed by comparing current water use rates from municipal, surface water, or groundwater sources to projected requirements for construction or operation of TRUW facilities. In addition, impacts on surface water were further assessed by examining the effect of potential withdrawals from and discharges to the major offsite stream at a given site.

Table 8.6–2 identifies sites where projected water usage under any alternative would increase by more than 1%. This 1% threshold is based on the assumption that lesser changes are not likely to have significant impacts.

Five of the 13 major sites are predicted to exceed the 1% threshold. Most exceedances are due largely to water used during the 2- to 3-year period for construction of treatment facilities. Although projected water requirements exceed current water use by more than 1% at INEL, LLNL, RFETS and SRS, these sites are not likely to experience adverse impacts because of sufficient capacities and the relatively small amount of additional water needed (DOE, 1996b).

Adverse impacts could be experienced at WIPP. As shown in the site data tables in Volume II, additional water use for the Centralized Alternative would be approximately 290% of current use of 15,000 gallons per day during the 2- to 3-year construction period and 110% of current use during operations. This appears high, but the capacity of the water supply system at WIPP was designed to allow for increased water demand if TRUW is disposed of there. Water use under the Centralized Alternative would require an additional 8% of the 540,000 gallons per day capacity of the water supply distribution system during

Table 8.6–2. TRUW Sites Predicted to Exceed 1% of Current Water Use for Construction or Operations

Alternative	Number of Sites		Treatment Standard[a]	INEL	LLNL	RFETS	SRS	WIPP
	CH Treat	RH Treat						
No Action[b]	11	5	WIPP-WAC					
Decentralized[c]	16	5	WIPP-WAC	1.2	2.8	2.1		
Regionalized 1	5	2	Reduce gas	1.2	2.8	2.2	1.2	
Regionalized 2	5	2	LDRs	1.3	2.8	3.0	1.4	
Regionalized 3	3	2	LDRs	1.4	2.8		1.4	
Centralized	WIPP	2	LDRs		2.8			290

Notes: CH = contact-handled TRUW; RH = remote-handled. Blank cells are less than or equal to 1%. Water sources are as follows: groundwater for INEL, LLNL, SRS; municipal water supply for RFETS and WIPP.
[a] Treatment standards include WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria; Reduce gas = intermediate TRUW treatment to reduce gas generation potential; and LDRs = Land Disposal Restrictions criteria.
[b] For No Action Alternative, storage is indefinite; no disposal at WIPP is assumed. However, impacts are provided for only the first 20 years of indefinite storage (see Section 8.3.1). For all other alternatives, disposal at WIPP is assumed.
[c] In the Decentralized Alternative, TRUW is processed at all 16 sites then transferred to 10 sites for interim storage, and then to WIPP for disposal.

construction and 3% during operations. WIPP does not withdraw water from any onsite surface water or groundwater body. Instead, water is supplied by municipal water via a pipeline from the city of Carlsbad, New Mexico. Because water for WIPP is supplied by an offsite municipal system, onsite water resources would not be affected.

As shown in the site data tables in Volume II, water use would be less than 1% of the average flow in the surface water body for DOE sites that withdraw water directly from a surface water source (Hanford, ORR, PGDP, and WVDP). In addition, it was assumed for this analysis that 100% of the water used at the facility during operations would be discharged as effluent from a wastewater treatment plant. For sites that discharge wastewater to natural surface waters (ANL-E, ORR, PGDP, RFETS, SRS, and WVDP), effluent discharges would be less than 1% of the average flow in the principal receiving water body at all sites. These negligible changes in flow should not affect surface water availability.

8.6.2 WATER QUALITY

Impacts to groundwater quality from disposal of TRUW were not evaluated because disposal of TRUW is not within the scope of the WM PEIS.

8.7 Ecological Resources Impacts

Loss of limited acreage of habitat at some sites from construction site clearing for TRUW facilities should not affect populations of nonsensitive plant and animal species because these species' habitats are well established regionally. DOE should be able to locate new TRUW facilities to avoid impacts to nearby wetlands and other sensitive habitats because construction sites are small compared to the total acreage at each site suitable for waste operations. A screening level risk assessment of TRUW facility airborne emissions indicated that terrestrial wildlife species are not likely to be affected. Transportation accidents leading to spills of TRUW into aquatic environments are not expected to have serious short- or long-term consequences under any alternative.

DOE analyzed the effects of construction site clearing to build TRUW treatment and storage facilities at the 10 major TRUW sites and the operation of treatment facilities on terrestrial ecological resources at proposed TRUW management sites (Table 8.7–1). Accidental releases during transportation of TRUW between DOE sites that could affect aquatic resources offsite were also evaluated.

Although DOE intends to select sites for waste management activities based on the WM PEIS, the WM PEIS will not be the basis for selecting specific locations for facilities at the sites. When selecting locations for facilities at sites, DOE will consider the results of relevant existing or new sitewide or project-level NEPA analyses, which would include analyses of potential impacts to sensitive species and habitats based on site-specific conditions.

8.7.1 GENERAL IMPACTS OF SITE CLEARING

None of the TRUW alternatives would require extensive clearing for construction of TRUW facilities. No more than 29 acres would be disturbed at any site under any alternative. These acreage requirements are small compared to the regional extent of habitat for nonsensitive species on or near the sites. Although site clearing would destroy individual plants and would kill or displace individual animals (particularly small

Table 8.7–1. Ecological Resources Impacts Evaluated for TRUW Alternatives

Ecological Impact Analyzed	Affected Ecological Resource	Analysis Method	Presentation of Results
Nonsensitive habitat effects	Terrestrial plants and animals	Comparison of habitat loss at TRUW construction sites to general habitat range	Text discussion
Terrestrial species exposures	Terrestrial animal species	Comparison of estimated radiation dose of representative species with toxicity standard	Text discussion
Sensitive habitat effects	Nearby wetlands and other sensitive habitats	Likelihood of impacts to nearby sensitive habitats by comparing construction acreage to available acreage of nonsensitive habitats	Text discussion
Sensitive species concerns	Federally- and State-listed endangered and threatened species	Numbers of Federally- and State-listed species displayed by site/alternative	Table 8.7–2
Effects of transportation accidents	Aquatic species in streams crossing transportation corridors	Results of scenario-based modeling analysis of accidental spill effects on fish in various size streams	Text discussion

mammals and song birds with limited home ranges), no effects on populations of these species are expected from proposed TRUW actions because nonsensitive species habitats are well established regionally.

