TABLE 5.2.5-1 National Environmental Research Parks and Other Natural Management Resource Areas within the Alternative Sites Proposed for a GTCC Disposal Facility

DOE Site	National Environmental Research Park	Other Natural Resource Areas
Hanford Site	Established in 1983, 366,000 acres.[a] Allows for comparative studies of ecological processes in sagebrush-steppe ecosystems.	Hanford Reach National Monument: Approximately 200,000 acres divided into six administrative units: • Fitzner-Eberhardt Arid Land Ecology Reserve: 77,000 acres • McGee Ranch-Riverlands Unit: 9,100 acres • Vernita Bridge Recreation Area: 800 acres • River Corridor Unit: 25,000 acres • Saddle Mountain Unit/Saddle Mountain National Wildlife Refuge: 32,000 acres • Wahluke Unit: 57,000 acres
Idaho National Laboratory (INL)	Established in 1975, 568,300 acres. Allows for comparative studies of ecological processes in sagebrush-steppe ecosystems to demonstrate the compatibility of energy technology development and a quality environment.	INL Sagebrush Steppe Ecosystem Reserve: 74,000 acres
Los Alamos National Laboratory (LANL)	Established in 1973, 28,400 acres. Allows for research in arid pinyon-juniper communities and their interface with coniferous forests and mountain meadows and valleys under various levels of stress and for the development of technology to resolve regulatory and compliance-related problems.	White Rock Reserve: Approximately 1,000 acres at TA-70 and TA-71
Nevada National Security Site (NNSS)	Established in 1992, 865,000 acres. Allows for investigations of environmental restoration and waste management activities.	NE[b]

TABLE 5.2.5-1 (Cont.)

DOE Site	National Environmental Research Park	Other Natural Resource Areas
Savannah River Site (SRS)	Established in 1972, 198,000 acres. Allows for ecological research of cypress swamp and southeastern pine and hardwood forests and for protection from public intrusion and most site-related activities. Includes 30 DOE Research Set-Aside Areas that are representative habitats on SRS.	• Crackerneck Wildlife Management Area and Ecological Reserve: 11,200 acres • Red-Cockaded Woodpecker Management Area: 87,200 acres • Supplemental Red-Cockaded Woodpecker Management Area: 47,100 acres • Savannah River Swamp Management Area: 10,000 acres • Lower Three Runs Corridor Management Area: 4,400 acres
Waste Isolation Pilot Plant (WIPP)	NE	NE
Waste Isolation Pilot Plant (WIPP) Vicinity	NE	NE

[a] To convert to hectares, multiply the acreage by 0.405.

[b] NE = not established. No NERP or other natural resource area designation has been established at the WIPP or WIPP Vicinity. No other natural resource area designation has been established for NNSS.

Sources: DOE (2000, 2007a); Evans et al. (2003); The Nature Conservancy (2003); USFS (2005)

The analysis of the impacts of a GTCC waste disposal facility on environmental justice issues follows guidelines described in *Environmental Justice Guidance under the National Environmental Policy Act* (CEQ 1997). The analysis method has three parts: (1) the geographic distribution of low-income and minority populations in the affected area is described; (2) an assessment is made of whether the impacts from construction and operations would be high and adverse; and (3) if the impacts would be high and adverse, a determination is made of whether these impacts would disproportionately affect minority and low-income populations.

Construction and operations of a GTCC waste disposal facility could affect environmental justice if any adverse health and environmental impacts resulting from either phase of development were significantly high and if these impacts disproportionately affected minority and low-income populations. If an analysis that accounted for any unique exposure pathways (such as subsistence fish, vegetation or wildlife consumption, or well-water consumption) determined that health and environmental impacts would not be significant, there could be no high and adverse impacts on minority and low-income populations. If impacts were found to be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations. Information needed to conduct the analysis would be collected and developed to support future evaluations that would be included in follow-on documents for the selected alternatives.

The analysis of environmental justice issues considered impacts in an 80-km (50-mi) buffer around the GTCC reference location in order to include any potential adverse human health or socioeconomic impacts related to the construction and operations that might occur. Accidental radiological releases, for example, have the potential to affect minority and low-income population groups located some distance from the site, depending on the size and nature of potential releases and on meteorological conditions. Any accidental release to the environment also has the potential to affect fish and other natural resources that might be used for subsistence by low-income and minority population groups located some distance from the site. The extent would depend on the size and nature of any potential release at the site.

The description of the geographic distribution of minority and low-income groups was based on demographic data from the 2000 Census (U.S. Bureau of the Census 2008). The following definitions were used to define minority and low-income population groups.

- *Minority.* Persons are included in the minority category if they identify themselves as belonging to any of the following racial groups: (1) Hispanic, (2) Black (not of Hispanic origin) or African American, (3) American Indian or Alaska Native, (4) Asian, or (5) Native Hawaiian or other Pacific Islander.

  Beginning with the 2000 Census, where appropriate, the census form allows individuals to designate multiple population group categories to reflect their ethnic or racial origin. In addition, persons who classify themselves as being of multiple racial origins may choose up to six racial groups. The term "minority" includes all persons, including those classifying themselves in multiple racial categories, except those who classify themselves as "White" (U.S. Bureau of the Census 2008).

  The CEQ guidance proposed that minority populations should be identified where either (1) the minority population of the affected area exceeds 50% or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

  The EIS applies both criteria in using the Census Bureau data for census block groups, wherein consideration is given to the minority population that is both more than 50% and 20 percentage points higher in the block than it is in the state (the reference geographic unit).

- *Low-income.* Individuals who fall below the poverty line. The poverty line takes into account family size and age of individuals in the family. The poverty threshold for 2009 for a family of five with three children below the age of 18 was $25,603. For any given family below the poverty line, all family members are considered as being below the poverty line for the purposes of analysis in the EIS. Although the poverty line is estimated annually, the data are not available at the census block group level used in the EIS analysis.

5.2.8 Land Use

Land Use

Land use is a classification of parcels of land relative to the presence of human activities (e.g., industry, agriculture, and recreation) and natural areas.

Land use is a classification of parcels of land relative to the presence of human activities (e.g., industry, agriculture, recreation) and natural areas. This section provides an overview of the considerations and data used to describe land use at the alternative sites. The evaluation of the potential impacts on land use from construction, operations, and post-closure of a GTCC waste disposal facility at each site depends on an adequate understanding of the existing land use at each alternative site and of whether the proposed GTCC waste disposal facility would be consistent with existing land use designations. The descriptions of land use for each alternative site cover the current land uses (1) at the DOE sites and WIPP Vicinity (including Section 35 that is administered by BLM), (2) in the areas surrounding the sites, and (3) within the GTCC reference location. The affected environment sections address past and current land uses that have influenced the GTCC reference location at each alternative site. The information presented for each site was obtained primarily from previous environmental studies and from various documents prepared for the alternative sites. The land use descriptions for each alternative site pay particular attention to special land uses both within and surrounding the alternative sites. These include national parks, designated wilderness areas, state lands (e.g., recreation areas and parks), NERPs or other natural resource designations, designated waste management areas, and so forth. Such land use attributes could be important considerations in determining which alternative sites are more suitable for locating the GTCC waste disposal facility.

5.2.9 Transportation

The transportation risk analysis estimated both radiological and nonradiological impacts associated with the shipment of GTCC LLRW and GTCC-like waste during disposal facility operations from their points of origin to the disposal sites considered in this EIS. Further details on the risk methodology and input data are provided in Section C.9 of Appendix C.

5.2.9.1 General Approach and Assumptions

Transportation impacts from both truck and rail shipments were estimated for each waste type considered. In either case, the shipment configurations and the number of shipments required were the same for each of the land disposal methods considered.

This EIS evaluates the total number of shipments expected over the life of the disposal facility. Shipment of waste is not presented on an annual basis because of the uncertainty associated with the time of future waste generation and disposal facility operations. Appropriate shipment schedules would be proposed in the future as part of a further analysis once a disposal site and a disposal method were selected.

The transportation risk assessment considers human health risks from routine transport (normal, incident-free conditions) of radiological materials and from potential accidents. In both cases, risks associated with the nature of the cargo itself, called "cargo-related" impacts, are considered. Risks related to the transportation vehicle (regardless of type of cargo), called "vehicle-related" impacts, are considered for potential accidents (see Figure 5.2.9-1 for an image of waste being loaded onto a transport vehicle). The transportation of hazardous chemicals is not part of this analysis because hazardous chemicals have not been identified as part of the waste inventory.

5.2.9.2 Routine Transportation Risk

The radiological risk associated with routine transportation is cargo-related and results from the potential exposure of people (including workers and the public) to low levels of external radiation near a loaded shipment. No direct physical exposure to radioactive material would occur during routine transport because these materials would be in packages designed and

FIGURE 5.2.9-1 Transport of Radioactive Waste Containers

maintained to ensure that they would contain and shield their contents during normal transport. Any leakage or unintended release would be considered under accident risks.

Collective population radiological risks were estimated for persons living in the vicinity of the shipment routes (off-link population), persons in all vehicles sharing the transportation route (on-link population), and persons who might be exposed while a shipment was stopped en route (persons at stops). For truck transportation, these stops include those for refueling, food, and rest. For rail transportation, stops were assumed to occur for purposes of classification.

Collective doses were also calculated for truck transportation crew members involved in the actual shipment of material and for railroad inspectors of rail shipments. Workers involved in loading or unloading were not considered. The doses calculated for the first three population groups were added together to yield the collective dose to the public; the dose calculated for the fourth group represents the collective dose to workers.

In addition to assessing the routine collective population risk, the radiological risks to individuals were estimated for a number of hypothetical exposure scenarios. Receptors included transportation crew members, departure inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living near a facility.

5.2.9.3 Accident Transportation Risk

The cargo-related radiological risk from transportation-related accidents lies in the potential release and dispersal of radioactive material into the environment during an accident and the subsequent exposure of people through multiple exposure pathways, such as exposure to contaminated soil, inhalation of airborne contaminants, or ingestion of contaminated food. The radiological transportation accident risk assessment estimated collective population risks as well as individual and population consequences.

The risk analysis for potential accidents differs fundamentally from the risk analysis for routine transportation because occurrences of accidents are statistical in nature. Accident risk is defined as the product of the accident consequence and the probability of the accident occurring. In this respect, the collective accident risk to populations is estimated by considering a spectrum of transportation-related accidents. The spectrum of accidents was designed to encompass a range of possible accidents, including low-probability accidents that have high consequences and high-probability accidents that have low consequences (e.g., "fender benders"). For radiological risk, the results for collective accident risk can be compared directly to the results for routine collective risk, because the latter results implicitly incorporate a probability of occurrence of 1 if the shipment takes place.

The calculation of the collective population dose following the release and dispersal of radioactive material includes the following exposure pathways:

- External exposure to the passing radioactive cloud,

- External exposure to contaminated ground,

- Internal exposure from inhalation of airborne contaminants, and
- Internal exposure from the ingestion of contaminated food (rural areas only).

Because predicting the exact location of a severe transportation-related accident is impossible when estimating population impacts, separate accident consequences were calculated for accidents occurring in three population density zones: rural, suburban, and urban. Moreover, to address the effects of the atmospheric conditions existing at the time of an accident, two atmospheric conditions were considered: neutral and stable. The highest-exposed individual for severe transportation accidents was considered to be located at the point of highest hazardous material concentration that would be accessible to the general public.

The vehicle-related accident risk refers to the potential for transportation accidents that could result directly in fatalities not related to the nature of the cargo in the shipment. This risk represents fatalities from physical trauma. State-average rates for transportation fatalities are used in the assessment. Vehicle-related accident risks are calculated by multiplying the total distance traveled by the transportation fatality rates. In all cases, the vehicle-related accident risks are calculated on the basis of distances for round-trip shipments, since the presence or absence of cargo would not be a factor in accident frequency.

5.2.10 Cultural Resources

Cultural resources include archaeological and historic architectural sites and structures, as well as places from the past having important public and scientific uses, and may include definite locations (sites or places) of traditional cultural or religious importance to specified social or cultural groups, such as American Indian tribes ("traditional cultural properties"). Cultural resources can be either man-made or natural physical features associated with human activity and, in most cases, are unique, fragile, and nonrenewable. Cultural resources that meet the eligibility criteria for listing on the *National Register of Historic Places* (NRHP) are termed "historic properties" under the National Historic Preservation Act (NHPA).

NHPA is a comprehensive law that creates a framework for managing cultural resources in the United States. It expands the NRHP; establishes State Historic Preservation Offices (SHPOs), Tribal Historic Preservation Offices, and the Advisory Council on Historic Preservation (ACHP); and provides a number of mandates for federal agencies. Section 106 of NHPA directs all federal agencies to take into account the effects of their undertakings (actions and authorizations) on cultural resources included in or eligible for the NRHP (i.e., "historic properties"). Section 106 of the Act is implemented by regulations of the ACHP (36 CFR Part 800). Section 106 regulations permit agencies to integrate compliance with the NEPA process. The agencies are complying with their Section 106 responsibilities for this EIS through this provision. This EIS represents the first phase of the Section 106 process, and compliance focuses on consultation and the programmatic definitions of resources that might be affected; the types of effects that might be anticipated; and recommendations to agencies on avoiding, minimizing, or mitigating adverse effects if development of a GTCC disposal facility does occur at the indicated site. Full compliance with Section 106 would occur when specific proposals were acted upon. A compilation of laws and regulations pertinent to cultural resources is presented in Table 5.2.10-1.

TABLE 5.2.10-1 Cultural Resource Laws and Regulations

Law or Order Name	Intent of Law or Order
Antiquities Act of 1906	This was the first law to protect and preserve cultural resources on federal lands. It makes it illegal to remove cultural resources from federal land without a permit, establishes penalties for illegal excavation and looting, and allows the President to establish historical monuments and landmarks.
National Historic Preservation Act (1966) (NHPA)	This law created the legal framework for considering the effects of federal undertakings on cultural resources in the United States. The law expands the NRHP and establishes the ACHP, SHPOs, and Tribal Historic Preservation Offices. Section 106 and its accompanying regulations direct all agencies to take into account the effects of their actions on properties included in or eligible for the NRHP, and they establish the process for doing so.
Executive Order 11593, *Protection and Enhancement of the Cultural Environment* (1971)	Executive Order 11593 requires federal agencies to inventory their cultural resources and to meet professional standards for recording any cultural resource that may have been altered or destroyed.
Archaeological and Historic Preservation Act (1974) (AHPA)	The AHPA addresses impacts on cultural resources resulting from federal activities and provides a funding mechanism to recover, preserve, and protect archaeological and historical data.
Archaeological Resources Protection Act of 1979 (ARPA)	ARPA establishes civil and criminal penalties for the unauthorized excavation, removal, damage, alteration, or defacement of archaeological resources; prohibits trafficking in resources from public lands; and directs federal agencies to establish educational programs on the importance of archaeology.
American Indian Religious Freedom Act of 1978 (AIRFA)	AIRFA protects First Amendment guarantees to religious freedom for American Indians. It requires federal agencies to consult when a proposed land use might conflict with traditional Indian religious beliefs or practices and to avoid interference to the extent possible. It also requires that American Indians be allowed access to locations of religious importance on federal land.
Native American Graves Protection and Repatriation Act of 1990 (NAGPRA)	NAGPRA establishes the rights of Indian tribes to claim ownership of certain "cultural items," including human remains, funerary objects, sacred objects, and objects of cultural patrimony. It requires federal agencies and museums to identify holdings of such remains and work toward their repatriation. Excavation or removal of such cultural items requires consultation with groups showing cultural affinity with the items, as does discovery of these items during land use activities.
Executive Order 13007, *Indian Sacred Sites* (1996)	Executive Order 13007 defines sacred sites and directs agencies to accommodate Indian religious practitioners' access to and use of sacred sites, avoid adverse effects, and maintain confidentiality. It does not create new rights but strongly affirms those that do exist.

TABLE 5.2.10-1 (Cont.)

Law or Order Name	Intent of Law or Order
Executive Order 13287, *Preserve America* (2003)	Executive Order 13287 encourages the federal government to take a leadership role in the protection, enhancement, and contemporary use of historic properties and establishes new accountability for agencies with regard to inventories and stewardship.
National Environmental Policy Act (NEPA) (1969)	This law requires federal agencies to analyze the impacts of an action on the human environment in order to ensure that federal decision makers are aware of the environmental consequences of a project before implementation.

5.2.11 Waste Management

Wastes generated from the three land disposal methods were estimated to determine if the waste types and volumes could affect waste management programs at each of the sites being evaluated under Alternatives 3 to 5. Potential impacts were determined by identifying whether current site waste handling programs (or capacities, if information is available) include the types of waste generated by the construction and operation of the land disposal facilities under Alternatives 3 to 5. It is also assumed that no prior contamination would be encountered during construction of the land disposal facilities.

5.3 ENVIRONMENTAL CONSEQUENCES COMMON TO ALL SITES UNDER ALTERNATIVES 3 TO 5

Environmental consequences from Alternatives 3 to 5 that are not site-specific are summarized below and are not repeated in the discussions presented in Chapters 6 through 11 for each of the alternative land disposal sites. Because the proposed disposal facilities are expected to be available to contain the waste for a very long time (for the next hundreds of years), the decommissioning phase of the proposed action could be better evaluated at the time the disposal facility would be ready to be decommissioned. Hence, evaluations for the decommissioning phase are not included in this EIS; instead, subsequent NEPA documentation would be prepared at a later time to address the decommissioning phase.

Post-closure activities would include minimal activities, such as periodic visits for site inspection and monitoring, that would involve light- or medium-duty vehicle traffic and infrequent repair or maintenance activities, as needed. There would be no water demands during the post-closure period. However, given enough time (on the order of thousands of years), it is possible that groundwater at the various sites could become contaminated with some highly soluble radionuclides (e.g., C-14, Tc-99, and I-129). Indirect impacts on surface water (except at NNSS) could also result from aquifer discharges (of contaminated groundwater) to seeps, springs, and rivers. There would be no impact on geologic and soil resources, land use, and cultural resources during the post-closure phase, because there would not likely be any additional land disturbance and because no additional geologic materials or soil would be used. Monitoring activities during post-closure are also not expected to have adverse impacts on these resources. It is expected that potential impacts from the post-closure phase on all the resource areas evaluated (i.e., the resource areas discussed above in addition to ecological resources, socioeconomics, environmental justice, transportation, and waste management) would be less than those from the construction and operations phases as presented in the site-specific chapters. Potential human health impacts for the post-closure phase are presented in the site-specific chapters.

5.3.1 Climate, Air Quality, and Noise

The analysis for air quality and noise examined the potential impacts resulting from construction, operations, and post-closure activities of the three land disposal facilities being evaluated. Activities associated with these phases can have impacts both at the site of activity and away from it, as air emissions are dispersed and noise is propagated from the point of generation to other locations. Potential consequences on climate and air quality from Alternatives 3 to 5 are site dependent and are discussed in Chapters 6 through 11 for the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity, respectively. Noise impacts during construction and operations are discussed in Section 5.3.1.1. Section 5.3.1.2 provides a qualitative discussion regarding global climate impacts.

5.3.1.1 Noise

5.3.1.1.1 Construction. During construction, the commuter and delivery vehicles moving around the facilities and along the traffic routes would generate intermittent noise. However, the contribution to noise from these intermittent sources would be limited to the immediate vicinity of the traffic route and would be minor in comparison with the contribution from continuous noise sources, such as compressors or bulldozers, during construction. Sources of noise during construction of the GTCC waste disposal facility would include standard construction activities involved with moving earth and erecting concrete and steel structures. Noise levels from these activities would be comparable to those from other construction sites of similar size. The noise levels would be highest during the early phases of construction, when heavy equipment would be used to clear the site. Typically, this early phase of construction would last for a few months of the entire construction period.

In general, the dominant noise source for most construction equipment is an insufficiently muffled diesel engine. However, noise from pile driving or pavement breaking would dominate in cases where these activities were involved. During construction, a variety of heavy equipment would be used. Average noise levels for typical construction equipment range from 74 dBA for a roller to 101 dBA for a pile driver (impact) at a distance of 15 m (50 ft) from a source (Hanson et al. 2006). Data on the typical noise from a bucket auger, which would be heavily used for borehole drilling, are not available, but data on noise from typical diesel-powered equipment indicate that the noise would range from 84 to 89 dBA (Barnes et al. 1977).

Accordingly, except for pile drivers and rock drills, most construction equipment has noise levels of 75 to 90 dBA at a distance of 15 m (50 ft) from the source. The types and amounts of construction equipment noise levels on a peak day under the three land disposal methods are presented in Table 5.3.1-1.

With regard to noise, when a known noise-sensitive receptor (e.g., school, hospital) is adjacent to a construction project and/or stringent local ordinances or specifications apply, a detailed impact analysis is warranted. However, for a general assessment of construction, it is adequate to assume that only the two noisiest pieces of equipment would operate simultaneously in order to estimate noise levels at the nearest receptor (Hanson et al. 2006). The highest composite noise levels from construction activities (e.g., two drill rigs) are estimated to be about 92 dBA at 15 m (50 ft) from the source. Considering geometric spreading only, and assuming a 10-hour daytime shift, the noise levels at a distance of 690 m (2,300 ft) from noise sources would be below the EPA guideline of 55 dBA as the L_{dn} for residential zones. This distance is smaller than the distance between the GTCC reference locations and the respective nearest known off-site residence. Estimated distances of the GTCC reference locations from the respective nearest known off-site residences are as follows: >6 km (4 mi) at Hanford; >11 km (7 mi) at INL; approximately 3.5 km (2.2 mi) at LANL (nearest residence in White Rock); >6 km (4 mi) at NNSS; >14 km (9 mi) at SRS; and >5 km (3 mi) at the WIPP Vicinity. The EPA guideline was established to protect against interference and annoyance due to outdoor activity (EPA 1974). Actual sound levels would be much lower as a result of air absorption and ground effects due to terrain and vegetation. Accordingly, noise from construction activities would be barely discernible or completely inaudible at the site boundaries and the nearest residences.

Most of these construction activities would occur during the day, when noise is tolerated better than at night because of the masking effects of background noise. Nighttime noise levels would drop to the background levels of a rural environment because construction activities would cease at night.

Construction activity can result in various degrees of ground vibration, depending on the equipment and construction methods used. Activities that typically generate the most severe vibrations are the detonation of high explosives and impact pile driving. All construction equipment causes ground vibration to some degree, but the vibration diminishes in strength with distance. For example, the vibration level at receptors beyond 70 m (230 ft) from a vibratory roller (94 VdB at 7.6 m [25 ft]) would diminish below the threshold of perception for humans and of interference with vibration-sensitive activities, which is around 65 VdB. During the construction phase, no major construction equipment that could cause ground vibration would be used. No sensitive structures would be located nearby. Therefore, there would be no adverse vibration impacts from construction activities.

5.3.1.1.2 Operations. During the operations phase, noise-generating activities would include those from the primary activities of receiving, handling, and emplacing waste packages and attendant noise sources from heavy equipment and vehicle traffic, similar to those at any other industrial site. It is estimated that between 2019 and 2035, there would be an annual

TABLE 5.3.1-1 Peak-Day Construction Equipment Usage by the Disposal Methods and Typical Noise Levels

Type of Construction Equipment	No.	Typical Level at 15 m (50 ft) from a Source (dBA)
Trench		
Loader	1	85
Dozer	1	85
Grader	1	85
Water truck	2	88
Vibratory roller	1	74
Dump truck	2	88
Borehole		
Loader	3	85
Dozer	1	85
Grader	1	85
Water truck	3	88
Vibratory roller	1	74
Dump truck	2	88
Drill rig	2	89
Vault		
Loader	3	85
Dozer	2	85
Grader	1	85
Water truck	1	88
Vibratory roller	1	74
Dump truck	3	88

Sources: Barnes et al. (1977); Hanson et al. (2006)

average of 570 truck shipments (Appendix D). Assuming 240 workdays per year, a daily average of slightly more than two shipments is anticipated.

When emplacement would take place at the disposal area, the operation of heavy equipment (e.g., a trailer tractor and a front-end loader) would generate a combined noise level of about 90 dBA at a distance of 15 m (50 ft) from the noise sources, a little lower than the level during construction. The noise levels at a distance of 530 m (1,700 ft) from noise sources would be below the EPA guideline of 55 dBA as the L_{dn} for residential zones. This distance is within the site boundaries evaluated for the land disposal methods, as discussed previously in Section 5.3.1.1.1. No residential locations exist within this distance. When other types of attenuation and the intermittency of operational activities are taken into account, these levels would be much lower. Accordingly, noise from operational activities would be barely discernible or completely inaudible at the site boundaries and the nearest residences.

As was the case for construction activities, no major heavy equipment that could cause ground vibration would be operating during operational activities, and no sensitive structures would be located nearby. Therefore, there would be no adverse vibration impacts from operations at the land disposal sites.

5.3.1.2 Climate Change Impacts

Climate changes are underway in the United States and globally, and they are projected to grow substantially over the next several decades unless immediate measures are taken to reverse this trend. Climate-related changes include rising temperature and sea level; increased frequency and intensity of extreme weather conditions (e.g., heavy downpours, floods, and droughts); earlier snowmelts and associated frequent wildfires; and reduced snow cover, glaciers, permafrost, and sea ice. After a thorough examination of the scientific evidence and careful consideration of public comments, the EPA announced on December 7, 2009, that greenhouse gases threaten the public health and welfare of the American people and should be considered within the Clean Air Act definition of air pollutants.

Greenhouse gases include those gases, such as water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, and perfluorocarbons, that are transparent to incoming solar (short-wave) radiation but opaque to long-wave (infrared) radiation and are thus capable of preventing long-wave thermal radiant energy discharged from the earth's surface from leaving earth's atmosphere. The net effect over time is a trapping of absorbed radiation and a tendency to warm the planet's surface and the boundary layer of the earth's atmosphere, which constitute the "greenhouse effect." Some greenhouse gases (CO_2, CH_4, and N_2O) are both naturally occurring and the product of industrial activities, while others (such as the hydrofluorocarbons) are man-made and are present in the atmosphere exclusively as a result of human activities. Each greenhouse gas has a different radiative forcing potential (the ability to affect a change in climatic conditions in the troposphere, expressed as the amount of thermal energy [in watts] trapped by the gas per square meter of the earth's surface). The radiative efficiency of a greenhouse gas is directly related to its concentration in the atmosphere.

This EIS presents an assessment comparing the CO_2 emissions estimated for the three land disposal methods with the CO_2 emissions for the states associated with the federal sites evaluated in Chapters 6 through 12 (i.e., Hanford Site, INL, LANL, NNSS, SRS, and the WIPP Vicinity). The assessment indicates that estimated CO_2 emissions from the borehole, trench, and vault disposal methods would be negligible. In addition, this Section 5.3.1.2 provides a qualitative assessment of the potential effects of global climate change on the proposed land disposal (borehole, trench, and vault) facilities for the long term, as discussed below.

Over a recent 50-year period (1958–2008), the annual average precipitation in the United States increased about 5%, but there were regional differences (Karl et al. 2009). The global climate change model predictions indicate that in the South, particularly in the Western United States, drier or prolonged drought conditions could arise, whereas Northern areas could become wetter.

Although the global climate change impacts are modeled only to the year 2100, these initial indications can be used to determine what impacts global climate change might have on the proposed borehole, trench, and vault waste disposal facilities at the various reference locations or regions evaluated in this EIS. On the basis of the global climate change predictions under a higher (i.e., worst-case) emission scenario (Karl et al. 2009), infiltration rates for the long term at sites located in the Southwest (e.g., LANL, NNSS, WIPP Vicinity, and the generic commercial location in the southern part of NRC Region IV) are expected to decrease slightly, while sites located in the Northwest would increase slightly (e.g., Hanford Site and INL). For sites in the Southeast, annualized precipitation rates are not expected to change much to 2100. On the basis of Karl et al. (2009), it can be said that the maximum increase or decrease in precipitation under a higher emission scenario would be plus or minus 10%. Under a lower emission scenario, these percentages would be lower, and thus climate changes would probably not have any significant impacts on the GTCC waste disposal operations and facilities. This is because essentially no precipitation changes are expected in humid sites such as SRS. For sites located in drier areas, such as Hanford, INL, LANL, NNSS, and WIPP Vicinity, small changes are expected. However, because current global climate change model projections extend only to the year 2100, it is uncertain whether the indications discussed here would continue for the 10,000-year period of interest for this EIS (i.e., human health estimates are carried out to 10,000 years and longer for post-closure performance of the borehole, trench, and vault disposal methods; see Section 5.3.4.3).

In addition to the potential increase or decrease in annualized precipitation rates, it is also predicted that global climate change impacts would result in more intense precipitation events (e.g., rainfall), which could affect the physical stability of the land disposal facilities. Global climate change impacts predicted also include temperature increases and a rise in the sea level. The modeled temperature increase of 2 to 11°F is not expected to impact the structural integrity of the facilities themselves or the waste contained in the facilities. The GTCC reference locations are not located in coastal areas and so are not likely be impacted by the rise in sea level.

5.3.2 Geology and Soils

Data on the geologic and soil material requirements for the borehole, trench, and vault disposal methods are provided in Table 5.3.2-1. Potential impacts on geology and soils from Alternatives 3 to 5 are site dependent and are discussed in Chapters 6 through 11 for the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.3 Water Resources

Impacts on water resources include direct and indirect impacts on surface waters and groundwater (unsaturated and saturated). Direct impacts are impacts that would occur at the place of origin. Indirect impacts would occur away from the point of origin. Direct and indirect impacts could occur during the construction, operations, and post-closure. Impacts could result from any of the three land disposal methods.

TABLE 5.3.2-1 Geologic and Soil Resource Requirements for Constructing a New GTCC Waste Disposal Facility, by Disposal Method[a]

	Amount Required (yd^3), by Method		
Material	Trench	Borehole	Vault
Concrete	25,600	18,600	88,200
Gravel	32,900	25,300	156,400
Sand	36,100	27,900	198,300
Clay	–[b]	–	56,000
Soil (from off-site)	–	–	254,000

[a] The values presented in this table are for facility construction only.

[b] A dash indicates "not required."

Direct and indirect impacts on surface water resources could include changes in surface water flow rates, depths, and quality. Direct and indirect impacts on groundwater could include changes in the rate of groundwater recharge, the depth to groundwater, its flow direction and velocity, and quality. Table 5.3.3-1 provides an estimate of the water needs for the three land disposal methods under consideration in this EIS. These estimates are the same for all sites. In addition, stormwater, truck washdown water, and sanitary waste water generated from the construction and operations of the three land disposal methods could be discharged at the various sites evaluated (see Table 5.3.11-1 for the estimated amounts). Tables 5.3.3-2 and 5.3.3-3 summarize direct and indirect impacts from the construction and operations, respectively, at all sites.

Site-dependent potential consequences on water resources under Alternatives 3 to 5 are discussed in Chapters 6 through 11 for the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.4 Human Health

The human health impacts associated with the disposal of GTCC LLRW and GTCC-like wastes are analyzed in this EIS for the construction, operations, and post-closure phases of the project. Different types of hazards and potentially impacted individuals were addressed for these three phases. The assessment of impacts was divided into those from normal operations and those from potential accidents. The impacts from transportation are discussed separately in Section 5.3.9.

The human health impacts during the construction and operations are expected to be about the same for the three land disposal methods. The post-closure impacts are site dependent,

TABLE 5.3.3-1 Water Consumption for the Three Land Disposal Methods

	Amount Consumed or Involved[a,b]		
Activity/ Resource	Trench	Borehole	Vault
Construction			
Total utility water for 20 yr (gal)	5,300,000	2,800,000	17,100,000
Annual utility water (gal/yr)	270,000	140,000	860,000
Operations			
Annual potable water (gal/yr)	310,000	240,000	310,000
Annual raw water (gal/yr)	1,100,000	410,000	1,100,000

[a] To convert to liters, multiply by 3.78.

[b] For sites located in arid regions of the country like NNSS, a site-specific evaluation would be needed to account for water availability, arid conditions, and other factors. These factors would be addressed as part of follow-on NEPA evaluations if NNSS is considered as a preferred site for GTCC waste disposal.

TABLE 5.3.3-2 Summary of Water Use Impacts from Construction of a Land Disposal Facility at the GTCC Reference Locations

Proposed Site	Water Source	Current Annual Site Water Use or Capacity (gal)[a]	Maximum Proposed Annual GTCC Facility Water Use (gal)[b]	Percent Increase
Hanford Site	Surface water (Columbia River)	216 million	855,000	0.40
INL	Groundwater (on-site wells)	1.1 billion	855,000	0.078
LANL	Groundwater (on-site wells)	359 million (in 2005)	855,000	0.24
NNSS	Groundwater (on-site wells)	293 million	855,000	0.29
SRS	Groundwater (on-site wells)	1.42 billion (in 2006)	855,000	0.060
WIPP Vicinity	Groundwater (Double Eagle South Well Field system)	5.4 million	855,000	0.24[c]

[a] Sources for current annual site water use are as follows: Hanford Site (DOE 2009), INL (DOE 2005b), LANL (LANL 2008), NNSS (USGS 2007), SRS (Mamatay 2007), and WIPP Vicinity (Sandia 2008).

[b] The maximum annual water use for the construction period would be 855,000 gal for the vault method.

[c] Although the water demand for the proposed GTCC waste disposal facility at the WIPP Vicinity site would increase WIPP's water use by 16% per year (i.e., 855,000 gal ÷ 5.4 million gal), it would increase the use of groundwater from the Double Eagle South Well Field system (which has a capacity of 360 million gal/yr) by only 0.24% per year (i.e., 855,000 gal ÷ 360 million gal).

TABLE 5.3.3-3 Summary of Water Use Impacts from Operations at a Land Disposal Facility at the GTCC Reference Locations

Proposed Site	Water Source	Current Annual Site Water Use or Capacity (gal)[a]	Maximum Proposed Annual GTCC Facility Water Use (gal)[b]	Percent Change
Hanford Site	Surface water (Columbia River)	216 million	1.4 million	0.65
INL	Groundwater (on-site wells)	1.1 billion	1.4 million	0.13
LANL	Groundwater (on-site wells)	359 million (in 2005)	1.4 million	0.39
NNSS	Groundwater (on-site wells)	293 million	1.4 million	0.48
SRS	Groundwater (on-site wells)	1.42 billion (in 2006)	1.4 million	0.099
WIPP Vicinity	Groundwater (Double Eagle South Well Field system)	5.4 million	1.4 million	0.39[c]

[a] Sources for current annual site water use are as follows: Hanford Site (DOE 2009), INL (DOE 2005b), LANL (LANL (2008), NNSS (USGS 2007), SRS (Mamatay 2007), and WIPP Vicinity (Sandia 2008).

[b] The maximum annual water use for the operational period would be about 1.4 million gal for the trench and vault methods.

[c] Although the water demand for the proposed GTCC waste disposal facility at the WIPP Vicinity site would increase WIPP's water use by 26% per year (i.e., 1.4 million gal ÷ 5.4 million gal), it would increase the use of groundwater from the Double Eagle South Well Field system (which has a capacity of 360 million gal/yr) by only 0.39% per year (i.e., 1.4 million gal ÷ 360 million gal).

and these are addressed for each of the sites in Chapters 6 through 11 for the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity, respectively. A summary of these results is provided in Section 5.3.4.3, and the results are discussed in more detail in the appropriate sections of Chapters 6 through 11. Post-closure human health impacts are also estimated on a regional basis for the generic commercial disposal locations; these are presented in Chapter 12.

The greatest risk to human health during normal operations would result from radiation doses and associated health risks to workers handling the wastes. The radiation doses to off-site individuals would be very low, since the actions taken to protect workers, such as use of shielding and remote handling equipment, would also serve to protect any nearby members of the public. However, it is possible that waste-handling accidents could occur and result in loss of shielding and possibly the release of radioactive contaminants that could become airborne and affect nearby off-site members of the general public.

The physical hazards to workers were considered during the construction and operations phases of the project. The only significant impact during the post-closure phase would be from the potential release of radioactive contaminants from the disposed wastes, which could reach individuals living near the site. During the operations phase, the radiation exposures of workers were considered in addition to the physical hazards associated with emplacement of the wastes into the disposal facility.

5.3.4.1 Operations

During operations, the wastes would arrive at the disposal facility, be unloaded from the transport vehicle, proceed through on-site staging activities, and be placed in the disposal facility. Many of these activities would require shielding to keep worker doses in compliance with DOE limits and ALARA. Remote handling equipment would be used as necessary to further reduce these exposures. All of these activities would keep the doses to members of the general public at very low levels, generally indistinguishable from those associated with exposure to normal background radiation. However, it is expected that workers would incur measurable radiation doses during waste disposal activities.

5.3.4.1.1 Workers. Two types of workers are addressed in the EIS: involved workers (those directly involved in handling and disposing of the wastes at the disposal sites) and noninvolved workers (those present at the site but not directly involved in waste disposal activities). Given the physical form of the wastes, the only pathway of concern for workers during normal operations would be external gamma irradiation. It is assumed that all of the wastes would arrive at the site as solid materials that could be placed directly into the disposal facility. Any necessary waste treatment would have already occurred at the site that generated or staged the wastes prior to shipment, and the impacts associated with these activities are outside the scope of this EIS.

The involved workers would incur radiation doses when they were in the general proximity of the waste containers during waste handling and disposal activities. The external gamma exposure rates of the GTCC LLRW and GTCC-like waste packages would cover a very wide range of values; wastes would range from those that could be managed directly because they had very low exposure rates to those that would have to be managed by using a large amount of shielding and remote handling equipment.

The external gamma dose rates associated with packages containing activated metal wastes were modeled by using the computer code MicroShield (Grove Software, Inc. 2005). The gamma exposure rates on the surfaces of these containers, assuming there would be no additional shielding, could exceed 1,000 roentgen/hour (R/h). These dose rates are somewhat smaller than, but generally comparable to, those associated with SNF and high-level radioactive wastes. However, these exposure rates would decrease quite quickly with distance. The external gamma dose rate would be about 1% of the surface dose rate at a distance of 5 m (16 ft) from the source and 0.01% of the surface dose rate at a distance of 50 m (160 ft). Shielding would be used to protect both the involved and noninvolved workers. Use of remote-handling equipment would also be necessary for these very-high-exposure-rate containers.

In addition to this direct gamma radiation, worker exposures could occur from secondary (or air-scattered) radiation. The computer code MicroSkyshine (Grove Software, Inc. 2008) was used to evaluate this component, again focusing on the activated metal waste containers by using the conceptual geometric configurations of the vault, trench, and borehole. This computer code was developed to address radiation exposures from secondary radiation when there is shielding between the radiation source (waste packages) and a potentially exposed individual (nearby worker). The shielding would greatly reduce the dose from direct (unscattered) radiation, but the dose from air-scattered radiation could be significant. This dose could result from waste packages in an open vault, trench, or borehole partially filled with waste. In this situation, the gamma radiation would be emitted from the waste packages to the air above the disposal unit and be scattered by air molecules in the atmosphere, and then a small fraction of the scattered radiation would be directed toward a nearby worker. MicroSkyshine is a standard computer code used for analyzing situations like this one that is relevant to disposal of GTCC wastes.

Although this dose component is significantly lower than the direct (unshielded) exposure associated with the activated metal waste containers, the exposure rates from skyshine radiation could exceed 10 mR/h and approach 100 mR/h close to the disposal facility if several waste containers were grouped together, such as in a trench, vault, or borehole prior to placement of the overlying cover. These exposure rates further indicate the need to use shielding to protect individuals working at the site.

Because the procedures to be used to manage these wastes at the site and the exact activities that would be conducted by each involved worker (and the worker's proximity to the waste containers) are not known at this time, it is difficult to calculate the dose to the workforce implementing the various alternatives. For purposes of this EIS, data on the radiation exposures of workers at existing DOE facilities were used to estimate the total dose that could be incurred by workers in disposing of these wastes. Worker doses are required to be kept below 5 rem/yr, as mandated in 10 CFR Part 835. In addition, administrative control limits would be set below this limit, and radiation exposures of the involved workers would be monitored for the duration of the project.

DOE has established an agency-wide administrative control limit of 2 rem/yr in its *Radiological Control Manual* (DOE 1994). This manual also requires that any contractors working on DOE projects (such as those who would be expected to work on disposing of GTCC waste) establish a lower administrative control limit, on the order of 0.5 to 1.5 rem/yr. A project-specific administrative control limit would be set in accordance with these requirements before any waste disposal activities would be implemented, and this limit would be based on the specific conditions of the selected alternative. In addition, extensive use would be made of remote-handling equipment and shielding to reduce potential exposures of the workers, in accordance with DOE's ALARA requirement.

The average dose received by workers at DOE waste processing and management facilities was 56 to 60 mrem/yr between 2004 and 2006. In 2006, 7,687 workers were monitored for radiation exposure, and 2,457 of them (about one-third) had measurable doses. With regard to the workers who had measurable doses, most (2,032 persons) received a dose of less than 100 mrem, 324 received a dose between 100 and 250 mrem, 91 received a dose between 250 and 500 mrem, 9 received a dose between 500 and 750 mrem, and only one received a dose between 750 and 1,000 mrem. No worker received a dose greater than 1 rem in 2006 (DOE 2007b).

For this EIS, the dose to the workforce was calculated by using an average annual dose to an FTE involved worker and the estimated number of FTE operators and technicians during the operations phase as given in Appendix D. The concept of an FTE worker was largely used to estimate costs for the various disposal options (see Appendix D). An annual FTE is simply the number of person-hours required for a given task divided by the number of working hours in a year; that is, it is the number of full-time workers necessary to complete the task. This work can be divided among a relatively large workforce. For example, if each of 100 individuals worked 3 months on a task (like waste disposal) over the course of a year, a total of 25 FTEs would be associated with this task during that year. The annual dose to an FTE worker would thus be larger than the dose to any individual worker. In this example, it could be four times greater.

It is expected that the GTCC wastes would be received at a disposal site intermittently (see Section 3.4.2). There might be only a few waste disposal campaigns in any week or month over the course of a year. Because of this, several crews might be used to dispose of these wastes. These crews would perform other functions when wastes were not available for disposal. So it is likely that a larger number of individuals than the number of FTEs given in Appendix D would actually be involved with waste disposal activities.

As noted above, the doses to workers at DOE facilities are a very low percentage of the limit given in 10 CFR Part 835. For this assessment, the average annual dose for an FTE involved worker is taken to be 0.2 rem/yr, which is about three times greater than the average dose to a badged worker for comparable activities at DOE sites in 2006. A higher dose rate was assumed for this analysis, since the dose rates for some of the waste containers (specifically those for activated metal wastes, which constitute about 17% of the GTCC waste volume) are expected to be significantly higher than those for the containers processed and disposed of at DOE sites in 2006. In addition, many of the occupationally exposed workers at DOE sites (such as those included in the data provided for 2006) likely spend much of their time in nonradioactive areas, and the calculation given here is based on the number of FTEs that would be needed to manage the wastes.

The number of operators and technicians necessary to receive, transfer, and dispose of the expected number of GTCC LLRW and GTCC-like waste packages is estimated to be 23 for waste disposal in trenches, 13 for boreholes, and 26 for vaults (Appendix D). Although it is assumed for purposes of analysis in this EIS that disposal operations would occur over a period lasting up to 64 years, the actual length of the operational period would depend on the actual wastes that were being disposed of and the times when these wastes were being generated.

On the basis of these estimates and the assumption of an average annual dose rate of 0.2 rem/yr per involved worker FTE, the annual worker doses would be 4.6 person-rem for trenches, 2.6 person-rem for boreholes, and 5.2 person-rem for vaults. Note that these annual worker doses are somewhat higher than but generally comparable to those associated with the storage of SNF at commercial nuclear power plants (see Section 3.5.1.1). These annual worker doses would result in annual LCF risks of 0.003, 0.002, and 0.003 for these three disposal methods, respectively. These LCF estimates were obtained by using a risk factor of 0.0006 LCF per person-rem, as identified in Section 5.2.4. The average annual dose rate of 0.2 rem/yr per involved worker FTE could be spread over a number of workers who make up the FTE. The average dose rate to any given individual worker is expected to be similar to the values given above for DOE waste processing and management activities, depending on the actual number of workers involved in these activities.

It should be noted that this dose to the workforce would be distributed among all workers involved in managing the wastes at the alternative sites over the entire time period that the facility would be receiving and disposing of wastes. Different workers would likely be rotated into these activities over time, so the maximum dose to any given worker over the entire duration of the project would likely be no more than a few rem. Wastes would be received intermittently over the operational time period. The annual dose to the highest-exposed worker would be no more than the DOE administrative control limit (2 rem/yr) for site operations.

The dose to noninvolved workers would be much less than the dose to involved workers. The noninvolved workers (such as those constructing additional facilities or working in the administration building) would be some distance away from the waste packages. As noted previously, the external gamma dose rate at 50 m (160 ft) from the waste package is only about 0.01% of the surface dose rate. Also, there would likely be significantly fewer noninvolved workers than involved workers when wastes would be processed at the site to ensure compliance with the DOE ALARA requirement. The annual collective dose to the noninvolved workforce is conservatively estimated to be less than 0.1 person-rem/yr for each of these three disposal methods. No LCFs would be expected to result from these doses to noninvolved workers.

5.3.4.1.2 General Public. The only exposures to members of the general public at off-site locations near the disposal site during normal operations would be from the external gamma radiation emitted by the waste containers at off-site locations near the disposal site. Access to the site would be restricted during this time frame. These doses are expected to be very small, since procedures to protect on-site workers handling the wastes would also serve to reduce the off-site doses to levels that would be indistinguishable from background.

The scattered (skyshine) dose at a distance of 100 m (330 ft) from the activated metal waste containers in the trench was calculated by MicroSkyshine to be about 0.050 mrem/h. This dose could occur from a waste container placed in the trench prior to placement of the cover (or interim shielding to reduce the overall skyshine dose in the vicinity). The exposure rates for the borehole and vault were calculated to be lower.

The actual dose received by an off-site individual would depend on the location of the disposal facility at a given site, the specific design used for the facility, procedures used to manage the wastes at the site (including the use of temporary shielding), the extent of the buffer zone, and the length of an individual's exposure. However, the dose to the highest-exposed member of the general public is not expected to exceed a few millirem over the duration of waste disposal activities and would likely be indistinguishable from that associated with natural background radiation.

5.3.4.2 Accidents

This EIS addresses the human health impacts on workers and members of the general public from a range of potential accidents at a disposal facility that could occur under the three land disposal methods. The impacts of these accidents are expected to be comparable for all three methods. An accident is an event or series of unexpected or undesirable events leading to a loss of waste containment or shielding that results in exposures to workers or members of the general public. The two important elements considered in the assessment of risks from potential accidents are the consequences of the accident and the expected frequency (or probability) of the accident. As noted earlier, all of the wastes received at the disposal facility are assumed to be in a solid form that can be disposed of directly. As such, very little material is expected to become airborne from an accident involving waste containers.

5.3.4.2.1 Accidents Involving Radioactive Releases of Material. A wide range of different types of accidents was evaluated for the land disposal methods. The accidents included those initiated by operational events, such as equipment or operator failure, and natural phenomena, such as earthquakes. Because the disposal methods involve similar operations and the same waste packages, the accidents evaluated are applicable to all three land disposal methods. Because of differences in the local weather patterns and the location of the potential receptors, the radiological impacts for Alternatives 3 to 5 are site-dependent and are discussed in Chapters 6 through 11 for the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity, respectively. These impacts for accidents are not addressed for the generic commercial disposal locations in this EIS.

No repackaging of waste is anticipated at the disposal facility. Thus, the only way a release of radioactive material to the environment from operational events could occur would be if a disposal container ruptured during handling operations. Handling operations would include the (1) transfer of disposal containers from their Type B packages as received at the Waste Receipt and Storage Building for temporary storage, (2) transfer from temporary storage to an on-site transport vehicle, and (3) transfer from the transport vehicle into the disposal unit. All such operations are expected to involve the use of forklifts and/or cranes. Table 5.3.4-1 summarizes the accident scenarios analyzed. Further details on the scenario analysis can be found in Appendix C.