8.7.2 Site Clearing Effects on Sensitive Habitats

WIPP has no sensitive habitats on or adjacent to the site; the other TRUW sites do contain sensitive habitats. The degree to which the habitats may be affected by noise or vibration, human presence, vehicle or equipment emissions, runoff, or encroachment by nearby construction activities at any site depends on DOE's ability to avoid siting facilities near these habitats. A measure of this ability is the percentage of available land required for facility construction under an alternative. Available acreage was estimated from site development plans, either using land designated for waste operations or subtracting the acreage of existing structures and sensitive habitats, such as wetlands and wildlife management areas, from the total site acreage. The analysis showed that the percent of available acreage required for the TRUW facilities ranged from 0.003% at SRS under the Centralized Alternative to 0.41% at the Hanford Site under Regionalized Alternatives 2 and 3. Considering the small amounts of available land required for TRUW facilities, DOE should have a great degree of flexibility in siting these facilities and should be able to employ a range of mitigative measures so that site clearing to implement any of the alternatives for TRUW management should not affect adjacent sensitive habitats.

Aquatic resources may be indirectly affected through increased runoff of water and soil to surface waters from construction sites. However, proper construction practices should minimize these effects. Direct discharges to surface waters from the routine operation of treatment facilities would comply with applicable regulations and would be limited by the use of accepted engineering techniques. Therefore, the impacts to aquatic organisms are expected to be minimal.

8.7.3 Effects of TRUW Treatment Facility Emissions

DOE used atmospheric emissions and deposition modeling to estimate the toxicity to terrestrial animals from airborne emissions of radionuclides from treatment facilities. This analysis used the same atmospheric emissions estimates as the human health risk assessment and provided estimates of radionuclides deposited on surface soils.

For this analysis, DOE examined those sites with the highest anticipated emissions. Potential toxicity to terrestrial wildlife was analyzed for selected sites under the Decentralized Alternative, Regionalized Alternatives 2 and 3, and the Centralized Alternative. The radionuclides Cs-137, H-3, Ni-63, Co-60, Sr-90, U-238, Pu-238, Pu-239, Pu-241, Y-90, Am-241, Pm-147, and Ba-137 were selected for the analysis. These radionuclides constitute 80% of the total activity of all radionuclides expected to be emitted. The remaining 20% of the radioactivity comes from smaller emissions of a large number of radionuclides. The conservative assumptions used to characterize the exposure scenario for wildlife (e.g., accumulation of contaminants for 10-year period with no loss due to decay or transport) compensate for limiting the analyses to 80% of the released activity. The concentrations of radionuclides were used in calculating Hazard Indexes for each selected combination of sites and alternatives as composite ratios between the estimated exposures of species to each contaminant and the estimated contaminant-specific toxic levels. A Hazard Index greater than 1 indicates a potential for the combined exposures to adversely affect the health of terrestrial species. For all Alternatives at all sites, the Hazard Index was determined to be less than 0.01, except at WIPP under the Centralized Alternative, where the maximum estimated dose produces a maximum estimated Hazard Index of 0.11. Therefore, impacts to terrestrial receptor populations as a result of emissions of radionuclides from treatment facilities are expected to be minimal. Additional information on the methods used to assess potential toxicity to terrestrial animals and on the results of the analysis is presented in Section C.4.4 of Volume III and the impacts technical report (DOE, 1996b).

8.7.4 CONSIDERATION OF SENSITIVE SPECIES

For comparison of the TRUW management program's potential to affect sensitive species, Table 8.7–2 lists the numbers of Federally and State-listed sensitive species occurring or potentially occurring at the 10 largest TRUW sites under each alternative. DOE anticipates that, in the majority of cases, any such impacts found significant in sitewide or project-specific NEPA reviews can be mitigated or eliminated by alteration of a proposed facility's location or other measures.

8.7.5 EFFECTS OF TRUW TRANSPORTATION ACCIDENTS

The ecological impacts of a transportation accident involving shipment of TRUW were analyzed on the basis of an assumed accident involving a release of TRUW from a vehicle into a stream. Analysis of such an accident requires an estimate of the spill release rate and assumed stream characteristics. The impacts of waste transportation accidents were evaluated as consequence assessments that did not include estimates of the probability of occurrence of these events. The transportation accident scenario involved spilling the

Table 8.7–2. Numbers of Federally Listed and State-Listed Endangered and Threatened Species Occurring or Potentially Occurring at the TRUW Sites (Federal/State)

Alternative	Number of Sites		Treatment Standard[a]	ANL-E	Hanford	INEL	LANL	LLNL	NTS	ORR	RFETS	SRS	WIPP
	CH Treat	RH Treat											
No Action[b]	11	5	WIPP-WAC	2/5	3/11	2/2	2/4	6/5	2/2	1/11	2/2	8/8	--
Decentralized[c]	16	5	WIPP-WAC	--	3/11	--	2/4	--	2/2	1/11	--	--	--
Regionalized 1	5	2	Reduce gas	--	3/11	2/2	2/4	--	--	1/11	--	8/8	--
Regionalized 2	5	2	LDRs	--	3/11	2/2	2/4	--	--	1/11	2/2	8/8	--
Regionalized 3	3	2	LDRs	--	3/11	2/2	--	--	--	1/11	2/2	8/8	--
Centralized	WIPP	2	LDRs	--	3/11	--	--	--	--	1/11	--	--	2/5

Notes: CH = contact-handled TRUW; RH = remote-handled; -- = no major action proposed at a site under the specified alternative.
[a] Treatment standards include WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria; Reduce gas = intermediate TRUW treatment to reduce volatile gas generation; and LDRs = Land Disposal Restrictions criteria.
[b] For No Action Alternative, storage is indefinite; no disposal at WIPP is assumed. For all other alternatives, disposal at WIPP is assumed.
[c] In the Decentralized Alternative, TRUW is processed at all 16 sites then transferred to 10 sites for interim storage, and then to WIPP for disposal.

contents of a TRUW shipment being transported by rail to the Hanford Site or LANL into streams of different sizes. As a result of the packaging used to transport TRUW, it was assumed that only a small fraction of the total inventory of TRUW (approximately 6 kg [14 lb.] out of a single shipment weight of 28,000 kg [61,000 lb.] of RH-TRUW, or 0.02%) would be released into the streams in an accident, as a result of small cracks and potential seal failures in the packaging containers (see Section 8.2.4).

The results of this analysis indicate that even if the entire release were concentrated in 1 cubic meter (m^3) of surface water, the dose to aquatic organisms would be at least five orders of magnitude below the National Council on Radiation Protection and Measurements recommended safe level. If spills were deposited in stream sediments, a few kilograms of sediment, at most, would be significantly contaminated. Since the total estimated release of radioactivity is less than 0.5 curie in the scenarios evaluated, it is unlikely that the released material would be detected above background radiation levels after its initial dispersal. In addition, impacts from the release of hazardous constituents are expected to be minor due to the small fraction of waste released. Additional information on the methods used to assess the potential consequences of a TRUW transportation accident on aquatic environments and on the results of the analysis is presented in Section C.4.4 of Volume III and the impacts technical report (DOE, 1996b).

8.8 Economic Impacts

Nationwide, the largest economic effects of TRUW management would occur under Regionalized Alternative 2 and would generally decrease as the alternatives become more centralized. The greatest benefit at any site occurs when TRUW is managed at that site. The greatest increase in jobs as a percent of regional employment would occur at INEL and WIPP under Regionalized Alternative 3 and the Centralized Alternative, respectively. None of the TRUW alternatives would substantially affect the national economy, although some 1,850 to 11,900 jobs would be directly or indirectly created.

DOE estimated the effects of expenditures for TRUW management on the local and national economies (see Table 8.8–1). Local economic effects were based on direct expenditures at each site for construction, operation and maintenance, and decontamination of treatment facilities. The socioeconomic region of influence (ROI), where local effects were evaluated, consists of the counties of residence of site employees. The local economy at each site was represented by employment, personal income, and industry data for the ROI counties. Local jobs and personal income were considered to be substantial benefits when they were

Table 8.8–1. Economic Impacts Evaluated for TRUW Alternatives

Economic Impact Analyzed	Affected Economic Resource	Analysis Method	Presentation of Results
Increased regional employment	Regional employment	Proposed site expenditures multiplied by regional employment multiplier at each TRUW site	Table 8.8–2
Increased regional incomes	Regional per capita income	Proposed site expenditures multiplied by regional income multiplier at each TRUW site	Text discussion
National economic effects	National economy	Proposed site plus total transportation expenditures multiplied by national employment and income multipliers	Text discussion

1% or greater than the 1990 baseline. Transportation expenditures were considered at the national level only.

Local economic effects were estimated on an annual basis. The impacts resulting from the construction and operation phase expenditures were combined to estimate total project effects at each site over 24 years. For all alternatives (except No Action), the construction phase at any site was assumed to take 4 years; the operations phase was assumed to take 15 years (a 10-year operations and maintenance period and a 5-year decontamination period); and 5 years was assumed to account for the continued effects on employment and income after each project phase ended. Job and personal income increases are shown for each site in the site tables in Volume II.

Across the alternatives, only regions surrounding the Hanford Site, INEL, LANL, and WIPP would experience a 1% or greater change in the number of jobs as a result of expenditures for TRUW management (Table 8.8–2). The Hanford Site would experience an increase in the number of direct, indirect, and induced jobs of 1% under Regionalized Alternatives 2 and 3, and LANL would experience a 1% change under the Decentralized and Regionalized 1 and 2 Alternatives. The increases in the number of new direct, indirect, and induced jobs were greatest at INEL and WIPP under the Regionalized 3 and Centralized Alternatives, respectively, showing a 2.1% change in the number of jobs. No sites would experience a 1% or greater increase in personal income under any of the alternatives.

Table 8.8–2. Employment Resulting From the Management of TRUW as a Percent of Regional Employment (sites where jobs were estimated to be 1% or more of the regional baseline)

Alternative	Number of Sites		Treatment Standard[a]	Hanford	INEL	LANL	WIPP
	CH Treat	RH Treat					
No Action[b]	11	5	WIPP-WAC				
Decentralized[c]	16	5	WIPP-WAC		1.4	1.0	
Regionalized 1	5	2	Reduce gas		1.6	1.0	
Regionalized 2	5	2	LDRs	1.0	1.8	1.1	
Regionalized 3	3	2	LDRs	1.0	2.1		
Centralized	WIPP	2	LDRs				2.1

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW. Blanks indicate sites where jobs were estimated to be less than 1% of the regional baseline.
[a] Treatment standards include WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria; Reduce gas = intermediate TRUW treatment to reduce gas generation potential; and LDRs = Land Disposal Restrictions criteria.
[b] For the No Action Alternative, storage is indefinite; no disposal at WIPP is assumed. For all other alternatives, disposal at WIPP is assumed.
[c] In the Decentralized Alternative, TRUW is processed at all 16 sites then transferred to 10 sites for interim storage, and then to WIPP for disposal.

The sum of the new direct, indirect, and induced jobs across the alternatives at 10 sites' ROIs range from approximately 1,250 (under the No Action Alternative) to 7,700 (under Regionalized Alternative 2). At the four sites listed in Table 8.8–2, job increases are in line with increases in the volume of TRUW managed at each site under the alternatives. These employment increases of up to 2.1% could be considered important benefits of TRUW management at those sites.

Under the No Action Alternative, in place of distinct construction and operations phases, all costs were assumed to occur in 25 years (20 years of storage operations plus 5 years for decontamination and decommissioning).

In addition to analyzing the effects on regional economies, DOE analyzed these effects on the national economy. None of the TRUW Alternatives would have substantial impacts on the national economy. The No Action Alternative has no construction activities, and therefore no construction impacts. The total number of jobs generated in the national economy from combined weighted construction and operations activities ranges from approximately 1,850 (under the No Action Alternative) to 11,900 jobs (under

Regionalized Alternative 2). In absolute terms, the number of jobs appears large, but 11,900 jobs represents only 0.009% of the 137 million jobs in the national economy. Similarly, the change in personal income due to the implementation of any of the alternatives ranges from $42 million (under the No Action Alternative) to $270 million (under Regional Alternative 2). This $270 million represents only 0.006% of the $4.7 trillion total personal income in the U.S. economy. The changes would likely represent a shift in the source of income from previous employment to employment in TRUW projects rather than a net increase in national personal income.

8.9 Population Impacts

No major population increases are expected to occur at any site under any alternatives; thus, community characteristics and the provision of services would not be affected.

Potential population changes in ROIs were estimated using the direct labor requirement to calculate potential worker in-migration. These estimates were used to evaluate the likelihood that associated effects, such as changes in community size and diversity, and the provision of necessary services, would be caused by such population changes.

No regions around any TRUW site would experience population increases greater than 1% of the current ROI population. Three sites are in regions that would experience an estimated population increase of more than 0.5%, which DOE believes would have a potential for minor social impacts—for INEL under the Decentralized and Regionalized Alternatives 1, 2, and 3, and WIPP under the Centralized Alternative.

8.10 Environmental Justice Concerns

Assessment of potential concerns regarding environmental justice associated with TRUW management indicated potential concerns about disproportionately high and adverse health risks or environmental impacts to minority and low-income groups at the INEL and WIPP sites. These potential impacts could be mitigated by selection of an alternative facility location or treatment technology, or the use of more efficient emissions controls.

The analysis of environmental justice concerns related to the management of TRUW was based on a review of the impacts reported in this chapter. This analysis was performed to reveal the potential for disproportionately high and adverse human health or environmental impacts on minority or low-income populations near each of the 13 major sites that might treat TRUW. Chapter 5 summarizes the methods and Appendix C provides the details of how this analysis was done. Appendix C also provides maps illustrating the distribution of minority and low-income populations within 50 miles of each of the 13 sites.