Physical damage to waste containers could result from low-speed vehicle collisions or from being dropped or crushed by falling objects. Only minor releases are expected at the facility should such accidents happen. Accidents involving CH waste containers are expected to result in higher impacts because these Type A containers, although fairly robust, are not as sturdy as the RH canisters or AMCs and their shielding casks. As a consequence, the CH waste containers

TABLE 5.3.4-1 Accidents Evaluated for the Land Disposal Facilities

			Frequency Range			
Scenario Number	Accident Scenario[a]	Accident Description	$>10^{-2}$/yr	10^{-4} to 10^{-2}/yr	10^{-6} to 10^{-4}/yr	$<10^{-6}$/yr
1	Single drum drops, lid failure in Waste Receipt and Storage Building	A single CH drum is damaged by a forklift and spills its contents onto the ground inside the Waste Receipt and Storage Building.		X		
2	Single SWB drops, lid failure in Waste Receipt and Storage Building	A single CH SWB is damaged by a forklift and spills its contents onto the ground inside the Waste Receipt and Storage Building.		X		
3	Three drums drop, puncture, lid failure in Waste Receipt and Storage Building	Three CH drums are damaged by a forklift and spill their contents onto the ground inside the Waste Receipt and Storage Building.		X		
4	Two SWBs drop, puncture, lid failure in Waste Receipt and Storage Building	Two CH SWBs are damaged by a forklift and spill their contents onto the ground inside the Waste Receipt and Storage Building.		X		
5	Single drum drops, lid failure outside	A single CH drum is damaged by a forklift and spills its contents outside.		X		
6	Single SWB drops, lid failure outside	A single CH SWB is damaged by a forklift and spills its contents outside.		X		
7	Three drums drop, puncture, lid failure outside	Three CH drums are damaged by a forklift and spill their contents outside.		X		
8	Two SWBs drop, puncture, lid failure outside	Two CH SWBs are damaged by a forklift and spill their contents outside.		X		

TABLE 5.3.4-1 (Cont.)

Scenario Number	Accident Scenario[a]	Accident Description	Frequency Range $>10^{-2}$/yr	10^{-4} to 10^{-2}/yr	10^{-6} to 10^{-4}/yr	$<10^{-6}$/yr
9	Fire inside the Waste Receipt and Storage Building, one SWB assumed to be affected	A fire or explosion within the Waste Receipt and Storage Building affects the contents of a single CH SWB.			X	
10	Single RH waste canister breach	A single RH waste canister is breached during its fall in the Waste Receipt and Storage Building.			X	
11	Earthquake affects 18 pallets, each with four CH drums	The Waste Receipt and Storage Building is assumed to be damaged during a design basis earthquake, with failure of the structure and confinement systems resulting.			X	
12	Tornado, missile hits one CH-SWB, contents released	A major tornado and associated tornado missiles result in failure of the Waste Receipt and Storage Building structure and its confinement systems.			X	
13	Flood	It is assumed that the location of the facility would be sited such that it would preclude severe flooding.				X

[a] Details of the accident scenario evaluated are presented in Appendix C.

would be more prone to lose a portion of their contents, and, in addition, airborne radioactive contamination from such material as activated metals would be minimal compared with contamination from Other Waste because the contamination associated with activated metal waste is very immobile. CH drum and SWB radionuclide inventories that gave the highest impacts were used in this facility accident analysis for accident numbers 1 through 9, 11, and 12. Accident number 10 was also evaluated for perspective, should an RH canister fail during an accident.

Fire from internal or external causes would be another potential cause for release of radioactive contamination. Internal causes would be minimized by proper treatment of the waste before packaging prior to receipt at the facility. External causes would be primarily linked to equipment fires, which could be minimized through proper maintenance and use of equipment. Accident number 9 considers the impacts from a short-term fire in the Waste Receipt and Storage Building.

Potential releases of radioactive material could also occur as a result of natural hazards. Such releases are only anticipated prior to emplacement (i.e., they would occur while the waste was at the Waste Receipt and Storage Building). However, it is assumed that the disposal facility would be sited in an area that is not prone to flooding, and depending on the area of the country in which it was situated, the facility would be built to meet local standards for earthquakes. Other natural hazards (such as tornadoes) in certain areas of the country could cause releases. Accident numbers 11 and 12 look at potential scenarios involving earthquakes and tornadoes, respectively.

The consequences for the highest-exposed individuals and the collective general public were estimated by using air dispersion models to predict the downwind air concentrations following a release. These models consider a number of factors, including the characteristics of the material released, location of the release, and meteorological conditions. The air concentrations were used to estimate the radiation doses and the potential LCFs associated with these doses. The consequences were estimated on the basis of the assumption that the wind was blowing in the direction that would yield the greatest impacts. For accidents involving releases of radioactive material, the consequences are expressed in the same way as are those from routine operations (i.e., as radiation doses and LCFs for the individuals receiving the highest impacts and exposed population for all important exposure pathways).

As long as the dose to an individual from accidental exposure is less than 20 rem and the dose rate is less than 0.60 rem/h, the health risk conversion factors given previously would be applicable, and the only important health impact would be the LCF. In other words, at those doses and dose rates, other possible radiation effects (e.g., fatalities from acute radiation syndrome, reproductive impairment, or cataract formation) do not need to be considered. These doses and dose rates for limiting the evaluation of health risk to cancer are given in Federal Guidance Report No. 13 (EPA 1999).

Highest-Exposed Individuals. The risk to involved workers would be very sensitive to the specific circumstances of the accident and depend on how rapidly the accident developed, the exact location and response of workers, the direction and amount of the release, the physical and thermal forces causing or caused by the accident, meteorological conditions, and the characteristics of the building if the accident occurred indoors. The involved workers would be radiation workers, and their exposures would be monitored and controlled by appropriate management methods.

The accident analysis evaluated the potential exposure of a hypothetical individual located 100 m (330 ft) downwind of an accident (radiation doses and LCFs). The exposure estimates include potential doses from inhalation, groundshine, and cloudshine for 2 hours following a hypothetical accidental release of radioactive material, as discussed above. The hypothetical individual receiving the greatest impacts would likely be a noninvolved worker at the disposal facility. At all the land disposal sites, any potential dose to an individual member of the public from an accidental release of radioactive material is expected to be much lower than those estimated here for the noninvolved worker. The radiological impacts to a hypothetical individual located downwind from an accident for Alternatives 3 to 5 are site-dependent and are discussed in Chapters 6 through 11 for the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

General Public. The general public consists of the population living within 80 km (50 mi) of the GTCC disposal facility at the reference locations evaluated. The exposure estimates include potential doses from inhalation, groundshine, cloudshine, and ingestion of contaminated crops for 1 year following a hypothetical accidental release of radioactive material as discussed above. More details on the analysis are provided in Appendix C. The radiological impacts on the general public for Alternatives 3 to 5 are site-dependent and are discussed in Chapters 6 through 11 for the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.4.2.2 Nonradiological Worker Impacts. The potential human health impacts from accidents include the physical consequences of accidents whether or not a release of radioactive material occurs. The physical consequences are given here in terms of injuries and illnesses (as lost workdays) as well as the likelihood of worker fatalities.

The human health impacts on noninvolved workers are assessed for the construction and operational phases. These impacts are expected to be the same for each land disposal site under consideration in this EIS but are disposal-technology-dependent, since the activities and workforce requirements differ for the various disposal methods. These impacts were estimated by using statistical data compiled for private industry and data on the number of workers estimated to be needed for all phases of the project.

The rates at which accidents and injuries occur during construction activities were obtained from information provided by the BLS, as reported by the National Safety Council (BLS 2007a,b). On the basis of 2006 statistical data for the construction industry, the number of lost workdays due to nonfatal injuries and illnesses was calculated by using a value of 6.0 per 100 FTE workers, while the work-related fatality rate was taken to be 13.2 per 100,000 FTE workers. The statistical rates for the past few years vary only slightly from these values. These rates were used for the construction phase of the project for the three disposal methods.

Worker fatality and injury risks are calculated as the product of the incidence rate (given above) and the number of FTE workers needed for constructing the land disposal GTCC waste facilities. Table 5.3.4-2 shows the calculation results for the three land disposal methods. The number of lost workdays due to injuries was calculated for the borehole, trench, and vault methods to be 16, 49, and 150, respectively; the number of lost workdays is proportional to the number of workers needed for the methods. While the numbers of fatalities calculated for the three disposal methods are different, they are all less than one (1), meaning no fatality is expected to occur among the involved workers during these two phases of the project.

The same approach was used for the operational period, although different rates were used to better reflect the type of expected activities. In addition, the results were given on an annual basis. The total number of injuries and fatalities can be obtained by multiplying the annual values given here by the assumed length of the operational period.

For nonfatal injuries, the 2006 statistics pertaining to the warehousing and storage industry were used, since this information is the most representative of the workers being evaluated in this EIS. For work-related fatalities, the statistics pertaining to the transportation and warehousing industries were modified, because "warehousing and storage" was not included as a separate category in the BLS fatality data. Among the reported fatality cases for the transportation and warehousing industry, 54% were related to highway accidents. Since transportation risks associated with the disposal of GTCC LLRW and GTCC-like wastes are addressed separately in this EIS, the fatalities of highway accidents included in these values were excluded. Therefore, the fatality rate used in this EIS analysis was 46% of the fatality rate for the transportation and warehousing industries. The nonfatal injury and illness rate (as lost workdays) used for involved workers during the operational period is 8.0 per 100 FTE workers, and the fatality rate is 7.4 per 100,000 FTE workers.

The number of FTE workers necessary for the operational period for the three land disposal methods represents the number of operators and technicians required to operate the disposal facility (see Appendix D). Although it is assumed that disposal operations would occur over a period lasting up to 64 years, the actual length of the operational period would depend on the actual wastes that were being disposed of and the time when the wastes were being generated. As shown in Table 5.3.4-2, the expected numbers of lost workdays per year due to nonfatal injuries were calculated to be 1 for the borehole method and 2 for the trench and vault methods. The total numbers of fatalities are all significantly less than one (1); therefore, no fatalities are expected to occur to the involved workers during operations of the three land disposal methods.

TABLE 5.3.4-2 Estimated Number of FTE Involved Workers, Nonfatal Injuries and Illnesses, and Fatalities Associated with the Construction and Operations of the Land Disposal Facilities[a]

Phase	Borehole	Trench	Vault
Construction			
Total FTEs[b]	260	820	2,400
Nonfatal injuries and illnesses[c]	16	49	150
Fatalities[d]	0.034	0.11	0.32
Operations			
Annual FTEs[e]	13	23	26
Annual nonfatal injuries and illnesses[f]	1	2	2
Annual fatalities[g]	0.00096	0.0017	0.0019

[a] The results for the construction phase represent the total number of injuries and fatalities for the three land disposal methods evaluated in the EIS. The results for the operations phase represent annual values. The total number of injuries and fatalities during the operations phase can be obtained by multiplying these annual values by the assumed length of the operational period.

[b] The total numbers of FTE workers needed during the construction phase was obtained from Appendix D. The values given here are those reported for construction of the three facility designs.

[c] The numbers of nonfatal injuries and illnesses (as lost workdays) were estimated on the basis of statistical data for the construction industry in 2006 (BLS 2007a). The nonfatal injury and illness rate was 6.0 per 100 FTEs.

[d] The numbers of fatalities were estimated on the basis of national census data for the construction industry in 2006 (BLS 2007b). The fatality rate was 13.2 per 100,000 FTEs.

[e] The annual numbers of FTE workers during the operations phase represent the average number of operators and technicians needed to operate the disposal facilities (Appendix D).

[f] The annual numbers of nonfatal injuries and illnesses (as lost workdays) were estimated on the basis of statistical data for the warehousing and storage industry in 2006 (BLS 2007a). The nonfatal injury and illness rate was 8.0 per 100 FTEs.

[g] The annual numbers of fatalities were estimated on the basis of national census data for the transportation and warehousing industry, excluding the fatalities caused by highway accidents, in 2006 (BLS 2007b). The fatality rate was 7.4 per 100,000 FTEs.

5.3.4.3 Post-Closure

For this EIS, the post-closure human health impacts were evaluated by considering the impacts that could occur to the general public from radioactive contaminants released from the waste packages emplaced in the land disposal facilities over the long term. It is assumed that no worker impacts would occur once the disposal sites were closed. Direct intrusion into the waste disposal units is qualitatively addressed in this EIS (see Section 5.5).

The two mechanisms by which off-site members of the general public could be affected by the disposal of these wastes in land disposal facilities in the long term are from (1) airborne emissions and (2) leaching of radioactive contaminants from the waste packages, followed by their transport to groundwater and migration to an accessible location, such as a groundwater well. Airborne emissions could include gases (such as radon, CO_2, and water vapor) and particulates should the disposal facility cover be completely lost through erosion. Particulate radionuclide air emissions are not expected to be significant, since it is very unlikely that the entire disposal facility cover would be lost through erosion. In addition, any material removed from the facility surface cover by erosion or weathering would be replaced to some extent by nearby soil that had been similarly removed. Nevertheless, this pathway was assessed for completeness.

Standard engineering practices and measures would be taken in designing and constructing the disposal facility in order to ensure long-term stability and minimize the likelihood of contaminant migration from the wastes to the surrounding environment. The facility would be sited in a location consistent with the requirements specified by the NRC for LLRW disposal facilities given in 10 CFR Part 61 and the *Radioactive Waste Management Manual*, DOE M 435.1-1 (DOE 1999a), which include siting them in locations with geologic characteristics that would minimize events that could compromise the containment characteristics of the disposal facility in the long term. Use of engineering controls in concert with the natural features of the selected site should ensure the long-term viability of the disposal facility.

For analysis of the long-term impacts on human health after closure of the disposal facility, a hypothetical individual is assumed to move near the site and reside in a house located 100 m (330 ft) from the edge of the disposal facility. This location was selected because it is the minimum distance identified in Manual DOE M 435.1-1 (DOE 1999a) for the location of the buffer zone surrounding a DOE LLRW disposal site at which compliance with dose standards needs to be demonstrated. No additional buffer zone beyond the area necessary to operate the LLRW disposal facility is assumed in this analysis. This assumption is expected to be conservative, since the DOE sites considered in this EIS are very large, and a significant buffer zone of greater than 100 m (330 ft) would likely be employed for this disposal facility.

For this analysis, a hypothetical individual is assumed to move to this location and develop a farm. It is assumed that this resident farmer would develop a groundwater well as the source of drinking water and would obtain much of his or her food (fruits, vegetables, meat, and milk) from the farm. A resident farmer was selected for this evaluation because this scenario would involve relatively intensive use of the land and provides a conservative basis for comparison of different options.

The hypothetical resident farmer could be exposed to airborne contaminants, including radon gas and its short-lived decay products, as well as gaseous radionuclides such as carbon-14 (C-14 in the form of CO_2) and hydrogen-3 (H-3 or tritium in the form of water vapor). These gases could diffuse out of the waste containers and move through the disposal facility cover and then be transported by the wind to the off-site residence of the farmer. This individual could also incur a radiation dose through the use of groundwater contaminated from the leaching of radionuclides in the waste containers and their transport to the underlying groundwater table.

Secondary soil contamination at off-site locations would be possible if contaminated groundwater was used for irrigation and if this practice continued for an extended period of time. Potential exposure pathways related to the use of contaminated groundwater include external irradiation; inhalation of dust particulates, radon gas (and its short-lived decay products), H-3, and C-14; and ingestion of water, soil, plant foods, meat, and milk. Plant foods (fruits and vegetables) could become contaminated through foliar deposition as well as root uptake. Meat and milk could become contaminated if livestock ingested contaminated water (obtained from the well) and fodder contaminated by this groundwater.

The potential for radiation exposure to this hypothetical receptor in the future would exist only if radionuclides were released from the waste containers and disposal facility. The most likely mechanism for this scenario to occur would be contact with infiltrating water. Water (such as that from precipitation) could infiltrate into the disposal area and contact the waste containers. No releases would occur while the waste containers and engineering barriers (such as a cover system) remained intact. However, over time, it is likely that the waste packages and engineering barriers would lose their integrity. When this situation occurred, water could contact the waste materials within the packages and move downward to the groundwater table.

Data on the performance of waste packages and engineering barriers over an extended time period are limited. Even when the data are available, using such data to predict the release rates of radionuclides over a very long time period can be difficult to defend, especially in the context of a comparative analysis that is not intended to consider extensive details. The potential impacts on groundwater are evaluated over a very long period in this EIS (10,000 years or longer to peak dose). How and when the waste packages and engineering barriers would begin to degrade and how this degradation would progress over time are very difficult to determine.

It was assumed for purposes of analysis in the EIS that the Other Waste type (as opposed to activated metals and sealed sources) would be solidified (e.g., with grout or another similar material) prior to being placed in the disposal units. This is a reasonable assumption and consistent with current disposal practices for such wastes, which include a wide variety of materials that could compact or degrade without such measures. Use of such a stabilizing agent was not assumed for the activated metal waste and sealed sources because their waste form makes them less susceptible to leaching.

In performing these evaluations, a number of engineering measures (e.g., a cover system) were included in the conceptual facility designs to minimize the likelihood of contaminant migration from the disposal units. It was assumed that these measures would remain intact for 500 years after the disposal facility closed. After 500 years, the barriers would gradually fail. To account for these measures, it was assumed that the water infiltration rate to the top of the waste disposal area would be zero for the first 500 years and then 20% of the natural rate for the area of the remainder of the period of calculation (10,000 years). A water infiltration rate of 20% of the natural rate for the area was only used for the waste disposal area. The natural background infiltration rate was used at the perimeter of the waste disposal units. This method is assumed to be a reasonable way to model the use of an improved cover for the purposes of this analysis. A sensitivity analysis was performed to evaluate the significance of these assumptions, and this is presented in Appendix E.

To evaluate the uncertainties that the key assumptions might have on the long-term human health impacts presented in this EIS, a sensitivity analysis was performed and is provided in Section E.5 of Appendix E. In this sensitivity analysis, the RESRAD-OFFSITE calculations were repeated each time different values were used for each of the key assumptions (the values for the other parameters were kept at their base values).

Three key parameters were addressed in the sensitivity analysis: (1) the water infiltration rate to the top of the disposal facility cover, (2) the effectiveness of the stabilizing agent (grout) used for Other Waste, and (3) the distance to the assumed hypothetical receptor. These three parameters relate to disposal facility design, waste form stability, and site characteristics.

The results indicated that the peak annual dose would increase as the water infiltration rate increased, because when more water would enter the waste disposal horizon, more radionuclides would be leached and released from the disposal facility. The increase in the peak dose would be approximately proportional to the increase in the water infiltration rate. This result is not unexpected, and it indicates the need for a very effective cover to minimize the amount of infiltrating water that could contact the GTCC wastes.

With regard to the use of a stabilizing agent for Other Waste, the release rates of radionuclides from the waste disposal area would be reduced as long as the agent remained effective. The use of the agent would reduce the annual dose and LCF risk associated with groundwater contamination for the corresponding period. Hence, the peak annual dose after the effective period would be lower than it would be when there was no waste stabilization or when the effective period of the stabilizing agent was shorter. The extent of this reduction would be very dependent on the specific site being addressed and the mix of radionuclides in the wastes.

Finally, the radiation dose incurred by the hypothetical resident farmer would decrease with increasing exposure distance, as would be expected. This reduction would occur because additional dilution of radionuclide concentrations in groundwater would result from the additional transport distance toward the location of the off-site well. As the distance would increase from 100 m (330 ft) to 500 m (1,600 ft), the maximum annual radiation dose would increase by more than 70%.

The results of this analysis are summarized in Table 5.3.4-3 for radiation doses and Table 5.3.4-4 for LCFs. These results are discussed further in the appropriate sections of Chapters 6 through 12 and Appendix E.

Because the radionuclide mix for each waste type (i.e., activated metals, sealed sources, and Other Waste) is different, the peak annual doses and LCF risks for each waste type do not necessarily occur at the same time. In addition, the peak annual doses and LCF risks for the entire GTCC waste inventory considered as a whole could be different from those for the individual waste types. Hence, estimated annual doses and LCF risks for the hypothetical resident farmer scenario evaluated for the post-closure phase are presented in two ways in this EIS. The first presents the peak annual doses and LCF risks when disposal of the entire GTCC waste inventory is considered. The second presents the peak annual doses and LCF risks when each waste type is considered on its own. Results are presented for each land disposal method as evaluated for each given site. The first set of results could be used as the basis for comparing the performance of each site and each land disposal method if the entire GTCC waste inventory was going to be disposed of at one site by using one method. The second set could be used as the basis for comparing the performance of each site and each land disposal method when disposal of each of the three waste types was being considered.

The tables in Chapters 6 through 12 (e.g., Tables 6.2.4-2 and 6.2.4-3 in Chapter 6; Tables 7.2.4-2 and 7.2.4-3 in Chapter 7 etc. to Chapter 11; Chapter 12 tables are those shown in Section 12.2) present the peak annual doses and LCF risks to the hypothetical resident farmer when disposal of the entire GTCC waste inventory at each site is being considered for the land disposal methods evaluated (the first set described above). In these tables, the doses contributed by each waste type to the peak annual dose reported (i.e., dose for each waste type at the time when the peak dose for the entire inventory is observed) are also tabulated. As discussed above, these doses (from the various waste types) do not represent the peak annual dose and LCF risk of the waste type itself when considered on its own.

The second set of results is presented in Tables E-22 through E-25 in Appendix E. Peak annual doses and LCF risks are reported for each waste type. Because these peak annual doses and LCF risks generally occur at different times, the results should not be summed to obtain total annual doses and LCF risks for comparison with those presented in Chapters 6 through 12 (although for some cases, these sums might be close to those presented in the site-specific chapters).

The human health impacts (annual doses and LCF risks) to the hypothetical resident farmer given in this EIS are intended to serve as indicators of the relative performance of each of the three land disposal methods at each of the sites evaluated. These can be considered to serve as a metric for comparing the relative performance of the land disposal methods at these sites. Further design considerations and site-specific modeling would be performed when implementation decisions were being made. By using robust engineering designs and redundant measures to contain the radionuclides in the disposal unit, the potential releases of radionuclides would be delayed and reduced to very low levels, thereby minimizing potential groundwater contamination and its associated human health impacts in the future.

TABLE 5.3.4-3 Comparison of Maximal Doses (mrem/yr) within 10,000 Years for the Resident Farmer Scenario Associated with the Use and Ingestion of Contaminated Groundwater at the Various GTCC Reference Locations Evaluated for the Land Disposal Methods[a,b]

Disposal Facility	Hanford	INL	LANL	NNSS	SRS	WIPP Vicinity
Borehole	4.8	820	160	0	NA[c]	0
Trench	48	2,100	380	0	1,700	0
Vault	49	2,300	430	0	1,300	0

[a] All values are given to two significant figures. The values are based on the entire inventory of GTCC LLRW and GTCC-like waste being disposed of in a borehole, trench, or vault facility at each site. These results do not address combinations of disposal methods, which could result in lower doses and LCF risks, depending on the waste types being disposed of.

[b] In addition to the dose associated with contaminated groundwater, there would be a small radiation dose from the airborne release of radioactive gases from the disposed-of wastes for the trench (<1.8 mrem/yr) and vault (<0.52 mrem/yr) disposal methods.

[c] NA = not applicable.

TABLE 5.3.4-4 Comparison of Maximal Latent Cancer Risks (LCF/yr) within 10,000 Years for the Resident Farmer Scenario Associated with the Use and Ingestion of Contaminated Groundwater at the Various GTCC Reference Locations Evaluated for the Land Disposal Methods[a]

Disposal Facility	Hanford	INL	LANL	NNSS	SRS	WIPP Vicinity
Borehole	0.000003	0.0005	0.00009	0	NA[b]	0
Trench	0.00003	0.001	0.0002	0	0.001	0
Vault	0.00003	0.001	0.0003	0	0.0008	0

[a] All values are given to one significant figure to reflect the uncertainties in these estimates. The values and are based on the entire inventory of GTCC LLRW and GTCC-like waste being disposed of in a borehole, trench, or vault facility at each site. These results do not address combinations of disposal methods, which could result in lower doses and LCF risks, depending on the waste types being disposed of.

[b] NA = not applicable.

In this analysis, the same land disposal facility concepts and designs were used at each of the various sites. As a result, some sites (specifically those in arid regions) performed better than those in more humid environments. This result should not be interpreted as implying that a site in a humid environment could not be used to dispose of GTCC wastes in an acceptable manner. Rather, this means that more engineering and administrative controls might be necessary. When considering which GTCC disposal alternative to select, DOE will consider the potential dose to the hypothetical resident farmer as well as other factors described in Section 2.9.

5.3.4.4 Intentional Destructive Acts

DOE evaluated the consequences of scenarios involving intentional destructive acts (IDAs), such as sabotage or terrorism events, associated with the GTCC waste types and disposal methods analyzed in this EIS. Potential IDA scenarios involving the GTCC LLRW and GTCC-like waste under consideration could occur during transport of the waste to the disposal facility, while the waste containers are being handled at the facility (unloading, temporary storage, and emplacement), or after emplacement.

5.3.4.4.1 Approach. GTCC LLRW and GTCC-like waste pose a potential terrorist threat because of their higher radioactivity in a given volume when compared to other LLRW. Such material could be incorporated into a radioactive dispersal device (RDD) intended to cause societal disruption, including significant negative economic impacts. The consequences of an IDA involving hazardous material depend on the material's chemical, radioactive, and physical properties, its accessibility, its quantity, its packaging, and its ease of dispersion, and also on the surrounding environment, including the number of persons in close proximity to an event. Because the characteristics of the activated metals, sealed sources, and Other Waste considered in this EIS (see Section 1.4.1) are different, the wastes are treated separately in this IDA analysis.

There are many detailed scenarios, ranging from minor incidents to widespread contamination, whereby this waste could be used in an IDA, Even though the likelihood of occurrence of any detailed scenario is speculative and cannot be determined, there are certain classes of events that may be identified and qualitatively analyzed to provide an upper range estimate of impacts.

In this analysis, generic IDA scenarios for transporting the waste to a disposal facility and for handling and disposing of the waste at the facility are evaluated and discussed separately. In the case of transportation, a limited amount of material is available in robust packaging, but it is more readily accessible to the public and could travel through areas of varying population density and land use. Initiating events could range from hijacking the transportation vehicle and its contents for future use in a single or multiple RDDs, causing an accident involving a transportation vehicle in an attempt to release radioactive material, or detonating explosives placed on or near the transportation vehicle (e.g., an improvised explosive device, rammed by a car or truck bomb) during transport. Regardless of the initiating event, the highest potential impacts would be similar to the severe transportation accident impacts discussed later in Section 5.3.9.3 and discussed in detail soon in Section 5.3.4.4.5 for the various waste types. Such impacts were evaluated over a range of scenarios, from rural areas with few people to highly populated urban areas.

In a similar fashion, it is expected that generic IDA scenarios at a disposal facility could cause a range of impacts similar to those analyzed for facility accidents earlier in Section 5.3.4.2.1 and in Chapters 6 through 11 (Sections 6.2.4.1, 7.2.4.1, etc.) for facilities. Such scenarios could involve an overt or covert land or aerial attack on the facility involving any number of assailants, with or without explosives or incendiary devices, and with or without insider assistance. The upper range of potential impacts is discussed soon in Section 5.3.4.4.5 for the land disposal methods analyzed.

Therefore, this IDA analysis focuses on the land disposal methods because DOE already considered the potential impacts of IDAs (i.e., acts of sabotage or terrorism) at WIPP, the geologic repository (see Section 4.3.4.4).

5.3.4.4.2 Security Measures. Appropriate security measures would be instituted to ensure the safety of facility workers and the surrounding off-site public. DOE is responsible for safe disposition of the GTCC LLRW and GTCC-like waste, whether it is in an NRC-licensed disposal facility, a facility operated at a DOE or commercial site, or a facility operated by DOE or a commercial entity.

DOE has acted in a strong and proactive manner to understand and preclude or mitigate the threats posed by IDAs. In accordance with DOE Order 470.4A, "Safeguards and Security Program," and Order 470.3B, "Graded Security Protection Policy," DOE conducts vulnerability assessments and risk analyses of facilities and equipment under its jurisdiction to evaluate the physical protection elements, technologies, and administrative controls needed to protect DOE assets. DOE Order 470.4A establishes the roles and responsibilities for the conduct of DOE's Safeguards and Security Program. DOE Order 470.3B (a) specifies those national security assets that require protection; (b) outlines threat considerations for safeguards and security programs to provide a basis for planning, design, and construction of new facilities or modifications to existing facilities; and (c) provides an adversary threat basis for evaluating the performance of safeguards and security systems. DOE also protects against espionage, sabotage, and theft of radiological materials.

DOE would conduct in-depth, site-specific safeguards and security inspections of the GTCC waste disposal facility to ensure that existing safeguards and security programs satisfied DOE requirements. Any issues identified would be resolved before the startup of the operations.

As part of the licensing requirements for a LLRW disposal facility, NRC regulations at 10 CFR 61.16 may require a physical security plan for the facility. Licensed LLRW disposal facilities also undergo periodic inspections. The primary purpose of the NRC inspection program for LLRW facilities is to verify that these facilities are operated and managed throughout their entire life cycle in a manner that provides protection from radioactivity to employees, members of the public, and the environment. Included in these inspections are reviews of site security and the security of handled radioactive materials.

5.3.4.4.3 Disposal Options. The three land disposal options (borehole, vault, and trench) share the same infrastructure, in that these three types of facilities are designed for receipt, secure temporary storage, and final disposal of the waste. No waste processing would be conducted at the facility, which would eliminate any potential for malevolent acts involving unpackaged waste or bulk hazardous chemicals. CH waste in 208-L (55-gal) drums or SWBs would be the most vulnerable to attack, either in temporary storage at the Waste Handling Building (WHB) or during on-site transport for final emplacement. The RH waste would pose a less desirable target for attack because of the added shielding required for handling, and, in the case of activated metals, because it would be in a form that is much less dispersible.

During transport to the disposal facility, waste materials would be in heavily shielded casks that would prevent the release of any radioactive material under any but the most severe conditions, as discussed in Section C.9.3.3 in Appendix C. Once at the facility, waste would be unloaded from the transport vehicle and placed in secure temporary storage. CH waste containers such as 208-L (55-gal) drums or SWBs would be taken out of the transport packaging, such as a TRUPACT-II container, and staged in a temporary storage area at the WHB prior to emplacement in a disposal unit. RH waste would either be stored in its Type B transport cask or be removed from its cask and temporarily stored in a heavily shielded room in the WHB before emplacement. Only limited numbers of waste containers would be in the WHB at any given time.

Emplacement of the waste would entail loading the CH containers by crane or forklift onto on-site transport vehicles, moving the waste to the disposal unit, and unloading the waste by crane or forklift into the disposal unit. CH waste might also be taken directly by forklift from the WHB to the disposal unit, depending on the final facility design and operating procedures. RH waste would be transferred to an on-site transfer cask. The cask would be loaded by crane onto an on-site transport vehicle, if it was not already on the vehicle during the waste transfer, and moved to the disposal unit, then unloaded by crane into the disposal unit.

Once emplaced in a closed disposal unit, the waste would be well-isolated from any potential IDA, thus significantly reducing the risk of contaminating the environment. The disposed-of waste would have a minimum cover of 5 m (17 ft). For the trench option, the 5-m (17-ft) cover would include the 1.1-m (3.8-ft)-thick, reinforced concrete, engineered barrier, whereas the vault option has a minimum cover of 5 m (17 ft) on top of its 1.1-m (3.8-ft)-thick reinforced concrete ceiling (see Section D.3 in Appendix D). Waste in the borehole would have a 30-m (100-ft) cover, including a 1.1-m (3.8-ft)-thick concrete layer. However, a large blast or excavation using typical earth-moving equipment could readily expose, at the least, the concrete cover on the trench or vault. Such an action would likely not initially disperse the waste but would make it easier to access. A borehole, with its 30-m cover and small cross section (smaller amount of waste per unit) precluding anything but specialized drilling equipment to reach the waste, would provide more security.

Compared to the vault and trench options, the borehole option would also provide the most security after emplacement before the disposal unit was closed. Because of the borehole's depth and smaller diameter, access to the waste in the borehole and the dispersion of the waste into the surrounding environment would be difficult. CH waste would be readily accessible in partially filled trenches or vault cells. RH waste would be less accessible in either case, lying beneath the 1.1 m (3.8 ft) of concrete of the radiation shield. Final covers on the trenches could be installed in sections as the waste was in place, thereby reducing the amount of material available to an IDA before closure of the entire trench.

5.3.4.4.4 Facility Location. The location of the disposal facility would affect how readily accessible the waste was and also the extent of human health impacts if an IDA occurred at the facility. The further a disposal site is from population centers, the less likely it is that the site would become a target, because terrorists would find it harder to blend in with the local population (i.e., they might be more easily detected while they were planning, preparing, and executing a potential IDA). In addition, an IDA at a location farther from potential victims would affect fewer individuals, and would likely be a less attractive option for terrorists. All specific disposal locations being considered are in relatively remote areas. Most locations under consideration for a disposal facility in this EIS are also within secure DOE areas, providing added protection for an operating facility or one that is still under institutional control.

5.3.4.4.5 Waste Types and Characteristics. Human health impacts of an IDA are directly related to what the characteristics of the radionuclide are (e.g., alpha or beta emitter and isotope half-life), how much radiological material is available for dispersal, how readily dispersible the material may be, and how the material is dispersed to the environment. For example, activated metals are highly radioactive gamma emitters that pose an external exposure threat, but they are not readily dispersible because of their solid metal form. Other Waste may consist of random pieces of maintenance, process, or demolition debris, such as contaminated metal, wood, cloth, plastic, or paper. Many of these items have loosely adhering radioactive contamination and/or are readily combustible, allowing the radioactive material to be more easily dispersed. Like activated metals, sealed sources contain highly radioactive gamma emitters. These materials are often doubly encapsulated in stainless steel and thus are not readily dispersible unless the source is first mechanically opened or somehow forcibly ruptured. The radioactive material in sealed sources can take on different forms that affect dispersibility. These include solid metals, ceramic or compressed disks, and powders.

Because of the physical and chemical characteristics of the different waste types as discussed above and in Section 1.4.1 and Appendix B, the IDA analysis of the GTCC LLRW and GTCC-like activated metals and Other Waste was conducted separately from the analysis of the sealed sources.

Activated Metals and Other Waste. For the activated metals and Other Waste considered for disposal, the initiating forces and resulting quantities of radioactive material that could be released by an IDA would be similar to those released in severe accidents, as analyzed in Section 5.3.9.3 for transportation and here in Section 5.3.4.2.1 and in Chapters 6 through 11 (Sections 6.2.4.1, 7.2.4.1, etc.) for facilities.

Unlike the evaluation of accidents, the evaluation of IDAs provides an estimate of the potential consequences of such events, without attempting to estimate the frequency or probability that an IDA would be attempted or would succeed. This is because there is no accepted basis for estimating the frequency of IDAs. Consequently, the evaluation does not account for security measures that might be implemented to help prevent such attacks. Final disposition of the waste in the types of disposal facilities considered in this EIS would greatly reduce the potential for diversion or theft associated with an IDA. The comparison of IDAs with accidents in the following sections is limited to the consequences that might result if an accident or IDA occurred, and it does not address the likelihood of either type of event.

Transportation impacts. It is expected that an IDA involving a shipment of activated metals or Other Waste would have impacts similar to those from a severe transportation accident. Because of high radionuclide inventories, most of the GTCC LLRW and GTCC-like waste is expected to require the use of Type B packaging for shipment, as discussed and described in Section C.9.4.2. The robust nature of these casks limits the potential release of radioactive material under the severest of accident conditions, as analyzed in Section 5.3.9.3. The severe accidents evaluated are generic in nature (i.e., there is no specific initiating event) but do involve extremes in mechanical and thermal (fire) forces.

The largest impacts were assessed for accidents involving fully loaded railcars (maximum amount of radioactive material available) in highly populated urban areas (largest affected population) under stable (calm) weather conditions (least amount of airborne dispersion, highest potential air concentrations of radioactive material). For these maximum reasonably foreseeable accidents, such an analysis is conservative in nature because any change in conditions would likely result in lower impacts. For this reason, it is not expected that during a single shipment, a terrorist attack could create conditions that would further increase impacts. For activated metal shipments, the largest impact would be a collective population dose of 60 person-rem, with no LCFs expected, as presented in Table 5.3.9-3. For the Other Waste category, a collective population dose of 3,200 person-rem, with the potential for two LCFs in the general population, is estimated for a railcar shipment of CH waste.

Facility impacts. Once received at a disposal facility, the GTCC LLRW and GTCC-like waste would be removed from their protective Type B shipping containers, stored temporarily in the WHB, and then transported on-site to a disposal unit, where they would be emplaced. An IDA committed at a disposal facility could occur during one of these phases; the largest potential impacts would likely occur during temporary storage of the waste in the WHB.

The on-site transportation of activated metal waste or Other Waste - RH would involve the use of a shielded on-site transfer cask to protect workers from the high radiation levels associated with these types of waste. The transfer cask would have properties similar to those of the Type B casks used for off-site transport and would limit dispersal if an accident or IDA occurred. Thus, IDA impacts involving the on-site transfer of activated metal or Other Waste - RH at the disposal facility are expected to be similar to those from a severe truck transportation accident involving one cask. Because all of the proposed disposal facility sites are in isolated rural areas, a collective population dose of 0.46 or 6.0 person-rem or less is expected, as given in Table 5.3.9-3 for a severe accident involving a truck carrying activated metal waste or Other Waste - RH, respectively, in a rural population zone.

The on-site transportation of Other Waste - CH would involve moving the waste in its disposal containers: either 208-L (55-gal) drums or SWBs. These Type A containers as described in Appendix B are not as robust as the Type B transportation casks and are more susceptible to dispersion of their contents as a result of an IDA event. The facility accident analyses described in 5.3.4.2.1 took this factor into account.

On-site movement of CH waste would involve either a single SWB or a 7-drum pack of 208-L (55-gal) drums. However, more waste can be contained by a direct-filled SWB than in seven 208-L (55-gal) drums. An SWB would be moved by forklift or similar conveyance from the WHB to the disposal unit. The facility accident with the largest impacts would be one that involved an SWB filled with Other Waste - CH in a fire (Accident No. 9). It is expected that an IDA event involving an SWB during on-site movement would have similar results, because it would provide maximum dispersion of the SWB contents to off-site locations. As seen in Chapters 6 through 12 (Sections 6.2.4.1, 7.2.4.1, etc.), the potential collective population consequences would range from 0.47 person-rem at the NNSS reference locations to 160 person-rem at LANL for Accident No. 9. Although Type A containers do not provide as much protection from dispersion after an IDA than do Type B containers, the impacts would still be less than or comparable to those from the off-site severe transportation accidents discussed above, because the population densities surrounding the sites would be low and because less material would be at risk. Impacts from site to site would vary, depending on the site meteorology and the surrounding population density and its distribution.

The IDA scenario that would encompass the most material at risk is the one that would occur during the temporary storage of the GTCC LLRW and GTCC-like waste after their receipt at a disposal facility. The conceptual facility designs used for this EIS do not include the amount of detail required to specify the total number of containers that could be stored at any one time, either physically or administratively. The amount of waste to be stored would be established during the implementation phase, limited to minimize worker risk, dependent on the security measures implemented, and dependent on the type of disposal units employed at the site. However, a rough estimate of potential consequences can be derived by scaling the CH waste facility (fire) accident by the number of SWBs that might be stored. For example, if 20 SWBs were in storage at the WHB and if all of them were involved in a serious fire, the collective off-site population consequence at the Hanford Site reference location would be about 1,500 person-rem or less, because it is likely that not all SWBs would have the maximum amount of radioactivity possible. The magnitude of such a consequence is about the same as that of the worst severe transportation accidents evaluated in urban areas.

Sealed Sources. With regard to the sealed sources being considered for disposal, the initiating forces and resulting quantities of radioactive material (from contents of sealed sources) that could be released by an IDA could be larger than the forces and quantities associated with severe accidents as analyzed in Section 5.3.9.3 for transportation and in Section 5.3.4.2.1 and

Chapters 6 through 11 (6.2.4.1, 7.2.4.1, etc.) for facilities. Sealing the sources would reduce their potential to release radioactivity during facility accidents in which the waste containers in which the sources were packaged were punctured or dropped. Sealing, in addition to the shielding afforded by the massive Type B containers used for transportation, would limit the potential release of their contents during severe transportation accidents. In the case of an IDA, the entire contents of one or more sealed sources could be made available for dispersion. Unlike the Other Waste, the sealed sources at risk would be in a concentrated form that would make multiple sources more amenable to consolidation and covert movement before a potential IDA. Thus, an IDA involving sealed sources could be preceded by the theft or diversion of the sources and their consolidation to prepare an RDD.

The use of sealed sources in an RDD could lead to a mass contamination event (NAS 2008; GAO 2008). Fortunately, it is very difficult to cause deterministic human health effects in more than a handful of people (Musolino and Harper 2006). As shown in Table 5.3.9-3, estimates indicate that the sealed source transportation accidents that would involve the most material at risk and greatest potential consequences would result in fewer than 10 LCFs over the long term in highly populated urban areas. Consolidation of the contents of sealed sources and detonation in an RDD without the protective containment provided by a Type B transportation cask could increase the potential impact by more than two orders of magnitude. However, even among people who were suffering from health effects, few people, if any, would receive a dose that could result in acute lethality (GAO 2008). For the highest collective urban human health impact estimated in Table 5.3.9-3, the average risk to a member of the affected population of contracting cancer from exposure in his or her lifetime would be about 1 chance in 3.5 million. The primary impacts of such an event would be to raise the level of fear and anxiety in the general population and extract a large economic toll on the community (NAS 2008).

Human health impacts would depend on the location of the release, the surrounding population density, the area topology, and the local meteorology. Potential exposure to individuals would also depend highly on their actions immediately following the release (Dombrowski and Fishbeck 2006). Such impacts would be influenced to some extent by emergency response capabilities and training in the affected area (Musolino and Harper 2006; Harper et al. 2007).

Because the exact nature, time, and location of an IDA are impossible to predict, a range of scenarios involving radiological releases similar to events that could involve sealed sources considered in this EIS were investigated in the past. Depending on the amount of activity involved, contaminated locations (where individuals might receive more than the suggested U.S. Department of Homeland Security relocation guidelines of 2 rem/yr [73 FR 45029]) could range in the tens of square kilometers (Harper et al. 2007; GAO 2008). Potential acute fatalities could be on the order of 10 to 50 people, with potential LCFs being in the hundreds (Dombroski and Fishbeck 2006; Rosoff and von Winterfeldt 2007). The economic impacts (e.g., relocation, business loss, decontamination, demolition, and disposal) could reach billions of dollars.

5.3.5 Ecological Resources

This section describes the potential impacts on ecological resources associated with a GTCC disposal facility regardless of the alternative site chosen. Both direct and indirect impacts on terrestrial vegetation and wetlands, wildlife, aquatic biota, and special status species are presented. Most impacts on ecological resources would occur during construction of the GTCC disposal facility, when most land disturbance would occur. Compliance with applicable environmental laws, regulations, and guidance (Chapter 13), coupled with use of mitigation measures, would minimize the adverse impacts described in this section (DOE 2003a).

5.3.5.1 Potential Impacts on Terrestrial Vegetation

Ground-disturbing activities during the construction of the GTCC disposal facility — including excavation, grading, and clearing of vegetation — would result in direct impacts on plant communities. The operation of heavy equipment would injure or destroy existing vegetation and compact and disturb soils. Soil aeration, infiltration rates, and moisture content could be affected. Deposition of fugitive dust from exposed soil surfaces or gravel roadways might result in reduced photosynthesis and primary production in adjacent terrestrial and wetland habitats. Impacts might include reduced growth and density of vegetation and changes in the plant community composition to more tolerant species. In areas where loose soils such as sand dunes occur, erosion might occur as a result of stormwater runoff, wind erosion, or sloughing of unstable slopes. Stabilization of slope margins might be difficult, and establishment of vegetative cover might be slow, possibly resulting in prolonged habitat losses near the construction area.

Removal of trees within or along forest or woodland areas could potentially result in an indirect disturbance to forest or woodland interior areas by changing the light and moisture conditions and by introducing nonforest or nonwoodland species, including potentially invasive species. In addition, trees remaining along the margin of the construction area might decline as a result of stress induced by altered conditions. Disturbance of surface soils near trees could also adversely affect trees along the margin. Root disturbance, soil compaction, topsoil loss, reduced soil moisture or reduced aeration, or altered drainage patterns might contribute to tree losses in addition to the loss of trees removed during land clearing.

Some plant species can benefit from land-disturbing activities because the activities create suitable habitat for them or create an opportunity to recruit seeds into new locations. Fencing, which would exclude larger herbivores, might also benefit some plant species. The species used to revegetate the GTCC reference location would be chosen in accordance with management policies at the site. As appropriate, regionally native plants would be used to landscape the disposal site. In arid regions, revegetation might be difficult.

Under Executive Order 13112, federal agencies are mandated, to the extent practicable, to prevent and control the spread of invasive species and to restore native species and habitat conditions. Even with judicious attempts to revegetate the GTCC reference location with native vegetation, site disturbance could facilitate the dispersal of invasive species by altering existing habitat conditions, stressing or removing native species, and allowing easier movement by wildlife or human vectors (Trombulak and Frissell 2000). Invasive plant species are present at all of the alternative DOE sites. Typically, seeds or other propagules of these species are easily dispersed, and they generally tolerate disturbed conditions. The introduction and spread of invasive plant species into disturbed areas represents a potential threat to biodiversity through displacement of native species, simplification of plant communities, and fragmentation of habitat (DOE 1999b). In addition, invasive species may alter ecological processes, such as fire regimes. Effects may include an increase in both the frequency and the intensity of wildfires, particularly as a result of the establishment of annual grasses (e.g., cheatgrass [*Bromus tectorum*] in the Western states), which produce large amounts of easily ignitable fuel over large contiguous areas. Native species, particularly shrubs, in habitats not adapted to frequent or intense fires might be adversely affected, and their populations could be greatly reduced in affected areas, creating opportunities for further increases in populations of invasive species. Vehicle traffic could also increase the potential for fires.

Contamination by compounds such as diesel fuel might result from accidental spills at the disposal site. Contaminants spilled onto ground surfaces could result in direct injury and mortality of plants, and migration through the soil could make recovery and restoration difficult. Habitats with highly permeable soils could experience rapid migration of contaminants through the root zone. Some contaminants might migrate to shallow groundwater and subsequently enter the root zone of nearby vegetation in the path of groundwater movement.

5.3.5.2 Potential Impacts on Wildlife

The construction and operations of the GTCC waste disposal facility might adversely affect wildlife through (1) habitat reduction, alteration, or fragmentation; (2) introduction of invasive vegetation; (3) injury or mortality of wildlife; (4) erosion and runoff; (5) fugitive dust; (6) noise; and (7) exposure to contaminants. The overall impact on wildlife populations would depend on the (1) type and amount of wildlife habitat that would be disturbed, (2) spatial and temporal extent of the disturbance, (3) wildlife that occupy the project site and surrounding areas, and (4) timing of construction activities relative to crucial life stages of wildlife (e.g., breeding season).

5.3.5.2.1 Habitat Disturbance. Developed and fenced areas could directly eliminate habitat, inhibit habitat use, or alter the dispersal and distribution patterns of wildlife. The amount of habitat that would be disturbed would be a function of the degree of disturbance already present in the project site area and the area disturbed for the disposal facility (i.e., up to 44 ha [110 ac] for boreholes, 24 ha [60 ac] for vaults, or 20 ha [50 ac] for trenches). The construction of a disposal facility would not only result in the direct reduction or alteration of wildlife habitat within the project footprint but could also affect the diversity and abundance of wildlife through the fragmentation of habitat.

Effects from habitat disturbance would be related to the type and abundance of the habitats affected and the wildlife species that occur in those habitats. For example, habitat disturbance could affect local wildlife populations, especially species whose habitats were uncommon and not well represented in the surrounding landscape. In contrast, few population-level impacts are expected for cases in which the GTCC waste disposal facility would be located on currently disturbed or modified lands, such as rangelands. The wildlife species least likely to be affected would be habitat generalists. Also, many wildlife species can tolerate and adapt to a variety of habitats and can therefore be found in habitats other than those considered typical for the species (Giffen et al. 2007).