8.10.1 RESULTS

From the standpoint of environmental justice, the potential for disproportionately high adverse human health effects from exposures to radionuclide emissions from TRUW treatment facility operations is low for most TRUW management alternatives and for all TRUW sites except INEL and WIPP. Incident-free TRUW storage and treatment facility operations present no significant risk and do not constitute a reasonably foreseeable adverse impact to the surrounding population of any site.

For the offsite population MEI during incident-free facility operations, screening criteria indicated a cancer fatality probability equal to or greater than 1.0E–06 at Hanford, INEL, LANL, ORR, RFETS, and WIPP for treatment to LDRs. Demographic analysis of the ROIs of these six sites indicated potential disproportionate effects at INEL under the Regionalized 3 Alternatives and at WIPP under the Centralized Alternative. The MEI would be located in a census tract at INEL that contains a low-income population proportion (20.3%) greater than the national average of 13.1%. The MEI at WIPP would be located in a census tract with a minority population proportion (69.7%) that exceeds the national average (24.4%) and a low-income population proportion (23.6%) that also exceeds the national average (13.1%).

It should be noted that use of an alternative treatment technology or employment of more efficient emissions controls than the controls assumed in the conceptual thermal treatment analyzed in the WM PEIS would enable DOE to treat TRUW with lower health risks to the nonworker MEI.

A more detailed analysis of potential concerns regarding environmental justice impacts would be conducted in NEPA reviews on site-specific activities involved in treating and storing TRUW.

8.10.1.1 Transportation

Incident-free TRUW transportation and reasonably foreseeable transportation accidents are not expected to result in disproportionately high and adverse human health effects on minority or low-income populations. As Section 8.4.2 indicates, the estimated total number of cancer fatalities resulting from incident-free transportation is zero under the No Action Alternatives and two under all other TRUW alternatives. These estimates of collective population fatalities are for the total of all shipments. Disproportionate shares of minority and low-income populations reside near interstate highways and railroads; however, the major routine risk to the public from truck transportation is from exposure during rest stops to travelers who are using the same rest stops. Minority and low-income populations are found to be disproportionately lower in use of highway rest stops (DOT, 1992). For rail shipments, the primary risks to the public would be from radiological exposure during railcar classification in railyards, primarily at the start and end of each shipment, and from the emission of diesel exhaust from the trains in urban areas. Therefore, disproportionately high and adverse health effects to minority or low-income populations from incident-free TRUW transportation are not expected to occur.

The expected number of cancer fatalities due to radiation exposure resulting from transportation accidents, taking into account both the consequences of such a release and the probability that an accident causing such a release will occur, is less than 0.5 under all alternatives. The expected number of transportation accident fatalities from trauma is approximately three under all TRUW alternatives except No Action, which would have none. Consequently, disproportionately high and adverse impacts on minority and low-income populations are not expected.

8.10.1.2 Environmental Impacts

In addition to the above, reviews of other technical disciplines pursuant to the methodology in Section 8.10.1 did not indicate any adverse impacts to water resources, ecology, economics, populations, land use, infrastructure, or cultural resources impacts. Air quality impacts are possible at three sites but no disproportionately high and adverse impacts are expected for any segment of the population.

8.11 Land Use Impacts

Because land requirements for TRUW facilities are relatively small, no impacts on current onsite land uses are expected. Site development plans indicate no potential conflicts between proposed treatment or storage facilities and other plans for the sites.

DOE examined the impacts of the alternatives on land use by comparing the acreage required for new treatment and storage facilities to the acreage either designated for waste operations or suitable for development (see Table 8.11–1). Suitable land is the total site acreage, minus the acreage of known cultural resources, sensitive habitats (including wetlands and wildlife management areas), prohibitive topographic features, and surface waters. Site development plans were also used to identify potential conflicts between the facilities proposed under each alternative and plans for future uses of the site.

None of the site development plans indicated any conflicts between TRUW management and other uses. Because the analysis showed that TRUW facilities would require less than 1% of the land available for waste operations at any site, DOE would have considerable flexibility in locating those facilities, and impacts on land use would probably be minimal. (See the site data tables in Volume II for percentage of waste operations area.) For the same reason, conflicts with adjacent offsite land use plans are considered unlikely.

Table 8.11–1. Land Use Impacts Evaluated for TRUW Alternatives

Land Use Impact	Affected Resource	Analysis Method	Presentation of Results
Effect on land use onsite at each TRUW site	Land use shown in site development plans	Comparison of waste management required land acreage with amount designated (or estimated) for waste management in site development plan	Text discussion
Conflicts with offsite uses	Adjacent land use	Consideration of conflict between proposed waste management uses and nearby land uses	Text discussion

Although DOE intends to select sites for waste management on the basis of the WM PEIS, the PEIS will not be the basis for selecting specific locations for facilities at those sites. When selecting locations for facilities at sites, DOE will consider the results of relevant existing or new sitewide or project-level NEPA analyses, which would include analyses of potential land-use conflicts or restrictions at particular locations on a site.

8.12 Infrastructure Impacts

Although no offsite infrastructure impacts are expected, proposed TRUW activities would affect onsite infrastructure at Hanford, INEL, and WIPP. In addition, increases in site employment at the Hanford Site, INEL, LANL, and WIPP would lead to traffic increases that would be sufficient to affect onsite transportation infrastructure. The greatest infrastructure impacts are expected at WIPP under the Centralized Alternative.

DOE evaluated the impacts on site infrastructure by comparing existing onsite capacities to requirements for water, wastewater treatment, and power under the alternative configurations for TRUW management (see Table 8.12–1). Water and power requirements were evaluated for both construction and operations; wastewater treatment was evaluated only for operations because construction wastewater was assumed to be negligible.

Table 8.12–1. Infrastructure Impacts Evaluated for TRUW Alternatives

Infrastructure Impact Analyzed	Affected Infrastructure Elements	Analysis Method	Presentation of Results
Onsite capacity to support TRUW facilities	Capacity of onsite water, power, and wastewater systems	Add increased TRUW facility use to current use—compare to current capacities	Table 8.12–2
	Onsite transportation infrastructure	Compare new site employment with current site employment as an index of increased stress	Table 8.12–3
Capacity of community infrastructure to support increased worker populations and their families	Regional water, power, wastewater treatment, and transportation infrastructure	Compare population increase with current regional population as an index of increased demand	Text discussion only

Where onsite maximum capacity information was unavailable, the proposed requirement was evaluated as a percentage of current use. Increased site employment (Table 8.12-2) was used as an indicator of potential impacts to onsite transportation infrastructure. Offsite infrastructure impacts were evaluated using estimates of increased population through in-migration of workers as an indicator of increased demand on community infrastructure.

Table 8.12–3 shows the increase in onsite demand for water, wastewater treatment, and power at sites where the increase exceeds 5%. The potential for a major impact is assumed to exist where an increase of 5% or greater causes total demand to exceed 90% of capacity. A moderate impact is assumed where total demand remains below 90% of capacity.

As shown in Table 8.12–3, with the single exception of WIPP under the Centralized Alternative, all of the onsite infrastructure impacts relate to demand for wastewater treatment or power. Wastewater treatment impacts would occur at Hanford under the Decentralized and all Regionalized Alternatives. Electrical power impacts would occur at INEL under all Regionalized Alternatives and the Centralized Alternative. The

Table 8.12–2. Percent Increase in Site Employment From Construction of TRUW Facilities (sites with employment increases equal to or greater than 5%)

Alternative	Number of Sites		Treatment Standard[a]	Hanford	INEL	LANL	WIPP
	CH Treat	RH Treat					
No Action[b]	11	5	WIPP-WAC				
Decentralized[c]	16	5	WIPP-WAC	6	6	7	
Regionalized 1	5	2	Reduce gas	7	7	8	
Regionalized 2	5	2	LDRs	9	9	7	
Regionalized 3	3	2	LDRs	9	11		
Centralized	WIPP	2	LDRs	6			**162**

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW. Bold indicates potential for major effects on transportation infrastructure onsite. Blank cells indicate an increase of less than 5%.
[a] Treatment standards include WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria; Reduce gas = intermediate TRUW treatment to reduce volatile gas generation; and LDRs = Land Disposal Restrictions criteria.
[b] For the No Action Alternative, storage is indefinite; no disposal at WIPP is assumed. However, impacts are provided for only the first 20 years of indefinite storage (see Section 8.3.1). For all other alternatives, disposal at WIPP will occur, but the alternatives do not include disposal actions.
[c] In the Decentralized Alternative, TRUW is processed at all 16 sites then transferred to 10 sites for interim storage.

Table 8.12–3. Increase in Demand for Water, Wastewater, or Power as a Percent of Current Capacity—TRUW (sites with increases exceeding 5%)

Alternative	Number of Sites		Treatment Standard[a]	Hanford	INEL	WIPP
	CH Treat	RH Treat				
No Action [b]	11	5	WIPP-WAC			
Decentralized [c]	16	5	WIPP-WAC	Wastewater (5.9)		
Regionalized 1	5	2	Reduce gas	Wastewater (7.0)	Power (6.4)	
Regionalized 2	5	2	LDRs	Wastewater (7.8)	Power (6.6)	
Regionalized 3	3	2	LDRs	Wastewater (7.8)	Power (6.6)	
Centralized	WIPP	2	LDRs		Power (6.6)	Water (7.7) Wastewater (82) Power (50.0)

Notes: CH = contact-handled TRUW; RH = remote-handled TRUW. Blanks indicate increases of 5% or less.
[a] Treatment standards include WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria; Reduce gas = intermediate TRUW treatment to reduce volatile gas generation; and LDRs = Land Disposal Restrictions criteria.
[b] For the No Action Alternative, storage is indefinite; no disposal at WIPP is assumed. However, impacts are provided for only the first 20 years of indefinite storage (see Section 8.3.1). For all other alternatives, disposal at WIPP is assumed.
[c] In the Decentralized Alternative, TRUW is processed at all 16 sites then transferred to 10 sites for storage, and then to WIPP for disposal.

greatest impacts on water demand, wastewater treatment, and power would occur at WIPP under the Centralized Alternative. A 7.7% increase in WIPP's demand for water is expected to have a moderate impact on water supply under this alternative. A moderate to major impact on wastewater treatment would also occur, increasing the current demand for treatment by 82%.

A further evaluation found that this increase might exceed the capacity of the current treatment system by 61%. Current power demand at WIPP would increase by 50%, although this increase would not cause total power demand to exceed 90% of current capacity. If new construction were needed to increase the power system's capacity, additional environmental impacts and costs might result.

Although DOE intends to select sites for waste management on the basis of the WM PEIS, the PEIS will not be the basis for selecting specific locations for facilities at the sites. When selecting locations for facilities at sites, DOE will consider the results of relevant existing or new sitewide or project-level NEPA analyses, which would evaluate potential impacts on infrastructure at specific sites.

8.13 Cultural Resources Impacts

Construction and operation of TRUW facilities could adversely affect cultural resources. Cultural resources surveys would be conducted at the site before construction would begin; however, protection measures would be identified and implemented.

Cultural and paleontological resources, including prehistoric, historic, fossil, and Native American sacred sites (Executive Order 13007), may be affected at sites where treatment and storage facilities for TRUW are proposed. Table 4.3–8 in Chapter 4 describes the status of cultural resources surveys at the 16 proposed TRUW sites and the reported resources at those sites. However, the impacts of the construction of TRUW facilities on cultural resources cannot be effectively analyzed at the programmatic level because the extent of those impacts depends on identifying specific locations for proposed facilities at a site.

Although DOE intends to select sites for waste management on the basis of the WM PEIS, the PEIS will not be the basis for selecting specific locations for facilities at those sites. When selecting locations for facilities at sites, DOE will consider the results of relevant existing or new sitewide or project-level NEPA analyses, which would include analyses of potential impacts to cultural resources at particular locations on a site.

Land requirements for the construction of TRUW facilities are sufficiently small under all alternatives that DOE would probably have enough flexibility in siting them to avoid impacts on cultural resources. If not, measures would be taken to protect these resources.

8.14 Costs

Costs increase as the level of treatment increases. Treatment to meet WIPP-WAC costs about the same as treatment to reduce gas generation potential. Treatment to meet LDRs costs approximately 22% more than the two less intensive treatments. Transportation costs are lower than facility costs, making shipment to available facilities at other sites generally less expensive than building a new facility at a site.

As indicated in Table 8.14-1, DOE estimated costs for building and operating treatment and storage facilities, and for transportation (INEL, 1995a,b). DOE evaluated costs associated with TRUW management from both a life-cycle and process perspective using 1994 dollars.

8.14.1 LIFE-CYCLE COSTS

DOE evaluated facility costs for four phases of the life-cycle of facilities and their operations: pre-operations, construction, O&M, and decontamination and decommissioning. Life-cycle costs do not include speculative factors such as impacts to long-term land value.

- Costs for pre-operation activities consist of technology and site adaptation, including bench-scale tests and pilot plant demonstrations; permitting; plant startup and cold-run costs; and related conceptual design, safety analysis, project management, and contingencies.
- Construction costs consist of expenses for building construction, equipment purchase and installation, contractor overhead, design and inspection, construction management, project management, and contingencies. Mobilization and demobilization costs are included for portable treatment units.
- Operations and maintenance costs consist of expenses for annual operations labor and material; maintenance labor and equipment; utilities; contractor supervision and overhead; and related project management and contingencies.
- Decontamination and decommissioning costs consist of expenses for facility decontamination and demolition, closure, post-closure, and environmental monitoring activities.