Although most fragmentation research has focused on forested areas, similar ecological impacts have been reported for the more arid and semiarid landscapes of the western United States, particularly shrub-steppe habitats that are dominated by sagebrush or salt desert scrub communities. For example, habitat fragmentation, combined with habitat loss and degradation, has been shown to be largely responsible for the decline in greater sage-grouse (*Centrocercus urophasianus*) throughout most of its range (Stritthold et al. 2000). Similar impacts could be expected for other species, such as the federally listed pygmy rabbit (*Brachylagus idahoensis*) and sagebrush lizard (*Sceloporus graciosus*).

The creation of edge habitat could (1) increase predation and parasitism of vulnerable forest interior animals in the vicinity of edges; (2) have negative consequences for wildlife by modifying their distribution and dispersal patterns; (3) be detrimental to species requiring large undisturbed areas, because increases in edges are generally associated with concomitant reductions in habitat size and possible isolation of habitat patches and corridors (habitat fragmentation); or (4) increase local wildlife diversity and abundance.

The ecological importance of the edge largely depends on how different it is from the regional landscape. For example, the influence of the edge would be less ecologically important where the landscape has a high degree of heterogeneity. Also, edge influence would be less ecologically important in a forest with a more open and diverse canopy (Harper et al. 2005). Landscapes with a patchy composition (e.g., tree-, shrub-, and grass-dominated cover) might already contain edge-adapted species that would make a created edge less likely to have any influence (Harper et al. 2005).

Although habitats adjacent to facilities might remain unaffected, wildlife tend to make less use of these areas. The combination of avoidance and stress reduces the capability of wildlife to use habitat effectively.

Long-term displacement of elk (*Cervus canadensis*), mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), or other species from critical (crucial) habitat or parturition areas as a result of habitat disturbance would be considered significant. For example, activities around parturition areas have the potential to decrease the usability of these areas for calving and fawning. A disposal facility located within a crucial winter area could directly reduce the amount of habitat available to the local population. This situation could force individuals to use suboptimal habitat, which could lead to debilitating stress and possibly to population-level effects.

While not an absolute barrier, the GTCC disposal facility might limit travel by wildlife species between areas on either side of the facility. Habitat specificity, seasonal changes in microclimate, and population pressures could influence the extent and rate at which small mammals would cross a cleared area. The size of the disposal facility could present a barrier to the movement of some small animals (due to distance) and larger mammals (due to the fence); human presence would also be a factor.

5.3.5.2.2 Introduction of Invasive Vegetation. Wildlife habitat could also be affected if invasive vegetation became established in the construction-disturbed areas and adjacent off-site habitats. The establishment of invasive vegetation could reduce habitat quality for wildlife and locally affect wildlife occurrence and abundance.

5.3.5.2.3 Wildlife Injury or Mortality. Construction activities would result in the direct injury or death of wildlife that (1) are not mobile enough to avoid construction activities (e.g., reptiles, small mammals), (2) utilize burrows (e.g., ground squirrels and burrowing owls [*Athene cunicularia*]), or (3) defend nest sites (such as ground-nesting birds). Although more mobile wildlife species, such as deer and adult birds, might avoid the initial clearing activity by moving into habitats in adjacent areas, it is conservatively assumed that adjacent habitats are at carrying capacity for the species that live there and could not support additional wildlife from the construction areas. The subsequent competition for resources in adjacent habitats would likely preclude the incorporation of the displaced individuals into the resident populations. Collision with vehicles could also be a source of wildlife mortality, especially in areas with concentrations of wildlife or in travel corridors. Wildlife might also be affected if increased access led to an increase in the legal and illegal taking of wildlife, which could affect local populations of some species.

5.3.5.2.4 Erosion and Runoff. Construction activities might result in increased erosion and runoff from freshly cleared and graded sites. This erosion and runoff could reduce water quality in nearby aquatic or wetland habitats used by amphibians and other wildlife. Potential impacts on wildlife could range from avoidance of the habitats to effects on reproduction, growth, and survival. The latter would occur primarily to amphibians that would inhabit these habitats. The potential for water quality impacts during construction would be short term for the duration of construction activities and post-construction soil stabilization (e.g., reestablishment of natural or man-made ground cover). Any impacts on amphibian populations would be localized to the surface waters or wetlands receiving site runoff. Although the potential for runoff would be temporary, pending the completion of construction activities and the stabilization of disturbed areas with vegetative cover, erosion could result in significant impacts on local amphibian populations if an entire recruitment class was eliminated (e.g., complete recruitment failure for a given year because of siltation of eggs or mortality of aquatic larvae).

5.3.5.2.5 Fugitive Dust. Little information is available regarding the effects of fugitive dust on wildlife; however, if exposure was of sufficient magnitude and duration, the effects could be similar to the respiratory effects identified for humans (e.g., breathing and respiratory symptoms). A more probable effect would be the dusting of plants, which could make forage less palatable. This effect would generally coincide with the area of displacement and stress to wildlife resulting from human activity. Fugitive dust generation during construction activities is expected to be short term and localized to the immediate construction area and is not expected to result in any long-term individual or population-level effects.

5.3.5.2.6 Noise. Principal sources of noise during construction activities would include truck traffic and the operation of heavy machinery. The most adverse impacts associated with construction noise could occur if critical life-cycle activities (e.g., mating and nesting) were disrupted. If birds were disturbed during the nesting season to the extent that they were displaced, then nest or brood abandonment might occur.

Much of the research on wildlife-related noise effects has focused on birds. This research has shown that noise may affect territory selection, territorial defense, dispersal, foraging success, fledging success, and song learning (e.g., Reijnen and Foppen 1994; Foppen and Reijnen 1994; Larkin 1996). Several studies (Foppen and Reijnen 1994; Reijnen and Foppen 1994, 1995; Reijnen et al. 1995, 1996, 1997) have shown reduced densities of some species adjacent to roads, with effects detectable from 20 to 3,530 m (66 to 11,600 ft) from the roads. On the basis of these studies, Reijnen et al. (1996) identified a threshold effect sound level of 47 dBA for all species combined and 42 dBA for the most sensitive species; the observed reductions in population density were attributed to a reduction in habitat quality caused by elevated noise levels. This threshold sound level of 42 to 47 dBA (which is somewhat below the EPA-recommended limit for residential areas) is at or below the sound levels generated by truck traffic that would likely occur at distances of 76 m (250 ft) from the construction area or access roads or the levels generated by typical construction equipment at distances of 760 m (2,500 ft) or more from the construction site.

Overall, the magnitude and duration of noise associated with trucks and construction equipment are expected to result in only minor annoyance to wildlife at the site and not result in any long-term adverse effects. The response of wildlife to this disturbance would vary by species; the individual animal's physiological or reproductive condition; the distance from the noise source; and the type, intensity, and duration of the disturbance.

5.3.5.2.7 Exposure to Contaminants. The depth of disposal and cover materials associated with the disposal facilities is expected to prevent or minimize the exposure of wildlife to radionuclides. Wildlife might be exposed to accidental spills or releases of oil, herbicides, fuel, or other hazardous materials. Exposure to these materials could affect reproduction, growth, development, or survival of exposed individuals. Potential impacts on wildlife would vary according to the material spilled, the volume of the spill, the location of the spill, and the species being exposed. Spills could contaminate soils and surface water and could affect wildlife associated with these media. The use by wildlife of areas contaminated with hazardous constituents could result in the wildlife also becoming contaminated, and if individuals left the area, they could spread the contaminants to other locations. A spill would likely have a population-level adverse impact only if it was very large or it contaminated a crucial habitat area. The potential for either event is very unlikely. Because the amounts of fuels and hazardous materials used are expected to be small, an uncontained spill would affect only a limited area. In addition, wildlife use of the area during construction would be very minor or nonexistent, thus greatly reducing the potential for exposure. Spill response plans would be in place to address any accidental spills or releases.

5.3.5.3 Potential Impacts on Aquatic Biota

The overall impact of a project on aquatic resources would depend on the type and amount of aquatic habitat disturbed or contaminated, the nature of the disturbance or contamination, and the biota that occupied the areas aquatic habitats. Surface waters do not occur within any of the reference locations evaluated for the GTCC disposal facility at any of the alternative DOE sites. Therefore, potential impacts on aquatic biota are limited to indirect impacts.

Characteristics of surface water runoff, such as flow direction and flow rates following rain events, are controlled, in part, by local topography and vegetation cover. As a consequence, any construction activities that affected the terrain and vegetation during construction of the GTCC waste disposal facility could alter the water flow patterns. Impacts on aquatic ecosystems could result if these alterations affected the amount and timing of runoff entering a particular water body.

During construction, ground disturbance could result in increased suspended sediment loads. Turbidity and sedimentation from erosion are part of the natural cycle of physical processes in water bodies, and most populations of aquatic organisms have adapted to short-term changes in these parameters. However, if sediment loads were unusually high or lasted for extended periods of time compared with natural conditions, adverse impacts could occur (Waters 1995). Increased sediment loads could decrease the rate of photosynthesis in plants and phytoplankton; decrease fish feeding efficiency; decrease the levels of invertebrate prey; reduce fish spawning success; adversely affect the survival of incubating fish eggs, larvae, and fry; and adversely affect amphibians, their larval stage, and their eggs. In addition, some migratory fishes might avoid streams that contained excessive levels of suspended sediments (Waters 1995).

The level of effects from increased sediment loads would depend on the natural condition of the receiving waters and the timing of sediment inputs. Whereas most aquatic systems would probably be affected by large increases in the levels of suspended and deposited sediments, aquatic habitats in which waters are normally turbid might be less sensitive to small to moderate increases in suspended sediment loads than would habitats that normally have clear waters. Similarly, increased sedimentation during periods of the year in which sediment levels might naturally be elevated (e.g., during wet parts of the year) might have impacts smaller than the sediment impacts that occur during periods in which natural sediment levels are expected to be lower.

Appropriate soil and erosion control measures would be used to protect aquatic resources. During construction, the impacts from erosion and sedimentation would be minor to negligible, and once the site was stabilized and revegetated, erosion and sedimentation impacts on nearby water resources would probably not occur.

The potential exists for toxic materials (e.g., fuels and herbicides) to be introduced accidentally into waterways during construction and maintenance activities. The level of impacts from releases of toxicants would depend on the type and volume of chemicals entering the waterway, the location of the release, the nature of the water body (e.g., size, volume, and flow rates), and the types and life stages of organisms present in the waterway. Mitigation measures would be taken during the development and maintenance of the GTCC disposal facility to restrict the use of machinery near waterways and to place restrictions on the application methods, quantities, and types of herbicides that are used in the vicinity of waterways in order to limit the potential for impacts on aquatic ecosystems. The GTCC waste disposal facility stormwater retention pond is not expected to become a highly productive aquatic habitat.

5.3.5.4 Potential Impacts on Special-Status Species

Potential impacts on threatened, endangered, and other special status-species would be fundamentally similar to those on vegetation, wildlife, and aquatic biota discussed earlier in this section. However, threatened, endangered, and other special-status species are far more vulnerable to impacts because their population sizes are smaller than those of the more common and widespread species. This small population size makes them more vulnerable to the effects of habitat fragmentation, habitat alteration, habitat degradation, human disturbance and harassment, and mortality of individuals. Their vulnerability makes it very important to comply with applicable laws, regulations, and Executive Orders (Chapter 13) and to successfully implement mitigation measures.

5.3.6 Socioeconomics

The socioeconomic impacts of constructing and operating GTCC waste disposal facilities were assessed for an ROI around each site, corresponding to the area in which construction and operational workers at the site would reside and spend their wages and salaries. The economic impacts of GTCC waste disposal facility construction and operations were measured in terms of employment and income. Since an in-migrant labor force is expected during both construction and operations of a disposal facility, impacts of construction and operations on population, housing, public services, education expenditures, and employment were also assessed. Impacts on the local transportation network of GTCC LLRW facility employees who would commute were also assessed.

Any socioeconomic impacts that would result from the transportation of GTCC waste, including impacts on property values, would be minimal. This is because it is likely that the current transportation of other hazardous materials and the risk of accidents involving these materials are already captured in housing values in the vicinity of transportation routes. An accident involving GTCC LLRW or GTCC-like waste might create additional impacts on the housing market only if residents were prevented from quickly returning to their homes.

Potential site-specific consequences relative to socioeconomics from Alternatives 3 to 5 are further discussed in Chapters 6 through 11 for the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.7 Environmental Justice

Potential consequences on environmental justice from Alternatives 3 to 5 would be site-dependent. They are discussed in Chapters 6 through 11 for the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.8 Land Use

Land use impacts focus on the net land area affected, the area's relationship to existing land uses in the project area, current growth trends and current and proposed land use designations, proximity to special use areas, and other factors pertaining to land use. The amount of land that would be cleared to construct a GTCC waste disposal facility would be up to 44 ha (110 ac) for the borehole method, 24 ha (60 ac) for the vault method, and 20 ha (50 ac) for the trench method. Therefore, current land use of up to 44 ha (110 ac) (or use of up to 24 ha [60 ac] at SRS) would be altered to (or, in several cases, remain) the land use associated with a radioactive waste disposal site.

Current land use was taken into account in identifying the GTCC reference locations at each alternative site in order to minimize potential land use conflicts at the outset. Because of the small area in which land use would change as a result of the GTCC waste disposal facility relative to the land use that currently exists in the area of the alternative sites, land use impacts would be considered moderate to minor. Potential consequences relative to land use from Alternatives 3 to 5 would be site-dependent and are discussed in Chapters 6 through 11 for the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.9 Transportation

Transportation impacts from the shipment of GTCC LLRW and GTCC-like waste were evaluated for each disposal site considered. The impacts from both routine and accident conditions were evaluated, as discussed in Appendix C, Section C.9. These impacts are presented in three subsections: (1) collective population risks during routine conditions and accidents, (2) radiological risks to individuals receiving the highest impacts during routine conditions, and (3) consequences to individuals and populations after the most severe accidents involving a release of radioactive or hazardous chemical material.

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rate for CH shipments to the land-disposal sites was set to 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rate was set to 2.5 and 5.0 mrem/h for truck and rail shipments, respectively. These assignments were based on shipments of similar types of waste. Dose rates for rail shipments are approximately double those for truck shipments because rail shipments are assumed to have twice the number of waste packages as those on a corresponding truck shipment. Impacts from accidents are dependent on the amount of radioactive material in a shipment and on the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

5.3.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group, without specifying individual receptors. Exposures to four different groups were considered: (1) persons living and working along the transport routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various methods, and it depends on the number and types of shipments as well as the origin and destination sites involved. These impacts are specific to the disposal site involved and are presented in conjunction with the site impacts given in Chapters 6 through 11.

5.3.9.2 Highest-Exposed Individuals during Routine Conditions

In addition to assessing the routine collective population risk, the risks to individuals for a number of hypothetical exposure scenarios were estimated as described further in Section C.9.2.2 in Appendix C. Receptors would include transportation workers, such as inspectors, and members of the public who would be exposed during traffic delays, while working at a service station, or while living or working near a facility. The distances and durations of exposure would be similar to those given in previous transportation risk assessments (DOE 1997a, 1999b, 2004a,b, 2008). The scenarios were not meant to be exhaustive but were selected to provide a range of potential exposure situations. The estimated doses and associated LCF estimates are provided in Tables 5.3.9-1 and 5.3.9-2, respectively.

The highest potential routine radiological exposure to an individual, with an LCF risk of 5×10^{-6}, would be for truck and rail inspectors who could be exposed at a distance of 1 m (3 ft) from a shipment of RH waste for up to an hour. There is also the possibility for multiple exposures in some cases. For example, if an individual lived or worked near the disposal site, the person could receive a combined dose of as much as approximately 0.5 or 1.0 mrem if present for all truck or rail shipments, respectively, over the course of about 50 years. This dose is still very low, about 300 times lower than the amount an individual receives in a single year from natural background radiation (about 310 mrem/yr). (As noted in Section 5.2.4.3, the average

TABLE 5.3.9-1 Estimated Routine Doses (rem) to the Highest-Exposed Individuals from Shipments of GTCC LLRW and GTCC-Like Waste, per Exposure Event

	Sealed Sources and Other Waste - CH		Other Waste - RH		Activated Metals - RH	
Receptor	Truck	Rail	Truck	Rail	Truck	Rail
Workers						
Inspector (truck and rail)	0.00072	0.0014	0.0044	0.0083	0.0044	0.0083
Railyard crew member	NA[a]	0.00024	NA	0.00064	NA	0.00064
Public						
Resident near route	1.6E-08	9.4E-08	4.1E-07	2.1E-07	4.1E-08	2.1E-07
Person in traffic	0.00064	NA	0.0037	NA	0.0037	NA
Person at service station	0.000014	NA	0.000037	NA	0.000037	NA
Resident near railyard	NA	3.2E-06	NA	7.2E-06	NA	7.2E-06

[a] NA = not applicable.

TABLE 5.3.9-2 Estimated Risk of Fatal Cancer (LCF) to the Highest-Exposed Individuals from Shipments of GTCC LLRW and GTCC-Like Waste, per Exposure Event

	Sealed Sources and Other Waste - CH		Other Waste - RH		Activated Metals - RH	
Receptor	Truck	Rail	Truck	Rail	Truck	Rail
Workers						
Inspector (truck and rail)	4E-07	9E-07	0.000003	0.000005	0.000003	0.000005
Railyard crew member	NA[a]	1E-07	NA	4E-07	NA	4E-07
Public						
Resident near route	1E-11	6E-11	2E-11	1E-10	2E-11	1E-10
Person in traffic	4E-07	NA	0.000002	NA	0.000002	NA
Person at service station	8E-09	NA	2E-08	NA	2E-08	NA
Resident near railyard	NA	2E-09	NA	4E-09	NA	4E-09

[a] NA = not applicable.

radiation dose to an individual from natural background radiation and man-made sources of radiation is about 620 mrem/yr.)

5.3.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considered the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. For perspective, impacts were assessed for shipments of each waste type (sealed sources, activated metals, Other Waste - CH, and Other Waste - RH) that would result in the highest potential impacts. Shipment inventories are provided in Appendix B.

Table 5.3.9-3 presents the radiological consequences to the population from severe accidents involving shipments of GTCC LLRW and GTCC-like waste. Up to 9 LCFs were estimated for a severe urban rail accident involving sealed sources (1,470 Ci of Am-241 in six TRUPACT-II packages), while only 0.04 LCF was estimated for a similar accident involving activated metals (6.6 MCi of activity in four AMCs). A number of factors contributed to these differences, including the amount and type of activity per shipment, the shipment configuration, the number of packages assumed to be breached during the accident, and the amount released to the environment in an aerosol form.

The estimated population doses and associated LCFs were higher for the sealed sources and Other Waste - CH than for the activated metals and Other Waste - RH because they had higher amounts of alpha-emitting radionuclides, which are more of an inhalation (internal) hazard. The dominant exposure pathway for suburban and urban areas was from inhaling the aerosolized contaminant plume as it drifted downwind immediately after an accident. Exposure impacts from activated metal accidents were also lower because radionuclide activity is fixed in the outer layers of metal components and is not easily aerosolized, even under the extreme conditions assumed for the severe accidents.

Severe rail accidents could have higher consequences than truck accidents because each railcar would carry more material than would each truck. It is conservatively assumed that all truck shipments of sealed sources and CH waste would consist of three fully loaded TRUPACT-II packages and that each railcar shipment would consist of six fully loaded TRUPACT-II packages. Likewise, all truck shipments of activated metals and Other Waste - RH would consist of one Type B package capable of shielding an AMC (in the case of activated metals) or an RH72B package (in the case of the Other Waste - RH). Railcar shipments are assumed to consist of a suitable Type B rail cask, with four AMCs for activated metals or two RH72B packages for Other Waste - RH. The same shipment configurations for the TRUPACT-II and RH72B packages were used in similar studies (DOE 1997a,b, 1998).

The severe accident consequence assessment assumed all packages in a shipment would become breached (DOE 1997a, 1998). However, it is unlikely that all six Type B packages, such

TABLE 5.3.9-3 Potential Radiological Consequences to the Population from Severe Transportation Accidents[a]

Dose and Risk, per Type of Waste	Mode	Neutral Weather Conditions[b]			Stable Weather Conditions[b]		
		Rural	Suburban	Urban[c]	Rural	Suburban	Urban[c]
Dose (person-rem)							
Sealed sources - CH	Truck	930	2,000	4,400	1,600	3,400	7,600
	Rail	1,900	3,900	8,700	3,300	6,800	15,000
Activated metals - RH	Truck	0.27	3.9	8.6	0.46	6.8	15
	Rail	1.1	16	35	1.9	27	60
Other Waste - CH	Truck	190	410	920	330	720	1,600
	Rail	380	830	1,800	650	1,400	3,200
Other Waste - RH	Truck	3.0	9.6	21	6.0	120	270
	Rail	5.9	19	43	12	240	540
Risk (LCF)[d]							
Sealed sources - CH	Truck	0.6	1	3	1	2	5
	Rail	1	2	5	2	4	9
Activated metals - RH	Truck	0.0002	0.002	0.005	0.0003	0.004	0.009
	Rail	0.0006	0.009	0.02	0.001	0.02	0.04
Other Waste - CH	Truck	0.1	0.2	0.6	0.2	0.4	1
	Rail	0.2	0.5	1	0.4	0.9	2
Other Waste - RH	Truck	0.002	0.006	0.01	0.004	0.07	0.2
	Rail	0.004	0.01	0.03	0.007	0.1	0.3

[a] National average population densities were used for the accident consequence assessment, corresponding to densities of 6 persons/km^2, 719 persons/km^2, and 1,600 persons/km^2 for rural, suburban, and urban zones, respectively. Potential impacts were estimated for the population within a 80-km (50-mi) radius, assuming a uniform population density for each zone.

[b] Neutral weather conditions constitute the most frequently occurring atmospheric stability condition in the United States. They are represented by Pasquill stability Class D with a wind speed of 4 m/s (9 mi/h) in the air dispersion models used in this consequence assessment. Observations at National Weather Service surface meteorologic stations at more than 300 U.S. locations indicate that on a yearly average, neutral conditions (Pasquill Classes C and D) occur about half (50%) of the time, stable conditions (Classes E and F) occur about one-third (33%) of the time, and unstable conditions (Classes A and B) occur about one-sixth (17%) of the time (Doty et al. 1976). For the accident consequence assessment, doses were assessed under neutral atmospheric conditions (Class D with winds at 4 m/s [9 mi/h]) and under stable conditions (Class F with winds at 1 m/s [2.2 mi/h]). The results for neutral conditions represent the most likely consequences. The results for stable conditions represent weather in which the least amount of dilution is evident; the air has the highest concentrations of radioactive material, which leads to the highest doses.

[c] It is important to note that the urban population density generally applies to a relatively small urbanized area; very few, if any, urban areas have a population density as high as 1,600 persons/km^2 extending as far as 80 km (50 mi). The urban population density corresponds to approximately 32 million people within the 80-km (50-mi) radius, well in excess of the total populations along most of the routes considered in this assessment.

[d] LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancers per person-rem.

as the TRUPACT-II packages, would become breached in one railcar accident and lead to a dose estimate of as much as 15,000 person-rem (9 LCFs) received by an urban population, as presented in Table 5.3.9-3. This dose is also spread over a footprint containing more than 1 million people, giving an average dose of less than 15 mrem per person. Such a dose is approximately 5% of the average annual dose received by an individual from natural background radiation.

Individuals in the vicinity of a severe accident could receive much higher doses, as shown in Table 5.3.9-4. A CEDE of up to 62 rem could be received by a nearby person downwind of the sealed source railcar accident. This dose would be from inhalation during passage of the aerosolized radioactive material (plume) after the accident. No deaths or symptoms of acute radiation syndrome are expected, but the increase in the lifetime risk of a fatal cancer would be 0.04. The dose received would be smaller if all of the TRUPACT-II packages were not breached, as might be expected, or if the contaminant material was released over a longer period of time (minutes), such as in a release involving a fire in which the person was not in the same location during passage of the entire plume.

Potential consequences relative to transportation from Alternatives 3 to 5 that would be site-dependent are discussed in Chapters 6 through 11 for the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.10 Cultural Resources

Potential impacts on cultural resources from Alternatives 3 to 5 would be site-dependent and are discussed in Chapters 6 through 11 for the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.11 Waste Management

Construction of the land disposal facilities would generate wastes typical of large construction projects. These wastes would include small quantities of hazardous solids, nonhazardous solids (e.g., concrete and steel spoilage, excavated materials), hazardous liquids (e.g., used motor oil and lubricants), and nonhazardous liquids (e.g., sanitary waste). Waste generated from operations would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable wastes). Some liquid LLRW would also be generated from truck washdown water. Operations would also generate a small quantity of nonhazardous (sanitary) liquids.

Table 5.3.11-1 presents the types and volumes of waste that would be generated from the construction and disposal operations associated with the land disposal methods evaluated for Alternatives 3 to 5. These waste types are similar to those currently handled at the various sites evaluated, except for the WIPP Vicinity reference location on BLM-administered land adjacent to the WIPP property boundary, where there are currently no ongoing operations. However,

TABLE 5.3.9-4 Potential Radiological Consequences to the Highest-Exposed Individual from Severe Transportation Accidents[a]

Type of Waste, per Mode	Neutral Weather Conditions[b]		Stable Weather Conditions[b]	
	Dose (rem)	Risk (LCF)[c]	Dose (rem)	Risk (LCF)[c]
Sealed sources - CH				
Truck	10	0.006	32	0.02
Rail	20	0.01	62	0.04
Activated metals - RH				
Truck	0.00049	0.0000003	0.0016	0.0000009
Rail	0.0021	0.000001	0.0065	0.000004
Other Waste - CH				
Truck	2.1	0.001	6.6	0.004
Rail	4.1	0.002	13	0.008
Other Waste - RH				
Truck	0.046	0.00003	0.14	0.00009
Rail	0.090	0.00005	0.29	0.0002

[a] The individuals receiving the highest doses and LCF risks were assumed to be at a downwind location that would maximize the short-term dose. These individuals were assumed to be about 140 to 150 m (460 to 490 ft) downwind for neutral weather conditions and 340 to 365 m (1,100 to 1,200 ft) downwind for stable weather conditions.

[b] Neutral meteorologic conditions constitute the most frequently occurring atmospheric stability condition in the United States. They are represented by Pasquill stability Class D with a wind speed of 4 m/s (9 mi/h) in the air dispersion models used in this consequence assessment. Observations at National Weather Service surface meteorologic stations at more than 300 U.S. locations indicate that on a yearly average, neutral conditions (Pasquill Classes C and D) occur about half (50%) of the time, stable conditions (Classes E and F) occur about one-third (33%) of the time, and unstable conditions (Classes A and B) occur about one-sixth (17%) of the time (Doty et al. 1976). For the accident consequence assessment, doses were assessed under neutral atmospheric conditions (Class D with winds at 4 m/s [9 mi/h]) and under stable conditions (Class F with winds at 1 m/s [2.2 mi/h]). The results for neutral conditions represent the most likely consequences. The results for stable conditions represent weather in which the least amount of dilution is evident; the air has the highest concentrations of radioactive material, which leads to the highest doses.

[c] When applied to individuals, the LCF risk is the increased lifetime probability of developing an LCF. LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancers per person-rem.

TABLE 5.3.11-1 Annual Waste Generated from the Construction and Operations of the Three Land Disposal Methods[a]

	Trench		Borehole		Vault	
Waste Type	Construction[b]	Operations[b]	Construction[b]	Operations[b]	Construction[b]	Operations[b]
Nonradioactive waste						
Hazardous solids (yd^3)	57	–[c]	18	–	168	–
Nonhazardous solids (yd^3)[d]	62,000	120	300,000	95	5,200	120
Hazardous liquids (gal)	23,000	–	7,300	–	68,000	–
Nonhazardous liquids (gal)	4,800,000	310,000	1,500,000	240,000	14,000,000	320,000
Radioactive waste						
Solid LLRW (yd^3)	–	16	–	10	–	16
Liquid LLRW (gal)	–	790,000	–	170,000	–	780,000

[a] Values given to two significant figures.

[b] The initial construction period is assumed to be 3.4 years; the operational period is assumed to be a 20-year period when most of the GTCC wastes are expected to be received for disposal.

[c] A dash indicates waste type is not generated.

[d] The volume reported for construction includes industrial waste and excavated soil material that could be used for the cover system; therefore, the inclusion here as waste would conservatively bound potential waste management impacts.

waste management resources available from the nearby WIPP repository could be used to manage any waste that might be generated by a land disposal facility at WIPP Vicinity.

Table 5.3.11-2 summarizes waste handling programs and capacities (when information was available) at the various sites evaluated for similar waste types. On the basis of the information provided in Table 5.3.11-2, the waste types and volumes that could be generated from the three land disposal methods would either be disposed of on-site or sent off-site for disposal. No impacts on waste management programs at the various sites are expected under Alternatives 3 to 5.

5.3.12 Cumulative Impacts

Cumulative Impacts

Cumulative impacts are the total impacts on a given resource resulting from the incremental environmental effects of an action or actions added to other past, present, and reasonably foreseeable future actions.

Consistent with 40 CFR 1508.7, in this EIS, a cumulative impact is "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or persons undertakes such actions." A cumulative impact assessment accounts for both geographic (spatial) and time (temporal) considerations of past, present, and reasonably foreseeable actions. Geographic boundaries can vary by discipline, depending on the amount of time that the effects remain in the environment, the extent to which such effects can migrate, and the magnitude of

TABLE 5.3.11-2 Waste Management Programs at the Various Sites Evaluated for the Land Disposal Methods

Site	Nonhazardous Liquids	Nonhazardous Solids	Hazardous Liquids	Hazardous Solids	Solid LLRW	Liquid LLRW
Hanford Site[a]	Nonhazardous liquids are discharged to on-site treatment facilities, such as septic tanks, subsurface soil absorption systems, and wastewater treatment plants.	Nonhazardous solid wastes are sent to municipal or commercial solid waste facilities.	Hazardous liquids would be sent off-site for treatment, recycling, recovery, and disposal at RCRA-permitted commercial facilities.	Same as hazardous liquids.	Solid LLRW that meets disposal requirements is disposed of on-site at the mixed waste trenches or the Environmental Restoration Disposal Facility. Those that do not meet requirements are sent off-site for disposal.	Liquid LLRW would be sent to the 200 Area Effluent Treatment Facility/Liquid Effluent Disposal Facility for treatment.
INL[b]	Sanitary wastes are treated and then discharged to impoundments, evaporation lagoons, or shallow subsurface drainage fields. Remaining sludge is placed in the on-site landfill.	When possible, nonhazardous wastes are recycled in accordance with waste minimization protocols. Those that cannot be recycled are disposed of in an on-site landfill complex (Central Facilities Area) or off-site.	Hazardous liquids are stored and then sent to off-site commercial disposal facilities.	Same as hazardous liquids.	Solid LLRW is treated and disposed of on-site and off-site. Storage capacity is 310 m^3 (403 yd^3).	Liquid LLRW is discharged to evaporation ponds in the Reactor Technology Complex (RTC). Liquid LLRW is solidified before disposal.
LANL[c]	Nonhazardous liquids are treated at the TA-46 Wastewater Treatment Plant and discharged to a permitted outfall.	Nonhazardous solids are processed at the TA-54 Material Recycling Facility. They are disposed of at the Los Alamos County Landfill, Rio Rancho Landfill, and/or recycling and scrap facilities.	Hazardous liquids produced by construction are handled at consolidated remote waste storage sites (CRWSSs) for off-site treatment and disposal.	Hazardous solids are treated at the CRWSSs and disposed of off-site.	Solid LLRW is treated at the TA-54 Solid Waste Operations Area G. The primary waste pathway is on-site treatment and disposal. Additional off-site disposal pathways are used as necessary.	Liquid LLRW is treated at theTA-50-1 Radioactive Liquid Waste Treatment Facility (RLWTF). The RLWTF generates effluent, which goes to a National Pollutant Discharge Elimination System (NPDES) outfall, and radioactive solid waste types, which are disposed of on-site.

TABLE 5.3.11-2 (Cont.)

Site	Nonhazardous Liquids	Nonhazardous Solids	Hazardous Liquids	Hazardous Solids	Solid LLRW	Liquid LLRW
NNSS[d]	Nonhazardous liquids are treated by using sewage lagoons or septic systems.	When possible, nonhazardous wastes are recycled in accordance with waste minimization protocols. Those that cannot be recycled are sent to appropriate permitted landfills.	Hazardous liquids are sent off-site to permitted treatment, storage, and disposal facilities.	Hazardous solids are shipped to commercial treatment and disposal facilities.	Solid LLRW is disposed of at the Area 5 Radioactive Waste Management Complex.	Same as solid LLRW.
SRS[e]	Sanitary and other nonhazardous liquids are treated at the Central Sanitary Wastewater Treatment Facility (CSWTF).	Nonsanitary nonhazardous solids are sent off-site for recycling or disposal. Sanitary nonhazardous solids are sent to the Three Rivers Landfill.	Hazardous liquids are sent off-site to permitted disposal facilities.	Hazardous solids are collected in containers and shipped off-site for treatment and disposal.	Solid LLRW is treated and disposed of on or off-site.	Same as solid LLRW.
WIPP Vicinity[f]	Nonhazardous liquids could be disposed of at on-site sanitary lagoons, as is done at the WIPP repository.	When possible, nonhazardous solids could be recycled in accordance with waste minimization protocols. Those that could not be recycled could be sent to appropriate disposal sites.	Hazardous liquids could be characterized, packaged, labeled, and manifested to off-site treatment, storage, and disposal facilities.	Nonmixed hazardous solids could be characterized, placed in containers, and stored until they could be transported off-site for treatment and/or disposal at a permitted facility.	Solid LLRW could be treated and disposed of off-site.	Same as solid LLRW.

[a] Source: DOE (2009).

[b] Source: DOE (2005a).

[c] Source: LANL (2010).

[d] Source: NNSA (2008).

[e] Sources: SRS (2005, 2010).

[f] Assumed waste operations would be similar to those conducted for WIPP.

the potential impact. The cumulative impacts are discussed in Chapters 6 through 11 for the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

The cumulative impacts section evaluates the impacts of constructing and operating a GTCC waste disposal facility (proposed action) in combination with the impacts of past, present, and reasonably foreseeable future actions taking place within and around each of the candidate sites. For most resources, the impacts of past and present actions are generally accounted for in the affected environment section. For example, the current air quality reflects both past and present activities occurring in the region. Off-site activities might also contribute to cumulative impacts; these include clearing land for agriculture and urban development, grazing, water diversion and irrigation projects, power generation projects, waste management activities, industrial emissions, and the development of transportation and utility networks.

Reasonably foreseeable future actions at each of the candidate sites include those that are ongoing, under construction, or planned for future implementation. These are also described and, together with the proposed action, considered for each evaluation.

5.4 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The resources that would be irreversibly or irretrievably committed during the disposal of GTCC LLRW and GTCC-like waste by using the land disposal methods evaluated under Alternatives 3 to 5 would include the land encompassed by the facility footprint, water, energy, raw materials, and other natural and man-made resources for construction of the disposal facility. The amount of resources consumed by the vault method would be the largest of those consumed by the three methods. Table 5.4-1 presents estimates of resources consumed for the construction of the three land disposal methods.

The operations of the land disposal methods would use up to 5.3 million L/yr (1.4 million gal/yr) of water resources. The water used would not be returned to its original source; however, the amount used would be small when compared with the annual production rates of the water source for the sites evaluated. Energy expended would be in the form of fuel for equipment and vehicles and electricity for facility operations. Each of the land disposal methods would consume up to approximately 800,000 L (210,000 gal) of diesel fuel annually to operate vehicles and emergency diesel generators during operations. The electrical energy requirement would be up to 1,160 MWh, which represents a small increase in electrical energy demand for the site areas. Table 5.4-2 presents estimates for annual utility consumption during disposal operations.

The resources that would be irreversibly or irretrievably committed during construction and operations of the GTCC land waste disposal methods would include materials that could not be recovered or recycled and materials that would be consumed or reduced to unrecoverable forms. For example, it is estimated that up to 810,000 kg (800 tons) of steel and 68,000 m^3 (88,200 yd^3) of concrete would be committed to the construction of the vault facility (see Table 5.4-1). In addition, about 195,000 m^3 (254,000 yd^3) of off-site soil would be needed for construction of the vault method. During operations, the proposed action would generate a small

TABLE 5.4-1 Estimates of the Materials and Resources Consumed during Construction of the Three Conceptual Land Disposal Facilities

Construction Materials and Resources	Total Consumption		
	Trench	Borehole	Vault
Utilities			
Water (gal)[a]	5,300,000	2,800,000	17,100,000
Electricity (MWh)[b,c]	34,000	10,800	101,000
Solids[b]			
Concrete (yd^3)	25,600	18,600	88,200
Steel (tons)	2,000	1,400	7,960
Gravel (yd^3)	32,900	25,000	156,000
Sand (yd^3)	3,600	28,000	198,000
Clay (yd^3)	NA[d]	NA	56,000
Soil (off-site) (yd^3)	NA	NA	254,000
Liquids			
Fuel (gal)[b]	580,000	3,030,000	3,400,000
Oil and grease (gal)	15,000	46,000	86,000
Gases			
Industrial gases (propane) (gal)[b]	5,400	4,300	13,600

[a] Water requirement is estimated on the basis of the assumptions that each FTE would require 20 gal/d and that cementation would require 25.1 lb of water per 100 lb of cement (see Appendix D).

[b] Methodology is described in Appendix D.

[c] Peak demand of 1.70, 0.51, or 4.57 MWh for the trench, borehole, and vault disposal facilities, respectively.

[d] NA = not applicable.

amount of nonrecyclable waste types, such as hazardous wastes that would be subject to RCRA regulations. Generation of these waste types would represent an irreversible and irretrievable commitment of material resources.

5.5 INADVERTENT HUMAN INTRUDER SCENARIO

The inadvertent human intruder scenario is not evaluated quantitatively for Alternatives 3 to 5 because the NRC had already incorporated the inadvertent human intruder protection concept in its classification system of LLRW as Class A, B, C, or GTCC. The NRC had already determined that for waste classified as GTCC, conventional near-surface land disposal is generally not protective of an inadvertent human intruder.

TABLE 5.4-2 Annual Utility Consumption during Disposal Operations

	Annual Consumption[a]		
Utility	Trench	Borehole	Vault
Potable water (U.S. gal/d)	310,000	240,000	310,000
Raw water (U.S. gal/d)[b, c]	1,100,000	420,000	1,110,000
Sanitary sewer (U.S. gal/d)	310,000	240,000	320,000
Natural gas (10^6 ft^3)	11,200	11,200	11,200
Diesel fuel (U.S. gal/d)	210,000	80,000	210,000
Electricity (MWh)	1,160	970	1,150

[a] Based on 240 operation-days per year.

[b] Includes potable water and water used in truck washdown.

[c] Estimate is based on the assumption that, on average, 2,290 L (605 gal) are used to wash down the truck transporting the GTCC waste (see Appendix D).

In promulgating 10 CFR Part 61, the NRC evaluated various scenarios by which an inadvertent human intruder might disrupt a waste trench (NRC 1981, 1982). This evaluation supported the development of the waste classification system in 10 CFR Part 61, which specifies radionuclide concentration limits for wastes that are appropriate for disposal near the surface. However, when 10 CFR Part 61 was promulgated, the NRC thought that the primary technology for disposing of LLRW would continue to be disposal in near-surface trenches, without engineered barriers.

The classification was also based on the concept that the number of inadvertent intrusion activities decreases with depth. Moreover, it is generally considered that for waste buried deeper than the normal residential intrusion zone (the normal zone being about 3 m [9 ft], which is generally required for residential dwellings with basements), the only potential for intrusion would occur during a drilling event, such as for the installation of a well. As the depth of a disposal facility gets deeper, it is generally considered that the likelihood of inadvertent intrusion also tends to decrease.

Although there is no consensus on the role of depth in protecting an inadvertent human intruder at intermediate depths, the International Atomic Energy Agency, in discussing intermediate-depth borehole designs, suggested that for boreholes at depths of 30 m (100 ft) or higher, the effects of intrusion should be managed by using institutional controls, but for boreholes below that depth, the effects do not need to be managed (IAEA 2003).

For the land disposal methods evaluated under Alternatives 3 to 5 in this EIS, it is expected that the protection of an inadvertent human intruder could be accomplished by incorporating one or more of the following waste disposal management activities or facility design features: institutional controls, disposal depth, control of waste concentrations, stabilization of the waste form, and intruder barriers. The designs considered for this EIS are suggested starting points for enhanced disposal facilities; if necessary, they could be fortified further, depending on-site-specific considerations and the actual waste characteristics once a final site(s) and disposal method(s) were selected.

The borehole conceptual design evaluated for Alternative 3 incorporates disposal depth and an intruder barrier (i.e., waste buried at a minimum depth of 30 m [100 ft] with a concrete barrier/cover to prevent or minimize the potential for a drilling intrusion). The trench and vault methods evaluated under Alternatives 4 and 5, respectively, also incorporate engineered barriers (i.e., a cover that is a minimum of 5-m [16-ft] thick with a concrete barrier for each) to prevent or minimize the probability of an inadvertent intrusion. Waste packaging activities would take into account the overall radionuclide concentrations or activity in the packages that would be emplaced. The activated metal waste from commercial reactors, which contains the majority of the radionuclide activity considered in this EIS, is already in a form that is resistive to drilling.

In summary, potential impacts could be minimized by mitigating either the probability of intrusion or its consequences if the intrusion occurred. Each combination of site and design addresses these two elements in different ways. Siting the disposal facility at a federal site could lower the likelihood of intrusion because it would increase the likelihood of retaining control. The remote locations of some of the federal sites evaluated in this EIS also help reduce the probability of intrusion into a waste disposal facility located at those sites. Design features could play a role in decreasing the consequences if an intrusion did occur. For instance, deep disposal might lead to a consideration of drilling intrusion only, whereas possibly for designs in which disposal is nearer the surface, more drastic types of intrusion would be considered. The form of the waste could also alter the consequences; for instance, activated metals cannot be broken up as easily as other waste forms. Considerations for institutional controls for Alternatives 3 to 5 are discussed in Section 5.6 below.

5.6 INSTITUTIONAL CONTROLS

As part of the long-term strategy for protecting human health and the environment, institutional controls would be incorporated in any facility used to dispose of GTCC LLRW and GTCC-like waste. Institutional controls refer to a set of measures, both active and passive in nature, to maintain the integrity and the protectiveness of a disposal facility. During the institutional control period (particularly during the period of active institutional controls), the potential for inadvertent human intruder would be minimized or eliminated. Institutional controls would also eliminate the potential for members of the public to be exposed to contaminants (e.g., by restricting the use of groundwater via deed restrictions).

Active institutional controls come in many forms (e.g., providing security guards to ensure that intrusion into a disposal facility does not occur, conducting routine inspections and monitoring, maintaining fences and other security infrastructures, and maintaining the integrity of the disposal facility itself). Passive institutional controls include fences, signs, and other markers that inform the public of the presence of a disposal facility long after active institutional controls have been completed. The passive institutional controls are expected to provide protection to the public in addition to the protection provided by engineering features that could be incorporated into the facility design, such as barriers and drill deflectors.

For the GTCC waste disposal facility or facilities, it is expected that both active and passive institutional controls would be implemented and relied on to allow the facility to perform adequately with respect to protection from inadvertent human intruders. Because the GTCC reference locations are on federally owned land where disposal facilities currently exist, it is expected that passive institutional controls (including maintaining federal ownership of the facility and lands) would be continued after the active institutional control period. It is DOE's policy (DOE P 454.1) to use institutional controls as essential components of a defense-in-depth strategy that uses multiple, relatively independent layers of safety to protect human health and the environment (including natural and cultural resources). DOE would maintain the institutional controls as long as necessary to perform their intended protective purposes.

The active institutional control period for a GTCC waste disposal facility would be determined as part of subsequent documentation (e.g., ROD) following this EIS. However, the long-lived nature of some of the radionuclides in the GTCC LLRW and GTCC-like waste should be taken into account in establishing the period of active institutional controls. The radionuclides in the GTCC LLRW and GTCC-like wastes are generally a combination of short-lived and very-long-lived radionuclides. A number of neutron activation products and fission products generally have short half lives (30 years or less), while the actinides and certain fission products, such as Tc-99 and I-129, have very long half-lives (more than 10,000 years). Hence, the total radioactivity and hazard of the wastes as a result of radioactive decay would not be significantly reduced after the first few hundred years. The short-lived radionuclides that would decay to inconsequential levels would have done so by then, and it would take several millennia for many of the long-lived radionuclides to decay to low levels. As a result, little would be gained by extending the length of the active institutional control period to much more than 100 years after closure.

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6 HANFORD SITE: AFFECTED ENVIRONMENT AND CONSEQUENCES OF ALTERNATIVES 3, 4, AND 5

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from the disposal of GTCC LLRW and GTCC-like waste under Alternative 3 (in a new borehole disposal facility), Alternative 4 (in a new trench disposal facility), and Alternative 5 (in a new vault disposal facility) at the Hanford Site. Alternatives 3, 4, and 5 are described in Section 5.1. Environmental consequences that are common to the sites for which Alternatives 3, 4, and 5 are evaluated (including the Hanford Site) are discussed in Chapter 5 and not repeated in this chapter. Impact assessment methodologies used for this EIS are described in Appendix C. Federal and state statutes and regulations and DOE Orders relevant to the Hanford Site are discussed in Chapter 13 of this EIS.

This chapter also includes American Indian text (presented in text boxes in Sections 6.1 and 6.4) that reflects the views and perspectives of the Nez Perce, the Confederated Tribes of the Umatilla Indian Reservation, and the Wanapum People. Full narrative texts are provided in Appendix G. The perspectives and views presented are solely those of the tribes. When tribal neutral language is used (e.g., Indian People, Native People, Tribes) within the tribal text, it reflects the input from these tribes, unless otherwise noted. DOE recognizes that American Indians have concerns about protecting the traditions and spiritual integrity of the land in the Hanford Site region, and that these concerns extend to the propriety of the Proposed Action. Presenting tribal views and perspectives in this EIS does not represent DOE's agreement with or endorsement of such views. Rather, DOE respects the unique and special relationship between American Indian tribal governments and the Government of the United States, as established by treaty, statute, legal precedent, and the U.S. Constitution. For this reason, DOE has presented tribal views and perspectives in this Draft EIS to ensure full and fair consideration of tribal rights and concerns before making decisions or implementing programs that could affect tribes.

6.1 AFFECTED ENVIRONMENT

This section discusses the affected environment for the various environmental resource areas evaluated for the GTCC reference location at Hanford. The GTCC reference location is south of the 200 East Area in the central portion of the Hanford Site (see Figure 6.1-1). The reference location was selected primarily for evaluation purposes for this EIS. The actual location would be identified on the basis of follow-on evaluations if and when it is decided to locate a land disposal facility at Hanford.

6.1.1 Climate, Air Quality, and Noise

6.1.1.1 Climate

The Hanford Site lies within the semiarid shrub-steppe Pasco Basin of the Columbia Plateau in south-central Washington state (Burk 2007), which is the lowest section in eastern

FIGURE 6.1-1 GTCC Reference Location at the Hanford Site

Washington. The region's climate is greatly influenced by the Pacific Ocean and the Cascade Mountain Range to the west and other mountain ranges to the north and east. The Pacific Ocean moderates temperatures throughout the Pacific Northwest, and the Cascade Range generates a rain shadow that limits rain and snowfall in the eastern half of Washington State. The Cascade Range also serves as a source of cold air drainage, which has a considerable effect on the wind regime at the Hanford Site. Mountain ranges to the north and east of the region shield the area from the severe winter storms and frigid air masses that move southward across Canada.

Climatological data for the Hanford Site are compiled at the Hanford Meteorology Station, which is located on the Hanford Site's Central Plateau, just outside the northeast corner of the 200 West Area and about 6 km (4 mi) northwest of the 200 East Area (Burk 2007). Because of the size and topographic features at Hanford, wind, precipitation, temperature, and other meteorological characteristics vary substantially.

The prevailing surface winds on Hanford's Central Plateau are from the northwest (Figure 6.1.1-1) and occur most often during winter and summer (Burk 2007). Winds from the southwest also occur frequently on the Central Plateau. During the spring and fall, there is an increase in the frequency of winds from the southwest and a corresponding decrease in winds from the northwest. In the southeastern portion of the Hanford Site, the prevailing wind direction near the surface is from the southwest during most months; winds from the northwest are much less common. Along the Columbia River, local winds are strongly influenced by the topography near the river. Stations that are relatively close together can exhibit significant differences in wind patterns. For example, Station 4 and Station 7 are only about 5 km (3 mi) apart, but the wind patterns at the two stations are very different (Figure 6.1.1-1).