8.14.2 PROCESS COSTS

DOE also analyzed costs based on treatment and storage. Treatment costs include costs to build and operate treatment facilities (such as thermal treatment) and common support facilities (such as maintenance, and certification/shipping facilities). DOE estimated costs for three treatment options: minimal treatment to current WIPP-WAC, an intermediate level of treatment to reduce gas generation potential, and treatment to meet LDRs. TRUW disposal is outside the WM PEIS scope; thus, life-cycle costs of disposal at WIPP were not included.

Table 8.14–1. Components of Cost Analysis

Impacts Assessed	Function Analyzed	Activities for Which Impacts are Assessed	Location of Impacts Assessment
Process costs	Treatment	Life-cycle costs for treatment including support facilities and retrieval/characterization facilities	Table 8.14–2
	Storage	Life-cycle costs for storage facilities for one-year of treatment production was included, assuming a moderate delay from treatment to shipment to disposal	Table 8.14–2
Transportation cost	Truck	Inter-site common carrier costs for transportation from generating sites to treating sites, and to disposal sites	Table 8.14–2
	Rail	See above	Table 8.14–2

Note: No Action Alternative includes 20 years of storage and limited operations and maintenance.

For the purpose of the WM PEIS analysis, TRUW storage capacity for one year of treatment was included, assuming a moderate delay from the completion of treatment until the waste is transported for disposal.

Transportation costs include the costs associated with the physical movement of waste from one site to another, for treatment, storage, or disposal. Transportation costs are evaluated for both truck and rail shipments (INEL, 1995a).

A summary of costs is shown in Table 8.14–2 based on 20 years of treatment and storage (INEL, 1996). The total cost of treating to reduce gas generation is only slightly more (4%) than treating to WIPP-WAC. The total cost of treating to meet LDRs in a comparable regional configuration is approximately 22% more than treating to WIPP-WAC. As waste is consolidated at fewer sites, costs for treatment to meet LDRs decrease, illustrating the economy of scale of using larger and fewer facilities.

Under the No Action Alternative, DOE would treat only waste that required urgent repackaging to prevent leakage at the site. The No Action Alternative costs provide a baseline for comparison with the other alternatives. The relative proportion of truck transportation costs is small, varying from 0% to 8% of the total costs. Rail transportation costs vary from 0% to 20% of the total costs.

Table 8.14–2. Life-Cycle Costs (billions of 1994 dollars)

Alternative	Number of Sites		Treat Standard	Total Costs[a] (including truck transportation)	Life-Cycle Costs				Process Costs[b]			Transportation Costs	
	CH Treat	RH Treat			Pre-ops	Const	O&M	D&D	RC	T	S	Truck	Rail
No Action[c]	11	5	WIPP-WAC	1.7	0	0	1.47	0.24	0	1.48	0.23	0	0
Decentralized[d]	16	5	WIPP-WAC	7.4	0.4	1.72	3.40	1.35	2.15	4.42	0.31	0.56	1.44
Regionalized 1	5	2	Reduce gas	7.7	0.5	1.79	3.53	1.36	2.15	4.70	0.33	0.51	1.40
Regionalized 2	5	2	LDRs	9.0	0.6	2.42	4.13	1.38	2.15	6.09	0.29	0.45	1.24
Regionalized 3	3	2	LDRs	8.5	0.6	2.31	3.80	1.31	2.15	5.61	0.24	0.49	1.29
Centralized	WIPP	2	LDRs	7.9	0.5	2.21	3.49	1.18	2.15	5.17	0.06	0.51	1.33

Notes: Pre-ops = preoperations; Const = construction; O&M = operations and maintenance; D&D = decontamination and decommissioning; RC = retrieval and characterization; T = treatment; S = storage; CH = contact-handled; RH = remote-handled.

[a] Total Facility Costs are presented twice in this table: as life-cycle costs and as process costs. The sum of life-cycle costs is equal to the sum of process costs. In Total Costs, also in the table, truck transportation costs are added to the facility costs. Therefore, Total Costs equal the sum of life-cycle costs and truck transportation costs and also equal the sum of process costs and truck costs.

[b] The costs of current storage are included in the site infrastructure costs, which are not included in this PEIS. The cost of one-year's storage after treatment, but prior to shipment for disposal at WIPP, is included.

[c] For the No Action Alternative storage is indefinite, costs are only estimated for 20 years, and no disposal at WIPP is assumed. However, costs are provided for only the first 20 years of indefinite storage (see Section 8.3.1). For all other alternatives, disposal at WIPP is assumed.

[d] In the Decentralized Alternative, TRUW is processed at all 16 sites, then transferred to 10 sites for interim storage, and then sent to WIPP for disposal.

8.15 Environmental-Restoration-Transferred Waste

The total volume of TRUW generated by environmental restoration activities that would be transferred to the waste management program is currently estimated to be about 60% of the volume of waste management TRUW. Because the radiological and hazardous chemical profiles and physical characteristics of the environmental restoration (ER) transferred TRUW have not yet been determined to the extent necessary to allow a meaningful evaluation of the potential environmental and human health impacts, the potential effects resulting from the treatment of the ER transferred TRUW are discussed separately in the WM PEIS. When the radiological and physical characteristics of the ER transferred waste are better known, DOE may need to assess the impacts of managing the ER transferred TRUW on a site-specific basis.

DOE is responsible for the management of wastes currently in inventory and those generated by future operations (referred to as "waste management" wastes). As discussed in Chapter 1, DOE is also responsible for the management and remediation of contaminated media, such as soils, groundwater, and buildings. DOE expects that most of the contaminated media at its sites will be remediated under the Environmental Restoration Program. The extent to which media are "cleaned up" is site-specific and will depend largely on regulatory requirements and decisions regarding future land use. For analysis purposes, a standard "base case" scenario was developed that estimates remediation costs across the DOE complex (DOE, 1996c). Although most waste generated by cleanup activities will be managed within the Environmental Restoration Program, some of the waste generated by these activities will be transferred to waste management facilities. In the WM PEIS, these wastes are referred to as "environmental restoration (ER) transferred wastes." At present, only estimates of the volumes of ER transferred waste are available. These estimates were used to provide a qualitative assessment of how the addition of ER transferred waste might impact TRUW alternatives described in this chapter.

Appendix B provides more detail about how some of the wastes generated during environmental restoration activities will be transferred to the waste management program for final disposition, and provides estimates of the volumes of ER transferred TRUW. Appendix B also discusses the assumptions and uncertainties involved in assessing how the ER transferred TRUW may affect waste management alternatives.

To conduct a health risk impact analysis for the additional ER transferred TRUW similar to that conducted for waste management TRUW, additional information is needed on the ER transferred waste streams. In addition to the volume of ER transferred waste, information is needed on the treatability of the individual transferred TRU waste streams that would include data about the radiological profile, chemical constituents, and physical form of the transferred waste. Characterization of the ER transferred wastes into one of the treatment categories identified for TRUW is needed to estimate the degree of further treatment needed and, thereby, the waste management costs. Information about the timing of the transfer of ER wastes to the waste management program is needed to determine the capacities of treatment and disposal facilities. This information is also crucial to conduct transportation and socioeconomic analyses. However, in many cases, this information will not be available until site-specific cleanup is underway.

To identify how the addition of ER transferred TRUW could affect the comparisons among waste management alternatives evaluated in the WM PEIS, DOE compared the volumes of waste management TRUW with the expected volumes of ER transferred TRUW. This analysis reveals the potential for

exceeding the capacity of treatment facilities of those sites and for those alternatives where the volume of ER transferred TRUW equals or exceeds the volume of waste management TRUW. Strategies that might be used to manage the additional ER transferred waste at these sites include increasing facility operational capacity and operating a facility longer to "work off" the increased waste load. The WM PEIS treatment facilities are assumed to have an effective operational life of at least 30 years, which allows for an additional 20 years of operational capacity beyond the 10 years needed to work off the waste management wastes.

Increased radiation and chemical exposure risks to site workers, offsite populations, and the environment are a function of the chemical constituents and radiological activity in the ER transferred wastes, which, at present, cannot be reliably predicted. However, because radiological activities and chemical concentrations of ER transferred waste are, in general, expected to be lower than those of comparable waste management waste, risks from the addition of ER transferred wastes are expected to be lower than those from the treatment of equivalent volumes of waste management wastes. Site-specific performance assessments would be conducted, and appropriate treatment restrictions would be imposed to manage any potential increased risks. The risks from physical hazards associated with operating treatment facilities to manage the ER transferred waste are related to the volume relationship between the ER transferred and waste management wastes. Transportation risks and costs are also dependent on waste volume rather than the composition of the waste.

Overall, the volume of ER transferred TRUW is expected to be about 60% of the waste management TRUW load (80,000 cubic meters compared with 132,000 cubic meters, respectively) (see Table B.6–1 in Appendix B). The additional ER transferred waste would affect waste treatment at SRS under the Decentralized and Regionalized Alternatives (see Table B.7-3). The additional ER transferred TRUW at SRS is expected to be 380% of the waste management load. The additional ER transferred TRUW would have little impact on the Centralized Alternative.

8.16 Comparison of Alternatives Summary

Health Risks. The most adverse health risks would occur under alternatives where TRUW is treated to meet LDRs—in Regionalized Alternatives 2 and 3 and the Centralized Alternative. These alternatives require the thermal treatment of organic TRUW, which would result in emissions of radionuclides (Pu-238 and Am-241) that have the most significant impact on offsite cancer risks. Although waste management

worker fatalities would result primarily from physical trauma, fatalities are lower when TRUW is treated to meet WIPP-WAC or reduce gas generation than when it is treated to meet LDRs. Estimated transportation fatalities are low in all alternatives.

Air Quality Impacts. The management of TRUW would not affect the air quality at most sites; however, emissions of radionuclides were estimated to exceed the applicable standards at LANL and WIPP in the alternatives involving treatment to meet LDRs at these sites (Regionalized Alternative 2 at LANL and the Centralized Alternative at WIPP). The exceedances at these sites could require additional measures to reduce emissions to acceptable levels. Emissions of other hazardous air pollutants and criteria pollutants were estimated to be below the applicable standards at all sites.

Water, Ecological, Cultural, and Land Use Impacts. Major impacts to these resources at the sites are unlikely for treatment of TRUW under any of the alternatives. However, ecological and cultural impacts analysis would require that further site-specific studies be conducted before locations for specific facilities would be selected at sites.

Economic Impacts. Nationwide, the largest economic effects of TRUW management would occur under the Decentralized Alternative and would generally decrease as the alternatives become more centralized. The greatest benefit at any site occurs when TRUW is managed at that site. The greatest number of jobs attributable to management of TRUW, as a percentage of the regional baseline, would occur at INEL and WIPP under Regionalized Alternative 3 and the Centralized Alternative, respectively. None of the TRUW alternatives would substantially affect the national economy, although some 1,900 to 12,000 jobs would be directly or indirectly created.

Population Impacts. No major population increases are expected to occur at any site under any alternatives and thus, community characteristics and the provision of services would not be affected.

Environmental Justice Concerns. Assessment of potential environmental justice concerns associated with TRUW management indicated a potential for disproportionately high and adverse health risks or environmental impacts to minority and low-income groups at the INEL and WIPP sites. This potential would be mitigated by selection of an alternative treatment technology, employment of more efficient emissions controls, and other measures.

Infrastructure Impacts. Infrastructure impacts on water use, wastewater treatment, and power are comparable for the Decentralized and Regionalized Alternatives but are much greater at WIPP under the Centralized Alternative.

Costs. Costs increase as the level of treatment increases. Treatment to WIPP-WAC and treatment to reduce gas generation potential cost approximately the same in nondiscounted 1994 dollars. Treatment to meet LDRs costs approximately 22% more in nondiscounted 1994 dollars. Transportation costs are lower than facility costs, making shipment to available facilities at another site generally less expensive than building a new facility when one does not exist at a site. The details of cost estimating are covered in Section 5.3.3 of Chapter 5.

Summary of Impacts by Alternative. Table 8.16–1 summarizes the impacts of each alternative.

The Preferred Alternative. Most of the Department's sites with TRUW would treat and store it onsite. Five sites would ship TRUW to other sites for treatment under the preferred alternative: Pantex would ship its de minimis inventory of TRUW to LANL; RFETS would ship some of its TRUW to INEL for treatment; ORR would send its CH-TRUW to SRS for treatment; SRS would send its RH-TRUW to ORR for treatment; and SNL-NM would send its TRUW to LANL for treatment. This preference assumes that the Waste Isolation Pilot Plant (WIPP) will require treatment to the waste acceptance criteria the Department has proposed to the Environmental Protection Agency for this geologic repository. The Department's preference could change if WIPP requires a different level of treatment. The Department would store its TRUW where it is treated pending a decision on its disposal or other disposition.

DOE's preferred alternative is a combination of parts of the Decentralized Alternative and several of the Regionalized Alternatives as shown in Table 3.7–1. It provides for cost-effective management of TRUW, poses low potential risks to the public, and has relatively small environmental impacts. DOE's preference is consistent with the preferred alternative identified in the Draft Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement (WIPP SEIS II) (DOE, 1996e).

Table 8.16–2 provides potential impacts for the preferred alternative by combining the impacts evaluated in the WM PEIS for the preferred alternative at each site. Treatment and storage impacts are taken from Volume II site data tables for the preferred alternative specified in the second row of Table 8.16–2.