At the Hanford Meteorology Station (HMS), about 6 km (4 mi) from the GTCC reference location, the prevailing wind direction is northwest; secondarily, it came from the west-northwest during the period from 1945 through 2004. The peak gusts are from the south-southwest, southwest, and west-southwest (Hoitink et al. 2005). The annual average wind speed at the 15-m (50-ft) level is about 3.4 m/s (7.6 mph). The fastest monthly average wind speeds, 4.1 m/s (9.1 mph), occur in June; the slowest, 2.7 m/s (6.0 mph), occur in December. The fastest wind speeds at the HMS are usually associated with flow from the southwest. However, the summertime drainage winds from the northwest frequently exceed 13 m/s (30 mph). The maximum speed of the drainage winds and their frequency of occurrence tend to decrease as one moves toward the southeast across the Hanford Site.

For the 1945–2004 period, the annual average temperature at the Hanford Site was 11.9°C (53.5°F) (Hoitink et al. 2005). January was the coldest month, averaging –0.5°C (31.1°F), and July was the warmest, averaging 24.8°C (76.6°F). During the last 60 years, the highest temperature was 45.0°C (113°F) and the lowest was –30.6°C (–23°F). The number of days with a maximum temperature of ≥32.2°C (90°F) was about 53, while the number of days with a minimum temperature of ≤0°C (32°F) was about 106.

The area around the Hanford Site is the driest section in eastern Washington. Annual precipitation at the Hanford Site averages about 17 cm (7 in.) (Hoitink et al. 2005). Precipitation is highest in the winter and the lowest in the summer, with spring and autumn being in between.

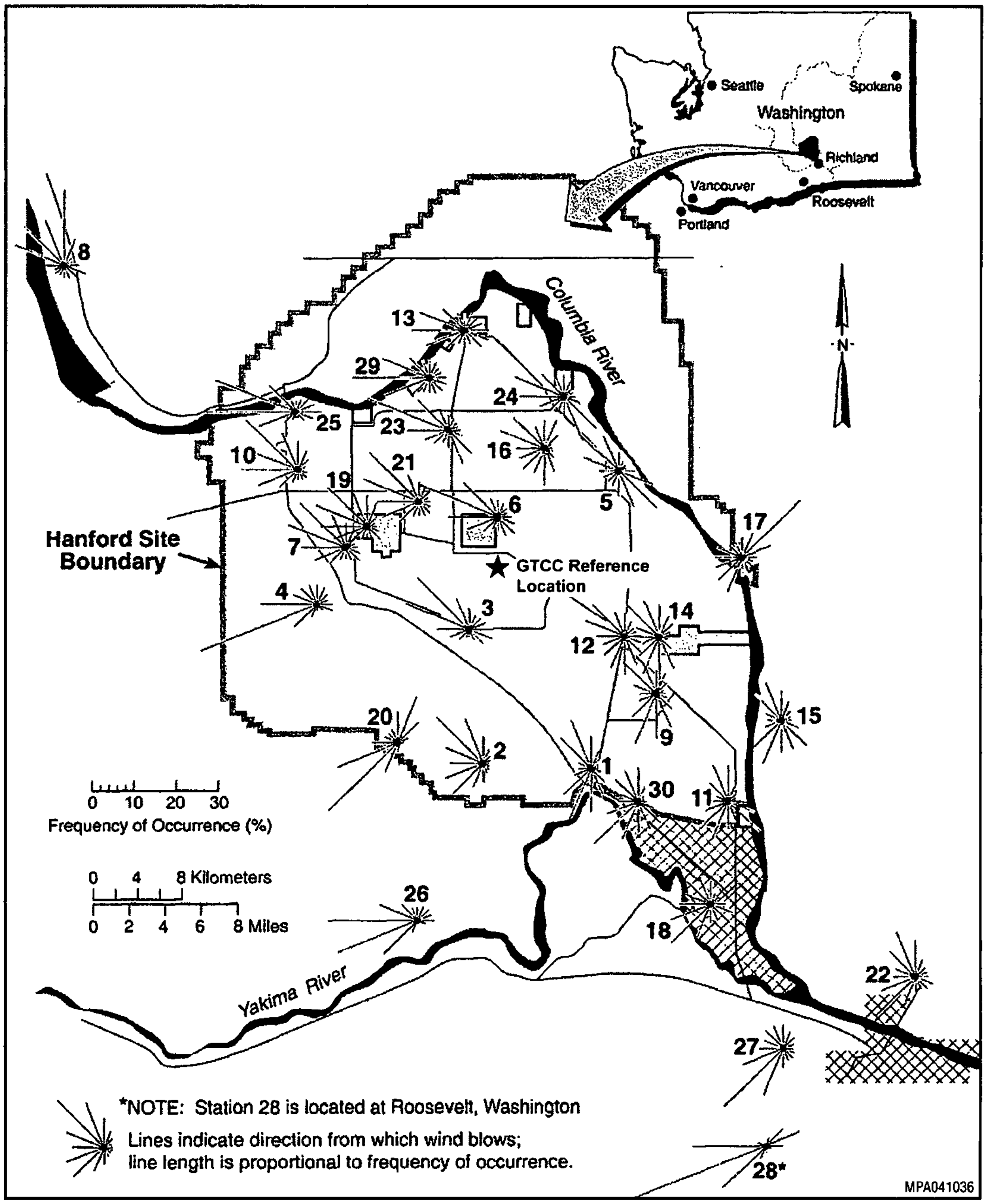

FIGURE 6.1.1-1 Wind Roses at the 9.1-m (30-ft) Level of the Hanford Meteorological Monitoring Network, Washington, 1982–2006 (Source: Burk 2007)

Measurable precipitation of 0.025 cm (0.01 in.) or more occurs an average of 68 days per year. Summer precipitation is usually associated with thunderstorms (Ruffner 1985). During July and August, it is not unusual for 4 to 6 weeks to pass without measurable rainfall. Measurable snow is a rarity, and, if it does occur, it remains on the ground for only a short time. Snow typically occurs from October through April. The annual average snowfall in the area is about 37.3 cm (14.7 in.), which peaks in December and January (Hoitink et al. 2005). The Central Basin is subject to Chinook winds that produce a rapid rise in temperature, and the snow partly melts and evaporates in the dry wind.

Severe weather usually includes thunderstorms, dust storms, glaze, and tornadoes. Thunderstorms occur in every month of the year except January and November (Hoitink et al. 2005). The thunderstorm season is essentially from April through September. For the period 1945 through 2004, there was an average of 10 thunderstorm days per year. The criterion for both dust and blowing dust is that horizontal visibility is reduced to 10 km (6 mi) or less. Dust is carried into the area from a distant source and may occur without strong winds. Blowing dust occurs when dust is picked up locally and occurs with stronger winds. There was an average number of five days per year with dust or blowing dust. Glaze is a coating of ice that forms when rain or drizzle freezes on contact with any surface having a temperature that is below freezing. There was an average number of six days per year with freezing rain or freezing drizzle. Washington does not experience hurricanes because of the cold waters off the Pacific Ocean.

Tornadoes in the northwestern portion of the United States, including the Hanford Site, are much less frequent and destructive than those in tornado alley in the central United States. For the period 1950–2006, 28 tornadoes were reported for 10 counties closest to the Hanford Site (Poston et al. 2007). For the same period, 11 tornadoes (an average of 0.2 tornado per year) were reported in the four counties that encompass the Hanford Site: Adams, Benton, Franklin, and Grant. However, most of these tornadoes were relatively weak; 10 were ranked less than or equal to F1 and one was F2 on the Fujita scale. No deaths or substantial property damage (in excess of $50,000) were associated with these tornadoes.

Fujita Scale of Tornado Intensities

• F0	Gale	40–72 mph	18–32 m/s
• F1	Moderate	73–112 mph	33–50 m/s
• F2	Significant	113–157 mph	51–70 m/s
• F3	Severe	158–206 mph	71–92 m/s
• F4	Devastating	207–260 mph	93–116 m/s
• F5	Incredible	261–318 mph	117–142 m/s

6.1.1.2 Existing Air Emissions

The Hanford Site is included in the CAA Title V air operating permit program because it is a “major source” as defined in the CAA and in *Washington Administrative Code* (WAC) 173-401-200(19). The Hanford Site operates under State License FF-01 for air emissions (Poston et al. 2007). Conditions specified in the license are incorporated into the Hanford Site Air Operating Permit, which was reissued by the Washington State Department of Ecology on December 29, 2006. The permit is intended to provide a compilation of applicable CAA requirements for both radioactive and nonradioactive (i.e., toxic and criteria pollutants)

American Indian Text

People have inhabited the Columbia Basin throughout the entire Younger Dryas era (from 10,000 years ago to the present). Several even earlier archaeological sites are known. Mammoth and bison harvest sites are found throughout the Columbia Plateau. As the temperatures rose throughout this period, the Pleistocene lakes began to shrink and wither away into alkali basins. The post-glacial grasslands of the Great Basin and Columbia Basin were replaced by desert grasses, juniper, and sage, and megafauna likewise decreased through ecological and hunting pressure. The glaciers in the Cascades, Wallowa and Steens mountains rapidly disappeared.

After about 5400 B.P. increasing precipitation and rising water tables were apparent again on both sides of the Cascades. Pollen history indicates continual short, sharp climatic shifts that, directly (e.g., soil moisture) or indirectly (e.g., fire and disease), produced rapid changes in the Northwest's vegetation. The plants and animals were now modern in form. Hunters switched to deer, elk, antelope and small game such as rabbits and birds. Fishing also became important along the coastal streams and in the Columbia River system, with an increasing emphasis on the annual runs of the salmon even though salmon runs date considerably farther back.

The human ethnohistory in the Columbia Basin is divided into cultural periods that parallel the climatic periods and represent cultural adaptations to changing environmental conditions. Throughout this entire period the oral history continually added information needed for survival and resiliency as the climate fluctuated. The oral history of local native people is consistent with contemporary scientific and historic knowledge of the region and validates the extreme climate changes that have occurred in the region over thousands of years. Cameron examined archaeological, ethnographic, paleoenvironmental, and oral historical studies from the Interior Plateau of British Columbia, Canada, from the Late Holocene period, and found correlations among all four sources of information.

Climate is one of the dominate issues of our time. Indian People have experience with volcanic periods when it seemed our world was on fire and times when our world was much colder. Distinct climatic periods have occurred during which Tribal life adapted to environmental changes and our oral history reflects these climate changes and adaptations. Scientific and historic knowledge validates tribal oral history for many thousands of years.

Columbia Plateau Tribes have stories about the world being transformed from a time considered prehistoric to what is known today. The Indian People remember volcanoes, great floods, and animals now extinct. Mammoth and bison harvest sites are found throughout the Columbia Plateau. They have memories of their world being destroyed by fire and water and believe it will happen again. Indian People on the Columbia Plateau have stories about the world being destroyed by fire and water. Some of these were directly experienced, for example, the Mazama eruption 6,800 years ago, and the last of the Missoula floods 13,000 years ago.

The Tribes know and remember about the weather and its changes because it was so important to forming their lives. Oral histories indicate that the climate was much wetter and supported vast forests in the region. Oral histories also recall a time when Gable

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Mountain or Nookshia, a major landscape feature on the Hanford Reservation, rose out of the Missoula floods. There is a story about Indian People who fought severe winds that were common a long time ago. One story tells of how a family trained their son by having him fight with the ice in the river until he became strong enough to fight the wind. He then beat the very strong winds of the past and now we do not have such winds.

Holocene is the term used to describe the climate since the last glaciers (11,700 years ago), covering much of the northwestern North America. This archaeological record confirms the prehistory that includes arctic foxes found with Marmes Rock Shelter. The Palynological data would be a good source for recreating climates that supported ecosystems of the past 10,000 years.

Climate change that will occur over the next 10,000 years will inevitably draw on knowledge from the past, whether the climate becomes wetter or drier. Evaluation of future climate scenarios will need to include as much variation as occurred in the last 10,000 years.

emissions at the Hanford Site and is implemented through federal and state programs. The Benton Clear Air Authority regulates open-air burning and oversees the site's compliance with asbestos regulations.

Annual emissions for major facility sources and total point and area sources of criteria pollutants and VOCs in Adams, Benton, Franklin, and Grant Counties for the year 2002 are presented in Table 6.1.1-1 (EPA 2009). Data for 2002 are the most recent emission inventory data available on the EPA website. Area sources consist of nonpoint and mobile sources. Because there are few major point sources in the area, area sources account for most of the emissions of criteria pollutants and VOCs. On-road sources are major contributors to total emissions of CO, NO_x, and VOCs; off-road sources to SO_2; and miscellaneous sources to PM_{10} and $PM_{2.5}$. Nonradiological emissions associated with any activities at the Hanford Site are less than 0.5% of those in Benton County and less than 0.2% of those in the four counties combined, as shown in the table.

Annual emissions for criteria air pollutants, VOCs, ammonia (NH_3), and toxic air pollutants during 2006 are presented in Table 6.1.1-2 (Poston et al. 2007). Nonradiological pollutants are primarily emitted from facilities in the 200 and 300 Areas on the Hanford Site. The 100, 400, and 600 Areas do not have any nonradiological emission sources of regulatory concern. In past years, gaseous NH_3 was emitted from the facilities, all located in the 200 East Area. During 2006, 200 Area tank farms produced reportable ammonia emissions. Emissions from carbon tetrachloride (CCl_4) vapor extraction work in the 200 West Area are categorized as "other toxic air pollutants" and do not need to be reported because they are below respective reportable quantities. On the basis of sitewide emissions in 2005, which were higher than those in 2006, air dispersion modeling indicates that concentrations from Hanford sources represent a small percentage of the ambient air quality standards (DOE 2009).

TABLE 6.1.1-1 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds from Selected Major Facilities and Total Point and Area Source Emissions in Counties Encompassing the Hanford Site[a]

	Emission Rate (tons/yr)					
Emission Category	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Adams County						
Point sources	0.0	0.0	0.0	0.0	0.0	0.0
Area sources	285	4,204	23,848	2,543	13,475	2,140
Total	285	4,204	23,848	2,543	13,475	2,140
Benton County						
Agrium U.S. Inc.[b]	*0.0*	*258*	*4.0*	*0.0*	*42.0*	*54.5*
DOE, Hanford Reservation	*3.0*	*12.0*	*27.0*	*9.0*	*2.6*	*1.7*
	0.48%[c]	*0.14%*	*0.04%*	*0.07%*	*0.03%*	*0.08%*
	0.18%	*0.05%*	*0.02%*	*0.03%*	*0.01%*	*0.02%*
Williams Pipeline	*0.1*	*117*	*17.4*	*0.3*	*0.01*	*0.01*
Point sources	3.2	388	49.4	10.2	44.7	56.4
Area sources	622	8,390	69,132	12,205	9,172	2,202
Total	626	8,778	69,182	12,215	9,217	2,258
Franklin County						
Point sources	0.0	0.0	0.0	0.0	0.0	0.0
Area sources	361	4,701	31,459	4,525	8,714	1,583
Total	361	4,701	31,459	4,525	8,714	1,583
Grant County						
Point sources	0.0	1.0	0.0	0.0	0.0	0.0
Area sources	383	5,366	45,981	6,647	15,985	2,682
Total	383	5,367	45,981	6,647	15,985	2,682
Four-county total	1,655	23,050	170,470	25,930	47,391	8,663

[a] Emission data for selected major facilities and for total point and area sources are for year 2002. CO = carbon monoxide, NO_x = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, SO_2 = sulfur dioxide, VOCs = volatile organic compounds.

[b] Data in italics are not added to yield totals.

[c] The top and bottom rows with % signs show emissions as percentages of Benton County total emissions and four-county total emissions, respectively.

Source: EPA (2009)

An agreement between DOE and EPA provides a plan and schedule to bring the Hanford Site into compliance with the NESHAP radionuclide requirements for continuous measurement of airborne emissions from applicable sources (Poston et al. 2007). In 2006, radiological emissions at the Hanford Site remained well below the levels that would cause off-site doses to exceed the standard of 10 mrem/yr.

TABLE 6.1.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, Ammonia, and Toxic Air Pollutants at the Hanford Site in 2006

	Emission Rate		
Pollutant	kg/yr	lb/yr	tons/yr
SO$_X$	2,900	6,400	3.2
NO$_X$	11,000	24,000	12.0
CO	13,000	28,000	14.0
VOCs	10,000	22,000	11.0
Total PM	3,700	8,200	4.1
PM$_{10}$	2,800	6,200	3.1
PM$_{2.5}$	1,000	2,200	1.1
Lead	0.44	0.97	4.85×10^{-4}
Ammonia	5,500	12,000	6.0
Other toxic air pollutants	4,500	9,900	4.95
Total criteria pollutants[a]	40,000	89,000	44.5

[a] Total criteria pollutants include SO$_X$, NO$_X$, CO, VOCs, total PM, and lead.

Source: Poston et al. (2007)

American Indian Text

The importance of clean fresh air is often overlooked in NEPA analysis. For example, while wind and fire are part of the natural regime, an intact soil surface with a cryptogam crust in the desert reduces dust resuspension during wind events.

The extensive cleanup and construction activities on Hanford contribute to blowing dust, increased traffic, diesel emissions, deposition or re-deposition of radionuclides, and generation of ozone, particulate matter, and other air pollutants with unknown human and environmental health effects.

The Indian People believe that radioactivity is brought into the air by high winds – commonly blowing 40-45 miles per hour and intermittently much stronger (http://www.bces.wa.gov/windstorms.pdf). High winds over 150 mile per hour were recorded in 1972 on Rattlesnake Mountain and in 1990 winds on the mountain were recorded at 90 miles per hour. Dust devils can be massive in size, spin up to 60 miles per hour, and frequently occur at the site. Tornadoes have been observed in Benton County which is regionally famous for receiving strong winds.

It gets so windy that the site managers at Environmental Restoration Disposal Facility (ERDF) occasionally send all workers home and close down the facility due to the degree of blowing dust making it unsafe to work. Air quality monitoring results, including radioactive dust, should be presented for ERDF, various plant operations, emission stacks, venting systems, and power generation sites. Also, fugitive dust can affect Viewshed and contribute to health affects during inversions.

6.1.1.3 Air Quality

With regard to the criteria pollutants (SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$, and lead), the Washington SAAQS are identical to the NAAQS for NO_2, CO, and PM_{10} (EPA 2008a; WAC 173-470, 173-475), as shown in Table 6.1.1-3. The State of Washington has established more stringent standards for SO_2 (WAC 173-474). In addition, the State has adopted standards for gaseous fluorides (expressed as hydrogen fluoride [HF]) (WAC 173-481) and still retains standards for total suspended particulates (TSPs) (WAC 173-470), which used to be one of criteria pollutants but was replaced by PM_{10} in 1987.

The Hanford Site is located primarily in Benton County; the northern portion of the site is located in Grant, Franklin, and Adams Counties. The counties encompassing the Hanford Site are designated as being in attainment for all criteria pollutants (40 CFR 81.348).

A variety of air monitoring activities have been conducted on and around the Hanford Site to assess the effectiveness of emission treatment and control systems and pollution management practices and to determine compliance with state and federal regulatory requirements (Fritz 2007a). The air pollutant of primary concern at the Hanford Site is radiological contamination. PM_{10} concentrations are generally low in the region. However, there have been infrequent instances of high levels of PM_{10} concentrations in the region because of exceptional natural events, such as dust storms and large wildfires. Concentrations of other criteria pollutants are relatively low because of low regional concentrations; thus, these pollutants are generally of less concern.

Nearby urban or suburban measurements are typically used as being representative of background concentrations at the Hanford Site. The highest concentration levels of all criteria pollutants, except for O_3 and $PM_{2.5}$, around the Hanford Site are less than or equal to 63% of their respective standards in Table 6.1.1-3 (EPA 2009). The highest O_3 and $PM_{2.5}$ concentrations, which are primarily of regional concern, are about 93% and 120% of the applicable standards, respectively. These higher percentages are due in part to recent changes in their standards. Overall, the areas surrounding the Hanford Site and the entire state of Washington are in attainment for all criteria pollutants and have good air quality.

Particulate matter (PM_{10} and $PM_{2.5}$) has been measured at the HMS on the Hanford Site since 2001 (Poston et al. 2007). During 2006, annual average PM_{10} concentrations were 12.7 $\mu g/m^3$, which are typical of those measured in recent years, and the 24-hour PM_{10} concentration did not exceed the EPA standard. During 2006, the measured annual average $PM_{2.5}$ concentration was 4.5 $\mu g/m^3$, while the highest 24-hour $PM_{2.5}$ concentration was 8.1 $\mu g/m^3$.

The Hanford Site and its vicinity are classified as PSD Class II areas. No Class I areas are located within 100 km (62 mi) of the GTCC reference location. The nearest Class I areas are the Alpine Lake and Goat Rocks Wilderness Areas, which are about 137 km (85 mi) west and northwest of the GTCC reference location, respectively (40 CFR 81.434). Two PSD permits for NO_2 emissions were issued to facilities at the Hanford Site during 1980, but they were

TABLE 6.1.1-3 National Ambient Air Quality Standards (NAAQS) or Washington State Ambient Air Quality Standards (SAAQS) and Highest Background Levels Representative of the GTCC Reference Location at the Hanford Site, 2003–2007

			Highest Background Level	
Pollutant[a]	Averaging Time	NAAQS/ SAAQS[b]	Concentration[c,d]	Location (Year)
SO_2	1-hour	75 ppb	0.238 ppm (60%)	Anacortes, Skagit Co. (2003)[e]
	3-hour	0.5 ppm[f]	0.080 ppm (16%)	Anacortes, Skagit Co. (2003)[e]
	24-hour	0.1 ppm	0.029 ppm (29%)	Anacortes, Skagit Co. (2005)[e]
	Annual	0.02 ppm	0.004 ppm (20%)	Seattle, King Co. (2005)[e]
NO_2	1-hour	0.100 ppm	–[g]	–
	Annual	0.053 ppm	0.018 ppm (36%)	Seattle, King Co. (2006)[e]
CO	1-hour	35 ppm	4.6 ppm (13%)	Yakima, Yakima Co. (2003)
	8-hour	9 ppm	3.4 ppm (38%)	Yakima, Yakima Co. (2003)
O_3	1-hour	0.12 ppm[h]	0.080 ppm (67%)	Klickitat Co. (2003)
	8-hour	0.075 ppm[f]	0.070 ppm (93%)	Klickitat Co. (2003)
TSP	24 hours	150 µg/m^3	–	–
	Annual geometric mean	60 µg/m^3	–	–
PM_{10}	24-hour	150 µg/m^3	95 µg/m^3 (63%)	Kennewick, Benton Co. (2005)
	Annual	50 µg/m^3	24 µg/m^3 (48%)	Kennewick, Benton Co. (2003)
$PM_{2.5}$	24-hour	35 µg/m^3 [f]	42 µg/m^3 (120%)	Kennewick, Benton Co. (2004)
	Annual	15.0 µg/m^3 [f]	7.6 µg/m^3 (51%)	Kennewick, Benton Co. (2004)
Lead[i]	Calendar quarter	1.5 µg/m^3 [f]	0.03 µg/m^3 (2.0%)	Seattle, King Co. (2002)[e, j]
	Rolling 3-month	0.15 µg/m	–	–
Gaseous fluorides (as HF)	24 hours	2.9	–	–
	7 days	1.7	–	–
	30 days	0.84	–	–
	Growing season[k]	0.5	–	–

[a] CO = carbon monoxide; HF = hydrogen fluoride; NO_2 = nitrogen dioxide; O_3 = ozone; $PM_{2.5}$ = particulate matter ≤2.5 µm; PM_{10} = particulate matter ≤10 µm; SO_2 = sulfur dioxide; TSP = total suspended particulates.

[b] The more stringent standard between the NAAQS and the SAAQS is listed when both are available.

[c] Values in parentheses are monitored concentrations as a percentage of SAAQS or NAAQS.

Footnotes continue on next page.

TABLE 6.1.1-3 (Cont.)

[d] Monitored concentrations are the highest arithmetic mean for calendar-quarter lead; 2nd-highest for 1-hour, 3-hour, and 24-hour SO_2, 1-hour and 8-hour CO, and 1-hour O_3; 4th-highest for 8-hour O_3; 99th percentile for 24-hour PM_{10}; 98th percentile for 24-hour $PM_{2.5}$; and arithmetic mean for annual SO_2, NO_2, PM_{10}, and $PM_{2.5}$.

[e] These locations with the highest observed concentrations in the state of Washington are not representative of the Hanford Site but are presented to show that these pollutants are not a concern over the state of Washington.

[f] NAAQS. No SAAQS exists.

[g] A dash indicates that no measurement is available.

[h] On June 15, 2005, the EPA revoked the 1-hour O_3 standard for all areas except the 8-hour O_3 nonattainment Early Action Compact (EAC) areas (these do not yet have an effective date for their 8-hour designations). The 1-hour standard will be revoked for these areas 1 year after the effective date of their designation as attainment or nonattainment for the 8-hour O_3 standard.

[i] Used old standard because no data in the new standard format are available.

[j] Measurements of lead have been discontinued in Washington since 2003.

[k] Period from April 1 to September 30.

Sources: 40 CFR 52.21; EPA (2008a, 2009); WAC 173-470, 173-474, and 173-475 (refer to http://www.ecy.wa.gov/laws-rules/ecywac.html)

terminated after permanent shutdowns (Fritz 2007a). There are no facilities currently operating at the Hanford Site that are subject to PSD regulations. A final PSD permit for the Waste Treatment Plant (WTP) was issued by the Washington State Department of Ecology in November 2003.

6.1.1.4 Existing Noise Environment

The State of Washington has established maximum permissible environmental noise levels that are defined for the zoning of the area according to the Environmental Designation for Noise Abatement (EDNA). Maximum noise levels are presented in Table 6.1.1-4. They are based on the EDNA classification of receiving properties and source areas. The Hanford Site is classified as EDNA Class C because of its industrial activities.

The noise-producing activities at the Hanford Site are associated with construction and operational activities and local traffic, similar to those at any other typical industrial site. Numerous field activities performed routinely at the Hanford Site have the potential to generate noise at levels above typical background noise levels (Fritz 2007b). These activities could possibly disturb wildlife when performed in remote areas. Noise sources at the Hanford Site include various facilities, equipment, and machines (e.g., cooling systems, transformers, engines, pumps, boilers, steam vents, and material handling equipment). However, traffic is the primary noise source at the site and nearby residences (DOE 2009).

TABLE 6.1.1-4 Washington Maximum Permissible Environmental Noise Levels (dBA)[a]

EDNA of Noise Source	EDNA of Receiving Property[b]		
	Class A[c]	Class B	Class C
Class A	55	57	60
Class B	57	60	65
Class C	60	65	70

[a] At any hour of the day or night, these applicable noise limitations may be exceeded for any receiving property in any 1-hour period by no more than (1) 5 dBA for a total of 15 minutes, (2) 10 dBA for a total of 5 minutes, or (3) 15 dBA for a total of 1.5 minutes.

[b] The three Environmental Designations for Noise Abatement (EDNAs) are as follows:
Class A (Residential): Lands where human beings reside and sleep (e.g., residential, hospitals)
Class B (Commercial): Lands involving uses requiring protection from noise that interferes with speech (e.g., commercial living accommodations, theaters, stadiums)
Class C (Industrial): Lands involving economic activities of a nature such that higher noise levels than those experienced in other areas are normally anticipated (e.g., warehouses, industrial properties).

[c] Between the hours of 10:00 p.m. and 7:00 a.m., the noise limitations in the table shall be reduced by 10 dBA for a receiving property within Class A EDNAs.

Source: WAC 173-60, "Maximum Environmental Noise Levels," http://www.ecy.wa.gov/biblio/wac17360.html. Accessed Dec. 2007.

The Hanford Site is located in a rural setting, and no residences and sensitive receptors (e.g., schools, hospitals) are located in the immediate vicinity of the GTCC reference location. Noise studies at the Hanford Site have been concerned primarily with occupational noise at workplaces (Fritz 2007b). Most industrial activities at the Hanford Site are located far away from the site boundaries, so noise levels at the site boundaries are not measurable or are barely distinguishable from background noise levels. Environmental noise measurements at Hanford were conducted during a site characterization for the Skagit/Hanford Nuclear Power Plant Site in 1981 and for the Basalt Waste Isolation Project in 1987. In the 1981 study, noise levels ranged from 30 to 61 dBA (L_{eq}) at 15 sites. In the 1987 study, background noise levels measured at five locations in undeveloped areas around the Hanford Site ranged between 24 and 36 dBA as L_{eq} (24-hour), in which wind was identified as the major contributor to background noise levels. For the New Production Reactor EIS in 1991, noise levels associated with traffic were estimated at a receptor located 15 m (50 ft) from the road edge of State Route (SR) 24 and SR 240. Noise levels were estimated to range from 62 to 75 dBA as L_{eq} (1-hour) for the baseline condition and during construction and operational phases.

For the general area surrounding the Hanford Site, countywide L_{dn}'s based on population density are estimated to be 31 for Adams County (typical of wilderness natural background levels), and 36, 38, and 41 dBA for Grant, Franklin, and Benton Counties, respectively (typical of rural areas) (Miller 2002; Eldred 1982).

American Indian Text

Native people understand that non-natural noise can be offensive while traditional ceremonies are being held. Traditional ceremonies have been held at the Hanford site in recent years. Some of the cultural use of the Hanford site by Tribes is being lost. Not all ceremonial sites are known to non-Indians. The noise generated by the Hanford facility may presently create noise interference for ceremonies held at sites like Gable Mountain and Rattlesnake Mountain. Noise generating projects, such as the GTCC proposed site, can interrupt the thoughts and focus and thus the spiritual balance and harmony of the community participants of a ceremony. The Tribes recommend that quiet zones and time periods should be identified for known Native American ceremonial locations on and near the Hanford Reservation. The general values or attributes provide solitude, quietness, darkness and wilderness-like or undegraded environments. These attributes provide unquantifiable value and are fragile.

6.1.2 Geology and Soils

6.1.2.1 Geology

6.1.2.1.1 Physiography. The Hanford Site is located in the Columbia Basin, an intermontane basin between the Cascade Range and the Rocky Mountains, in the Pacific Northwest. The basin forms the northern part of the Columbia Plateau physiographic province and the Columbia River flood-basalt province. It has four structural subprovinces, two of which are important to the Hanford Site: the Yakima Fold Belt and the Palouse Slope (Figure 6.1.2-1). The Yakima Fold Belt is a series of anticlinal ridges and synclinal valleys in the southwestern part of the Columbia Basin that has a predominant east-west structural trend. The Palouse Slope is the northeastern part of the Columbia Basin and shows little deformation, with only a few faults and low-amplitude, long-wavelength folds on an otherwise gently westward-dipping paleoslope (Chamness and Sweeney 2007).

The Hanford Site lies within the Pasco Basin, a smaller basin in the Yakima Fold Belt along the southwestern margin of the Palouse Slope (Figure 6.1.2-1). The Saddle Mountains form the northern boundary of the Pasco Basin; Rattlesnake Mountain forms part of its southern boundary. The 200 East Area lies in the Cold Creek syncline between Yakima Ridge and Umtanum Ridge in the central portion of the Pasco Basin (Figure 6.1.2-2) (Chamness and Sweeney 2007).

The synclinal valleys and basins between anticlinal ridges have been filled by river and stream sediments; as a result, the Hanford Site has relatively low relief. Catastrophic flood events

American Indian Text

The Indian People recommend that DOE pay more attention to landscape features and visual and aesthetic services that flow from the geologic formations at Hanford. Cultural and sacred landscapes may be invisible unless they are disclosed by the peoples to whom they are important. Tribal values lie embedded within the rich cultural landscape and are conveyed to the next generation through oral tradition by the depth of the Indian languages. Numerous landmarks are mnemonics to the events, stories, and cultural practices of native peoples. Oral histories impart basic beliefs, taught moral values and the land ethic, and helped explained the creation of the world, the origin of rituals and customs, the location of food, and the meaning of natural phenomena. The oral tradition provides accounts and descriptions of the region's flora, fauna, and geology. Within this landscape are songs associated with specific places; when access is denied a song may be lost.

American Indian Text

The Yakima Fold Belt and the Palouse Slope play potentially very significant roles at Hanford both culturally and geologically. Rattlesnake and Gable Mountains are examples of folded basalt structures within the Yakima Fold Belt. These geological features have direct bearing on the ground water and groundwater flow direction. There are oral history accounts of these basalt features above the floodwaters of Lake Missoula. Many other topography features have oral history explanations such as the Mooli Mooli (flood ripples along the river terrace) and the sand dunes.

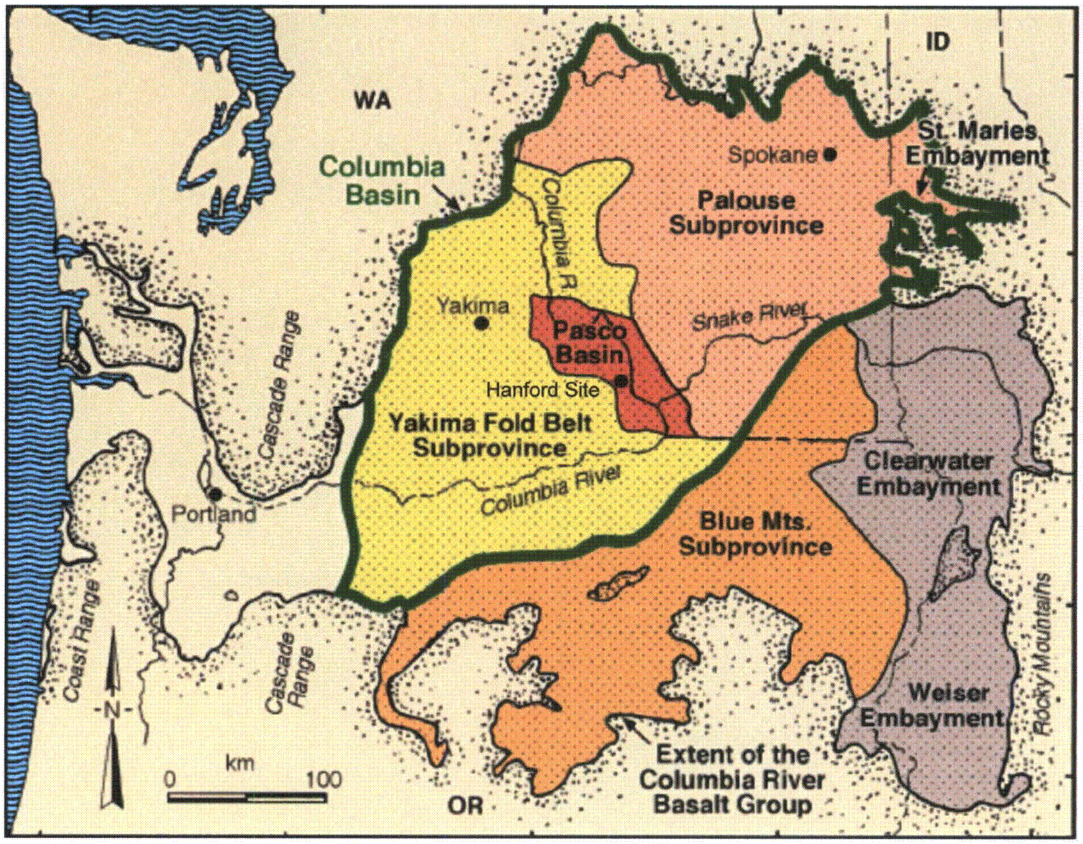

FIGURE 6.1.2-1 Location of the Hanford Site on the Columbia Plateau (Source: Modified from Chamness and Sweeney 2007)

(from glacial Lake Missoula and others) during the Late Pleistocene eroded sediments and scoured basalt bedrock, forming the scablands to the north of the Pasco Basin. The scablands are characterized by branching flood channels, giant current ripples, ice rafted erratics, and giant flood bars. These landforms can be readily seen on the Hanford Site. Since the end of the Pleistocene (about 10,000 years ago), winds have locally reworked flood sediments, depositing dune sands in the lower elevations and windblown silt around the margins of the Pasco Basin. Most sand dunes have been stabilized by vegetation, although there are active dunes in the Hanford Reach National Monument, to the north of the 300 Area (Chamness and Sweeney 2007; Normark and Reid 2003).

6.1.2.1.2 Topography. The 200 Areas are situated on a broad plateau (alluvial terrace) of relatively low relief. Elevations range from 229 m (750 ft) MSL on the plateau to about 119 m (390 ft) MSL at the Columbia River.

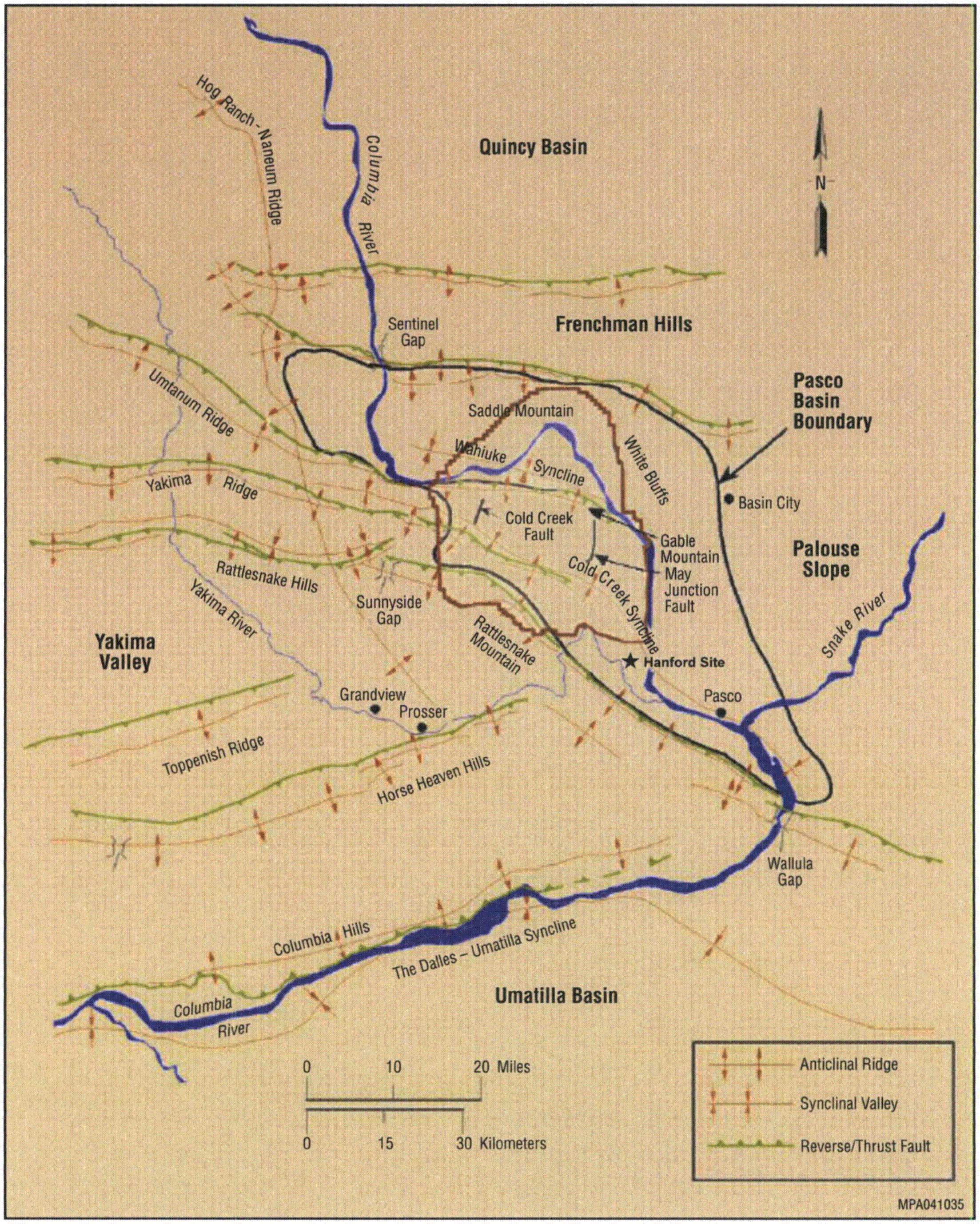

FIGURE 6.1.2-2 Physical Geology in the Vicinity of the Hanford Site (Source: Modified from Chamness and Sweeney 2007)

6.1.2.1.3 Site Geology and Stratigraphy. The GTCC reference location is situated south of the 200 East Area in the central portion of the Hanford Site. The site lies about 11 km (7 mi) due south of the Columbia River. Surficial sediments in the 200 East Area consist of active and stabilized eolian sand dunes of Holocene age.

The stratigraphy consists of a sequence of Tertiary sediments overlying the basalt flows of the Columbia River Basalt Group on the north limb of the Cold Creek syncline (Figure 6.1.2-2). Sediments include the upper Miocene to Pliocene Ringold Formation; Pleistocene flood gravels, sands, and silt of the Hanford Formation; and Holocene eolian deposits. The sedimentary sequence generally thickens toward the center of the syncline. The following summary of stratigraphy at the Hanford Site is based on Chamness and Sweeney (2007), Reidel and Fecht (2005), and Reidel (2005). Figure 6.1.2-3 presents a stratigraphic column for the Hanford Site and vicinity; Figure 6.1.2-4 shows the stratigraphy at the IDF site based on the work of Reidel (2005).

Columbia River Basalt Group. The Columbia River Basalt Group and interbedded sedimentary rocks (Ellensburg Formation) form the main bedrock of the Columbia Basin and the Hanford Site. The Columbia River Basalt Group consists of tholeiitic flood-basalt flows that erupted 17 and 6 million years ago (during the Miocene) and now cover an area of about 230,000 km^2 (88,000 mi^2) of eastern Washington and Oregon and western Idaho. At the IDF site, the Columbia River Basalt is encountered at depths of about 122 to 152 m (400 to 500 ft). The top of the basalt unit slopes gently to the south, following the dip of the Cold Creek syncline. There are at least 50 individual basalt flows beneath the Hanford Site with a total combined thickness of more than 3 km (1.9 mi). The Columbia River Basalt Group has been divided into five formations; from oldest to youngest, they are Picture Gorge Basalt, Imnaha Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt (Figure 6.1.2-3). Only the Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt are exposed at the Hanford Site.

The interbedded sedimentary rocks of the Ellensburg Formation consist predominantly of volcanic-derived sediment. Toward the central and eastern part of the basin, fluvial mainstream and overbank sediments of the ancestral Clearwater-Salmon and Columbia Rivers dominate.

Ringold Formation. The Ringold Formation is made up of fluvial and lacustrine sediments deposited by the ancestral Columbia and Clearwater-Salmon River systems between 3.4 and 8.5 million years ago (from the Miocene to the Pliocene). Only the member of Wooded Island is present beneath the 200 East Area. It consists of fluvial gravels separated by fine-grained deposits typical of overbank and lacustrine environments. The gravels are clast- and matrix-supported, pebble-to-cobble gravels with a fine to coarse sand matrix. The common lithologies are basalt, quartzite, and intermediate to felsic volcanics. Interbedded lenses of silt and sand are also common. The Ringold Formation reaches a maximum thickness of 87 m (285 ft) on the west side of the IDF site; it is entirely missing beneath the north and northeast parts of the 200 East Area.

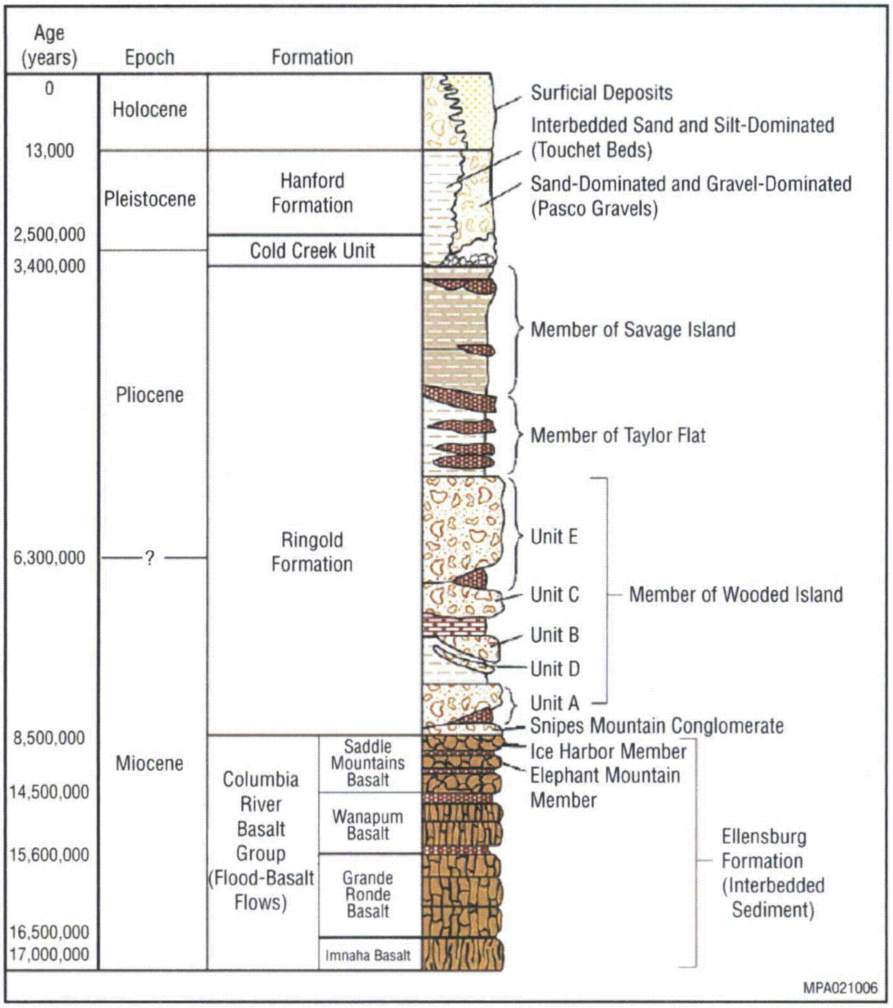

FIGURE 6.1.2-3 Generalized Stratigraphy of the Pasco Basin and Vicinity (Source: Chamness and Sweeney 2007)

Cold Creek Unit. The surface of the Ringold Formation was eroded extensively by the ancestral Columbia River and by catastrophic Pleistocene floodwaters. During this time, the Columbia River flowed through various channels between Umtanum Ridge and Gable Mountain (Figure 6.1.2-2) and eroded a wide channel to the south across the middle of the Hanford Site. The channel gradually shifted course to the east, where it continued to erode the eastern half of the site, removing the uppermost layers of the Ringold Formation. The eroded channel can be traced from Gable Gap across the eastern part of the 200 East Area and to the southeast. It is deepest below the northern portion of the IDF site. The channel is thought to be a smaller part of a much larger trough that underlies the 200 East Area.