Table 8.16–1. Comparison of TRUW Alternatives—Selected Impacts

Alternative	Number of Sites		Treatment Standard	Treatment Worker Physical Hazard Fatalities	Treatment Worker Cancer Fatalities	Offsite Population Cancer Fatalities	Truck Radiation Fatalities	Truck Non-Radiation Fatalities	Number of Sites With Air Pollutants That Exceed Standards	Highest Air Pollutant Percentages at Any Site	Truck Shipments	Cost ($ Billions)	Comment
	CH Treat	RH Treat											
No Action[a]	11	5	WIPP-WAC	*	*	*	0	0	0	8 (CO-RFETS)	0	1.7	Extended Storage not in compliance with RCRA
Decentralized[b]	16	5	WIPP-WAC	2	1	*	4	3	0	49 (NO_2-ANL-E)	24,000	7.4	10 sites provide interim storage, then ship to WIPP
Regionalized 1	5	2	Reduce gas	3	1	*	3	3	0	40 (NO_2-ANL-E)	22,000	7.7	4 western, 2 eastern sites shred and grout to reduce gas generation
Regionalized 2	5	2	LDRs	4	1	1	3	2	1	134 (Rad-LANL)	19,000	9.0	4 western, 2 eastern sites treat to meet LDRs
Regionalized 3	3	2	LDRs	3	1	*	3	3	0	34 (NO_2-ANL-E)	21,000	8.5	2 western, 2 eastern sites treat to meet LDRs
Centralized 5	WIPP	2	LDRs	2	1	*	3	3	1	137 (Rad-WIPP)	22,000	7.9	WIPP + 1 eastern, 1 western site treat to meet LDRs

CH = contact handled TRUW; RH = remote handled TRUW; LDRs= Land Disposal Restrictions; WIPP-WAC = Waste Isolation Pilot Plant-Waste Acceptance Criteria; * = greater than 0 but less than 0.5.
[a] For No Action Alternative, storage is indefinite, no disposal at Waste Isolation Pilot Plant is assumed; however, risks are provided for only the first 20 years of indefinite storage (see Section 8.3.1). For all other alternatives, disposal at WIPP is assumed.
[b] In Decentralized Alternative, TRUW is processed at all 16 sites, then transferred to interim storage at 10 sites, then to WIPP.

Table 8.16–2. The Preferred TRUW Alternative—Selected Impacts

Impact Area	Decision	ANL	Hanford	INEL[c]	LLNL	LANL	NTS	ORR	Pantex	PGDP	RFETS	SNL-NM[d]	SRS	WIPP	WVDP[d]	Total
Preferred alternative	T	D	D	R3	D	D	D	R1	*[e]	D	D	R1	R1	D	D	
Worker physical hazard fatalities	T	1.2E-01	2.6E-01	1.8E+00	1.1E-01	3.8E-01	6.8E-02	1.0E-01	--	1.3E-02	2.1E-01	--	1.5E-01	--	--	3.2E+00
Worker cancer fatalities	T	8.8E-03	1.3E-01	2.5E-01	5.6E-04	1.4E-01	2.1E-04	2.8E-03	--	4.6E-07	7.7E-03	--	7.7E-02	--	--	6.2E-01
Offsite population cancer fatalities	T	2.0E-06	2.3E-05	4.1E-02	3.5E-06	5.4E-05	1.1E-10	8.3E-07	--	3.5E-09	9.3E-06	--	1.4E-04	--	--	4.1E-02
Truck radiation fatalities	These numbers reflect intersite transportation results and are not attributable to individual sites.															≤4
Truck nonradiation fatalities																≤3
Highest air pollutant percentage		49% NO_2	2% NO_2	17% PM_{10}	0%	1% NO_2	6% CO	0%	--	1% NO_2	19% CO	--	1% NO_2/PM_{10}	--	--	No sites exceed
Cost (10^9 \$)[a]		0.33	1.81	2.49	0.23	0.92	0.096	0.48	--	0.05	0.38	--	0.86	--	--	7.65
Truck shipments[b]		590	10,260	7,610	260	1,590	90	2,440	--	10	830	10	1,240	23,860	--	48,790

[a] Cost for truck transportation (estimated at \$0.6 billion) were added to these site totals for a total alternative cost of \$8.2 billion.
[b] Shipments include inbound shipments to INEL (2,060), ORR (390), and SRS (160). Total one-way shipments between two sites, as defined for shipment totals in Table 8.16–1, are 48,790 ÷ 2 = 24,395 shipments.
[c] Includes impacts of onsite treatment of RH-TRUW to meet current WIPP-WAC.
[d] SNL-NM and WVDP are included because they are major sites that would manage TRUW onsite under the Regionalized 1 and Decentralized Alternatives, respectively, noted here as the Preferred Alternatives at those sites. However, health risks and environmental impacts were not evaluated at SNL-NM and WVDP; they are expected to be minimal because the TRUW volumes are very small (less than 2 cubic meters).
[e] The current DOE plan is to ship the very small amount of CH-TRUW at Pantex to LANL for treatment and storage.

Chapter 8
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Transuranic Waste Alternatives

Alt.	CH Treat	RH Treat	Treat Stand	ANL-E	Hanford	INEL	LANL	LLNL	NTS	ORR	PGDP	RFETS	SNL-NM[d]	SRS	WIPP	WVDP[d]
No Action	11	5	WIPP WAC	TS	TS	TS	TS	TS	S	TS	S	TS	S	TS		S
D	16	5	WIPP-WAC	TS	TS	TS	TS	TS	TS	TS	T	TS	T	TS		T
R-1	5	2	Reduced gas		TS[a]	TS	TS			TS[b]		TS		TS		
R-2	5	2	LDRs		TS[a]	TS	TS			TS[b]		TS		TS		
R-3	3	2	LDRs		TS[a]	TS				TS[b]				TS		
C	WIPP	2	LDRs		TS[c]					TS[b]					T	

Notes: T = treatment to one of three standards: process to current WIPP-WAC; shred and grout to reduce potential for gas generation in the repository (Reduced gas); and treat to meet LDRs using thermal organic destruction and complete treatment train. S = storage after treatment for one year, prior to transport for disposal, for all alternatives except No Action or store current inventory under No Action Alternative. Blanks indicate that TRUW is not treated or stored at a site under the specified alternative.

[a] The Hanford Site treats both CH and RH waste.

[b] ORR treats RH waste only.

[c] The Hanford Site treats RH waste only.

[d] SNL-NM and WVDP are included because they are major sites that would manage TRUW onsite under the Regionalized 1 and Decentralized Alternatives, respectively; noted here as the preferred alternatives at those sites. However, health risks and environmental impacts were not evaluated at SNL-NM and WVDP; they are expected to be minimal because the TRUW volumes are very small (less than 2 cubic meters).