Thin, laterally discontinuous alluvial deposits separate the Ringold Formation from the overlying Hanford Formation in some parts of the Hanford Site. These deposits are collectively referred to as the Cold Creek Unit and consist of a Plio-Pleistocene unit, pre-Missoula gravels,

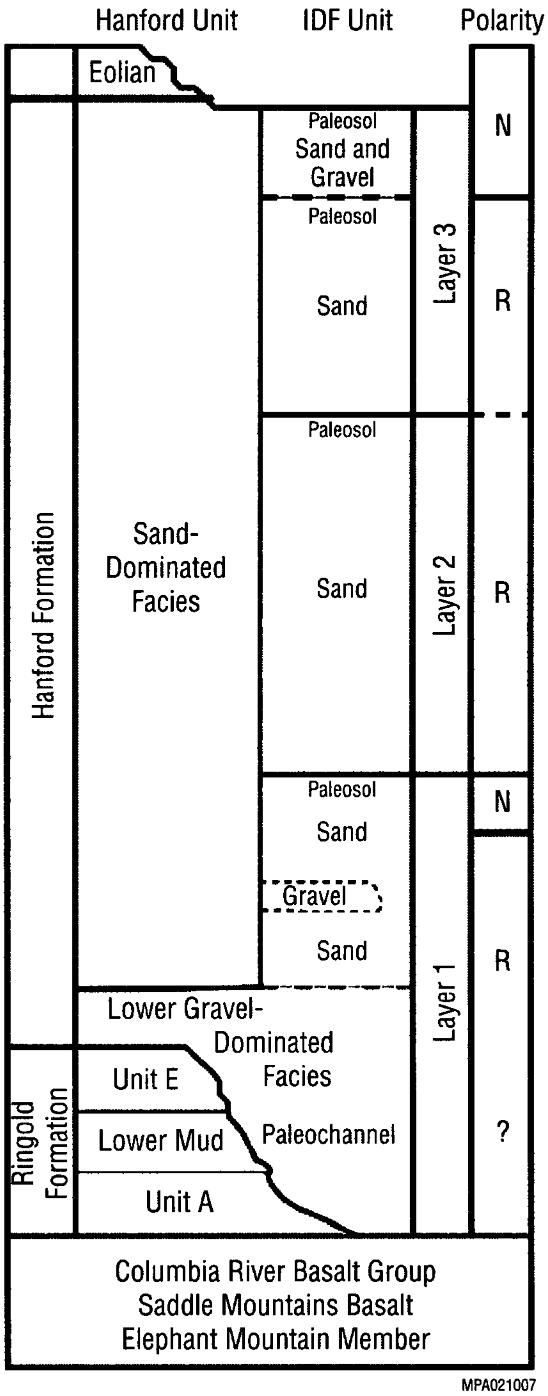

FIGURE 6.1.2-4 Stratigraphy at the IDF Site (Source: Reidel 2005)

and early Palouse soil. The Plio-Pleistocene unit unconformably overlies the Ringold Formation in the western Cold Creek syncline in the vicinity of the 200 West Area. Depending on location, the Plio-Pleistocene unit is made up of interfingering carbonate-cemented silt, locally referred to as the "caliche layer," sand and gravel, carbonate-poor silt, and sand; and/or basaltic detritus consisting of weathered and unweathered basaltic gravels deposited as locally derived slope wash, colluviums, and sidestream alluvium.

Pre-Missoula gravels are composed of quartzose to gneissic pebble-to-cobble gravel with a sand matrix. These gravels are up to 25-m (82-ft) thick, contain less basalt than underlying Ringold gravels and overlying Hanford deposits, have a distinctive white or bleached color, and sharply truncate underlying strata. The early Palouse soil consists of up to 20 m (66 ft) of silt and fine-grained sand. Deposits composing the early Palouse soil are massive, brownish-yellow, and compact.

Hanford Formation. The Hanford Formation rests unconformably atop the eroded surface of the Ringold Formation. It is as thick as 116 m (380 ft) in the vicinity of the IDF site. The unit is thickest in the northern part of the site where the erosional channel has cut into Ringold Formation; it thins to the southwest along the margin of the trough under the eastern portion of the IDF site. The sediments of the Hanford Formation were deposited between 2 million and 13,000 years ago by the catastrophic floodwaters from glacial Lake Missoula, glacial Lake Columbia, glacial Lake Bonneville, and ice-margin lakes.

The glaciofluvial sediments of the Hanford Formation consist of poorly sorted, pebble to cobble gravel and of fine- to coarse-grained sand, with lesser amounts of interstitial and interbedded silt and clay. They are divided into three facies (units): a lower gravel-dominated facies, an upper sand-dominated facies, and an interbedded sand- and silt-dominated facies (Figure 6.1.2-3). The gravel-dominated facies was deposited by high-energy floods and consists of coarse-grained, basaltic sand and granular to boulder gravel with an open framework texture, massive bedding, and large-scale planar cross bedding in outcrop. These deposits make up most of the Hanford Formation in the northern portion of the 200 Areas.

The sand-dominated facies were deposited adjacent to main flood channel courses during the waning stages of flooding and are most common in the central and southern parts of the 200 Areas. They consist of fine- to coarse-grained sand and granular gravel interlayered with deposits of Cascade ash. The sands have a high basalt content and are generally black, gray, or salt-and-pepper in color. The silt content of the sands varies and is lowest where the sands are well sorted. The interbedded sand- and silt-dominated facies were deposited in slack water conditions and in back-flooded areas. They consist of thin-bedded, plane-laminated, and ripple cross-laminated silt and fine- to coarse-grained sand. The beds are typically a few to several tens of inches or centimeters thick and have normally graded bedding. The interbedded sand- and silt-dominated unit tends to be absent in the vicinity of the IDF site.

Eolian Sand Dunes. Active and stabilized eolian sand dunes are a common feature across the Hanford Site. In the 200 East Area, the dunes have a parabolic form in plan view.

Dune deposits include Mazama ash from an eruption that occurred 6,000 years ago. The dunes have massive cross bedding, which indicates eastward transport. Active blowouts are common. Most dunes and interdune areas at Hanford are stabilized by vegetation and have only local areas of active sand transport.

6.1.2.1.4 Seismicity. The seismicity of the Columbia Plateau is relatively low compared with other regions of the Pacific Northwest, the Puget Sound, and western Montana/eastern Idaho. The largest known earthquake in the Columbia Plateau occurred in 1936 near Milton-Freewater, Oregon. It had a Richter magnitude of 5.75 and was followed by a number of aftershocks. The largest earthquakes near the Hanford Site occurred in 1918 and 1973. Both events had a magnitude of 4.4 and were located less than 16 km (10 mi) to the north of the Hanford Site near Othello (Chamness and Sweeney 2007).

Earthquakes in the central Columbia Plateau tend to occur in clusters or "swarms." The areas north and east of the Hanford Site are regions of concentrated earthquake swarm activity. Earthquake swarms have also occurred at several locations within the Hanford Site. About 90% of the earthquakes occurring in swarms have magnitudes of 2 or less and have shallow focal depths (usually less than 4 km [2 mi]). Each swarm typically lasts several weeks to months and consists of several to a hundred or more earthquakes clustered in an area of 5 to 10 km (3 to 6 mi) in the lateral dimension, with the longest dimension in an east-west direction (Chamness and Sweeney 2007).

Seismic data from the Hanford Seismic Network and the Hanford Strong Motion Accelerometer Network located on and around the Hanford Site are reported in the site's annual seismic report. Seismograph stations and strong motion accelerometer sites are located throughout the site, including one (H2E) at the 200 East Area. A total of 117 earthquakes occurred at the Hanford Site between October 1, 2005, and September 30, 2006. Of these, the majority (78) were swarms with magnitudes usually less than 2; the remaining earthquakes (39) were considered random, occurring in prebasalt sediments or crystalline basement rocks. None of the earthquakes occurring in FY 2006 were thought to result from movement along faults associated with major anticlinal ridges in the Hanford Site area (Rohay et al. 2006).

Probabilistic seismic hazard analyses have determined that the facilities at the Hanford Site should be able to withstand peak horizontal accelerations of 0.10g from an earthquake with a return frequency of once in 500 years (annual probability of 0.002) and 0.20g from an earthquake with a return frequency of once in 2,500 years (annual probability of 0.0004) (Chamness and Sweeney 2007).

American Indian Text

Geologic structure of the Pacific Northwest includes a feature called the Olympic-Wallowa Lineament (the OWL). Surface and depth data have identified a structural "line" within the earth's crust that can be traced roughly from southeast of the Wallowa Mountains, under Hanford, through the Cascades and under Seattle and the Sound. Such lineaments are signals of crustal structure that are not yet well identified. Emerging research being reported through the USGS is highlighting the importance of Seattle area faults connecting under the Cascades into the Yakima Fold Belt and on along the OWL. The geologic stress on the surface of the earth in the local region have a north-south compressional force direction that has caused the surface to wrinkle in folds that trend approximately east-west, thus creating the Yakima Fold Belt. Fault movement along these folds occurs all the time, and studies have shown these to be considered active fault zones.

6.1.2.1.5 Volcanic Activity. Flood basalt volcanism associated with the Columbia River Basalt Group occurred during an 11-million-year episode between 17 and 6 million years ago. Most of the lava during this episode was extruded during the first 2 to 2.5 million years of that period. There has been no volcanic activity during the last 6 million years. The recurrence of Columbia River basalt volcanism is not considered to be a credible volcanic hazard (Tallman 1996).

Volcanism in the Cascade Range has been active since the Pleistocene (2 million years ago). Several volcanoes in this range are active today, including Mount Mazama (Crater Lake) and Mount Hood in Oregon and Mount St. Helens (the most active in the range), Mount Adams, and Mount Rainier in Washington state. They will likely remain active for the next 100 years. The three closest volcanoes to the Hanford Site are Mount Adams, 150 km (93 mi) to the west-southwest; Mount Rainier, 175 km (109 mi) to the northwest; and Mount St. Helens, 200 km (124 mi) to the west-southwest. Given these distances, the only volcanic hazard is ash accumulation following the eruption of a Cascade Range volcano (Tallman 1996).

Probabilistic volcanic hazard studies of the Cascade Range completed by the USGS calculated that the annual probability that the accumulation of volcanic ash in Washington would exceed 1 cm (0.39 in.) after an eruption is 0.001 (once every 1,000 years). The annual probability that the volcanic ash accumulation would exceed 10 cm (3.9 in.) is 0.00012 (once every 8,300 years). Design ashfall loads range from 14.6 kg/m^2 (2.99 lb/ft^2) for a hazard probability of 0.0021 (once every 476 years) to 146.5 kg/m^2 (30.0 lb/ft^2) for a hazard probability of 0.000043 (once every 23,256 years), assuming an uncompacted ash density of 769 kg/m^2 (158 lb/ft^2) and a 50% compaction ratio (Tallman 1996).

6.1.2.1.6 Slope Stability, Subsidence, and Liquefaction. No natural factors in the GTCC reference location that would affect the engineering aspects of slope stability or subsidence have been reported.

Liquefaction of saturated sediments is a potential hazard during or immediately following large earthquakes. Whether soils will liquefy depends on several factors, including the magnitude of the earthquake, peak ground velocity, liquefaction susceptibility of soils, and depth to groundwater. Given the deep water table in the 200 Areas, liquefaction is not likely to be a hazard. However, groundwater levels in the 200 Areas are changing as a result of changes in wastewater discharge practices in the area.

6.1.2.2 Soils

American Indian Text

Native Peoples understand the importance of soils and minerals. Oral history has suggested that soils have a medicinal purpose for healing wounds as well as used for building structures, creating mud baths, and filtering water. Material from the White Bluffs was used for cleaning hides, making paints, and whitewashing villages.

Soil characteristics: soil chemistry (ph, ion activity, micronutrients, microorganisms), lack of this knowledge is a data gap such as the influence of past tank leaks on soil chemistry and characteristics/properties. Sandy soils have high transmissivity. Soil integrity is important to tribes since the soils support plant life, which supports many other life forms, which are all important to tribes.

The undisturbed soils within the study area are predominantly sands and loamy sands. In the area of the GTCC reference location, the Rupert sand and Burbank loamy sand predominate. The Rupert sand is a brown to grayish brown, coarse-grained sand that grades to dark grayish brown at a depth of about 90 cm (35 in.). The sand has developed under grass, sagebrush, and hopsage in alluvial fan deposits mantled by wind-blown sand. It forms hummocky terraces and dune-like ridges. The Burbank loamy sand is a coarse-grained sand, very dark grayish brown in color, that ranges in thickness from 41 to 76 cm (16 to 30 in.) and is underlain by gravel (Hajek 1966).

6.1.2.3 Mineral and Energy Resources

The Hanford Site excavates borrow materials from existing borrow pits and quarries throughout the site, including the various parts of the 200 Area and the areas between them (but not in the area of the GTCC reference location). Historically, mineral resources, including gravel, sand, and basalt, have been used to make concrete, to construct roads, as cap material for closing waste sites, and in general construction (DOE 2001a).

No reported energy resources are being developed within the boundaries of the Hanford Site. Deep natural gas production from anticlines in the basalt of Pasco Basin has been tested by oil exploration companies without commercial success (DOE 1995).

6.1.3 Water Resources

American Indian Text

Water sustains all life. As with all resources, there is both a practical and a spiritual aspect to water. Water is sacred to the Indian People, and without it nothing would live. When having a feast, a sip of water is taken either first or after a bite of salmon, then a bit of salmon, then small bites of the four legged animals, then bites of roots and berries, and then all the other foods.

The quality of purity is very important for ceremonial use of water. The concept of sacred water or holy water is global, and often connects people, places, and religion; religions that are not land-connected may lose this concept. Additionally, concepts related to the flow of services from groundwater and the valuation of groundwater is receiving increased attention.

6.1.3.1 Surface Water

6.1.3.1.1 Rivers and Streams.

Columbia River. The Columbia River is the principal surface water body on the Hanford Site. It flows through the northern portion of the site and forms part of the site's eastern boundary. Flow in the river is from north to south across the site, with eventual discharge to the Pacific Ocean. The river is impounded by 11 dams within the United States; seven are upstream and four are downstream of the Hanford Site. The Hanford Reach is the last free-flowing, nontidal segment of the Columbia River in the United States. It extends from Priest Rapids Dam, immediately upstream of the Hanford Site about 82 km (51 mi) southeast, to Lake Wallula, 29 km (18 mi) downstream of the Hanford Site near Richland, Washington (Thorne and Last 2007). Figure 6.1.3-1 shows surface water features at Hanford.

Flows through the Hanford Reach fluctuate significantly and are controlled primarily by releases from three upstream storage dams: Grand Coulee in the United States and Mica and Keenleyside in Canada. Flows in the Hanford Reach are directly affected by releases from Priest Rapids Dam; however, Priest Rapids operates as a run-of-the-river dam rather than a storage dam. Flows are controlled to generate power and promote salmon egg and embryo survival. Columbia River flow rates near Priest Rapids during the 90-year period from 1917 to 2007 averaged about 3,330 cms (117,550 cfs). Daily average flows during this period ranged from 570 to 19,500 cms (20,000 to 690,000 cfs). The lowest and highest flows occurred before the construction of upstream dams. During the 10-year period from 1997 through 2006, the average flow rate was about 3,300 cms (116,500 cfs). Storage dams on tributaries of the Columbia River also affect flows (Thorne and Last 2007).

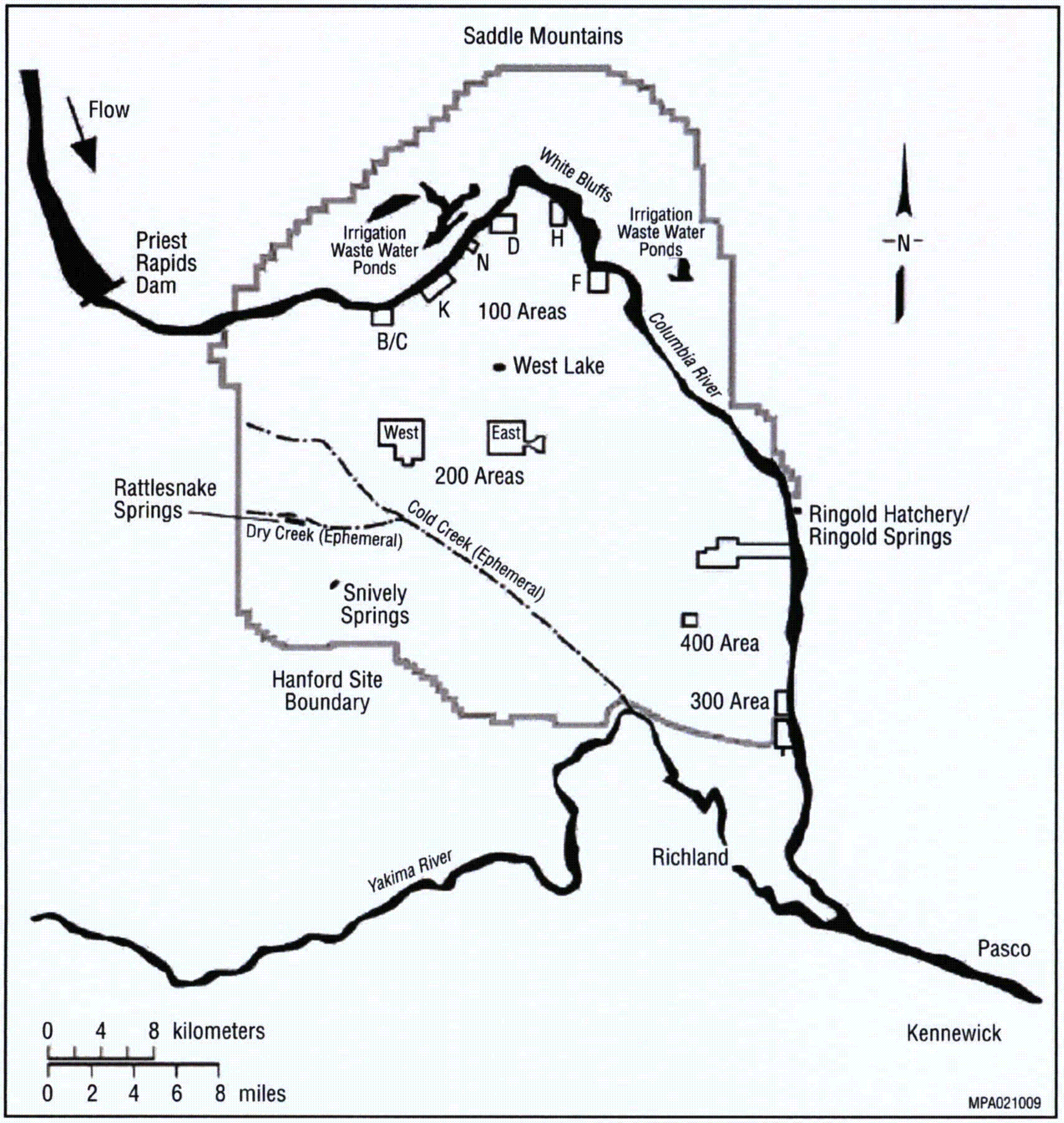

FIGURE 6.1.3-1 Surface Water Features on the Hanford Site (Source: Thorne and Last 2007)

Peak daily average flow during 2006 was 7,731 cms (273,000 cfs). Columbia River flows typically peak from April through June during spring runoff from snowmelt, and they are lowest from September through October. As a result of daily discharge fluctuations from upstream dams, the depth of the river varies over a short time period. River stage changes of up to 3 m (10 ft) during a 24-hour period may occur along the Hanford Reach. The width of the river varies from approximately 300 to 1,000 m (1,000 to 3,300 ft) within the Hanford Reach (Thorne and Last 2007).

Major floods on the Columbia River are typically the result of rapid melting of the winter snowpack over a wide area during periods of high precipitation. The maximum historical flood on record occurred in 1894, with a peak discharge of 21,000 cms (724,000 cfs) at the Hanford Site. The largest recent flood took place in 1948, with an observed peak discharge of 20,000 cms (700,000 cfs) at the Hanford Site. Exceptionally high runoff in 1996 resulted in a maximum discharge of nearly 11,750 cms (415,000 cfs). Construction of several flood-control/water-storage dams upstream of the Hanford Site has increased control of the river's flow and reduced the likelihood of flood recurrence (Thorne and Last 2007).

Flood potential on the Columbia River was evaluated by estimating the probable maximum flood, which takes into account the upper limit of precipitation falling on the drainage area and other hydrologic factors (e.g., antecedent moisture conditions, snowmelt, and tributary conditions) that could result in maximum runoff. The probable maximum flood for the Columbia River downstream of Priest Rapids Dam was calculated to be 40,000 cms (1.4 million cfs), which is greater than the 500-year flood (Figure 6.1.3-2). This flood would inundate parts of the 100 Areas adjacent to the Columbia River, but the central portion of the Hanford Site, including the 200 Areas, would remain unaffected. The USACE (1989) derived the standard project flood, giving both regulated and unregulated peak discharges for the Columbia River downstream of Priest Rapids Dam. Frequency curves for both unregulated and regulated peak discharges are also given for the same portion of the Columbia River. The regulated standard project flood for this part of the river was given as 15,200 cms (540,000 cfs), and the 100-year regulated flood was given as 12,400 cms (440,000 cfs). Impacts on the Hanford Site would be negligible and less than the probable maximum flood (Thorne and Last 2007). According to 10 CFR Part 1022, a floodplain is defined as the lowlands adjoining inland and coastal waters and relatively flat areas and flood-prone areas of offshore islands, including, at a minimum, that area inundated by a ≥1%-chance flood in any given year (i.e., the "100-year floodplain" caused by the 100-year flood).

Upstream dam failures could arise from a number of causes, with the magnitude of the resulting flood depending on the degree of breaching at the dam. The USACE evaluated a number of scenarios on the effects from failures of Grand Coulee Dam, assuming flow conditions of 11,000 cms (400,000 cfs). For emergency planning, USACE hypothesized 25% and 50% breaches, that is, the "instantaneous" disappearance of 25% or 50% of the center section of the dam, resulting from the detonation of explosives. The discharge or flood wave resulting from such a breach at Grand Coulee Dam was determined to be 600,000 cms (21 million cfs) (Thorne and Last 2007).

In addition to the areas inundated by the probable maximum flood, shown in Figure 6.1.3-2, the remainder of the 100 Areas, the 300 Area, and nearly all of Richland would be flooded. No determinations were made regarding failures of dams upstream, associated failures downstream of Grand Coulee Dam, or breaches greater than 50% of Grand Coulee Dam. The 50% scenario was believed to represent the largest realistically conceivable flow resulting from either a natural or a human-induced breach.

The possibility of a landslide resulting in river blockage and flooding along the Columbia River was also examined for an area bordering the east side of the river upstream of Richland.

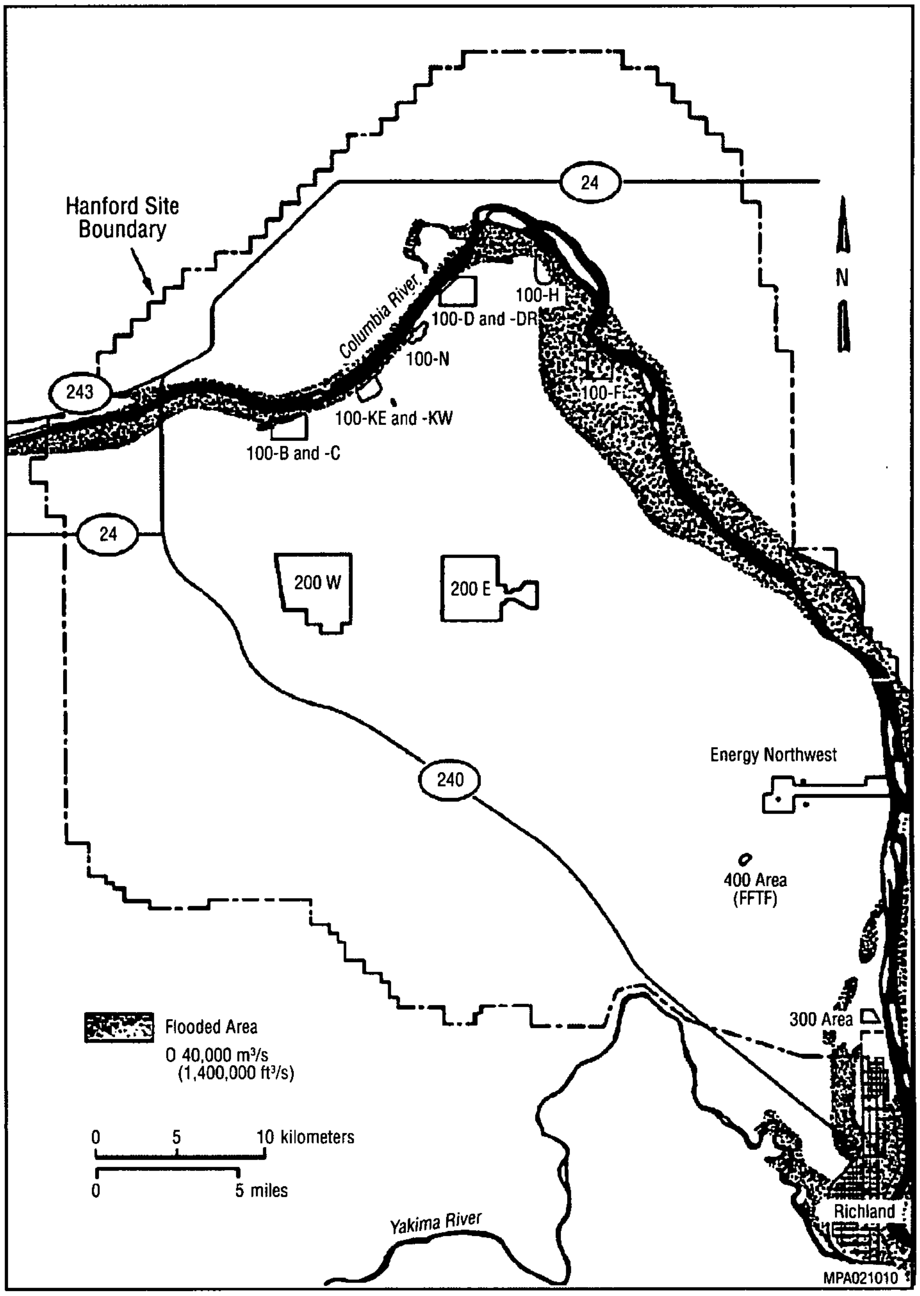

FIGURE 6.1.3-2 Flood Area for the Probable Maximum Flood on the Columbia River, Hanford Site (Source: Thorne and Last 2007)

The possible landslide area considered was the 75-m-high (250-ft-high) bluffs generally known as White Bluffs in the northern portion of the Hanford Site (and north of the river). Calculations were made for a 8 × 10^5 m^3 (1 × 10^6 yd^3) landslide volume, with a concurrent flood flow of 17,000 cms (600,000 cfs) and a 200-year flood, resulting in a flood-wave crest elevation of 122 m (400 ft) MSL. Areas inundated upstream of such a landslide event would be similar to those inundated during the probable maximum flood (Thorne and Last 2007).

The primary uses of the Columbia River include the production of hydroelectric power, irrigation of cropland in the Columbia Basin, and transportation of materials by barge. Several communities along the Columbia River rely on the river for drinking water. The Columbia River is also used as a source of both drinking water and industrial water for several Hanford Site facilities. In addition, the river is used extensively for recreation (Thorne and Last 2007; Poston et al. 2007).

American Indian Text

The Columbia River is the lifeblood of the Indian People. It supports the salmon and every food or material that they rely on for subsistence. It is an essential human right to have clean water. If water is contaminated it then contaminates all living things. Tribal members that exercise a traditional lifestyle would also become contaminated. A perfect example is making a sweat lodge and sweating. It is a process of cleansing and purification. If water is contaminated then the sweat lodge materials and process of cleansing would actually contaminate the individual.

Indian People are well known for adopting technology if it were instituted wisely and did not sacrifice or threaten the survival of the group as a whole. This approach applies to tribal use of groundwater. Even though groundwater was not used except at springs, tribes would have potentially used technology for developing wells and would have used groundwater if seen to be an appropriate action. The existing contamination is considered an impact to tribal rights to utilize this valuable resource.

The hyporheic zone in the Columbia River needs to be more fully characterized to understand the location and potential of groundwater contaminants discharging to the Columbia River.

Contaminated groundwater plumes at Hanford are moving towards the Columbia River and some contaminants are already recharging to the river. It is the philosophy of the Indian People that groundwater restoration and protection be paramount to DOE's management of Hanford. Institutional controls, such as preventing use of groundwater, should only be a temporary measure for the safety of people and animals. It will be questioned when DOE views institutional controls as a viable long-term management option to allow natural attenuation. The timeline of natural attenuation may not best represent a Tribal preference of a proactive corrective cleanup measure(s). for contamination plumes. Cleanup should be a priority before considering placement of additional waste like GTCC in the 200 area.

Yakima River. The Yakima River is located south of the Hanford Site and follows a portion of the southwestern boundary just to the west of the 300 Area. It drains surface runoff from about one-third of the Hanford Site. The Yakima River has much lower flows than the Columbia River, with an average daily flow of about 100 cms (3,530 cfs), according to 72 years of daily flow records kept by the USGS. The average monthly maximum and minimum are 497 cms (17,550 cfs) and 4.6 cms (165 cfs), respectively. Exceptionally high flows were observed during 1996 and 1997; the highest average daily flow rate during 1996 was nearly 1,300 cms (45,900 cfs). Average daily flow during 2000, a low water year, was 89.9 cms (3,176 cfs). The average daily flow during 2006 was 100 cms (3,530 cfs). The Yakima River is considered to be a losing river because the elevation of the river surface is higher than the local water table (Thorne and Last 2007).

There have been fewer than 20 major floods on the Yakima River since 1862. The most severe floods occurred during November 1906, December 1933, May 1948, and February 1996. During these events, discharge magnitudes at Kiona, Washington, were recorded at 1,870 cms (66,000 cfs), 1,900 cms (67,000 cfs), 1,050 cms (37,000 cfs), and 1,300 cms (45,900 cfs), respectively. The recurrence intervals for the 1933 and 1948 floods are estimated at 170 and 33 years, respectively. The development of irrigation reservoirs within the Yakima River Basin has considerably reduced the flood potential of the river. The southern border of the Hanford Site could be susceptible to a 100-year flood on the Yakima River (Thorne and Last 2007; Figure 6.1.3-3).

Cold Creek. Cold Creek and its tributary, Dry Creek, are ephemeral streams within the Yakima River drainage system in the southwestern portion of the Hanford Site (Figure 6.1.3-1). These streams drain areas to the west of the site and cross the southwestern part of the site toward the Yakima River (Figure 6.1.3-1). When surface flow occurs, it infiltrates rapidly and disappears into the surface sediments in the western part of the site.

The GTCC reference location at Hanford is situated about 16 km (10 mi) northeast of Cold Creek in the 200 East Area.

During 1980, a flood risk analysis of Cold Creek was conducted as part of the characterization of a basaltic geologic repository for high-level radioactive waste. Such design work is usually done according to the standard project flood criteria or probable maximum flood criteria rather than the worst-case or 100-year flood scenario. Therefore, in lieu of 100- and 500-year floodplain studies, a probable maximum flood evaluation was performed. It was based on a large rainfall or combined rainfall/snowmelt event in the Cold Creek and Dry Creek watershed. The probable maximum flood discharge rate for the lower Cold Creek Valley was 2,265 cms (80,000 cfs), compared with 564 cms (19,900 cfs) for the 100-year flood (Figure 6.1.3-4). Modeling indicated that SR 240 along the southwestern and western portions of the site would be unusable (Thorne and Last 2007).

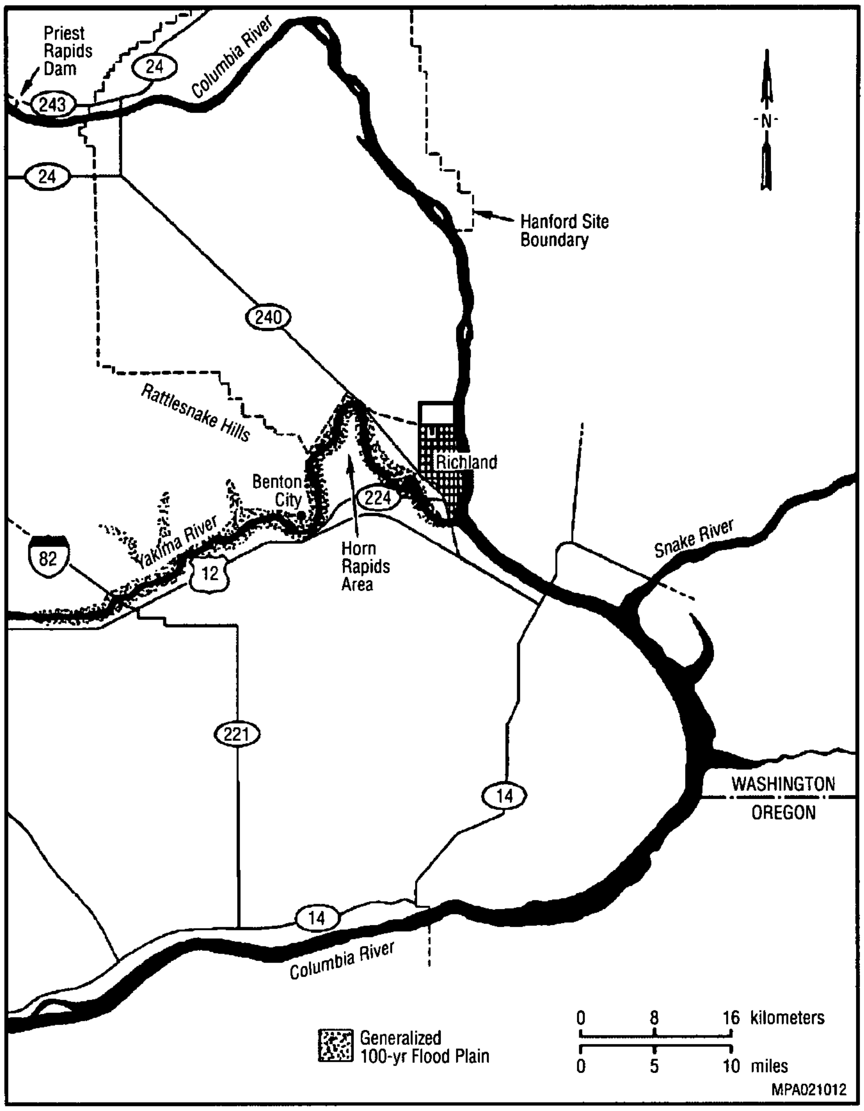

FIGURE 6.1.3-3 Flood Area from a 100-Year Flood of the Yakima River near the Hanford Site (Source: Thorne and Last 2007)

6.1.3.1.2 Other Surface Water.

Springs. Springs are found on the slopes of the Rattlesnake Hills along the western edge of the Hanford Site (Figure 6.1.3-1). There is also an alkaline spring at the east end of Umtanum Ridge. Rattlesnake and Snively Springs form small surface streams. Water discharged from Rattlesnake Springs flows into Dry Creek for about 3 km (1.9 mi) before disappearing into the ground (Thorne and Last 2007).

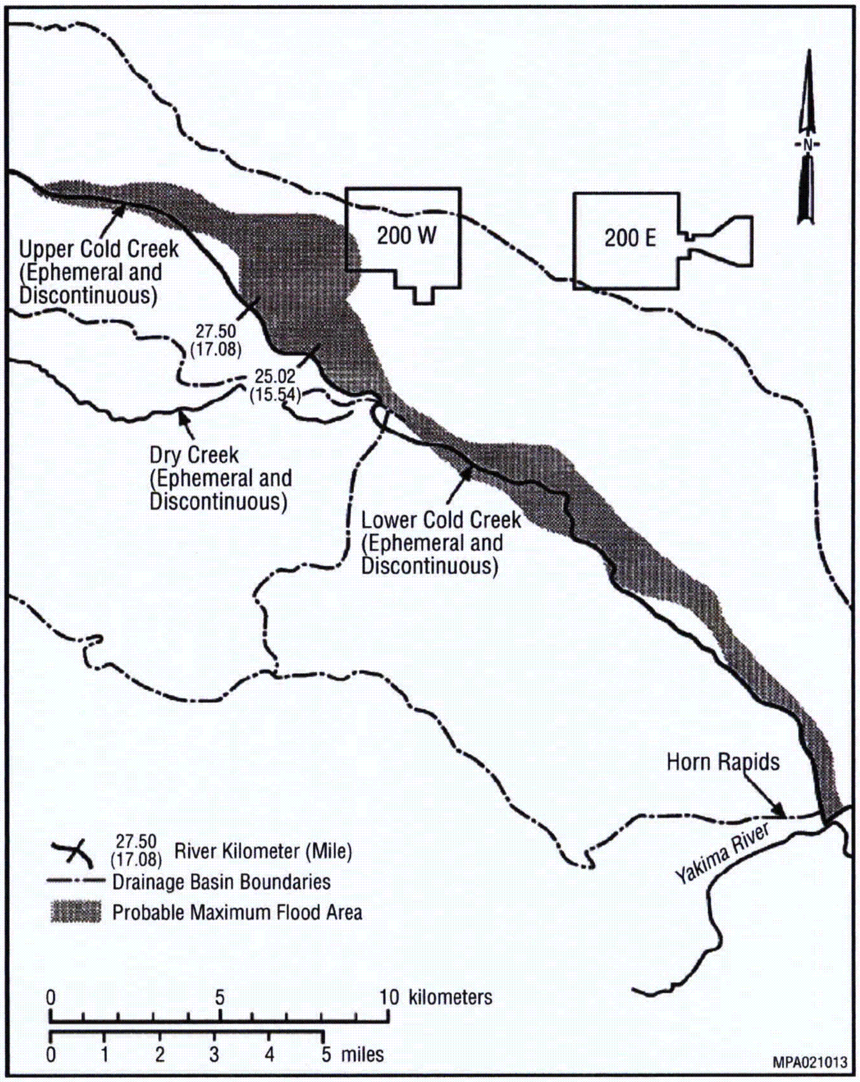

FIGURE 6.1.3-4 Extent of Probable Flood in Cold Creek Area, Hanford Site (Source: Thorne and Last 2007)

Riverbank springs were documented along the Hanford Reach long before Hanford operations began. During the early 1980s, researchers identified 115 springs along the Benton County shoreline of the Hanford Reach. The presence of shoreline springs varies with the river stage, which is controlled by upriver conditions and operations at upriver dams. Seepage occurs both below the river surface and on the exposed riverbank, particularly at a low river stage. Water flows into the aquifer (resulting in "bank storage") as the river stage rises, then it discharges from the aquifer in the form of shoreline springs as the river stage falls. Following an extended period of low river flow, groundwater discharge zones located above the water level of the river may cease to exist once the level of the aquifer comes into equilibrium with the level of the river. Thus, springs are most readily identified immediately following a decline in the river stage. Bank storage of river water also affects the contaminant concentration of the springs.

Spring water discharged immediately following a river stage decline generally consists of river water or a mixture of river water and groundwater. The percentage of groundwater in the spring water discharge increases over time following a drop in the river stage (Thorne and Last 2007).

Ponds. West Lake is a natural alkaline lake that lies to the north of the 200 East Area (Figure 6.1.3-1). West Lake is about 1.4 ha (3.5 ac) and is located approximately 8 km (5 mi) northeast of the 200 West Area and about 3 km (1.9 mi) north of the 200 East Area. West Lake was considered to be an ephemeral lake before operations began at the Hanford Site, with water-level fluctuations depending on groundwater-level fluctuations. The lake sits in a topographically low area that intersects the water table and is recharged by groundwater. West Lake does not receive direct discharges of effluent from site facilities; however, wastewater discharges at other Hanford facilities influencing the water table indirectly affect water levels in the lake. The lake's water levels have been decreasing over the past several years because of reduced wastewater discharge at other facilities (Thorne and Last 2007).

The Treated Effluent Disposal Area is located to the east of the 200 East Area (Figure 6.1.3-1). It consists of two disposal ponds, each about 145 by 145 m (475 by 475 ft). The disposal ponds receive permitted industrial wastewater from the 200 East Area. Once in the ponds, wastewater is allowed to evaporate or infiltrate into the ground (Thorne and Last 2007).

Several naturally occurring vernal ponds are located on the Hanford Site, including 10 at the eastern end of Umtanum Ridge, seven in the central part of Gable Butte, and three at the eastern end of Gable Mountain. The ponds occur in depressions perched atop a shallowly buried basalt surface and are formed as water collects over the winter (they dry up by summer). The ponds range in size from about 6.1 by 6.1 m (20 by 20 ft) to 45.7 by 30 m (150 by 100 ft) and tend to occur in clusters (Thorne and Last 2007).

Wetlands. Wetlands on the Hanford Site occur in the riparian zone along the Columbia River (DOE 2009). Irrigation on the east and west sides of the Wahluke Slope and on White Bluffs has created two wetland areas just north of the Columbia River (Figure 6.1.3-1; Thorne and Last 2007).

6.1.3.1.3 Surface Water Quality. The water quality of the Columbia River from Grand Coulee Dam to the Washington-Oregon border, which includes the Hanford Reach, has been designated as Class A by Washington State (Poston et al. 2009). Class A waters are suitable for essentially all uses, including raw drinking water, recreation, and wildlife habitat. For the Columbia River downstream from Grand Coulee Dam, the aquatic life designation is "salmon and trout spawning, noncore rearing, and migration." (Noncore refers to areas in which physical, chemical, and biological conditions are not specifically good for mating, reproduction, rearing, feeding, migration, and/or avoidance of disturbances such as floods and fire.) This designation provides for the protection of the spawning, noncore rearing, and migration of salmon and trout and other associated aquatic life. The recreational use designation for the Columbia River downstream from Grand Coulee Dam is "primary contact," which provides for activities that may involve complete submersion by the participant. The entire Columbia River is designated for all water supply and miscellaneous uses by the State of Washington (Poston et al. 2009).

In 1999, members of the Washington congressional delegation renewed their effort to identify the 82-km (51-mi) Hanford Reach as a Wild and Scenic River. The Hanford Reach is the last free-flowing segment of the Columbia River and an important spawning habitat for far-north migrating Chinook salmon. In 2000, President Clinton signed an Executive Order creating the Hanford Reach National Monument. At 79,000 ha (195,000 ac), the Hanford Reach National Monument is the second largest nationally protected area in Washington, and it is the only national monument managed by the USFWS (Dicks 1999; Tate 2005).

American Indian Text

A Presidential Proclamation established the Hanford Reach National Monument (Monument) (Presidential Proclamation 7319) and it directed the DOE and the U.S. Fish and Wildlife Service (FWS) jointly manage the monument. The Monument covers an area of 196,000 acres on the Department of Energy's (DOE) Hanford Reservation. DOE permits and agreements delegates authorities to FWS for 165,000 acres. The DOE directly manages approximately 29,000 acres, and the Washington Department of Fish and Wildlife currently manages the remainder (approximately 800 acres) through a separate DOE permit. The Monument is co-managed by the FWS and the DOE; each agency has several missions they fulfill at the Hanford Site. The FWS is responsible for the protection and management of Monument resources and people's access to Monument lands under FWS control. The FWS also has the responsibility to protect and recover threatened and endangered species; administer the Migratory Bird Treaty Act; and protect fish, wildlife and Native American and other trust resources within and beyond the boundaries of the Monument.

The FWS developed a comprehensive conservation plan (CCP) for management of the Monument as part of the National Wildlife Refuge System as required under the National Wildlife Refuge System Improvement Act. The CCP is a guide to managing the Monument lands (165,000 acres). It should be understood that FWS management of the Monument is through permits or agreements with the DOE.

Tribes participated in the development of the CCP with regard to protection of natural and cultural resources and tribal access. Based on the Presidential Proclamation that established the Hanford Reach National Monument, Affected tribes assume that all of Hanford will be restored and protected.

Metals and anions in water from the Columbia River have been detected at locations upstream and downstream of the Hanford Site. Arsenic, antimony, cadmium, chromium, copper, lead, mercury, nickel, selenium, thallium, and zinc were detected in most samples, with similar concentrations at most locations. When taking into account total hardness (47 to 77 mg/L) as calcium carbonate ($CaCO_3$) from 1992 through 2008, all metal and anion concentrations in river water were less than the Washington ambient surface water quality criteria for the protection of aquatic life. Arsenic concentrations exceeded the EPA human health standard for the consumption of water and organisms; however, this value is 10,500 times lower than the state chronic toxicity value (Poston et al. 2009).

Columbia River samples collected along cross-river transects had slightly elevated concentrations of nitrate, chloride, and sulfate along both shorelines at the 100-North Area in 2008. They were also elevated at the city of Richland and the 300 Area. Elevated nitrate concentrations at the Hanford Site shoreline are from the contaminated groundwater plumes emanating from the 200 Area. Elevated concentrations of nitrate, chloride, and sulfate in other samples have been attributed to groundwater seepage associated with high fertilizer usage and extensive irrigation upstream of the Columbia River to the north and east (Poston et al. 2009).

Radionuclide concentrations monitored in Columbia River water were low throughout 2008. Tritium (H-3), U-234, U-238, and naturally occurring Be-7 and K-40 were consistently detected in filtered river water at levels greater than their reported minimum detectable concentrations. Sr-90, U-235, and Pu-239/240 were detected occasionally, but at levels near the minimum detectable concentrations. The concentrations of all other radionuclides were typically below the minimum detectable concentrations. Tritium, Sr-90, I-129, and Pu-239/240 are present in worldwide fallout from historical nuclear weapons testing as well as in effluent from Hanford Site facilities. Tritium and uranium are naturally occurring elements in the environment. The average gross alpha and gross beta concentrations in Columbia River water at Richland during 2008 were less than the Washington State criteria for ambient surface water quality of 15 and 50 pCi/L, respectively (Poston et al. 2009).

Surface water sampled across transects at various locations along the Columbia River shows a statistical increase in tritium and uranium between samples taken upstream of the site at Vernita Bridge and those taken downstream of the site at the Richland pump house. These constituents are known to be entering the river from contaminated groundwater beneath the Hanford Site. For samples collected in 2008, the highest tritium concentration measured in cross-river transect water was 560 ± 200 pCi/L; the highest concentration in near-shore water was 2,900 ± 610 pCi/L (both samples were collected near the Hanford town site). The highest uranium concentration, 1.1 ± 0.22 pCi/L, was measured for the sample from the Benton County and Franklin County shore of the 300 Area transect. Elevated uranium in this location was likely the result of groundwater seepage and water from irrigation return canals that had elevated uranium levels from the use of phosphate fertilizers (Poston et al. 2009).

Measurements of Sr-90 at the Richland pump house were not statistically higher than those at the Vernita Bridge, even though Sr-90 is known to enter the river through groundwater inflow at the 100-North Area. The maximum Sr-90 concentration for 2008 was 0.20 ± 0.054 pCi/L for a near-shore sample collected at the 100-North Area (Poston et al. 2009).

During 2008, samples of the surface layer of Columbia River sediment were collected from six locations that were permanently submerged. Samples were also collected from the Priest Rapids Dam Reservoir and from the McNary Dam Reservoir and were obtained from slack water areas along the Hanford Reach and at the City of Richland. Radionuclides consistently detected at low levels in Columbia River sediment in 2008 included K-40, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239/240, and progeny products from naturally occurring radionuclides. Detectable amounts of most metals were found in all river sediment samples. Maximum and average concentrations of most metals were higher for samples collected upstream of Priest Rapids Dam than for samples from either the Hanford Reach or McNary Dam and may be associated with mining in the area. There are no Washington freshwater sediment quality criteria for comparison to the measured metal values (Poston et al. 2009).

Two on-site ponds, West Lake and the Fast Flux Test Facility (FFTF) Pond (Figure 6.1.3-1), were also sampled in 2008. Samples were obtained quarterly and included water from both ponds and sediment from West Lake. All water samples were analyzed for tritium, and samples from the FFTF pond were also analyzed for gross alpha, gross beta, and gamma-emitting radionuclides. All radionuclide concentrations in on-site pond water samples were less than the applicable DOE-derived concentration guides and Washington State ambient surface water quality criteria (Poston et al. 2009). Concentrations in West Lake sediment samples were similar to concentrations measured in prior years (i.e., detectable concentrations for gross alpha, gross beta, K-40, Sr-90, Cs-137, and uranium isotopes) (PNNL 2003).

6.1.3.2 Groundwater

6.1.3.2.1 Unsaturated Zone. Groundwater occurs in both the unsaturated (vadose) and saturated zones at Hanford. The unsaturated zone at Hanford consists of glacio-fluvial sands and gravels. The depth to saturated groundwater varies from about zero in the vicinity of the Columbia River to more than 100 m (330 ft) in the area of the central plateau (Chamness and Sweeney 2007). In the vicinity of the GTCC reference location, the thickness of the vadose zone is about 100 m (330 ft) (DOE 2009). The lower part of the unsaturated zone also consists of fluvial-lacustrine sediments of the Ringold Formation (Thorne and Last 2007).

6.1.3.2.2 Aquifer Units.

Basalt-Confined Aquifer System. The relatively permeable sedimentary interbeds and the more porous interflow zones of the basalt flow layers compose the confined aquifers within the Columbia River Basalt Group. Groundwater in this aquifer system generally flows toward the Columbia River; however, vertical interaquifer flow also occurs between the unconfined aquifer system and the confined aquifer system. Water chemistry data indicate that interaquifer flow has occurred in an area north of the 200 East Area, near the Gable Mountain anticlinal structure (Thorne and Last 2007). Figure 6.1.2-3 shows a stratigraphic column for Hanford.

Unconfined (Suprabasalt) Aquifer System. The unconfined aquifer system in the 200 East Area is composed primarily of the unconsolidated glaciofluvial sands and gravels of the Hanford Formation and Unit A gravels of the Ringold Formation. In some areas, such as most of the 200 West Area and some portions of the 100 Area, the fluvial-lacustrine sediments (Unit E) of the Ringold Formation make up the lower portion of the unconfined aquifer system.

The pre-Missoula gravels of the Cold Creek Unit lie between these formations and below the water table. The other subunits of the Cold Creek Unit are generally above the water table. Along the southern edge of the 200 East Area, the water table is in the Ringold Unit E gravels. The upper Ringold facies were eroded in most of the 200 East Area by the ancestral Columbia River and, in some places, by the Missoula floods that subsequently deposited Hanford gravels and sands on what was left of the Ringold Formation. On the north side of the 200 East Area, there is evidence of erosional channels that may allow interaquifer flow between the unconfined and uppermost basalt-confined aquifer. Depth to groundwater ranges from 0 m (0 ft) at the Columbia River to more than 100 m (330 ft) beneath parts of the central plateau (Thorne and Last 2007).

Horizontal hydraulic conductivities in the Hanford Formation sands and gravels and the coarse-grained multilithic facies of the Cold Creek Unit (pre-Missoula gravels) range from about 10 to 3,000 m/d (30 to 900 ft/d). Sediments in the underlying Ringold formation are more consolidated and partially cemented and are 10 to 100 times less permeable than the sediments of the Hanford Formation. Because the Hanford Formation and possibly the Cold Creek Unit sand and gravel deposits are much more permeable than the Ringold gravels, the water table is relatively flat in the 200 East Area, but groundwater flow velocities are higher (Thorne and Last 2007).

Slug tests at five monitoring wells in the vicinity of the GTCC reference location indicate permeabilities ranging from more than about 25 m/d (82 ft/d) to more than 45 m/d (148 ft/d) (Reidel 2005).

The hydrology of the 200 Area has been strongly influenced by the discharge of large quantities of wastewater to the ground over a 50-year period between the 1940s and 1990s. The discharges caused elevated groundwater levels across much of the Hanford Site, resulting in a large groundwater mound beneath the former U Pond in the 200 West Area and a smaller mound beneath the former B Pond, just to the northeast of the 200 East Area. The general increase in groundwater elevation caused the unconfined aquifer to extend upward into the Hanford Formation over a larger area, particularly near the 200 East Area. This resulted in an increase in groundwater velocity because of both the greater volume of groundwater and the higher permeability of the newly saturated Hanford Formation sediments (Thorne and Last 2007).

Discharges to the ground have greatly decreased since 1984 and currently contribute a volume of recharge to the unconfined aquifer system that is in the same range as the estimated natural recharge from precipitation. Decreases in the water table elevation in the past 20 years have been greatest at the 200 West Area and are estimated to be more than 8 m (26 ft). Water levels are expected to continue to decrease as the unconfined groundwater system reaches equilibrium with the new level of artificial recharge (Hartman et al. 2007; Thorne and Last 2007).

6.1.3.2.3 Groundwater Flow. Groundwater in the unconfined aquifer system flows from recharge areas in the elevated region near the western boundary of the Hanford Site toward the Columbia River on the eastern and northern boundaries (Figure 6.1.3-5). The Columbia River is the primary discharge area for the unconfined aquifer. The Yakima River borders the Hanford

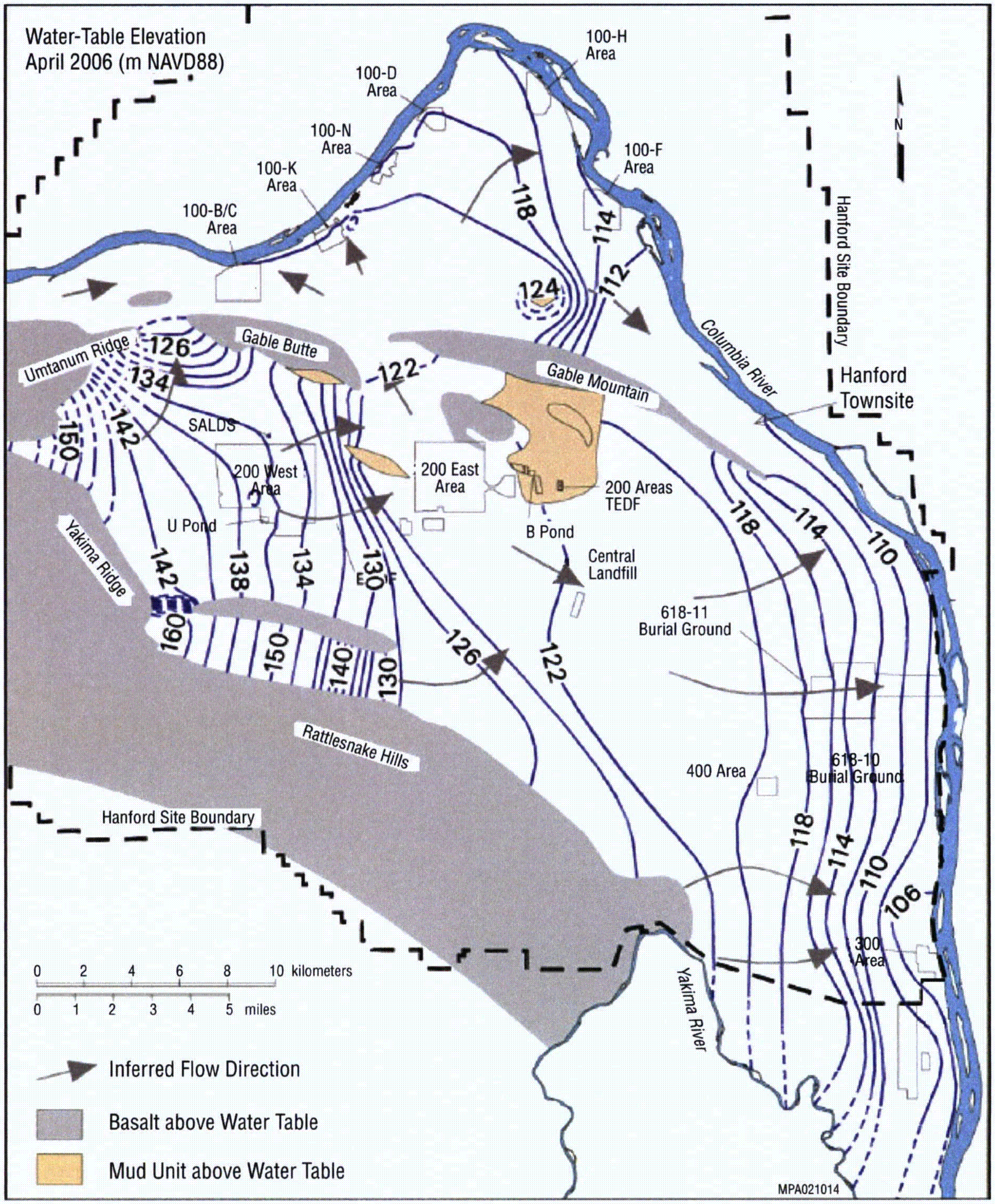

FIGURE 6.1.3-5 Water Table Elevations in Meters (1 m = 3.3 ft) and Inferred Groundwater Flow Directions for the Unconfined Aquifer at Hanford in March 2006 (Source: Hartman et al. 2007)

Site on the southwest and is generally regarded as a source of recharge. The rate of total discharge of groundwater from the Hanford Site aquifer to the Columbia River is in the range of 1.1 to 2.5 cms (39 to 88 ft^3/s), a very small rate relative to the river's average flow of 3,300 cms (116,500 ft^3/s) (Hartman et al. 2007; Thorne and Last 2007).

Along the Columbia River shoreline, daily river-level fluctuations may result in changes in the water table elevation of up to 3 m (10 ft). During the high-river-stage periods of 1996 and 1997, some wells near the Columbia River showed water-level changes of more than 3 m (10 ft). As the river stage rises, a pressure wave is transmitted inland through the groundwater. The longer the duration of the higher-river stage, the farther inland the effect is propagated. The pressure wave is observed farther inland than the water actually moves. For the river water to flow inland, the river level must be higher than the groundwater surface and must remain high long enough for the water to flow through the sediments. Typically, this inland flow of river water is restricted to within several hundred feet of the shoreline (Thorne and Last 2007).

Because precipitation at the Hanford Site is low (long-term average annual precipitation is 7 in. or approximately 17 cm) and because evapotranspiration is high (in an arid climate, potential evapotranspiration can exceed precipitation), recharge rates to underlying aquifers are low (Hoitink et al. 2005). In the vicinity of the GTCC reference location, annual recharge is estimated to be approximately 3.5 mm (0.14 in). (DOE 2005).

At the 200 East Area, the water table is relatively flat because of the highly permeable sediment of the Hanford Formation. The hydraulic gradient near B Pond in the 200 Area varies from about 0.003 east of the mound apex to 0.006 west-southwest of the former location of the main pond (PNNL 2005). Groundwater enters the 200 East Area vicinity from the west and divides, with some migrating to the north through Gable Gap and some moving to the southeast toward the central part of the site. Groundwater flow in the unconfined aquifer is currently altered where extraction or injection wells are used for pump-and-treat systems (Hartman et al. 2007; Thorne and Last 2007).

Studies have indicated that the residence time of groundwater at the Hanford Site is on the order of thousands of years in the unconfined aquifer and more than 10,000 years for groundwater in the shallow confined aquifer, consistent with the recharge conditions expected for a semiarid climate. However, groundwater travel time from the 200 East Area to the Columbia River has been shown to be much faster, in a range of 10 to 30 years, because of the large volumes of wastewater discharged at the site in the past and the relatively high permeability of the Hanford Formation sediments. Travel times from the 200 Area to the Columbia River are expected to decrease because of the decrease in wastewater volume discharged in these areas and the reduced hydraulic gradient that will occur over time as a result (Thorne and Last 2007).

After the beginning of Hanford operations during 1943, the water table rose about 27 m (89 ft) under the U Pond disposal area in the 200 West Area and about 9.1 m (30 ft) under disposal ponds near the 200 East Area. The volume of water that was discharged to the ground at the 200 West Area was actually less than that discharged at the 200 East Area. However, the lower hydraulic conductivity of the aquifer near the 200 West Area inhibited groundwater movement in this area, resulting in a higher groundwater mound. The presence of the groundwater mounds locally affected the direction of groundwater movement, causing radial flow from the discharge areas. Until about 1980, the edge of the mounds migrated outward from the sources over time. Groundwater levels have declined over most of the Hanford Site since 1984 because of decreased wastewater discharges; however, a residual groundwater mound beneath the 200 West Area is still shown by the curved water table contours near this location. A small groundwater mound near the wastewater disposal sites of the 200 Area Treated Effluent Disposal Facility (TEDF) (east of 200 East Area) and State-Approved Land Disposal Site (SALDS) (north of 200 West Area) is also still apparent (Thorne and Last 2007).

Recharge rates from precipitation across the Hanford Site are estimated to range from near zero to more than 100 mm/yr (3.94 in./yr). Between 1944 and the mid 1990s, the volume of artificial recharge from Hanford wastewater disposal was significantly greater than the natural recharge. An estimated 1.7×10^{12} L (4.44×10^{11} gal) of liquid was discharged to disposal ponds and cribs during this period. Because of the reduction in discharges, groundwater levels are falling, particularly around the operational areas (Chamness and Sweeney 2007). Vertical gradients between the basalt-confined aquifer and the unconfined aquifer are upward on most of the Hanford Site (Murray et al. 2003; Hartman et al. 2007; Thorne and Last 2007).

American Indian Text

Purity of water is very important to the Indian People, and thus DOE should be managing for an optimum condition considering Tribal cultural connection and direct use of water, rather than managing for a minimum water quality threshold. From the perspective of the Indian People, the greatest long-term threat at the Hanford site lies in the contaminated groundwater. There is insufficient characterization of the vadose zone and groundwater. There is a tremendous volume of radioactive and chemical contamination in the groundwater. The mechanisms of flow and transport of contaminants through the soil to the groundwater are still largely unknown. The volumes of contamination within the groundwater and direction of flow are still only speculative. Due to lack of knowledge and limited technical ability to remediate the vadose zone and groundwater puts the Columbia River at continual risk.

6.1.3.2.4 Groundwater Quality. The natural quality of groundwater at the Hanford Site varies depending on the aquifer system and depth, which are generally related to the residence time in the aquifer. Some of the shallower basalt-confined aquifers in the region (e.g., the Wanapum basalt aquifer) have exceptionally good water quality. Deeper basalt-confined aquifers, however, typically have a high dissolved solids content, and some have fluoride concentrations that exceed the drinking water standard of 4 mg/L (Thorne and Last 2007).

Groundwater in the unconfined aquifer beneath large areas of the Hanford Site has been contaminated by radiological and chemical constituents because of past site operations. These contaminants were primarily introduced through wastewater discharged to cribs, ditches, injection wells, trenches, and ponds. Additional contaminants from spills, leaking waste tanks, and burial grounds (landfills) have also entered groundwater in some areas. Contaminant plumes had sources in the 200 East Area and extend to the east and southeast; contaminant concentrations in these plumes are expected to decline through radioactive decay, mineral adsorption, chemical degradation, and dispersion. However, contaminants also exist within the vadose zone beneath waste sites as well as in waste storage and disposal facilities. These contaminants have the potential to continue to move downward into the aquifer (Hartman et al. 2007; Thorne and Last 2007).

Groundwater contamination is being actively remediated through pump-and-treat operations at the 200 West Area, 100-D Area, and 100-H Area. Extraction wells in the 100-K, 100-D, 100-H, and 200 West Areas capture contaminated water from the surrounding areas. These operations are summarized in Hartman et al. (2007). At the 100-N Area, pump-and-treat remediation has been terminated, and a passive treatment barrier is being used to reduce contaminant migration. Currently, no active groundwater remediation is occurring at the operable unit (200-PO-1) underlying the southern portion of the 200 East Area (Hartman et al. 2007).

Radiological and chemical constituents in groundwater at the Hanford Site are monitored to characterize physical and chemical trends in the flow system, establish groundwater quality baselines, assess groundwater remediation, and identify new or existing groundwater problems. Groundwater monitoring is also performed to verify compliance with applicable environmental laws and regulations. Samples were collected from 778 wells and 247 shoreline aquifer tubes during FY 2006 to determine the distributions of radiological and chemical constituents in Hanford Site groundwater. A total of 3,357 samples of Hanford groundwater were analyzed for chromium, 1,680 samples for nitrate, and 1,180 for tritium. Other constituents frequently analyzed include Tc-99, uranium, and CCl_4. The monitoring results are reported in the Hanford Site groundwater monitoring report for FY 2006 (Hartman et al. 2007).

Operable Unit 200-PO-1 encompasses the southern portion of the 200 East Area and a large part of the Hanford Site extending to the east and southeast. Groundwater within 200-PO-1 is contaminated with plumes of tritium, nitrate, and I-129 that exceed drinking water standards (Table 6.1.3-1). In FY 2006, tritium concentrations continued to decline as a result of radioactive decay and dispersion. Other contaminants (e.g., Sr-90 and Tc-99) were detected in limited areas near cribs or tank farms (Hartman et al. 2007).

6.1.3.3 Water Use

Prior to closure of the plutonium processing facilities at Hanford, a large quantity of process water was used. This water was primarily obtained from the Columbia River. Since the plutonium facilities were closed and the FFTF was placed on standby in 2007, much less water is being used. Currently, the 100-B Area Export Water System supplies raw/untreated water to the 200 Area Plateau and provides source water for fire protection, processing, and domestic water systems located across the entire Hanford Site (Klein 2007). Water is pumped from the Columbia River by using a 28,000-L/min (7,500-gpm) pump at the 181B River Pump Station. Water flows to the 182B Pump House and Reservoir for further distribution across the site. In 1998, the 200 East Area of Hanford had an annual water use of about 690 million L

American Indian Text

Hanford has delineated contamination areas called operable units (OUs); both subsurface contamination OUs and surface contamination OUs. When describing the affected environment for land use it is essential to reference this information that should be presented in the soils and groundwater sections. Understanding the types and extent of surface and subsurface contamination will give better understanding of the CLUP land use designations. For example, the proposed GTCC site at Hanford lies somewhere in or near the 200 ZP-1 groundwater OU. This OU has contamination from uranium, technetium, iodine 129 and other radioactive and chemical constituents.

TABLE 6.1.3-1 Maximum Concentrations of Selected Groundwater Contaminants at Operable Unit 200-PO-1 during FY 2006

Contaminant/Unit	DWS (DCG)[a]	Wells	Aquifer Tubes
Antimony (filtered) (μg/L)[b]	6		
Arsenic (filtered) (μg/L)	10	10.5	
Carbon tetrachloride (μg/L)	5	0.44	
C-14 (pCi/L)	2,000 (70,000)		
Cs-137 (pCi/L)	200 (3,000)		
Chloroform (TCM)[c] (μg/L)	100	0.62	
Chromium (dissolved) (μg/L)	100	41.1	
cis-1,2-Dichloroethene (μg/L)	70		
Co-60 (pCi/L)	100 (5,000)		
Cyanide (μg/L)	200		
Fluoride (mg/L)	4	7.3	0.21
Gross alpha (pCi/L)	15	33.5	
Gross beta (pCi/L)	50	2,020	3.27
I-129 (pCi/L)	1 (500)	9.11	
Mercury (μg/L)	2	0.09	
Nitrate (mg/L)	45	127	5.75
Nitrite (mg/L)	3.3	1.05	
Pu-239/240 (pCi/L)	NA[d] (30)		
Sr-90 (pCi/L)	8 (1,000)	20.6	
Te-99 (pCi/L)	900 (100,000)	7,740	
Tetrachloroethene (PCE)[c] (μg/L)	5	1.7	
Trichloroethene (TCE)[c] (μg/L)	5	0.81	
Tritium (pCi/L)	20,000 (2,000,000)	571,000	3,790
Uranium (μg/L)	30	27.2	

[a] DWS = drinking water standard, DCG = DOE derived concentration guide.

[b] Detection limit is higher than DWS; not a known contaminant of interest on the Hanford Site.

[c] TCM = chloroform, PCE = tetrachloroethylene, TCE = trichloroethylene.

[d] NA = no DWS for Pu-239/240.

Source: Hartman et al. (2007)

(182 million gal) and a capacity of about 2.6 billion L (686 million gal). This water was supplied by the Export Water System (DOE 1998).

6.1.4 Human Health

American Indian Text

Tribal health involves access to traditional foods and places. Both of these are located on the Hanford facility and can be impacted by placement of the GTCC waste in the 200 area.

Definition of Tribal health – Native American ties to the environment are much more complex and intense than is generally understood by risk assessors. All of the foods and implements gathered and manufactured by the traditional American Indian are interconnected in at least one way, but more often in many ways. Therefore, if the link between a person and his/her environment is severed through the introduction of contamination or physical or administrative disruption, the person's health suffers, and the well being of the entire community is affected.

To many American Indians, individual and collective well being is derived from membership in a healthy community that has access to, and utilization of, ancestral lands and traditional resources. This wellness stems from and is enhanced by having the opportunity and ability to live within traditional community activities and values. If the links between a tribal person and his or her environment were severed through contamination or DOE administrative controls, the well being of the entire community is affected.

Potential radiation exposures to the off-site general public residing in the vicinity of the Hanford Site could result from the airborne release of radionuclides through stacks or vents, discharge of liquid effluent to the Columbia River, and movement of contaminated groundwater to the Columbia River. As a result, potential exposure pathways for members of the off-site public include inhalation, air submersion, ingestion of foods contaminated through air deposition and water irrigation, external radiation from ground deposition, ingestion of aquatic food taken from the Hanford Reach of the Columbia River, and external radiation and ingestion of water through boating, swimming, and shoreline activities along the Hanford Reach of the Columbia River (Poston et al. 2009).

The doses to the general public in the vicinity of the Hanford Site are a small fraction of the dose limit of 100 mrem/yr set by DOE to protect the public from the operations of its facilities (DOE Order 5400.5). Table 6.1.4-1 provides the radiation doses estimated for an individual located in the Sagemoor area of the site vicinity in 2008. In addition to doses for this individual, the table also provides the collective dose for the population living within 80 km (50 mi) of the Hanford Site. The collective dose was estimated by considering similar exposure pathways to the highest exposed individual, with estimated fractions of the population expected to be affected by each pathway (Poston et al. 2009).

TABLE 6.1.4-1 Estimated Annual Radiation Doses to Workers and the General Public at the Hanford Site

Receptor	Radiation Source	Exposure Pathway	Dose to Individual (mrem/yr)	Dose to Population (person-rem/yr)
On-site workers	Groundwater contamination	Water ingestion	0.1[a]	
	Air contamination	Inhalation	0.0055[b]	
	Soil contamination and waste storage	Direct radiation	17–22[c]	
General public	Airborne release	Submersion, inhalation, ingestion of plant foods (contaminated through deposition), direct radiation from deposition	0.040[d]	0.34[e]
	Liquid effluent	Direct radiation from recreation, ingestion of water and plant foods (contaminated through irrigation)	0.0047[f]	0.097[g]
	On-site waste management and storage	Direct radiation	0.01[h]	
	Liquid effluent	Ingestion of bass muscle	0.0055[i]	
Worker/public	Natural background radiation and man-made sources		620[j]	300,000[k]

[a] Dose corresponds to drinking 1 L of water per day for 250 days in a year. It was calculated on the basis of measured groundwater concentrations at the FFTF in 2008 (Poston et al. 2009).

[b] The inhalation dose was calculated with CAP88-PC along with stack emission data. According to the CAP88-PC results, in 2008, the dose from stack emissions to a worker at the Laser Interferometer Gravitational Wave Observatory was 0.0055 mrem/yr.

[c] Direct radiation exposure was monitored for a total of 53,888 individuals from 1997 to 2001. Only 20% of those monitored had readings above zero. The average readings ranged from 17 to 22 mrem/yr.

[d] The radiation dose from an airborne release was estimated with Hanford Site air emission data and the GENII computer code. In 2008, the location of the individual receiving the highest impacts was determined to be at Sagemoor. In addition, the dose from airborne releases at this location was also calculated by CAP88-PC to demonstrate compliance with the 10-mrem/yr standard given in 40 CFR Part 61. The dose calculated by using CAP88-PC was well below the standard (Poston et al. 2009).

Footnotes continue on next page.

TABLE 6.1.4-1 (Cont.)

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[e] The collective dose was estimated for the population residing within 80 km (50 mi) of a Hanford Site facility. The population size is about 486,000 (Poston et al. 2009).

[f] The radiation dose attributable to liquid effluents was calculated on the basis of the differences in radionuclide concentrations between upstream and downstream sampling points on the Columbia River (Poston et al. 2009).

[g] The collective dose was calculated by considering a population of 130,000 for the drinking water pathway, 125,000 for the aquatic recreation pathway, and 2,000 for the ingestion of plant foods pathway.

[h] Thermoluminescent dosimeter (TLD) measurements indicate the highest external dose rate at the site boundary is along the 100-N Area shoreline, with a reading of 0.002 mrem/h greater than the average shoreline readings (Poston et al. 2006). An assumed stay time of 5 hours per year along the 100-N Area shoreline would give a dose of 0.01 mrem/yr. The boundary external exposures were not included in the dose estimated for the general public because no one could actually reside in these boundary locations. However, the Columbia River allows public access to within approximately 100 m (330 ft) of the N Reactor and supporting facilities at this location (Poston et al. 2006).

[i] The dose was estimated to result from ingesting 1 kg (2.2 lb) of bass muscle caught from the Columbia River (Poston et al. 2009). Because the exposure scenario has a relatively low probability of occurrence, it was not included in the calculation of the dose to the highest exposed individual.

[j] Average dose to a member of the U.S. population as estimated in Report No. 160 of the National Council on Radiation Protection and Measurements (NCRP 2009).

[k] Collective dose to the population of 486,000 within 80 km (50 mi) of the Hanford Site from natural background radiation and man-made sources.

American Indian Text

Risk assessments should take a public health approach to defining community and individual health. Public health naturally integrates human, ecological, and cultural health into an overall definition of community health and well-being. This broader approach used with risk assessments is adaptable to indigenous communities that, unlike westernized communities, turn to the local ecology for food, medicine, education, religion, occupation, income, and all aspects of a good life.

The off-site dose to the individual receiving the highest impacts from airborne releases was estimated to be 0.040 mrem/yr (Poston et al. 2009), which represents 0.4% of the EPA standard of 10 mrem/yr for airborne releases given in 40 CFR Part 61. When the estimated dose from radioactive liquid effluents is added to this, the total dose received by the off-site individual would be about 0.045 mrem/yr (Poston et al. 2009). This dose is well below the DOE limit of 100 mrem/yr from all applicable exposure pathways.

The collective radiation dose for the population of 468,000 living within 80 km (50 mi) of the Hanford Site was estimated to be about 0.44 person-rem in 2008. Distributing the collective dose evenly among this population, the average dose received by an off-site individual would be about 0.0091 mrem/yr. This is about 0.00015% of the dose expected for a member of the U.S. population from natural background radiation and man-made sources (620 mrem/yr).

Individuals working at the Hanford Site are routinely monitored for radiation exposure. The primary radiation dose limit established by DOE to control worker exposure is 5 rem/yr (10 CFR Part 835). As discussed in Section 5.3.4.1.1, DOE established an administrative control level of 2 rem/yr for all DOE activities. The Hanford Site established a site-specific administrative control limit of 500 mrem/yr for the majority of the workers, and only on rare occasions would workers incur doses greater than 500 mrem/yr. Worker doses at the Hanford Site have been significantly below the 500-mrem/yr limit, largely as a result of the implementation of the ALARA program. Use of DOE's ALARA program ensures that worker doses are kept well below applicable standards.

For on-site workers, potential radiation exposures from the inhalation and water ingestion pathways were much smaller than those from the external radiation pathway. In 2008, the estimated inhalation dose to a non-DOE individual working at the site was estimated to be 0.0055 mrem/yr, and the estimated dose to an on-site worker from drinking contaminated water was estimated to be 0.1 mrem/yr. Both of these dose estimates are conservative; the actual doses from these two pathways were probably much lower (Poston et al. 2009).

American Indian Text

The following four categories of an undisturbed environment contribute to individual and community health. Impacts to any of these functions can adversely affect health. Metrics associated with impacts within each of these categories are presented by Harper and Harris.

Human Health-Related Goods and Services: This category includes the provision of water, air, food, and native medicines. In a tribal subsistence situation, the land provided all the food and medicine that was necessary to enjoy long and healthy lives. From a risk perspective, those goods and services can also be exposure pathways.

Environmental Functions and Services: This category includes environmental functions such as soil stabilization and the human services that this provides, such as erosion control or dust reduction. Dust control in turn would provide a human health service related to asthma reduction.

Environmental functions such as nutrient production and plant cover would provide wildlife services such as shelter, nesting areas, and food, which in turn might contribute to the health of a species important to ecotourism. Ecological risk assessment includes narrow examination of exposure pathways to biota as well as examination of impacts to the quality of ecosystems and the services provided by individual biota, ecosystems, and ecology.

Social and Cultural Goods, Functions, Services, and Uses: This category includes many things valued by suburban and tribal communities about particular places or resources associated with intact ecosystems and landscapes. Some values are common to all communities, such as the aesthetics of undeveloped areas, intrinsic existence value, environmental education, and so on.

Economic Goods and Services: This category includes conventional dollar-based items such as jobs, education, health care, housing, and so on. There is also a parallel non-dollar indigenous economy that provides the same types of services, including employment (i.e., the functional role of individuals in maintaining the functional community and ensuring its survival), shelter (house sites, construction materials), education (intergenerational knowledge required to ensure sustainable survival throughout time and maintain personal and community identity), commerce (barter items and stability of extended trade networks), hospitality, energy (fuel), transportation (land and water travel, waystops, navigational guides), recreation (scenic visitation areas), and economic support for specialized roles such as religious leaders and teachers.

6.1.5 Ecology

American Indian Text

Indian People have lived in these lands for a very long time and thus have learned about the resources and their ecological interrelationships. They knew about environmental indicators that foretold seasons and conditions that guided them. When Cliff Swallows first appear in the spring, their arrival is an indicator that the fish are coming up the river. Doves are the fish counters, telling how many fish are coming. Many natural phenomena foretell when the earth is coming alive again in the spring, even if things are dormant underground. The Tribes have traditional ecological knowledge of this environment and tribal people have ceremonies that acknowledge the arrival of Spring. The winds bring information about what will happen. It provides guidance about how to bring balance back to the land.

The Hanford Site is located within a shrub-steppe desert dominated by perennial shrubs and bunchgrasses (*Agropyron* spp.). The relatively undisturbed shrub-steppe, riverine, and riparian habitats at the Hanford Site are considered to be biologically important (The Nature Conservancy 2003b). Shrub-steppe habitat is considered a priority habitat (habitat types or elements with unique or significant value to a diverse assemblage of species) by the State of Washington (WDFW 2008) and a Level III resource (biological resources that require mitigation because of their state listing, potential for federal or state listing, unique or significant value for biota, special administration designation, or environmental sensitivity) under the Hanford Site Biological Resources Management Plan (DOE 2001b). On upland, undisturbed areas (especially on zonal, silt loam soils), the vegetation is dominated by big sagebrush (*Artemisia tridentata*) and associated shrubs, perennial bunchgrasses, and forbs, whereas plant communities on sandy soils and stony loams are characterized by bitterbrush (*Purshia tridentata*) and several species of desert buckwheat (*Eriogonum* spp.). In the areas where fires have removed shrubs, large areas of grass-dominated communities have developed (Poston and Sackschewsky 2007).

In 2000, 66,322 ha (163,884 ac) of land were burned by the 24 Command Fire (a wildfire); 56,246 ha (138,986 ac) of the burning took place within the Hanford Site. This wildfire consumed nearly all of the vegetative cover within the Fitzner Eberhardt Arid Lands Ecology Reserve and a large portion of Hanford's central plain (Tiller et al. 2000). The extent of the fire included areas to the west, south, and east of but not including the GTCC reference location at the Hanford Site. About 85% of the vegetation was significantly reduced within the fire area, including 18 ha (44 ac) of willow riparian habitat. Potential long-term impacts from the fire include establishment of invasive species and changes in natural plant communities (DOE 2009). Most of the disturbed areas at Hanford (including areas burned by wildfire and abandoned farmlands), where the native shrub component has been modified severely or replaced altogether, are dominated by nearly pure stands of cheatgrass (DOE 1999).

Invasive plant species are one of the most serious threats to native biodiversity at the Hanford Site (The Nature Conservancy 2003a,b). About 25% of the nearly 730 plant species that occur on the Hanford Site are nonnative species (Sackschewsky and Downs 2001), with cheatgrass and diffuse knapweed (*Centaurea diffusa*) being among the dominant nonnative species. Vegetation types with a significant cheatgrass understory (which often occur in heavily grazed or disturbed areas) are generally of lower habitat quality than those areas with a bunchgrass understory (Poston and Sackschewsky 2007).

The GTCC reference location primarily contains a sagebrush/bunchgrass-cheatgrass plant community (Poston et al. 2009). The dominant plant species on the 200 Area Plateau are big sagebrush, rabbitbrush (*Chrysothamnus* spp.), cheatgrass, and Sandberg's bluegrass (*Poa secunda*) (Sackschewsky and Downs 2001). The understory vegetation in these communities includes forbs, bunchgrasses, and a cryptogamic soil crust. The common bunchgrass species include needle-and-thread (*Hesperostipa comata*), Indian ricegrass (*Oryzopsis hymenoides*), Cusick's bluegrass (*Poa cusickii*), and Idaho fescue (*Festuca idahoensis*) (Sackschewsky and Downs 2001). Most of the waste disposal and storage sites in the 200 Areas are planted with nonnative crested or Siberian wheatgrass (*Agropyron cristatum* or *A. fragile*) to stabilize surface soil, control soil moisture, or displace more invasive deep-rooted species, such as Russian thistle (*Salsola kali*) (Poston and Sackschewsky 2007). Russian thistle and rabbitbrush that occur in these areas are deeply rooted. Deeply rooted plants have the potential to accumulate radionuclides or other contaminants (DOE 1999).

Wetlands on the Hanford Site primarily occur in the riparian zone along the Columbia River. Rattlesnake and Snively Springs also support riparian wetland habitats. Large wetland ponds created by irrigation runoff occur north of the Columbia River. These ponds are used extensively as nesting sites by waterfowl (DOE 2009). Other wetland habitats include the man-made ponds and ditches occurring on the Hanford Site, including the B Pond Complex near the 200 East Area. Since effluent flows to the B Pond Complex have ceased, that complex is slowly reverting to an upland shrub-steppe ecosystem. Wetland plants, such as cattails and bulrushes, occur in scattered patches at West Lake (DOE 1999). No wetland habitats occur within the immediate vicinity of the GTCC reference location.

More than 300 species of terrestrial vertebrates occur on the Hanford Site (46 mammals, 246 birds, 12 reptiles, and 5 amphibians) (Poston and Sackschewsky 2007). Common mammal species at the Hanford Site include elk (*Cervus canadensis*), mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), American badger (*Taxidea taxus*), black-tailed jackrabbit (*Lepus californicus*), mountain cottontail (*Sylvilagus nuttallii*), Townsend's ground squirrel (*Spermophilus townsendii*), northern pocket gopher (*Thomomys talpoides*), bushy-tailed woodrat (*Neotoma cinerea*), brown rat (*Rattus norvegicus*), and house mouse (*Mus musculus*) (Downs et al. 1993). During summer, the pallid bat (*Antrozous pallidus*), little brown myotis (*Myotis lucifugus*), and Yuma myotis (*M. yumanensis*) are common at riparian habitats and near buildings (Downs et al. 1993). The Great Basin pocket mouse (*Perognathus parvus*) and North American deermouse (*Peromyscus maniculatus*) are the most abundant and second most abundant mammal species on the Hanford Site, respectively. The coyote is the most abundant large carnivore. Mule deer are common and range over the entire Hanford Site but are most common along the Columbia River (Downs et al. 1993; Fitzner and Gray 1991). Within the Hanford Site, elk occur primarily within the Fitzner Eberhardt Arid Lands Ecology Reserve. They do not occur in the vicinity of the 200 East Area (Tiller et al. 2000) but are occasionally observed on the 200 Area Plateau and at the White Bluffs boat launch area. A number of bat species, the Norway rat, and the house mouse are common near buildings (Fitzner and Gray 1991). The black-tailed jackrabbit is commonly associated with mature stands of sagebrush, while mountain cottontails are commonly associated with buildings, debris piles, and equipment laydown areas associated with laboratory and industrial activities (DOE 1999).

Among the bird species that have been recorded at the Hanford Site, 145 species are considered to be common (Poston and Sackschewsky 2007). Common passerines include the western meadowlark (*Sturnella neglecta*), horned lark (*Eremophila alpestris*), long-billed curlew (*Numenius americanus*), vesper sparrow (*Pooecetes gramineus*), sage sparrow (*Amphispiza belli*), sage thrasher (*Oreoscoptes montanus*), grasshopper sparrow (*Ammodramus savannafum*), and loggerhead shrike (*Lanius ludovicianus*) (DOE 1999). Common upland game birds include the chukar (*Alectoris chukar*), California quail (*Callipepla californica*), and ring-necked pheasant (*Phasianus colchicus*). Western sage grouse (*Centrocercus urophasianus phaios*), gray partridge (*Perdix perdix*), and scaled quail (*Callipepla squamata*) also occur on the site. Twenty-six species of raptors have been observed on the Hanford Site, with 11 species known to nest on the site (DOE 1999). These species include the American kestrel (*Falco sparverius*), red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*Buteo swainsoni*), golden eagle (*Aquila chrysaetos*), northern harrier (*Circus cyaneus*), prairie falcon (*Falco mexicanus*), barn owl (*Tyto alba*), great horned owl (*Bubo virginianus*), long-eared owl (*Asio otus*), and burrowing owl occur year long at the Hanford Site. The ferruginous hawk (*Buteo regalis*) will nest on transmission line support structures (DOE 1999). Bird species that occur within wetland and riparian habitats include a number of neotropical migrants, migratory waterfowl, and shorebirds. Large numbers of ducks and geese occur along the Hanford Reach of the Columbia River during fall and winter months, with white pelicans (*Pelecanus erythrorhynchos*), double-crested cormorants (*Phalacrocorax auritus*), and common loons (*Gavia immer*) also occurring during winter months (DOE 1999). Waterfowl, shorebirds, and other birds also make use of the on-site waste ponds and West Lake (Fitzner and Gray 1991). Fitzner and Rickard (1975) observed 126 bird species that utilized the small waste ponds (including their associated vegetation and air space) on the 200 Area Plateau.

The side-blotched lizard (*Uta stansburiana*) is the most common reptile species occurring throughout the Hanford Site. The most common snake species include the racer (*Coluber constrictor*), the gophersnake (*Pituophis catenifer*), and the western rattlesnake (*Crotalus viridis*) (Poston and Sackschewsky 2007). Amphibians reported from the Hanford Site include the Great Basin spadefoot toad (*Scaphiopus intermontanus*), western toad (*Bufo boreas*), Woodhouse's toad (*B. woodhousei*), tiger salamander (*Ambystoma tigrinum*), bullfrog (*Rana catesbeiana*), and Pacific treefrog (*Pseudacris regilla*) (Poston and Sackschewsky 2007; Bilyard et al. 2002). They occur near permanent water bodies and along the Columbia River (DOE 1999).

American Indian Text

There are big horned rattlesnakes that are very big rattlesnakes. These were a part of our lives and we treated them with respect. We called them grandfather. Most of these green and black rattlesnakes began to disappear years ago but some lasted until a few years ago. These big horned snakes seem to be gone now due to changes in the land. The elk used to live down here, but now the changes have pushed most of them away (Wanupum elder).

The major aquatic habitat on the Hanford Site is the Columbia River (DOE 2009). It is located about 11 km (6.8 mi) from the 200 East Area (DOE 2009). The Yakima River, a major tributary to the Columbia River, also crosses through a small portion of the southern boundary of the site. Other natural aquatic habitats on the site include small spring-streams and seeps located primarily in the Rattlesnake Hills area; West Lake (also known as West Pond) located north of the 200 East Area (currently less than 2 ha [5 acres] in size); and three clusters of about 20 vernal pools and ponds located at the eastern end of Umatanum Ridge, central portion of Gable Butte, and at the eastern end of Gable Mountain. Several artificial ponds also occur on the Hanford Site. Three Liquid Effluent Retention Facility impoundments occur just east of the 200 East Area. None of these habitats occur within the immediate vicinity of the GTCC reference location.

The federally and state-listed species occurring or potentially occurring on the Hanford Site are listed in Table 6.1.5-1. None of the federally threatened, endangered, or candidate species occur within the GTCC reference location (Poston and Sackschewsky 2007).

American Indian Text

Artificial light can be a "pollutant" when it creates measurable harm to the environment. Light can affect nocturnal and diurnal animals such as bats, owls, night crawlers and other species. Night light also has known affects on diurnal creatures and plants by interrupting their natural patterns. Light can affect reproduction, migration, feeding and other aspects of a living organism's survival. Artificial light can also reduce the quality of experience, including star gazing, during tribal cultural and ceremonial activities. Extensive light pollution is already being produced by the Hanford site.

TABLE 6.1.5-1 Federally and State-Listed Threatened, Endangered, and Other Special-Status Species on the Hanford Site

Common Name (Scientific Name)	Status[a] Federal/State
Plants	
Awned halfchaff sedge (*Lipocarpha aristulata*)	-/ST
Beaked spike-rush (*Eleocharis rostellata*)	-/SS
Canadian St. John's wort (*Hypericum majus*)	-/SS
Chaffweed (*Anagallis minimus*)	-/ST
Columbia milkvetch (*Astragalus columbianus*)	SC/SS
Columbia yellowcress (*Rorippa columbiae*)	SC/SE
Coyote tobacco (*Nicotiana attenuata*)	-/SS
Desert cryptantha (*Cryptantha scoparia*)	-/SS
Desert dodder (*Cuscuta denticulata*)	-/ST
Desert evening-primrose (*Oenthera caespitosa*)	-/SS
Dwarf evening primrose (*Camissonia pygmaea*)	-/SS
Fuzzytongue penstemon (*Penstemon eriantherus whitedii*)	-/SS
Geyer's milkvetch (*Astragalus geyeri*)	-/ST
Grand redstem (*Ammannia robusta*)	-/ST
Gray cryptantha (*Cryptantha leucophaea*)	SC/SS
Great Basin gilia (*Gilia leptomeria*)	-/ST
Hepatic monkeyflower (*Mimulus jungermannioides*)	SC/X
Hoover's desert parsley (*Lomatium tuberosum*)	SC/SS
Lowland toothcup (*Rotala ramosior*)	-/ST
Palouse goldenweed (*Pyrrocoma liatriformis*)	SC/ST
Piper's daisy (*Erigeron piperianus*)	-/SS
Rosy pussypaws (*Calyptridium roseum*)	-/T
Small-flowered evening primrose (*Camissonia minor*)	-/SS
Snake River cryptantha (*Cryptantha spiculifera*)	-/SS
Spreading loeflingia (*Loeflingia squarrosa* var. *squarrosa*)	-/ST
Suksdorf's monkeyflower (*Mimulus suksdorfii*)	-/SS
Umtanum desert buckwheat (*Eriogonum codium*)	C/SE
Ute ladies'-tresses (*Spiranthes diluvialis*)	T/E
White Bluffs bladderpod (*Physaria tuplashensis*)	C/ST
White eatonella (*Eatonella nivea*)	-/ST
Molluscs	
California floater (*Anodonta californiensis*)	SC/SCa
Giant Columbia River spire snail (*Fluminicola columbiana*)	SC/SCa
Shortfaced lanx (*Fisherola nuttallii*)	-/SCa
Insects	
Columbia clubtail (*Gomphus lynnae*)	SC/SCa
Columbia River tiger beetle (*Cicindela columbica*)	-/SCa
Silver-bordered fritillary (*Boloria selene atrocostalis*)	-/SCa
Fish	
Bull trout (*Salvelinus confluentus*)	T/SCa
Leopard dace (*Rhinichthys flacatus*)	-/SCa
Marginal sculpin (*Cottus marginatus*)	SC/SS

TABLE 6.1.5-1 (Cont.)

Common Name (Scientific Name)	Status[a] Federal/State
Fish (Cont.)	
Mountain sucker (*Catostomus platyrhynchos*)	-/SCa
Pacific lamprey (*Lampetra tridentata*)	SC/-
River lamprey (*Lampetra ayresi*)	SC/SCa
Steelhead (redband trout) (*Oncorhynchus mykiss*)	SC/SCa
Western brook lamprey (*Lampetra richardsoni*)	SC/-
Amphibians and Reptiles	
Northern sagebrush lizard (*Sceloporus graciosus graciosus*)	SC/SCa
Sagebrush lizard (*Sceloporus graciosus*)	SC/SCa
Striped whipsnake (*Masticophis taeniatus*)	-/SCa
Western toad (*Bufo boreas*)	SC/SCa
Birds	
American white pelican (*Pelecanus erythrorhychos*)	-/SE
Bald eagle (*Haliaeetus leucocephalus*)	SC/SS
Burrowing owl (*Athene cunicularia*)	SC/SCa
Common loon (*Gavia immer*)	-/SS
Ferruginous hawk (*Buteo regalis*)	SC/ST
Flamulated owl (*Otus flammeolus*)	-/SCa
Golden eagle (*Aquila chrysaetos*)	-/SCa
Greater sage-grouse (*Centrocercus urophasianus*)	C/ST
Lewis's woodpecker (*Melanerpes lewis*)	-/SCa
Loggerhead shrike (*Lanius ludovicianus*)	SC/SCa
Merlin (*Falco columbarius*)	-/SCa
Northern goshawk (*Accipiter gentilis*)	SC/SCa
Peregrine falcon (*Falco peregrinus*)	SC/SS
Sage sparrow (*Amphispiza belli*)	-/SCa
Sage thrasher (*Oreoscoptes montanus*)	-/SCa
Sandhill crane (*Grus canadensis*)	-/SE
Western grebe (*Aechmophorus occidentalis*)	-/SCa
Yellow-billed cuckoo (*Coccyzus americanus*)	C/SCa
Mammals	
Black-tailed jackrabbit (*Lepus californicus*)	-/SCa
Merriam's shrew (*Sorex merriami*)	-/SCa
Pallid Townsend's big-eared bat (*Corynorhinus townsendii pallescens*)	SC/SCa
Pygmy rabbit (*Brachylagus idahoensis*)	E/E
Townsend's ground squirrel (*Spermophilus townsendii*)	SC/SCa
Washington ground squirrel (*Spermophilus washingtoni*)	C/SCa
White-tailed jackrabbit (*Lepus townsendii*)	-/SCa

Footnotes continue on next page.

TABLE 6.1.5-1 (Cont.)

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[a] C (candidate): A species for which the USFWS or National Oceanic and Atmospheric Administration (NOAA) Fisheries has on file sufficient information on biological vulnerability and threats to support a proposal to list as endangered or threatened.

E (endangered): An animal or plant species in danger of extinction throughout all or a significant portion of its range.

SC (species of concern): An informal term referring to a species that might be in need of conservation action. This may range from a need for periodic monitoring of populations and threats to the species and its habitat, to the necessity for listing as threatened or endangered. Such species receive no legal protection under the ESA and use of the term does not necessarily imply that a species will eventually be proposed for listing.

SCa (state candidate): Under review for state listing.

SE (state endangered): In danger of becoming extinct or extirpated from Washington.

SM (state monitor): Taxa of potential concern.

SS (state sensitive): Vulnerable or declining and could become endangered or threatened in state.

ST (state threatened): Likely to become endangered in Washington.

T (threatened): A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

X: Possibly extinct or extirpated from Washington.

-: Not listed.

Sources: Caplow (2003); DOE (2009); Poston and Sackschewsky (2007); Poston et al. (2009); USFWS (2007a,b,c); WDFW (2009); WDNR (2009); letter from K.S. Berg, USFWS, to A.M. Edelman, DOE (see Appendix F of this EIS)

6.1.6 Socioeconomics

Socioeconomic data for Hanford describe an ROI consisting of two counties, Benton and Franklin Counties in Washington, that surrounds the site. More than 90% of Hanford workers reside in these counties (Fowler and Scott 2007).

6.1.6.1 Employment

In 2005, total employment in the ROI stood at 111,341 and was expected to reach 116,287 by 2008. Employment grew at an annual average rate of 1.5% between 1995 and 2005 (U.S. Bureau of the Census 2008a). The economy of the ROI was dominated by the agricultural

American Indian Text

Columbia River salmon runs, once the largest in the world, have declined over 90% during the last century. The 7.4 – 12.5 million average annual number of fish above Bonneville Dam have dropped to 600,000. Of these, approximately 350,000 are produced in hatcheries. Many salmon stocks have been removed from major portions of their historic range.

Multiple salmon runs reach the Hanford Nuclear Reservation. These runs include Spring Chinook, Fall Chinook, Sockeye, Silver and Steelhead. The runs tend to begin in April and end in November. Salmon runs have been decimated as a result of loss and change to habitat. The changes include non-tribal commercial fisheries, agriculture interests, and especially construction of hydro-projects on the Columbia River. Protection and preservation of anadromous fisheries were not a priority when the 227 Columbia River dams were constructed. Some dams were constructed without fish ladders and ultimately eliminated approximately half of the spawning habit available in the Columbia System.

The Hanford Reach is approximately 51 miles long and is the only place on the upper main stem of the Columbia River where Chinook salmon still spawn naturally. This reach is the last free flowing section of the Columbia River above Bonneville Dam. It produces about eighty to ninety percent of the fall Chinook salmon run on the Columbia River.

Tribal elders say that the last runs of big salmon (Chinook) that came through the Hanford Reach occurred in 1905. Non-Tribal Commercial fisheries on the lower Columbia are largely responsible for the loss of the large Chinook salmon. The Columbia River Tribes, out of a deep commitment to the fisheries and in spite of the odds, plan to restore stocks of Chinook, Coho, Sockeye, Steelhead, Chum, Sturgeon and Pacific Lamprey. This effort was united in 1995 under a recovery plan called the Wy-Kan-Ush-Mi Wa-Kish-Wit (Spirit of the Salmon). Member tribes are the Nez Perce Umatilla, Warm Springs and Yakama.

Indian People see themselves as the keepers of ancient truths and laws of nature. Respect and reverence for the perfection of Creation are the foundation of their culture. Salmon are part of our spiritual and cultural identity. Tribal values are transferred from generation to generation with the salmon returns. Without salmon, tribes would loose the foundation of their spiritual and cultural identity.

All tribes affected by the Hanford site are co-managers of Columbia River fisheries including assisting in tagging fry and counting redds along the Hanford Reach for the purposes of estimating fish returns. This information is essential in the negotiation of fish harvest between the USA and Canada as well as between Indian and non-Indian fishermen. In many ways, the loss of salmon mirrors the plight of native people. Elders remind us that the fate of humans and salmon are linked. The circle of life has been broken with the loss of traditional fishing sites and salmon runs on the Columbia River.

and service industries, with employment in these activities contributing about 73% to all employment (Table 6.1.6-1). Trade was also a large employer in the ROI, contributing about 12% to total ROI employment. During fiscal year (FY) 2006, an average of 9,759 employees were employed by DOE and its contractors (Fowler and Scott 2007).

TABLE 6.1.6-1 Hanford Site County and ROI Employment by Industry in 2005

Sector	Benton County	Franklin County	ROI Total	% of ROI Total
Agriculture[a]	24,574	15,919	40,493	36.4
Mining	175	60	235	0.2
Construction	3,571	1,168	4,739	4.3
Manufacturing	3,467	3,568	7,035	6.3
Transportation and public utilities	784	828	1,612	1.4
Trade	9,483	3,458	12,941	11.6
Finance, insurance, and real estate	2,337	775	3,112	2.8
Services	35,561	5,593	41,154	37.0
Other	10	10	20	0.0
Total	79,962	31,379	111,341	–

[a] USDA (2008).

Source: U.S. Bureau of the Census (2008a)

American Indian Text

Direct production by tribes is part of the economy that needs to be represented, especially considering the Tribe's emphasis on salmon recovery. This type of individual commerce in modern economics is termed and calculated as "direct production". The increase in direct production would be relational to the region's salmon recovery, yet there is no economic measure (within the NEPA process) to account for this robust element of a traditional economy.

In a traditional sense, direct production is a term of self and community reliance on the environment for existence as opposed to employment or modern economies. Direct production is use of salmon and raw plant materials for foods, ceremonial, and medicinal needs and the associated trading or gifting of these foods and materials. Direct production needs to be understood, and should include elements like: use of plant foods, ceremonial plants, medicinal plants, beadwork, hide work, tule mats and dried salmon.

An example of this economy would be the documented number of Native Americans that fished at Celilo Falls; as many as 1500 fisherman assembled at the site not far from Hanford during the peak fishing seasons. Trading between and among tribes include but are not limited to items like dentalia shells, mountain sheep horns, bows, horses, baskets, tule mats, art, bead work, leather and raw hide, and buffalo.

American Indian Text

Modern Tribal Economy

A subsistence economy is one in which currency is limited because many goods and services are produced and consumed within families or bands, and currency is based as much on obligation and respect as on tangible symbols of wealth and immediate barter. It is well-recognized in anthropology that indigenous cultures include networks of materials interlinked with networks of obligation. Together these networks determine how materials and information flow within the community and between the environment and the community. Today, there is an integrated interdependence between formal (cash-based) and informal (barter and subsistence-based) economic sectors that exists and must be considered when thinking of economics and employment of tribal people.

Indian People engage in a complex web of exchanges that often involves traditional plants, minerals, and other natural resources. These exchanges are a foundation of community and intertribal relationships. Thus there are natural resource issues, some of which are located on Hanford, that involve direct production that permeate Indian life. Indian People catch salmon that become gifts to others living near and far. Sharing self-gathered food or self-made items is a part of establishing and maintaining reciprocal relationships. People have similar relationships between places and elements of nature, which are based on mutual respect for the rights of animals, plants, places and people.

Use of the Hanford site and surrounding areas by tribes was tied primarily to the robust Columbia River fishery. Past social activities of native people include gatherings for such activities like marriages, trading, feasts, harvesting, fishing, and mineral collection. Tribal families and bands lived along the Columbia either year round or seasonally for catching, drying and smoking salmon. The reduction of salmon runs, loss of fishing sites due to dam impoundments and Hanford land use restrictions have contributed to the degradation of the supplies necessary for this gifting and barter system of our tribal culture.

The future of salmon and treaty-reserved fisheries will likely be determined during the life of the GTCC waste. With the tremendous efforts to recover salmon (and other fish species) by tribes, government agencies, and conservation organizations, Tribal expectations are that these species will be recovered to healthy populations.

If aquatic species were to recover, the regional economy and tribal barter economy would likely greatly increase in the Hanford area. These fish returns and the associated social and economic potential should be considered within the lifecycle of a GTCC waste repository.

6.1.6.2 Unemployment

Unemployment rates have varied across the counties in the ROI (Table 6.1.6-2). Over the 10-year period 1999–2008, the average rate in Franklin County was 7.8%, with a lower rate of 5.8% in Benton County. The average rate in the ROI over this period was 6.2%, higher than the average rate in the state of 5.7%. Unemployment rates for the first two months of 2009 contrasted markedly with rates for 2008 as a whole; in Franklin County, the unemployment rate increased to 10.4%, while in Benton County, the rate reached 7.9%. The average rates for both

TABLE 6.1.6-2 Hanford Site Average County, ROI, and State Unemployment Rates (%) in Selected Years

Location	1999–2008	2008	2009[a]
Benton County	5.8	5.4	7.9
Franklin County	7.8	6.8	10.4
ROI	6.2	5.7	8.6
Washington	5.7	5.3	8.4

[a] Rates for 2009 are the average for January and February.

Source: U.S. Department of Labor (2009a–d)

the ROI (8.6%) and the state (8.4%) during this period were higher than the corresponding average rates for 2008.

6.1.6.3 Personal Income

Personal income in the ROI stood at almost $6.5 billion in 2005 and was expected to reach $6.9 billion in 2008, growing at an annual average rate of growth of 2.6% over the period 1995–2005 (Table 6.1.6-3). ROI personal income per capita also rose over the same period and was expected to reach $28,949 in 2008, compared with $27,776 in 1995. Per-capita incomes were higher in Benton County ($32,446 in 2005) than elsewhere in the ROI. Total income increased over the period 1995–2005 and 2005–2008 in both counties and in the ROI as a whole. However, income in Franklin County, with an average annual growth of 2.7%, did not grow as fast as the population, which grew at an annual average growth rate of 3.7% between 1990 and 2006, leading to a decline in per-capita income in Franklin County and in the ROI as a whole.

6.1.6.4 Population

The population of the ROI was at 226,033 in 2006 (U.S. Bureau of the Census 2008b) and was expected to reach 238,088 by 2008 (Table 6.1.6-4). In 2006, 159,463 people were living in Benton County (about 70% of the ROI total). Over the period 1990–2006, the population in the ROI as a whole grew moderately, with an average annual growth rate of 2.6%, with a higher-than-average annual growth in Franklin County (3.7%). The population in Washington as a whole grew at a rate of 1.7% over the same period.

TABLE 6.1.6-3 Hanford Site County, ROI, and State Personal Income in Selected Years

Income	1995	2005	Average Annual Growth Rate (%), 1995–2005	2008[a]
Benton County				
Total personal income (2006 $ in millions)	3,993	5,124	2.5	5,459
Personal income per capita (2006 $)	26,632	32,446	0.9	32,775
Franklin County				
Total personal income (2006 $ in millions)	1,021	1,337	2.7	1,433
Personal income per capita (2006 $)	22,314	21,236	–0.5	20,040
ROI total				
Total personal income (2006 $ in millions)	5,014	6,461	2.6	6,892
Personal income per capita (2006 $)	27,776	29,251	0.5	28,949
Washington				
Total personal income (2006 $ in millions)	171,763	230,433	3.0	248,788
Personal income per capita (2006 $)	31,338	36,624	1.6	37,628

[a] Argonne National Laboratory estimates.

Source: DOC (2008)

TABLE 6.1.6-4 Hanford Site County, ROI, and State Population in Selected Years

Location	1990	2000	2006	Average Annual Growth Rate (%), 1990–2006	2008[a]
Benton County	112,560	142,478	159,463	2.2	166,560
Franklin County	37,473	49,347	66,570	3.7	71,528
ROI total	150,033	191,825	226,033	2.6	238,088
Washington	4,903,043	5,894,121	6,395,798	1.7	6,611,856

[a] Argonne National Laboratory projections.

Sources: U.S. Bureau of the Census (2008b); estimated data for 2006

6.1.6.5 Housing

The housing stock in the ROI as a whole grew at an annual rate of 2.3% over the period 1990–2000 (Table 6.1.6-5), with total housing units expected to reach 88,735 in 2008. A total of 13,506 new units were added to the existing housing stock in the ROI between 1990 and 2000. On the basis of annual population growth rates, 5,424 housing units in the ROI were expected to be vacant in 2008, of which 1,739 were expected to be rental units available to construction workers at the GTCC waste disposal facility.

6.1.6.6 Fiscal Conditions

Expenditures of the various jurisdictions and school districts in the ROI are presented in Table 6.1.6-6. Additional revenues to support these expenditures could come primarily from state and local sales tax revenues associated with employee spending during construction and

TABLE 6.1.6-5 Hanford Site County, ROI, and State Housing Characteristics in Selected Years

Parameter	1990	2000	2008[a]
Benton County			
Owner occupied	26,663	36,344	42,487
Rental	15,564	16,522	19,315
Vacant units	2,650	3,097	3,620
Total units	44,877	55,963	65,422
Franklin County			
Owner occupied	7,277	9,740	14,118
Rental	4,919	5,100	7,392
Vacant units	1,468	1,244	1,803
Total units	13,664	16,084	23,313
ROI			
Owner occupied	33,940	46,084	56,605
Rental	20,483	21,622	26,707
Vacant units	4,118	4,341	5,424
Total units	58,541	72,047	88,735
Washington			
Owner occupied	1,171,580	1,467,009	1,756,149
Rental	700,851	804,389	962,930
Vacant units	159,947	179,677	215,090
Total units	2,032,378	2,451,075	2,934,169

[a] Argonne National Laboratory projections.

Source: U.S. Bureau of the Census (2008b)

TABLE 6.1.6-6 Hanford Site County, ROI, and State Public Service Expenditures in 2006 ($ in millions)

Location	Local Government	School District
Benton County	111.6	131.8
Franklin County	43.4	59.6
ROI total	155.0	191.4
Washington	30,477	7,751

Source: U.S. Bureau of the Census (2008c)

operations and be used to support additional local community services currently provided by each jurisdiction.

6.1.6.7 Public Services

Data on employment related to providing public safety, fire protection, community and educational services, and local physician services in the counties, cities, and school districts likely to host relocating construction workers and operations employees are presented. This information is used to determine whether additional demands on these various public services could result from the construction and operations of a GTCC waste disposal facility. Table 6.1.6-7 presents data on employment and levels of service (number of employees per 1,000 population) for public safety. Table 6.1.6-8 provides staffing and level-of-service data for school districts. Table 6.1.6-9 covers physicians.

6.1.7 Environmental Justice

Figures 6.1.7-1 and 6.1.7-2 and Table 6.1.7-1 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer around the Hanford Site from Census Bureau data for the year 2000 and from CEQ guidelines (CEQ 1997). Persons whose incomes fall below the federal poverty threshold are designated as low income. Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or multi-racial (with at least one race designated as a minority race under CEQ). Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals who also identified themselves as being part of one or more of the population groups listed in the table.

TABLE 6.1.6-7 Hanford Site County, ROI, and State Public Service Employment in 2006

	Benton County		Franklin County	
Service	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	221	1.4	90	1.4
Fire protection[b]	149	0.9	42	0.9
General	1,084	6.8	512	7.7

	ROI		Washington	
Service	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	311	1.4	9,527	0.5
Fire protection[b]	191	0.8	6,696	1.0
General	1,596	7.1	200,030	31.3

[a] Level of service represents the number of employees per 1,000 persons in each county.

[b] Does not include volunteers.

Source: U.S. Bureau of the Census (2008b,c)

TABLE 6.1.6-8 Hanford Site County, ROI, and State Education Employment in 2006

Location	No. of Teachers	Level of Service[a]
Benton	1,528	9.6
Franklin	755	11.3
ROI total	2,283	10.1
Washington	53,508	8.4

[a] Level of service represents the number of teachers per 1,000 persons in each county.

Sources: National Center for Educational Statistics (2008); U.S. Bureau of the Census (2008b,c)

TABLE 6.1.6-9 Hanford Site County, ROI, and State Medical Employment in 2006

County	No. of Physicians	Level of Service[a]
Benton	385	2.4
Franklin	63	0.9
ROI total	448	2.0
Washington	16,243	2.5

[a] Level of service represents the number of physicians per 1,000 persons in each county.

Sources: AMA (2006); U.S. Bureau of the Census (2008b)

American Indian Text

President Clinton signed Executive Order 12898 to address Environmental Justice issues and to commit each federal department and agency to "make achieving Environmental Justice part of its mission." According to the Executive Order, no single community should host disproportionate health and social burdens of society's polluting facilities. Many American Indians are concerned about the interpretation of "Environmental Justice" by the U.S. Federal Government in relation to tribes. By this definition, tribes are included as a minority group. However, the definition as a minority group fails to recognize tribes' sovereign nation-state status, the federal trust responsibility, or protection of treaty and statutory rights of American Indians. Because of a lack of the these details, tribal governments and federal agencies have not been able to develop a clear definition of Environmental Justice in Indian Country, and thus it is difficult to determine appropriate actions.

American Indian and Alaskan Natives use and manage the environment holistically; everything is viewed as living and having a spirit. Thus, many federal and state environmental laws and regulations designed to protect the environment do not fully address the needs and concerns of American Indian and Alaskan Natives. Land based resources are the most important assets to tribes spiritually, culturally and economically.

DOE analysis of Environmental Justice is uniformly inadequate to address Native American rights, resources, and concerns. At Hanford, Tribal rights, health, and resources are always more impacted than those of the general population due to the traditional lifeways, close connections to the natural and cultural resources, and natural resource trusteeship. Thus, Hanford EJ analyses generally find that beneficial impacts of new missions, such as new jobs or more taxes, accrue to the local non-native community, yet fail to recognize that the majority of negative impacts accrue to Native Americans, such as higher health risk, continuation of restricted access, lack of natural resource improvement, and so on. The identification of rural EJ populations, particularly Native Americans, is not always obvious if an impacted area is not directly on a reservation. Further, Native American communities face environmental exposures that are greater than those faced by other EJ communities because of their greater contact with the environment that occurs during traditional practices and resource uses.

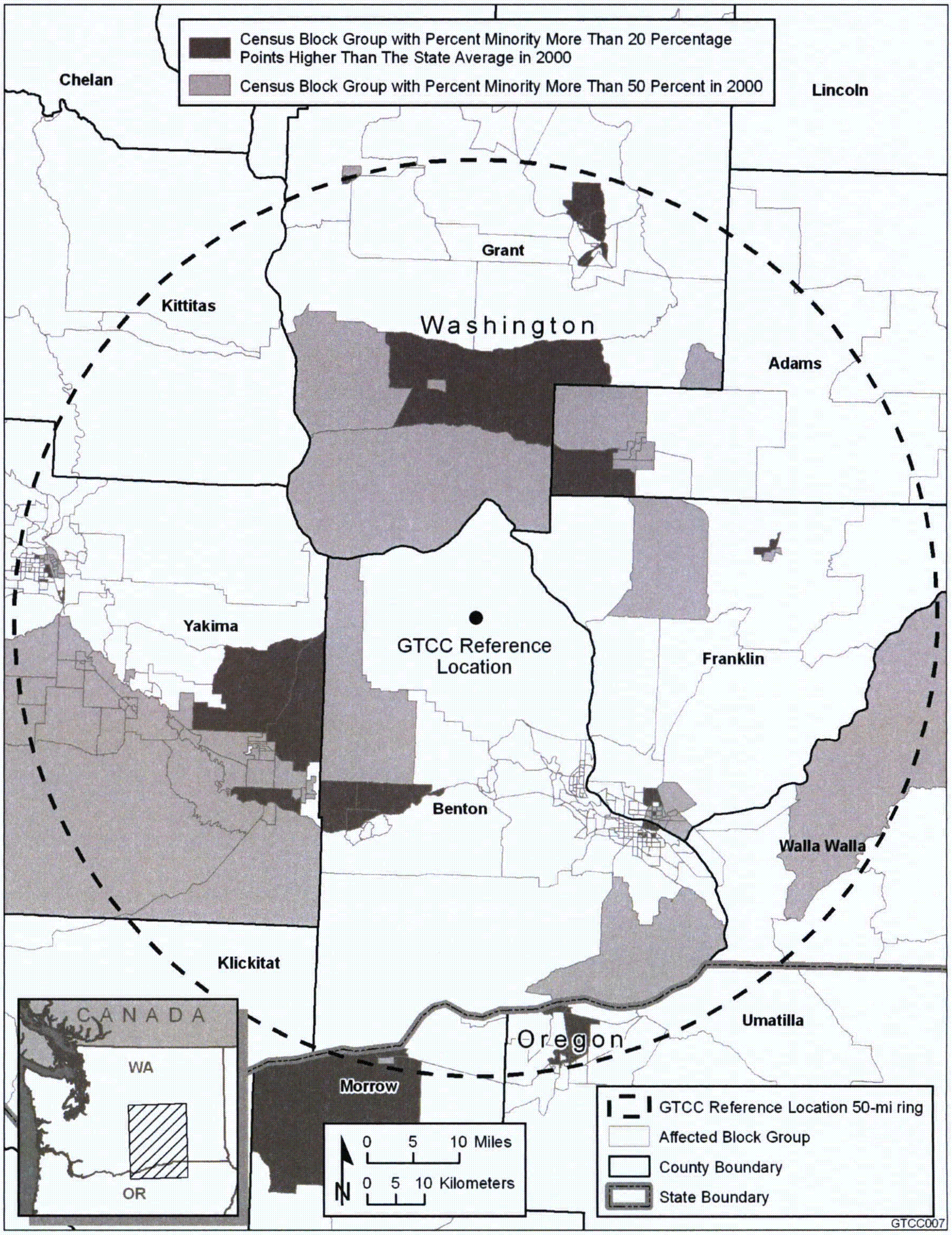

FIGURE 6.1.7-1 Minority Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at the Hanford Site (Source: U.S. Bureau of the Census 2008b)

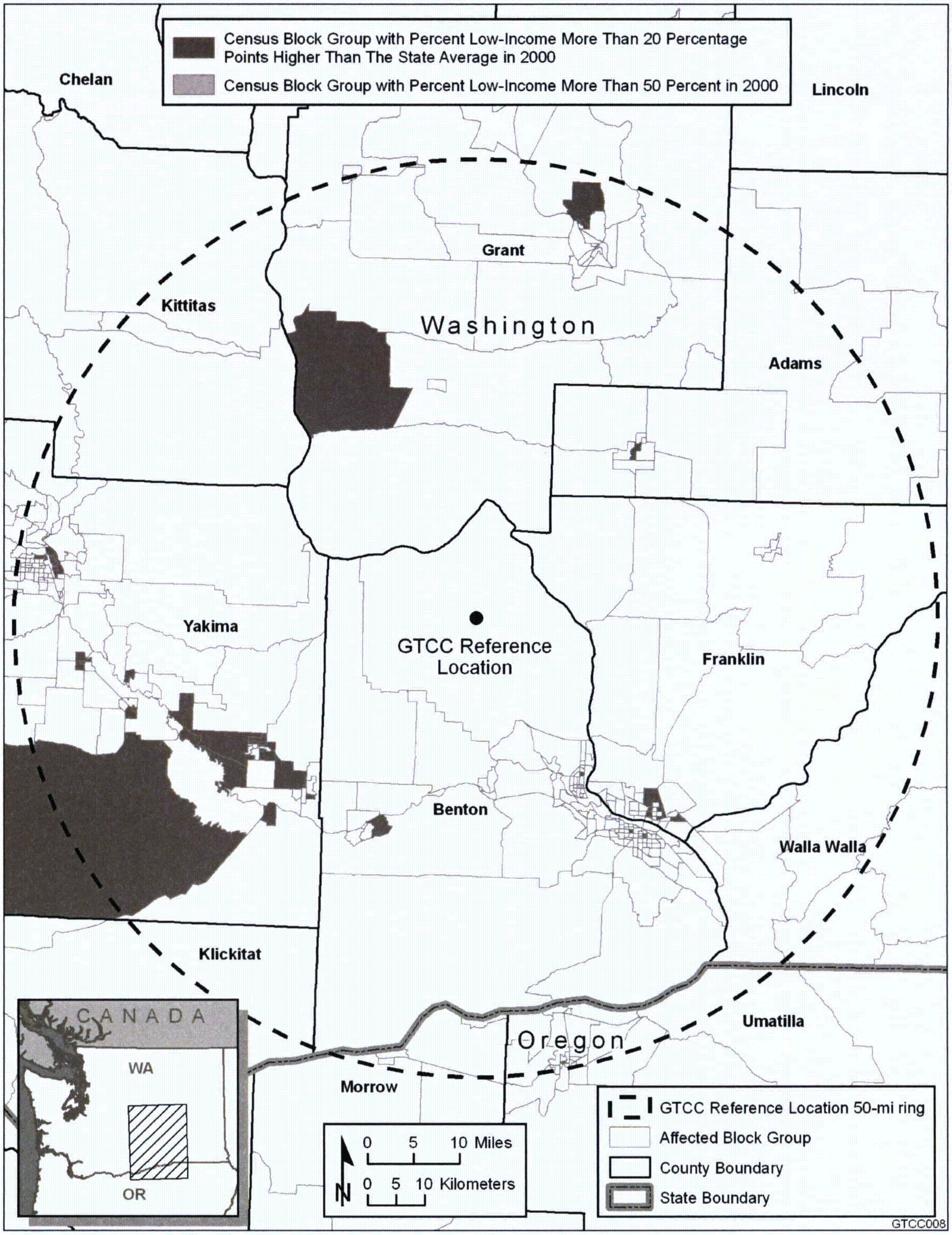

FIGURE 6.1.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at the Hanford Site (Source: U.S. Bureau of the Census 2008b)

TABLE 6.1.7-1 Minority and Low-Income Populations within an 80-km (50-mi) Radius of the Hanford Site

Population	Oregon Block Groups	Washington Block Groups
Total population	39,201	476,177
White, non-Hispanic	27,968	299,103
Hispanic or Latino	9,482	148,117
Non-Hispanic or Latino minorities	1,751	28,957
One race	1,241	20,971
Black or African American	427	4,724
American Indian or Alaskan Native	397	9,171
Asian	332	6,268
Native Hawaiian or other Pacific Islander	33	294
Some other race	52	514
Two or more races	510	7,986
Total minority	11,233	177,074
Percent minority	28.7%	37.2%
Low-income	4,790	79,088
Percent low-income	12.2%	16.6%
State percent minority	13.4%	18.2%
State percent low-income	11.6%	10.6%

Source: U.S. Bureau of the Census (2008b)

6.1.8 Land Use

The 151,775-ha (375,040-ac) Hanford Site was established in 1943 as a defense materials production site that included nuclear reactor operations, uranium and plutonium processing, storage and processing of SNF, and management of radioactive and hazardous wastes. To support its mission, nine plutonium production reactors were constructed on the site. People who had been residing on the site were relocated, and the existing farmsteads and villages were abandoned. The reactors operated through the 1960s; most of them were phased out by 1969. By 1970, only the N Reactor was operational. It stopped producing plutonium in 1988 (Fitzner and Gray 1991).

Since its incorporation into the Hanford Site, the land has been protected from livestock grazing, agricultural encroachment, and recreational off-highway use (Vaughan and Rickard 1977). In 1967, a 26,000-ha (64,000-ac) area of Hanford (the Arid Land Ecology Reserve in the southwestern section of the Hanford Site) was designated as an environmental research area. In 1977, the entire Hanford Site was designated as a NERP. In 1978, the Hanford Reach of the Columbia River was re-opened for public access after a period of 25 years of restricted access. Public access west of the river is still restricted. However, wildlife research by Hanford Site contractors and university personnel is encouraged within this area (Fitzner and Gray 1991).

American Indian Text

The Indian People recommend that DOE continue efforts to identify special places and landscapes with spiritual significance. Newly identified sites would be added to those already requiring American Indian ceremonial access and needing long-term stewardship.

The Tribes maintain that aboriginal and treaty rights allow for the protection, access to, and use of resources. These rights were established at the origin of the Native People and persist forever. There are sites or locations within the existing Hanford reservation boundary with tribal significance that are presently restricted through DOE's institutional controls and should be considered for special protections or set aside for traditional and contemporary ceremonial uses. Sites like the White Bluffs, Gable Mountain, Rattlesnake Mountain, Gable Butte, and the islands on the river are known to have special meaning to Tribes and should be part of the discussion for special access and protection. These locations should be placed in co-management with DOE, FWS and the Tribes for long-term management and protection.

American Indian Text

The Native people will continue to work with DOE via its cooperative agreement on cleanup issues to ensure that treaty rights and cultural and natural resources are being protected and that interim cleanup decisions are protective of human health and the environment.

Land use categories at Hanford include preservation, conservation, recreation, industrial, and R&D (DOE 2009). Only about 6% of the site has been disturbed for DOE facilities, which are widely dispersed throughout the site (DOE 2009). Much of the site is undeveloped, providing a safety and security buffer for the smaller areas used for site operations. Programs currently conducted at the Hanford Site include management of radioactive wastes; cleanup of waste sites, soils, and groundwater related to past releases; stabilization and storage of SNF; renewable energy technologies; waste disposal technologies; contamination cleanup; and plutonium stabilization and storage. The GTCC reference location would be situated within an industrial (exclusive) area that borders the extensive conservation (mining) land use area.

The 200 Areas cover about 5,100 ha (12,600 ac) within the Central Plateau portion of the Hanford Site. The 200 East and West Area facilities were built to process irradiated fuel from production reactors. Subsequent liquid wastes that were produced as a result of fuel processing were placed in tanks or disposed of in cribs, ponds, or ditches in the 200 Area. Treatment, storage, and disposal of solid wastes are conducted near the 200 Area. Unplanned releases of radioactive and nonradioactive waste have contaminated some portions of the 200 Area. The U.S. Navy also uses Hanford nuclear waste treatment, storage, and disposal facilities. DOE constructed the Environmental Restoration Disposal Facility (ERDF) next to the southeast corner of the 200 West Area to provide disposal capacity for environmental remediation waste (e.g., LLRW, mixed LLRW, and dangerous wastes) generated during remediation of the 100, 200, and 300 Areas of the Hanford Site. A commercial LLRW disposal facility operated by American Ecology currently occupies about 40 ha (100 ac) of the 200 Area Plateau. This facility, located just west of the GTCC reference location, is located on lands leased by the State of Washington from the federal government and subleased to US Ecology, Inc. Descriptions of the activities that occur in the other operational areas and other developed areas of the Hanford Site can be found in DOE (2009).

Most of the Hanford Site is administered by DOE for waste management, environmental restoration, and R&D. Some portions are administered by other agencies. In 2000, the President issued a proclamation establishing the 78,900-ha (195,000-ac) Hanford Reach National Monument that surrounds the central portion of the Hanford Site (The Nature Conservancy 2003b). The Monument includes land adjacent to the Columbia River and other areas on the Hanford Site that encompass the Saddle Mountain National Wildlife Refuge and the Fitzner-Eberhardt Arid Lands Ecology Reserve. The USFWS manages most of the lands within the Monument under existing agreements with DOE. Those lands within the Monument not subject to existing agreements are managed by DOE; however, DOE must consult with the Secretary of the Interior when developing any management plans that could affect these lands.

Land use within the vicinity of the Hanford Site includes urban and industrial development, wildlife protection areas, recreation, irrigated and dry land farming, and livestock grazing. These land use practices are not expected to change drastically during the upcoming decades. An LLRW decontamination, supercompaction, plasma gasification, macro-encapsulation, and vitrification unit (operated by Permafix) and a commercial nuclear fuel fabrication facility (operated by AREVA) adjoin the Hanford Site.

American Indian Text

The National Monument encompasses a biologically diverse landscape containing an irreplaceable natural and historic legacy. Limited development over approximately 70 years has allowed for the Monument to become a haven for important and increasingly scarce plants and animals of scientific, historic and cultural interest. It supports a broad array of newly discovered or increasingly uncommon native plants and animals. Migrating salmon, birds and hundreds of other native plant and animal species, some found nowhere else in the world, rely on its natural ecosystems. The Monument also includes 46.5 miles of the last free-flowing, non-tidal stretch of the Columbia River, known as the "Hanford Reach."

American Indian Text

The present DOE land use document for Hanford, called the Comprehensive Land Use Plan (CLUP), has institutional controls that limit present and future use by Native Americans. DOE plans to remove some institutional controls over time as the contamination footprint is reduced as a result of instituting the 2015 vision along the river and also the proposed cleanup of the 200 area. With removal of institutional controls, the affected tribes assume they can resume access to usual and accustomed areas. Future decisions about land transfer must consider the implications for Usual and Accustomed uses (aboriginal and treaty reserved rights) in the long-term management of resource areas. The 50-year management time horizon of the CLUP does create permanent land use designations. On the contrary, land use designations or their boundaries can be changed in the interim at the discretion of DOE and/or Hanford stakeholders. The CLUP is often misused by assuming designations are permanent. Also, it is important to note that the interim land use designations in the CLUP cannot abrogate treaty rights. That requires an act of Congress.

American Indian Text

There are several federal regulations, policies, and executive orders that define tribal access that override institutional controls of the Comprehensive Land Use Plan (CLUP) or the Comprehensive Conservation Plan (CCP) when risk levels are acceptable for access. The following is a brief summary of those legal references:

- According to the American Indian Religious Freedom Act, tribal members have a protected right to conduct religious ceremonies at locations on public lands where they are known to have occurred before. There has been an incomplete effort to research the full extent of tribal ceremonial use of the Hanford site.
- Executive Order 13007 supports the American Religions Freedom Act by stating that Tribal members have the right to access ceremonial sites. This includes agencies to maintain existing trails or roads that provide access to the sites.
- DOE managers that are considering the placement of GTCC waste at Hanford must evaluate any potential impact to ceremonial access as part of their trust responsibility to Tribes.

There are locations that have specific protections due to culturally significant findings, burial sites, artifact clusters, etc. These types of areas are further described under the Cultural Resources Sections. As decommissioning and reclamation occurs across the Hanford site, any culturally significant findings will continue to expand the list of sites and their locations with special protections that override existing land use designation as outlined in the CLUP or other documents.

6.1.9 Transportation

The Tri-Cities (Kennewick, Pasco, and Richland) serve as a regional transportation and distribution center with major air, land, and river connections. Interstate highways that serve the area are I-82 and I-182. I-82 is 8 km (5 mi) south-southwest of the Hanford Site. I-182, an urban connector route that is 24-km (15-mi) long and located 8 km (5 mi) south-southeast of the site, provides an east-west corridor linking I-82 to the Tri-Cities area. I-90, located north of the site, is the major link to Seattle and Spokane and extends to the East Coast. I-82 serves as a primary link between Hanford and I-90, as well as I-84. I-84, located south of the Hanford Site in Oregon, is a major corridor leading to Portland, Oregon. SR 224, also south of the site, serves as a 16-km (10-mi) link between I-82 and SR 240. SR 24 enters the site from the west, continues eastward across the northernmost portion of the site, and intersects SR 17 approximately 24 km (15 mi) east of the site boundary. SR 17 is a north-south route that links I-90 to the Tri-Cities and joins US 395, continuing south through the Tri-Cities. Northern US 395 also provides direct access to I-90. SR 240 and 24 traverse the Hanford Site and are maintained by the state.

Access to the Hanford Site is via three main routes: Hanford Route 4S from Stevens Drive or George Washington Way in the City of Richland, Route 10 from SR 240 near its intersection with SR 225, or Route 11A from SR 240. Another route, through the Rattlesnake Barricade, is located 35 km (22 mi) northwest of Stevens Drive and is accessible only to passenger vehicles. The estimated total number of commuters to this area is 3,100. Approximately 87% of the workers commuting to the 200 Areas are from the Tri-Cities, West Richland, Benton City, and Prosser. Table 6.1.9-1 summarizes traffic counts in the vicinity of the Hanford Site.

A DOE-maintained road network within the Hanford Site consists of 607 km (377 mi) of asphalt-paved road and provides access to the various work centers. Primary access roads on the Hanford Site are Routes 1, 2, 3, 4, 6, 10, and 11A. The 200 East Area is accessed primarily by Route 4 South from the east, by Route 4 North off Route 11A from the north, and by

TABLE 6.1.9-1 Traffic Counts in the Vicinity of the Hanford Site

Location	Average Daily Traffic Volume
I-182, vicinity of SR 240	35,000
SR 240, between Columbia Center Blvd. and I-182	54,000
Stevens Drive	
At Horn Rapids Road	8,300
North of SR 240	22,000
George Washington Way	
At Hanford Site entrance	1,800
North of McMurray	18,000
Just north of I-182	43,000

American Indian Text

Native people have been traveling this homeland to usual and accustomed areas for a very long time. Early modes of transportation began with foot travel. Domesticated dogs were utilized to carry burdens. Dugout canoes were manufactured and used to traverse the waterways when the waters were amiable. Otherwise, trails along the waterways were used. The arrival of the horse changed how people traveled. Numerous historians note its arrival to the Columbia Plateau in the late 1700's but they are mistaken. The arrival of the horse was actually a full century earlier in the late 1600's. Its acquisition merely quickened movement on an already extant and heavily used travel network. This travel network was utilized by many tribal groups on the Columbia Plateau and was paved by thousands of years of foot travel. Early explorers and surveyors utilized and referenced this extensive trail network. Some of the trails have become major highways and the Columbia and Snake Rivers are still a crucial part of the modern transportation network.

The Middle Columbia Plateau of the Hanford area is the crossroads of the Columbia Plateau located half way between the Great Plains and the Pacific Northwest Coast. In this area, major Columbia River tributaries (the Walla Walla, Snake, and Yakima Rivers) flow into this section of the main stem Columbia River. These rivers formed a critical part of a complex transportation network north, south, east, and west through the region including the Columbia River through the Hanford site. The slow water at the Wallula Gap was one of the few places where horses could traverse the river year round. The river crossing at Wallula provided access to a vast web of trails that crossed the region. Portions of these trails are known to cross the Hanford site.

Present Transportation:

There are two interstate highways that near the site [Interstate 90 (I-90) and Interstate 84 (I-84)]. Interstate 84 was part of the ancient trail system, at one time called the Oregon Trail, and is a primary transportation corridor for nuclear waste that enters the State of Oregon at Ontario, Oregon. I-84 and a Union Pacific rail line also cross the Umatilla Indian Reservation, including some steep and hazardous grades that are notorious nationally for fog and freezing fog, freezing rain and snow.

GTCC waste would need to be delivered to Hanford by rail, barge or highway. The Native people believe that decision-making criteria need to be presented in the EIS to clarify how rail, barge or highway routing will be determined. Treaty resources and environmental protections are important criteria in determining a preferred repository location. The public needs to be assured that the public health and high valued resources like salmon and watersheds are going to be protected. Northwest river systems have received significant federal and state resources over recent decades in an attempt to recover salmon and rehabilitate damaged watersheds. DOE needs to describe how public safety, salmon and watersheds "fit" into the criteria selection process for determining a GTCC waste site and multiple shipping options. The protection and enhancement of existing river systems are critical to sustaining tribal cultures along the Columbia River. The interstate highway system is a primary transportation corridor for shipping nuclear waste through the states of Oregon, Washington, and Idaho. Waste moving across these states will cross many major salmon bearing rivers that are important to the Tribes. Major rail lines also cross multiple treaty resource areas.

Route 11A for vehicles entering the site at the Yakima Barricade. A new access road was opened in late 1994 to provide access directly to the 200 Areas from SR 240. Public access to the 200 Areas and interior locations of the Hanford Site has been restricted by guarded gates at the Wye Barricade (at the intersection of Routes 10 and 4), the Yakima Barricade (at the intersection of SR 240 and Route 11A), and Rattlesnake Barricade south of the 200 West Area.

The Hanford Site rail system originally consisted of approximately 210 km (130 mi) of track. It connected to the Union Pacific commercial track at the Richland Junction (at Columbia Center in Kennewick) and to a now-abandoned commercial ROW (Chicago, Milwaukee, St. Paul, and Pacific Railroad) near Vernita Bridge in the northwest section of the site. Prior to 1990, annual railcar movements numbered about 1,400 sitewide, and they transported materials such as coal, fuel, hazardous process chemicals, and radioactive materials and equipment. In October 1998, 26 km (16 mi) of track from Columbia Center to Horn Rapids Road were transferred to the Port of Benton and are currently operated by the Tri-City & Olympia Railroad.

6.1.10 Cultural Resources

The Hanford Site is located in central Washington and is bordered on the north and east by the Columbia River. The Hanford Site is located in an arid shrub-steppe climate. The area is rich in cultural material and has been used extensively both in the prehistoric and historic periods. The earliest evidence for human activity at the site dates from roughly 8,000 years ago. Most activity was concentrated near the Columbia River and its tributaries; the surrounding areas were used primarily for hunting. Historic use of the area began in 1805 when the Lewis and Clark expedition traveled through the area on the Columbia River. More permanent settlement began in the 1860s when a ferry was established on the Columbia River. Towns that developed along the river include Hanford, White Bluffs, Ringold, Wahluke, and Richland. The locations of the towns of Hanford and White Bluffs were chosen in 1943 by officials in the Manhattan Engineer District (Manhattan Project) for the location of a plutonium production plant. The site was chosen because of its remoteness from population centers and its proximity to railroads and clean water. Plutonium created at the Hanford Site was used in the Trinity Test and in the bomb that was detonated over Nagasaki, Japan. The Hanford Site's role in nuclear research expanded throughout the Cold War (1946–1989).

Cultural resources at the Hanford Site are managed through the DOE-Richland Operations Office (RL) PNNL Hanford Cultural Resources Management Program with support from the various Hanford Site contractors. Evidence from both the prehistoric and historic periods has been found at the Hanford Site (Kennedy et al. 2007); 1,550 cultural resources sites and isolated finds and 531 buildings and structures have been documented (Duncan et al. 2007). DOE-RL, the SHPO, and the ACHP have entered into a programmatic agreement (PA) to help guide the management of Cold War historic structures at the site.

The DOE Cultural Resources Management Program at the Hanford Site actively engages and consults with members of area Native American Indian Tribal Governments, including the Yakama Nation, Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Nez Perce Tribe, and Wanapum, concerning activities that may affect important cultural, religious, and historic resources. Tribal representatives participate in field activities as well as attend numerous project meetings to provide input into project planning.

The 200 Area at the Hanford Site was created during the Manhattan Project in 1943. The location was the site of the first chemical separations plant. Chemical separation was the third step in the process of creating plutonium for use in weapons. The first step was creating the fuel rods for use in a reactor. The second step was installing the fuel rods in a reactor. Once the fuel rods were removed from the reactor, they were taken to the 200 Area, where the plutonium was removed through chemical separation. The 200 Area once contained more than 500 buildings. It has been heavily disturbed by historic era activity. Numerous archaeological surveys indicate that the 200 Area was used sporadically. During the historic period, a trail that would later become White Bluffs Road crossed the 200 Area. Findings indicate that historic activity has concentrated along White Bluffs Road. White Bluffs Road is located only in the 200 West Area. No features associated with the road appear in the 200 East Area. Most post-1943 cultural resources found in the 200 Area relate to the atmospheric dispersion grid that monitored contaminant dispersion from Hanford Site facilities. The grid is located between the 200 East and West Area sites.

Archaeological surveys of the 200 East Area have recovered only isolated artifacts and not sites (Kennedy et al. 2007). No farming or ranching is reported for the 200 East Area. The only historically significant structures in the 200 East Area relate to Manhattan Project era activities. The Hanford Site Plant Railroad historic property is within the viewshed of the 200 East Area. The 200 Area is within the Gable Mountain and Gable Butte Cultural District, which is associated with American Indian traditional hunting and religious activities.

American Indian Text

From a tribal perspective, all things of the natural environment are recognized as a cultural resource. This is a different perspective from those who think of cultural resources as artifacts or historic structures. The natural environment provides resources for a subsistence lifestyle for tribal people. This daily connection to the land is crucial to Tribal culture and has been throughout time. All elements of nature therefore are the connection to tribal religious beliefs. Oral histories confirm this cultural and religious connection.

American Indian Text

According to our religion, everything is based on nature. Anything that grows or lives, like plants and animals, is part of our religion. Horace Axtell (Nez Perce Tribal Elder)

The area you are talking about with this GTCC disposal is in a very important place which we think of as the center of our lives. Rattlesnake Mountain is one point, Saddle Mountain is another point, and Hog Butte (a part of Umtanum Ridge) is another point and together they outline this area. Each of these mountains is connected with the others and both these mountains and the ceremonies conducted on them are interrelated. A song from Rattlesnake Mountain can go to Saddle Mountain, then to Hog Butte and if it comes back to you that is special. When you holler from one mountain to another and if it came back changed, it would be interpreted then it would be used to guide life.

This area had a wheel – a calendar which guided us in our movements and activities. The wheel had spokes which we duplicated at our villages. At each village we placed a white stone in the ground and atop this we stood a high post. The post would cast a shadow which was read. When it reached a certain angle, like the spoke in the wheel, we would respond. The wheel was a reference point that held our time schedules. Gable Mountain is a central area which is also a point of reference for many of our ceremonies. Into this area comes the wind. It blows the sand which transforms spirits. Some of these we call horses which were both real and not real. They lived along the big river. The wind and some of the spirits were guided (controlled) by stick people, which live between the river and Rattlesnake Mountain. Across the river is what you call White Bluffs. This is a part of our physical origin. Many of the reference points you see on the ground are organized like the stars – they are related in important ways that are described in our detailed songs and stories. So you see, this area is so important to us. We cannot tell you all the stories – just enough so you understand the importance of this place to us and why we are so concerned to repair it and have it returned to us as the Creator intended. (Wanapum People)

American Indian Text

At Hanford there are three overlapping cultural landscapes that overlie the natural landscape. These are not displacements of a previous landscape by a new landscape, but a coexistence of all three simultaneously even if one landscape is more visible in a particular area. The first represents the American Indians, who have created a rich archeological and ethnographic record spanning more than 10,000 years. This is the only stretch of the Columbia River that is still free-flowing, and one of the few areas in the Mid-Columbia Valley without modern agricultural development. As a result, this is one of the few places where native villages and campsites can still be found. Still today, local American Indian tribes revere the area for its spiritual and cultural importance, as they continue the traditions practiced by their ancestors. The second landscape was created by early settlers, and the third by the Manhattan Project. Today, DOE is removing much of the visible portion of the Manhattan landscape, returning the surface of the site to a more natural state (restoration and conservation) and thus revealing the cultural landscape that remains underneath.

For thousands of years American Indians have utilized the lands in and around the Hanford Site. Historically, groups such as the Yakama, the Walla Walla, the Wanapum, the Palouse, the Nez Perce, the Columbia, and others had ties to the Hanford area. "The Hanford Reach and the greater Hanford Site, a geographic center for regional American Indian religious activities, is central to the practice of the Indian religion of the region and many believe the Creator made the first people here. Indian religious leaders such as Smoholla, a prophet of Priest Rapids who brought the Washani religion to the Wanapum and others during the late 19th century, began their teachings here. Prominent landforms such as Rattlesnake Mountain, Gable Mountain, and Gable Butte, as well as various sites along and including the Columbia River, remain sacred. American Indian traditional cultural places within the Hanford Site include, but are not limited to, a wide variety of places and landscapes: archaeological sites, cemeteries, trails and pathways, campsites and villages, fisheries, hunting grounds, plant gathering areas, holy lands, landmarks, important places in Indian history and culture, places of persistence and resistance, and landscapes of the heart. Because affected tribal members consider these places sacred, many traditional cultural sites remain unidentified."

American Indian Text

Salmon remain a core part of the oral traditions of the tribes of the Columbia Plateau and still maintains a presence in native peoples' diet just as it has for generations. Salmon are recognized as the first food at tribal ceremonies and feasts. One example is the ke'uyit, which translates to "first bite." It is a ceremonial feast that is held in spring to recognize the foods that return to take care of the people. It is a long-standing tradition among the people and it is immersed in prayer songs and dancing. Salmon is the first food that is eaten by the attendants. Extending gratitude to the foods for sustaining the life of the people is among the tenets of plateau lifestyle. Nez Perce life is perceived as being intertwined with the life of the Salmon. A parallel can be seen between the dwindling numbers of the Salmon runs and the struggle of native people.

American Indian Text

Viewsheds tend to be panoramic and are made special when they contain prominent topography. Viewscapes are tied with songscapes and storyscapes, especially when the vantage point has a panorama composed of multiple locations from either song or story. Viewscapes are critical to the performance of some Indian ceremonies. The Native people utilize vantage points to maintain a spiritual connection to the land. Viewsheds must remain in their natural state; they tend to be panoramic and are made special when they contain prominent uncontaminated topography. The viewshed panorama is further enhanced by abrupt changes in topography and or habitats. Nighttime viewsheds are also significant to indigenous people who still use the Hanford Reach. Each tribe has stories about the night sky and why stars lie in their respective places. The patterns convey spiritual lessons via oral traditions. Often, light pollution from neighboring developments diminishes the view of the constellations. It is getting difficult to find places to simultaneously relate the oral traditions and view the corresponding constellations. There are several culturally significant viewsheds located on the Hanford site. The continued use of these sites brings spiritual renewal. Special considerations should be given to tribal elders and youth to accommodate traditional ceremonies. Interruption of the vista by large facilities or bright lights impairs the cultural services associated with the viewshed.

American Indian Text

"Subsistence" in the narrow sense refers to the hunting, fishing, and gathering activities that are fundamental to the way of life and health of many indigenous peoples. The more concrete aspects of a subsistence lifestyle are important to understanding the degree of environmental contact and how subsistence is performed in contemporary times. Also, traditional knowledge can be learned directly from nature. Through observation this knowledge is recognized and a spiritual connection is often attained as a result. Subsistence utilizes traditional and modern technologies for harvesting and preserving foods as well as for distributing the produce through communal networks of sharing and bartering. The following is a useful explanation of "subsistence," slightly modified from the National Park Service:

> "While non-native people tend to define subsistence in terms of poverty or the minimum amount of food necessary to support life, native people equate subsistence with their culture. It defines who they are as a people. Among many tribes, maintaining a subsistence lifestyle has become the symbol of their survival in the face of mounting political and economic pressures. To Native Americans who continue to depend on natural resources, subsistence is more than eking out a living. The subsistence lifestyle is a communal activity that is the basis of cultural existence and survival. It unifies communities as cohesive functioning units through collective production and distribution of the harvest. Some groups have formalized patterns of sharing, while others do so in more informal ways. Entire families participate, including elders, who assist with less physically demanding tasks. Parents teach the young to hunt, fish, and farm. Food and goods are also distributed through native cultural institutions. Nez Perce young hunters and fisherman are required to distribute their first catch throughout the community at a first feast (first bite) ceremony. It is a ceremony that illustrates the young hunter is now a man and a provider for his community. Subsistence embodies cultural values that recognize both the social obligation to share as well as the special spiritual relationship to the land and resources."

6.1.11 Waste Management

Site management of the waste types generated by the land disposal methods for Alternatives 3 to 5 is discussed in Section 5.3.11.

6.2 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

The potential impacts from the construction, operations, and post-closure of the land disposal methods (borehole, trench, and vault) are presented in this section for the resource areas evaluated. The affected environment for each resource area is described in Section 6.1. The GTCC reference location for Hanford is presented in Figure 6.1-1.

6.2.1 Climate and Air Quality

This section discusses potential climate and air quality impacts from the construction and operations of each of the three disposal methods (borehole, trench, and vault) at the Hanford Site.

6.2.1.1 Construction

During the construction period, emissions of criteria pollutants (e.g., SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$), VOCs, and the primary greenhouse gas CO_2 would be caused by fugitive dust emissions from earth-moving activities and engine exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Typically, the potential impacts from exhaust emissions on ambient air quality would be smaller than those from fugitive dust emissions.

Air emissions of criteria pollutants, VOCs, and CO_2 from construction activities are estimated for the peak year when site preparation and construction of the support facility and some disposal cells would take place. Estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. These estimates are provided in Table 6.2.1-1 for each disposal method. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in Table 6.2.1-1, total peak-year emission rates are estimated to be rather small when compared with the emission total for the four counties encompassing the Hanford Site (Adams, Benton, Franklin, and Grant Counties). Peak-year emissions for all criteria pollutants (except PM_{10} and $PM_{2.5}$) and VOCs would be the highest for the vault facility because constructing it would consume more materials and resources than would constructing the other two facilities. Emissions from building the borehole facility would be almost as high as those from building the vault facility. Construction of the borehole facility would disturb a larger area; thus, fugitive dust emissions from the borehole method are estimated to be highest. Peak-year emissions of all pollutants would be the lowest for the trench method, and this method would disturb the smallest area among the disposal methods. In terms of contribution to the emissions total, peak-year emissions of SO_2 from the vault method would be the highest, about 0.20% of the four-county emissions total, while it is estimated that emissions of other criteria pollutants and VOCs would each be 0.14% or less of the four-county emissions total.

TABLE 6.2.1-1 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction of the Three Land Disposal Facilities at the Hanford Site

		Construction Emissions (tons/yr)					
Pollutant	Total Emissions (tons/yr)[a]	Trench (%)		Borehole (%)		Vault (%)	
SO_2	1,655	0.90	(0.06)[b]	3.0	(0.18)	3.2	(0.20)
NO_x	23,050	8.1	(0.04)	26	(0.11)	31	(0.13)
CO	170,470	3.3	(<0.01)	11	(0.01)	11	(<0.01)
VOCs	25,930	0.90	(<0.01)	2.7	(0.01)	3.6	(0.01)
PM_{10}[c]	47,391	5.0	(0.01)	13	(0.03)	8.6	(0.02)
$PM_{2.5}$[c]	8,662	1.5	(0.02)	4.1	(0.05)	3.6	(0.04)
CO_2		670		2,200		2,300	
County[d]	4.53×10^6		(0.02)		(0.05)		(0.05)
Washington[e]	9.44×10^7		(0.0007)		(0.002)		(0.002)
U.S.[e]	6.54×10^9		(0.00001)		(0.00003)		(0.00004)
Worldwide[e]	3.10×10^{10}		(0.000002)		(0.000007)		(0.000007)

[a] Total emissions in 2002 for all four counties encompassing the Hanford Site (Adams, Benton, Franklin, and Grant Counties). See Table 6.1.1-1 for criteria pollutants and VOCs.

[b] As percent of total emissions.

[c] Estimates for GTCC construction include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

[e] Annual CO_2 emissions in Washington, the United States, and the world in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

Background concentration levels for PM_{10} and annual $PM_{2.5}$ at the Hanford Site are well below the standards (less than 63%), but those for 24-hour $PM_{2.5}$ are about 120% of the standard (see Table 6.1.1-3). All construction activities at the Hanford Site would occur at least 6 km (4 mi) from the site boundary and thus would not contribute much to concentrations at the boundary or at the nearest residence. Construction activities would still be conducted so as to minimize potential impacts of construction-related emissions on ambient air quality. Also, construction permits typically require fugitive dust control by established, standard, dust-control practices, primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles.

Although O_3 levels in the area approach the standard (about 93%) (see Table 6.1.1-3), the four counties encompassing the Hanford Site are currently in attainment for O_3 (40 CFR 81.348). O_3 precursor emissions from the GTCC disposal facility under all methods would be relatively small, less than 0.13% and 0.01% of the four-county total for NO_x and VOC emissions, respectively, and they would be much lower than those for the regional air shed in which emitted precursors are transported and formed into O_3. Accordingly, potential impacts of O_3 precursor releases from construction on regional O_3 would not be of concern.

The major air quality concern with respect to emissions of CO_2 is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. The combustion of fossil fuels makes CO_2 the most widely emitted greenhouse gas worldwide. CO_2 concentrations in the atmosphere have continuously increased, from about 280 ppm in preindustrial times to 379 ppm in 2005, a 35% increase. Most of this increase has occurred in the last 100 years (IPCC 2007).

The climatic impact of CO_2 does not depend on the geographic locations of its sources because CO_2 is stable in the atmosphere and is essentially uniformly mixed; that is, the global total is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the construction of a disposal facility is useful in understanding whether CO_2 emissions from the site are significant with respect to global warming. As shown in Table 6.2.1-1, the highest peak-year amount of CO_2 emission from construction would be under 0.05%, 0.002%, and 0.00004%, respectively, of the 2005 four-county total, state, and U.S. CO_2 emissions (EIA 2008). Potential impacts on climate change from construction emissions would be small.

Appendix D assumes an initial construction period of 3.4 years. The disposal units would be constructed as the waste became available for disposal. The construction phase would extend over more years; thus, emissions for nonpeak years would be lower than peak-year emissions in the table. In addition, construction activities would occur only during daytime hours, when air dispersion is most favorable. Accordingly, potential impacts from construction activities on ambient air quality would be minor and intermittent.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and is not applicable to the proposed action at the Hanford Site because the area is classified as being in attainment for all criteria pollutants (40 CFR 81.348).

6.2.1.2 Operations

Criteria pollutants, VOCs, and CO_2 would be released into the atmosphere during the operational period. These emissions would include fugitive dust emissions from emplacement activities and exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Estimated annual emissions of criteria pollutants, VOCs, and CO_2 at the facility are presented in Table 6.2.1-2. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in Table 6.2.1-2, estimates indicate that annual emissions for the trench and vault methods during operations would be at almost the same levels and higher than emissions during construction; emissions for the borehole method would be lower than for the trench and vault methods and lower during operations than construction. Compared with annual emissions for the counties encompassing the Hanford Site, the annual emissions of SO_2 for the trench and vault methods would be the highest, about 0.20% of the emissions total, while emissions of other criteria pollutants and VOCs would be about 0.01% or less.

TABLE 6.2.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations of the Three Land Disposal Facilities at the Hanford Site

Pollutant	Total Emissions (tons/yr)[a]	Operation Emissions (tons/yr)					
		Trench (%)		Borehole (%)		Vault (%)	
SO_2	1,655	3.3	(0.20)[b]	1.2	(0.07)	3.3	(0.20)
NO_x	23,050	27	(0.12)	10	(0.04)	27	(0.12)
CO	170,470	15	(0.01)	6.7	(<0.01)	15	(0.01)
VOCs	25,930	3.1	(0.01)	1.2	(<0.01)	3.1	(0.01)
PM_{10}[c]	47,391	2.5	(0.01)	0.91	(<0.01)	2.5	(0.01)
$PM_{2.5}$[c]	8,662	2.2	(0.03)	0.81	(0.01)	2.2	(0.03)
CO_2		3,200		1,700		3,300	
County[d]	4.53×10^6		(0.07)		(0.04)		(0.07)
Washington[e]	9.44×10^7		(0.003)		(0.002)		(0.003)
U.S.[e]	6.54×10^9		(0.00005)		(0.00003)		(0.00005)
Worldwide[e]	3.10×10^{10}		(0.00001)		(0.00001)		(0.00001)

[a] Total emissions in 2002 for all four counties encompassing the Hanford Site (Adams, Benton, Franklin, and Grant Counties). See Table 6.1.1-1 for criteria pollutants and VOCs.

[b] As percent of total emissions.

[c] Estimates for GTCC operations include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

[e] Annual CO_2 emissions in Washington, the United States, and the world in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

It is expected that concentration levels from operational activities for PM_{10} and $PM_{2.5}$ (which include diesel particulate emissions) would remain below the standards, except for the 24-hour $PM_{2.5}$ level, which is already above the standard. As discussed in the construction section, established fugitive dust control measures (primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles) would be implemented to minimize potential impacts on ambient air quality.

With regard to regional O_3, precursor emissions of NO_x and VOCs from operations would be comparable to those from construction (about 0.12% and 0.01% of the four-county emission totals, respectively) and are not anticipated to contribute much to regional O_3 levels. The highest CO_2 emissions among the disposal methods would be comparable to the highest construction-related emissions; thus, their potential impacts on climate change would also be negligible. PSD regulations are not applicable to the proposed action because the proposed action is not a major stationary source.

6.2.2 Geology and Soils

Direct impacts from land disturbance would be proportional to the total area of land disturbed during site preparation activities (e.g., grading and backfilling) and construction of the GTCC waste disposal facility and related infrastructure (e.g., roads). Land disturbance would include the surface area covered for each disposal method and the vertical displacement of geologic materials for the trench and borehole methods. An increased potential for soil erosion would be an indirect impact from land disturbance at the construction site. Indirect impacts would also result from the use of geologic materials (e.g., aggregate) for facility construction. The impact analysis also considers whether the proposed action would preclude the future extraction and use of mineral materials or energy resources.

6.2.2.1 Construction

Impacts from disturbing the land surface area would be a function of the disposal method implemented at the site (Table 5.1-1). Of the three disposal facilities, the borehole facility would have the greatest impact in terms of land area disturbed. It also would result in the greatest disturbance with depth, with boreholes being completed in unconsolidated clay, silt, sand, and gravel (Hanford Formation).

Geologic and soil material requirements are listed in Table 5.3.2-1. Of the three disposal methods, the vault method would require the most material since it would involve the installation of interim and final cover systems. This material would be considered permanently lost. However, none of the three disposal methods are expected to result in adverse impacts on geologic and soil resources at the Hanford Site, since these resources are in abundant supply at the site and in the surrounding area. However, follow-on evaluations would have to be done so that potential impacts on any new borrow area that would be used as the source for the soil required to build the proposed GTCC waste disposal facility would be considered.

No significant changes in surface topography or natural drainages are anticipated in the construction area. However, the disturbance of soil during the construction phase would increase the potential for erosion in the immediate vicinity. This potential would be greatly reduced, however, by the low precipitation rates at the Hanford Site. Also, mitigation measures would be implemented to avoid or minimize the risk of erosion.

The GTCC waste disposal facility would be sited and designed with safeguards to avoid or minimize the risks associated with seismic and volcanic hazards. The Hanford Site is in a seismically active region, and earthquake swarms of low magnitude occur frequently on and around the site. The annual probability of a volcanic event (basaltic eruption) is considered to be negligible, since there has been no such volcanic activity in the last 6 million years. Volcanic hazard studies that account for volcanism in the Cascade Range estimate that there would be design ashfall loads at the site. The potential for other hazards (e.g., subsidence and liquefaction) is considered to be low.

6.2.2.2 Operations

The disturbance of soil and the increased potential for soil erosion would continue throughout the operational phase as waste was delivered to the site for disposal over time. The potential for soil erosion would be greatly reduced, however, by the low precipitation rates at the Hanford Site. Mitigation measures would also be implemented to avoid or minimize the risk of erosion.

Impacts related to the extraction and use of valuable geologic materials are expected to be low, since only the area within the facility itself would be unavailable for mining, and the potential for energy development at the site is considered to be low. Activities on-site would not have adverse impacts on the extraction of economic minerals in the surrounding region.

6.2.3 Water Resources

Direct and indirect impacts on water resources could occur as a result of water use at the proposed GTCC waste disposal facility during construction and operations. Table 5.3.3-1 provides an estimate of the water consumption and discharge volumes for the three land disposal methods; Tables 5.3.3-2 and 5.3.3-3 summarize the impacts on water resources (in terms of change in annual water use) from construction and normal operations, respectively. A discussion of potential impacts during each project phase is presented in the following sections. In addition, contamination due to potential leaching of radionuclides from the waste inventory into groundwater could occur, depending on the post-closure performance of the land disposal facilities discussed in Section 6.2.4.2

6.2.3.1 Construction

Of the three land disposal facilities considered for the Hanford Site, construction of a vault facility would have the highest water requirement (Table 5.3.3-1). Water demands for construction at the Hanford Site would be met by using surface water from the Columbia River and the 100-B Area Export Water System. No groundwater would be used at the site during construction. As a result, no direct impacts on groundwater resources are expected. The potential for indirect surface water impacts related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures. The GTCC reference location is not within the floodplain for the probable maximum flood along the Columbia River.

As of 1998, the water capacity at Hanford's 200 East Area was about 2.6 billion L/yr (696 million gal/yr). This water is obtained from the Columbia River, which has an average flow rate of about 197 million L/min (52 million gpm). Construction of the proposed GTCC waste disposal facility would increase the annual water use at the 200 East Area (as reported in 1998) by a maximum of about 0.4% (vault method) over the 20-year period that construction would occur. This increase would have a negligible effect on the flow and stage (water elevation) of the river (with a decrease in flow of about 3×10^{-6} percent).

Construction activities could potentially change the infiltration rate at the site of the proposed GTCC waste disposal facility, first by increasing the rate as ground would be disturbed in the initial stages of construction and later by decreasing the rate as impermeable materials (e.g., the clay material and geotextile membrane assumed for the cover or cap for the land disposal facility designs) would cover the surface. These changes are expected to be negligible since the area of land associated with the proposed GTCC waste disposal facility (up to 44 ha [110 ac], depending on the disposal method) would be small relative to the Hanford Site. Disposal of waste (including sanitary waste) generated during construction of land disposal facilities would have a negligible impact on the quality of water resources at the Hanford Site (see Sections 5.3.11 and 6.3.11). The potential for indirect impacts on surface water or groundwater related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

6.2.3.2 Operations

Of the three land disposal methods considered for the Hanford Site, operating a trench facility would have the highest water requirement (Table 5.3.3-1). Water demands for operations at the Hanford Site would be met by using surface water from the Columbia River and the 100-B Area Export Water System. No groundwater would be used at the site during operations. As a result, no direct impacts on groundwater resources are expected. The potential for indirect impacts on surface water related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures.

Operations of the proposed GTCC waste disposal facility would increase annual water use at the Hanford Site by a maximum of about 0.65% (vault method). For the constant rate of use, an additional withdrawal of 10.2 L/min (2.7 gpm) would be required. This increase would have a negligible effect on the flow and stage (water elevation) of the river (with a decrease in flow of about 5×10^{-6} percent).

Disposal of waste (including sanitary waste) generated during operations of land disposal facilities would have a negligible impact on the quality of water resources at the Hanford Site (see Sections 5.3.11 and 6.3.11). The potential for indirect impacts on surface water or groundwater related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

6.2.4 Human Health

Potential impacts on members of the general public and on involved workers from the construction and operations of the waste disposal facilities are expected to be comparable for all of the sites evaluated in this EIS for the land disposal methods, and these impacts are described in Section 5.3.4. The following sections discuss the impacts from hypothetical facility accidents associated with waste handling activities and the impacts during the long-term post-closure phase. They address impacts on members of the general public who might be affected by these waste disposal activities at the Hanford Site GTCC reference location, since these impacts would be site dependent.

6.2.4.1 Facility Accidents

Data on the estimated human health impacts from hypothetical accidents at a GTCC waste disposal facility located on the Hanford Site are provided in Table 6.2.4-1. The accident scenarios are discussed in Section 5.3.4.2.1 and Appendix C. A reasonable range of accidents that included operational events and natural causes was analyzed. The impacts presented for each accident scenario are for the sector with the highest impacts, and no protective measures are assumed; therefore, they represent the maximum impacts expected from such an accident.

The collective population dose includes exposure from inhalation of airborne radioactive material, external exposure from radioactive material deposited on the ground, and ingestion of contaminated crops. The exposure period is assumed to last for 1 year immediately following the accidental release. It is recognized that interdiction of food crops would likely occur if a significant release occurred, but many stakeholders are interested in what could happen if there was no interdiction. For the accidents involving CH waste (Accidents 1–9, 11, 12), the ingestion dose would account for approximately 20% of the collective population dose shown in Table 6.2.4-1. External exposure would be negligible in all cases. All exposures would be dominated by the inhalation dose from the passing plume of airborne radioactive material downwind from the hypothetical accident immediately following release.

The highest estimated impact on the general public, 95 person-rem, would result from a release from an SWB caused by a fire in the Waste Handling Building (Accident 9). Such a dose is not expected to lead to any additional LCFs in the population. This dose would be to the 144,000 people living southeast of the facility, resulting in an average dose of approximately 0.0007 rem per person. Because this dose would be from internal intake (primarily inhalation, with some ingestion) and because the DCFs used in this analysis are for a 50-year CEDE, this dose would be accumulated over the course of 50 years.

The dose to an individual (expected to be a noninvolved worker because there would be no public access within 100 m [300 ft] of the GTCC reference location) includes exposure from the inhalation of airborne radioactive material and 2 hours of exposure to radioactive material deposited on the ground. As shown in Table 6.2.4-1, the highest estimated dose to an individual, 16 rem, would be for Accident 9 from inhalation exposure immediately after the postulated release. This estimated dose is for a hypothetical individual located 100 m (330 ft) to the north-northwest of the accident location. As discussed above, the estimated dose of 16 rem would be accumulated over a 50-year period after intake and would not result in acute radiation syndrome. A maximum annual dose of about 5% of the total individual dose to the noninvolved worker would occur in the first year. The increased lifetime probability of a fatal cancer for this individual would be approximately 1% on the basis of a total dose of 16 rem.

TABLE 6.2.4-1 Estimated Radiological Human Health Impacts from Hypothetical Facility Accidents at the Hanford Site[a]

		Off-Site Public		Individual[b]	
Accident No.	Accident Scenario	Collective Dose (person-rem)	Latent Cancer Fatalities[c]	Dose (rem)	Likelihood of LCF[c]
1	Single drum drops, lid failure in Waste Handing Building	0.0021	<0.0001	0.00035	<0.0001
2	Single SWB drops, lid failure in Waste Handing Building	0.0048	<0.0001	0.00078	<0.0001
3	Three drums drop, puncture, lid failure in Waste Handling Building	0.0037	<0.0001	0.00063	<0.0001
4	Two SWBs drop, puncture, lid failure in Waste Handling Building	0.0067	<0.0001	0.0011	<0.0001
5	Single drum drops, lid failure outside	2.1	0.001	0.35	0.0002
6	Single SWB drops, lid failure outside	4.8	0.003	0.78	0.0005
7	Three drums drop, puncture, lid failure outside	3.7	0.002	0.63	0.0004
8	Two SWBs drop, puncture, lid failure outside	6.7	0.004	1.1	0.0007
9	Fire inside the Waste Handling Building, one SWB is assumed to be affected	95	0.06	16	0.01
10	Single RH waste canister breach	<0.0001	<0.0001	<0.0001	<0.0001
11	Earthquake affects 18 pallets, each with 4 CH drums	60	0.04	10	0.006
12	Tornado, missile hits one SWB, contents released	19	0.01	3.1	0.002

[a] CH = contact-handled, RH = remote-handled, LCF = latent cancer fatality, SWB = standard waste box.

[b] The individual receptor is assumed to be 100 m (330 ft) downwind from the release point. This individual is expected to be a noninvolved worker because there would be no public access within 100 m (330 ft) of the GTCC reference location.

[c] LCFs are calculated by multiplying the dose by the health risk conversion factor of 0.0006 fatal cancer per person-rem (see Section 5.2.4.3). Values are rounded to one significant figure.

6.2.4.2 Post-Closure

The potential radiation dose from the airborne release of radionuclides to off-site members of the public after the closure of a disposal facility would be small. RESRAD-OFFSITE estimates (see Table 5.3.4-3) indicate there would be no measurable exposure from this pathway for the borehole method. Small radiation exposures are estimated for the trench and vault methods. It is estimated that the potential inhalation dose at a distance of 100 m (330 ft) from the disposal facility would be less than 1.8 mrem/yr for trench disposal and 0.52 mrem/yr for vault disposal. The potential radiation exposures would be caused mainly by inhalation of radon gas and its short-lived progeny.

The borehole method would provide better protection against potential exposures from airborne releases of radionuclides because of the greater depth of the cover material. The boreholes would be 30 m (100 ft) bgs, and this depth of overlying soil would inhibit the diffusion of radon gas, CO_2 gas (containing C-14), and tritium (H-3) water vapor to the atmosphere above the disposal area. However, because the distance to the groundwater table would be closer from boreholes than from trenches or vaults, radionuclides that leached out from wastes in the boreholes would reach the groundwater table in a shorter time than radionuclides that leached out from the trenches or vaults.

Within 10,000 years, Tc-99 and I-129 could reach the groundwater table and a well installed by a hypothetical resident farmer located a distance of 100 m (330 ft) from the downgradient edge of the disposal facility. Both of these radionuclides are highly soluble in water, a quality that could lead to potentially significant groundwater doses to the hypothetical resident farmer. The peak annual dose associated with the use of contaminated groundwater from disposal of the entire GTCC waste inventory at the Hanford Site was calculated to be 4.8 mrem/yr for the borehole method, 49 mrem/yr for the vault method, and 48 mrem/yr for the trench method. These two radionuclides would contribute essentially all of the dose to the hypothetical resident farmer within the first 10,000 years after closure of the disposal facility. The exposure pathways considered in this analysis include the ingestion of contaminated groundwater, soil, plants, meat, and milk; external radiation; and the inhalation of radon gas and its short-lived progeny.

Tables 6.2.4-2 and 6.2.4-3 present the peak doses and LCF risks, respectively, to the hypothetical resident farmer (from the use of potentially contaminated groundwater within the first 10,000 years after closure of the disposal facility) when disposal of the entire GTCC waste inventory by using the land disposal methods evaluated is considered. In these tables, the doses contributed by each waste type (i.e., the dose for each waste type at the time or year when the peak dose for the entire inventory is observed) to the peak dose reported are also tabulated. The doses presented from the various waste types do not necessarily represent the peak dose and LCF risk of the waste type itself when considered on its own.

For borehole disposal, it is estimated that the peak dose and LCF risk would occur at about 1,800 years, with GTCC LLRW activated metal waste being the primary dose contributor. The peak doses and LCF risks were calculated to occur at about 3,300 years and 2,900 years after disposal for vault and trench disposal, respectively. These times represent the time after

TABLE 6.2.4-2 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at the Hanford Site[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual Dose from Entire Inventory
Borehole disposal									4.8[b]
Group 1 stored	0.17	-	0.0	0.013	0.0	0.0	0.0042	0.11	
Group 1 projected	2.6	0.0	-	0.00038	0.0	0.0	0.0016	0.036	
Group 2 projected	1.3	0.0	0.0091	0.047	-	-	0.0023	0.066	
Vault disposal									49[b]
Group 1 stored	0.26	-	0.0	0.044	0.0	0.0	0.012	40	
Group 1 projected	4.0	0.0	-	0.0013	0.0	0.0	0.0045	0.12	
Group 2 projected	2.0	0.0	0.025	1.6	-	-	0.0062	0.23	
Trench disposal									48[b]
Group 1 stored	0.33	-	0.0	0.042	0.0	0.0	0.014	39	
Group 1 projected	5.0	0.0	-	0.0013	0.0	0.0	0.0055	0.12	
Group 2 projected	2.5	0.0	0.031	1.5	-	-	0.0076	0.22	

[a] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual doses to the hypothetical resident farmer at the time of the peak annual dose from the entire GTCC waste inventory. These contributions do not represent the maximum doses that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses that could result from each of the waste types are presented in Tables E-22 through E-25 in Appendix E.

[b] The times for the peak annual doses of 4.8 mrem/yr for boreholes, 49 mrem/yr for vaults, and 48 mrem/yr for trenches were calculated to be about 1,800 years, 3,300 years, and 2,900 years, respectively, for disposal of the entire GTCC waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual doses from the specific waste types at the time of these peak doses. For borehole disposal, the primary contributor to the dose is GTCC LLRW activated metals; for trench and vault disposal, the primary contributor to the dose is GTCC-like Other Waste - RH. Tc-99 and I-129 would be the primary radionuclides causing this dose.

TABLE 6.2.4-3 Estimated Peak Annual LCF Risks from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at the Hanford Site[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual LCF Risk from Entire Inventory
Borehole disposal									3E-06 [b]
Group 1 stored	1E-07	-	0E+00	7E-09	0E+00	0E+00	3E-09	6E-08	
Group 1 projected	2E-06	0E+00	-	2E-10	0E+00	0E+00	1E-09	2E-08	
Group 2 projected	8E-07	0E+00	5E-09	3E-07	-	-	1E-09	4E-08	
Vault disposal									3E-05[b]
Group 1 stored	2E-07	-	0E+00	3E-08	0E+00	0E+00	7E-09	2E-05	
Group 1 projected	2E-06	0E+00	-	8E-10	0E+00	0E+00	3E-09	7E-08	
Group 2 projected	1E-06	0E+00	2E-08	1E-06	-	-	4E-09	1E-07	
Trench disposal									3E-05[b]
Group 1 stored	2E-07	-	0E+00	3E-08	0E+00	0E+00	8E-09	2E-05	
Group 1 projected	3E-06	0E+00	-	8E-10	0E+00	0E+00	3E-09	7E-08	
Group 2 projected	1E-06	0E+00	2E-08	9E-07	-	-	5E-09	1E-07	

[a] These annual LCF risks are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to one significant figure, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual LCF risks to the hypothetical resident farmer at the time of the peak annual LCF risk from the entire GTCC waste inventory. These contributions do not represent the maximum LCF risks that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum LCF risks that could result from each waste type individually generally occur at different times than the peak annual LCF risk from the entire inventory.

[b] The times for the peak annual LCF risks of 3E-06 for boreholes, 3E-05 for vaults, and 3E-05 for trenches were calculated to be about 1,800 years, 3,300 years, and 2,900 years, respectively, for disposal of the entire GTCC waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual LCF risks for the specific waste types at the time of these peak LCF risks. For borehole disposal, the primary contributor to the LCF risk is GTCC LLRW activated metals; for trench and vault disposal, the primary contributor to the LCF risk is GTCC-like Other Waste - RH. Tc-99 and I-129 would be the primary radionuclides causing this risk.

failure of the engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The major dose contributor for these two disposal methods would be GTCC-like Other Waste - RH, with GTCC LLRW contributing about 15% of the total dose.

Tables E-22 through E-25 in Appendix E present peak doses for each waste type when considered on its own. Because these peak doses generally occur at different times, the results should not be summed to obtain total doses for comparison with those presented in Table 6.2.4-2 (although for some cases, these sums might be close to those presented in the site-specific chapters).

Figure 6.2.4-1 is a temporal plot of the radiation doses associated with the use of contaminated groundwater for a period extending to 10,000 years, and Figure 6.2.4-2 shows these results to 100,000 years for the three land disposal methods. Note that the time scale in Figure 6.2.4-1 is logarithmic, while the time scale in Figure 6.2.4-2 is linear. A logarithmic time scale was used in the first figure to better illustrate the projected radiation doses to a hypothetical resident farmer in the first 10,000 years following closure of the disposal facility.

Although Tc-99 and I-129 would result in measureable radiation doses for the first 10,000 years, the inventory in the disposal areas would be depleted rather quickly, and the doses would gradually decrease with time after about 5,000 years. After the depletion of these two radionuclides, no other radionuclides would reach the groundwater table within 10,000 years. In the very long term, however, various isotopes of uranium and Np-237 that were originally contained in the waste streams or generated from radioactive decay could reach the groundwater table and result in doses to this hypothetical resident farmer. The maximum annual doses would exceed 100 mrem/yr for all three disposal methods and would occur within the first 25,000 years following closure of the disposal facility. There is a high degree of uncertainty associated with estimates that project this far into the future.

The results given here are assumed to be conservative because the location selected for the residential exposure is 100 m (330 ft) from the edge of the disposal facility. Use of a longer distance, which might be more realistic for the sites being evaluated, would significantly lower the estimated doses (i.e., by as much as 70%). A sensitivity analysis performed to determine the effect of a distance longer than 100 m (330 ft) is presented in Appendix E.

These analyses assume that engineering controls would be effective for 500 years following closure of the disposal facility. This means that essentially no infiltrating water would reach the wastes from the top of the disposal units. It is assumed that after 500 years, the engineered barriers would begin to degrade, allowing infiltrating water to come in contact with the disposed-of wastes. For purposes of analysis in the EIS, it is assumed that the amount of infiltrating water that would contact the wastes would be 20% of the site-specific natural infiltration rate for the area, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate for the area. This approach is assumed to be conservative because it is expected that the engineered systems (including the disposal facility cover) would last longer than 500 years, even in the absence of active maintenance measures.

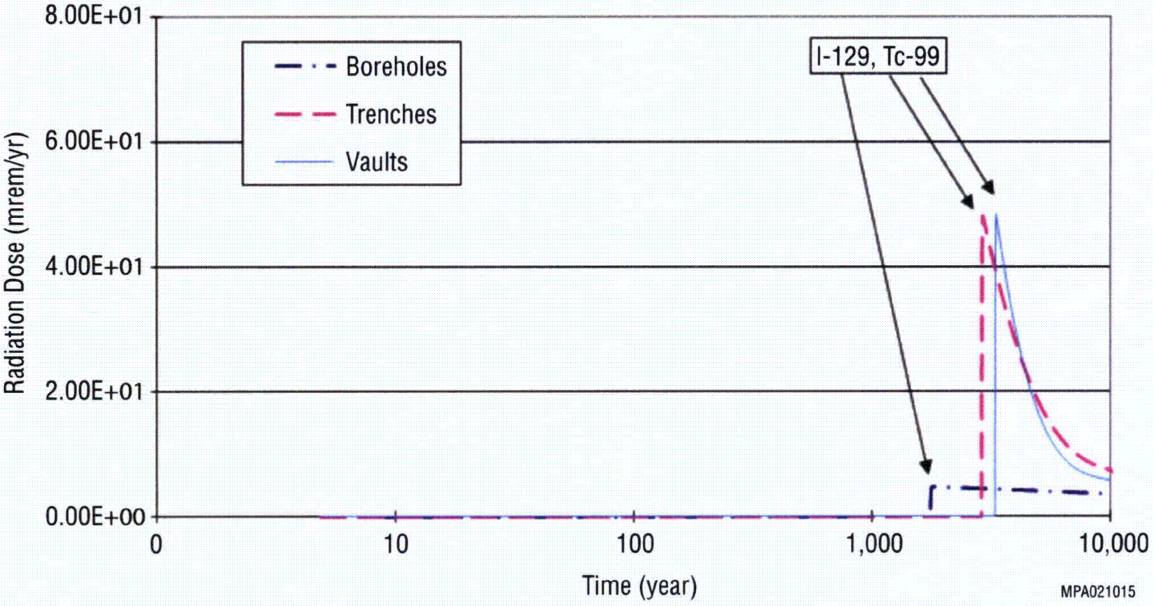

FIGURE 6.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal for the Three Land Disposal Methods at the Hanford Site

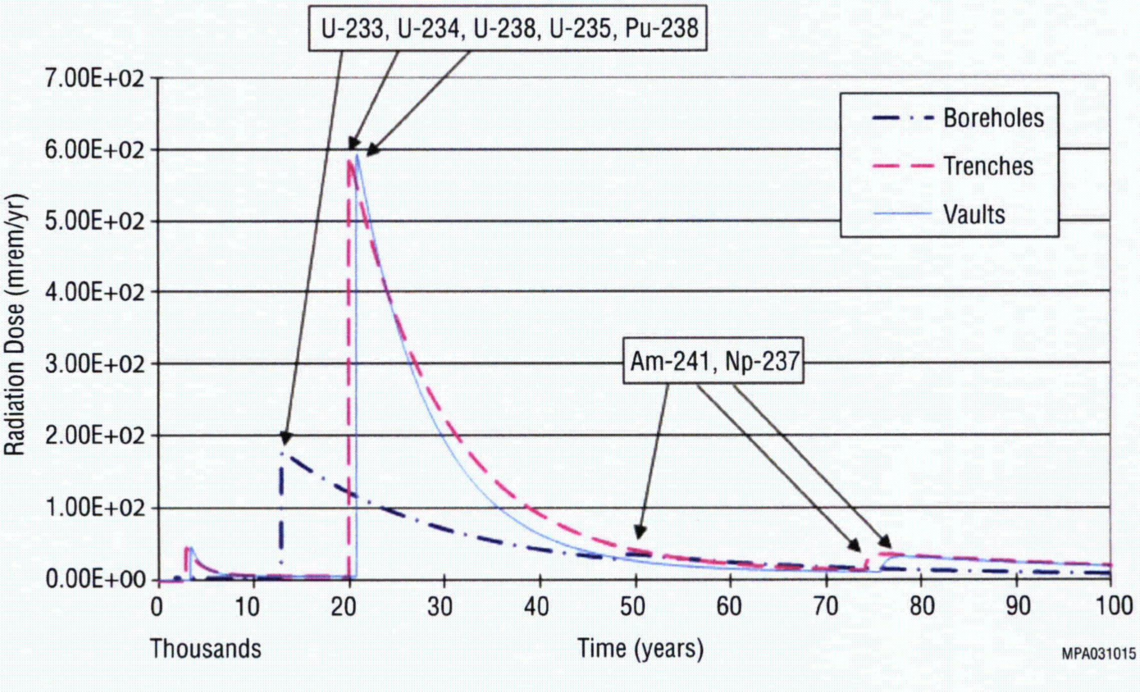

FIGURE 6.2.4-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Three Land Disposal Methods at the Hanford Site

It is assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. Consistent with the assumptions used for engineering controls, no credit was taken in this analysis for the effectiveness of this stabilizing agent after 500 years. That is, any water that would contact the wastes after 500 years would be able to leach radioactive constituents from the disposed-of materials. These radionuclides could then move with the percolating groundwater to the underlying groundwater system. This scenario is assumed to be conservative because grout or other stabilizing materials could retain their integrity for longer than 500 years.

Sensitivity analyses performed relative to these assumptions indicate that if a higher infiltration rate to the top of the disposal facilities was assumed, the doses would increase in a linear manner from those presented. Conversely, the doses would decrease in a linear manner with lower infiltration rates. This finding indicates the need to ensure that there is a good cover over the closed disposal units. Also, the doses would be lower if it was assumed that the grout would last for a longer time. Because of the long-lived nature of the radionuclides associated with some of the GTCC LLRW and GTCC-like waste, any stabilization effort (such as grouting) would have to be effective for longer than 5,000 years in order to substantially reduce doses that could result from potential future leaching of the disposed-of waste.

The radiation doses presented in the post-closure assessment in this EIS are intended to be used for comparing the performance of each of the land disposal methods at each site evaluated. The results indicate that the use of robust engineering designs and redundant measures (e.g., types and thicknesses of covers and long-lasting grout) to contain the radionuclides in the disposal facility could delay the potential release of radionuclides and could reduce the release to very low levels, thereby minimizing the potential groundwater contamination and associated human health impacts in the future. DOE will consider the potential doses to the hypothetical resident farmer as well as other factors in developing the preferred alternative as discussed in Section 2.9.

6.2.5 Ecology

Section 5.3.5 presents an overview of the potential impacts on ecological resources that could result from the construction, operations, decommissioning, and post-closure maintenance of the GTCC waste disposal facility, regardless of the location selected for it. This section evaluates the potential impacts of the facility on the ecological resources at the Hanford Site.

It is expected that the initial loss of sagebrush-dominated habitats followed by the eventual establishment of low-growth vegetation (including sagebrush) on the disposal site would not create a long-term reduction in the local or regional ecological diversity. Also, loss of sagebrush would be compensated for by required restoration elsewhere on the Hanford Site (e.g., at a ratio of up to 3:1). After closure of the GTCC waste disposal site, the cover would become initially vegetated with annual and perennial plants. Reestablishment of mature sagebrush stands could take a minimum of 10 to 20 years (Poston and Sackschewsky 2007). As appropriate, regionally native plants would be used to landscape the disposal site in accordance with "Guidance for Presidential Memorandum on Environmentally and Economically Beneficial

Landscape Practices on Federal Landscaped Grounds" (EPA 1995). An aggressive revegetation program would be necessary so that nonnative species, such as cheatgrass, Russian thistle, and diffuse knapweed, would not become established. These species are quick to colonize disturbed sites and are difficult to eradicate because each year they produce large amounts of seeds that remain viable for long periods of time (Blew et al. 2006).

It is expected that the mountain cottontail would occur where cover associated with construction was available (Downs et al. 1993). However, species associated with sagebrush habitats, such as the northern sagebrush lizard and black-tailed jackrabbits, would be locally affected by construction of the GTCC waste disposal facility. Ground-nesting birds that have been observed in the 200 Area include the horned lark, killdeer (*Charadrius vociferous*), long-billed curlew, and western meadowlark. Ground disturbance during the nesting season could destroy eggs and young of these species and displace nesting individuals to other areas of the Hanford Site. Construction at other times of the year would result in a loss of the habitat available to these bird species on the Hanford Site.

Because no natural aquatic habitats occur within the immediate vicinity of the GTCC reference location, impacts on aquatic biota are not expected. DOE would use appropriate erosion control measures to minimize off-site movement of soils. It is expected that the GTCC waste disposal facility retention pond would not become a highly productive aquatic habitat. However, depending on the amount of water and length of time that water would be retained within the pond, aquatic invertebrates could become established within it. Waterfowl, shorebirds, and other birds might also make use of the retention pond, as would mammal and reptile species that might enter the site. Amphibian species might also make use of the retention pond.

Since no federally listed or candidate species occur within the immediate vicinity of the GTCC reference location, none of these species would be affected by construction, operations, or post-closure of the waste disposal facility. Construction of the GTCC waste disposal facility could affect state candidate species, such as the sage sparrow, northern sagebrush lizard (*Sceloporus graciosus graciosus*), and black-tailed jackrabbit, which have a strong affinity for sagebrush habitats. However, the area of sagebrush habitat that would be disturbed by construction is small relative to the overall area of such habitat on the Hanford Site. Therefore, removal of sagebrush habitat would have a small impact on the populations of these species and other species that live in sagebrush habitats.

Development of the GTCC waste disposal facility would result in the loss of shrub-steppe habitat, which is considered a priority habitat by the State of Washington and a Level III resource under the Hanford Site Biological Resources Management Plan. Impacts on Level III resources require mitigation. When avoidance and minimization are not possible or are insufficient, mitigation via rectification or compensation is recommended (DOE 2001b). Therefore, impacts associated with the GTCC waste disposal facility (Section 5.3.5) that could affect ecological resources would be minimized and mitigated.

6.2.6 Socioeconomics

6.2.6.1 Construction

The potential socioeconomic impacts from constructing a GTCC waste disposal facility and support buildings at the Hanford Site would be relatively small for all disposal methods. Construction activities would create direct employment of 47 people (borehole method) to 145 people (vault method) in the peak construction year and an additional 56 indirect jobs (borehole method) to 152 indirect jobs (vault method) in the ROI (Table 6.2.6-1). Construction activities would constitute less than 1% of total ROI employment in the peak year. A GTCC facility would produce between $4.2 million in income (borehole method) and $12.3 million (vault method) in income in the peak year of construction.

In the peak year of construction, between 21 people (borehole method) and 64 people (vault method) would in-migrate to the ROI (Table 6.2.6-1) as a result of employment on-site. In-migration would have only a marginal effect on population growth and would require no more than 2% of vacant rental housing in the peak year for all disposal methods. No significant impact on public finances would occur as a result of in-migration, and no more than two local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small to moderate impact on levels of service in the local transportation network surrounding the site.

6.2.6.2 Operations

The potential socioeconomic impacts from operating a GTCC waste disposal facility would be small for all disposal methods. Operational activities would create 38 direct jobs (borehole method) to 51 direct jobs (vault method) annually and an additional 36 indirect jobs (borehole method) to 43 indirect jobs (vault method) in the ROI (Table 6.2.6-1). A GTCC waste disposal facility would also produce between $3.9 million in income (borehole method) and $5.0 million in income (vault method) annually during operations.

Two people would move to the area at the beginning of operations (Table 6.2.6-1). However, in-migration would have only a marginal effect on population growth and would require less than 1% of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur as a result of in-migration, and no new local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small impact on levels of service in the local transportation network surrounding the site.

TABLE 6.2.6-1 Effects of GTCC Waste Disposal Facility Construction and Operations on Socioeconomics at the ROI for the Hanford Site[a]

	Trench		Borehole		Vault	
Impact Category	Construction	Operation	Construction	Operation	Construction	Operation
Employment (number of jobs)						
Direct	62	48	47	38	145	51
Indirect	57	42	56	36	152	43
Total	119	90	103	75	297	94
Income ($ in millions)						
Direct	2.1	3.2	1.8	2.6	6.0	3.4
Indirect	2.4	1.5	2.4	1.3	6.3	1.6
Total	4.5	4.7	4.2	3.9	12.3	5.0
Population (number of new residents)	27	2	21	2	64	2
Housing (number of units required)	14	1	10	1	32	1
Public finances (% impact on expenditures)						
Cities and counties[b]	<1	<1	<1	<1	<1	<1
Schools[c]	<1	<1	<1	<1	<1	<1
Public service employment (number of new employees)						
Local government employees[d]	0	0	0	0	1	0
Teachers	0	0	0	0	1	0
Traffic (impact on current levels of service)	Small	Small	Small	Small	Moderate	Small

[a] Impacts shown are for waste facility and support buildings in the peak year of construction and the first year of operations.

[b] Includes impacts that would occur in the cities of Richland, West Richland, Kennewick, Benton City, Prosser, Pasco, and Connell and in the counties of Benton and Franklin.

[c] Includes impacts that would occur in the school districts of Richland, Kennewick, Finley, Kiona-Benton, Prosser, Patterson, Pasco, Star, Education, North Franklin, and Kahlotus.

[d] Includes police officers, paid firefighters, and general government employees.

6.2.7 Environmental Justice

6.2.7.1 Construction

No radiological risks and only very low chemical exposure and risk are expected during construction of the trench, borehole, or vault facilities. Chemical exposure during construction would be limited to airborne toxic air pollutants at less than standard levels and would not result in any adverse health impacts. Because the health impacts from each facility on the general population within the 80-km (50-mi) assessment area during construction would be negligible, no impacts on minority and low-income population as a result of the construction of a GTCC waste disposal facility are expected.

6.2.7.2 Operations

Because incoming GTCC waste containers would only be consolidated for placement in trench, borehole, and vault facilities, with no repackaging necessary, there would be no radiological impacts on the general public during disposal operations and no adverse health effects on the general population. In addition, no surface releases that might enter local streams would occur. Because the health impacts of routine operations on the general public would be negligible, it is expected that there would be no disproportionately high and adverse impact on minority and low-income population groups within the 80-km (50-mi) assessment area. Subsequent NEPA analysis to support any GTCC implementation would consider any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well water use) to determine any additional potential adverse health and environmental impacts.

6.2.7.3 Accidents

A GTCC waste release at each of the facilities would have the potential for causing LCFs in the surrounding area. However, it is highly unlikely that such an accident would occur. Therefore, the risk to any population, including low-income and minority communities, is considered to be low. In the unlikely event of a GTCC release at a facility, the communities most likely to be affected could be minority or low-income, given the demographics within 80 km (50 mi) of the GTCC reference location.

If an accident that produced significant contamination occurred, appropriate measures would be taken to ensure that the impacts on low-income and minority populations would be minimized. The extent to which low-income and minority population groups would be affected would depend on the amount of material released and the direction and speed at which airborne material was dispersed from any of the facilities by the wind. Although the overall risk would be very small, the greatest short-term risk of exposure following an airborne release and the greatest 1-year risk would be to the population groups residing to the southeast of the site because of the prevailing wind direction. Airborne releases following an accident would likely have a larger impact on the area than would an accident that released contaminants directly into the soil surface.

Monitoring of contaminant levels in soil and surface water following an accident would provide the public with information on the extent of any contaminated areas. Analysis of contaminated areas to decide how to control the use of high-health-risk areas would reduce the potential impact on local residents.

6.2.8 Land Use

Section 5.3.8 presents an overview of the potential land use impacts that could result from the GTCC waste disposal facility regardless of the location selected for it. This section evaluates the potential impacts on land use at the Hanford Site. The amount of land altered for the GTCC waste disposal facility would be up to 44 ha (110 ac).

The GTCC reference location is situated within an industrial (exclusive) land use zone immediately to the south of the 200 East Area. Thus, there would be no change in overall land use patterns at the Hanford Site under any of the three land disposal methods. Land use on areas surrounding the Hanford Site would not be affected. Future land use activities that would be permitted within or immediately adjacent to the GTCC waste disposal facility would be limited to those that would not jeopardize the integrity of the facility or cause a safety risk to security workers or the public.

6.2.9 Transportation

The transportation impacts from the shipments that would be required to dispose of all GTCC LLRW and GTCC-like waste at the Hanford Site were evaluated. As discussed in Section 5.3.9, the transportation of all cargo by both truck and rail modes as separate options is considered for the purposes of this EIS. There is currently no active rail transportation on the Hanford Site. Evaluations with regard to new rail spurs and upgrades to existing rail lines would be addressed in follow-on NEPA analyses, as appropriate. Transportation impacts are expected to be the same no matter which disposal method is chosen (boreholes, trenches, or vaults) because the same type of transportation packaging would be used regardless of the disposal method chosen.

As discussed in Appendix C, Section C.9, three impacts from transportation were calculated: (1) collective population risks during routine conditions and accidents (Section 6.2.9.1), (2) radiological risks to the highest exposed individual during routine conditions (Section 6.2.9.2), and (3) consequences to individuals and populations after the most severe accidents involving a release of radioactive or hazardous chemical material (Section 6.2.9.3).

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441

(Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rate for CH shipments to Hanford is assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rate is assumed to be 2.5 and 5.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. These assignments are based on shipments of similar types of waste. Dose rates from rail shipments are approximately double those for truck shipments because rail shipments are assumed to have twice the number of waste packages as a truck shipment. Impacts from accidents are dependent on the amount of radioactive material in a shipment and on the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

6.2.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group; no individual receptors are specified. Exposure to four different groups were considered: (1) persons living and working along the transportation routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for cargo-related causes for routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and are calculated only for traffic accidents (fatalities caused by physical trauma).

Estimated impacts from the truck and rail options are summarized in Tables 6.2.9-1 and 6.2.9-2, respectively. For the truck option, it is estimated that about 12,600 shipments resulting in about 50 million km (30 million mi) of travel would cause no LCFs in the truck crew or the public. One fatality directly related to accidents might result. It is projected that no LCFs would result from the rail option, but one fatality from an accident could occur. The rail option would involve approximately 5,010 railcar shipments involving about 20 million km (12 million mi) of travel. The estimated total truck distance travelled of about 50 million km (30 million mi) would be about 0.04% of the total vehicle miles travelled (173,130 million km or 107,602 million mi) by heavy-duty trucks in the United States in 2002 (DOT 2005).

6.2.9.2 Highest-Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals might be exposed to radiation in the vicinity of a shipment. Risks to these individuals for a number of hypothetical exposure-causing events were estimated. The receptors include transportation workers, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living and or working near a destination site. The assumptions about exposure are given in Section C.9.2.2 of Appendix C, and transportation impacts are discussed in Section 5.3.9. The scenarios for exposure are not meant to be exhaustive; they were selected to

TABLE 6.2.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at the Hanford Site[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[c]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	20	77,600	0.81	0.023	0.12	0.14	0.28	0.00017	0.0005	0.0002	0.0017
Past PWRs	143	490,000	5.1	0.14	0.73	0.9	1.8	0.00085	0.003	0.001	0.011
Operating BWRs	569	2,180,000	23	0.57	3.2	4	7.8	0.0034	0.01	0.005	0.046
Operating PWRs	1,720	6,620,000	69	1.8	9.8	12	24	0.012	0.04	0.01	0.14
Sealed sources - CH	209	698,000	0.29	0.066	0.4	0.5	0.96	0.041	0.0002	0.0006	0.014
Cesium irradiators - CH	240	802,000	0.34	0.076	0.45	0.58	1.1	0.0061	0.0002	0.0007	0.016
Other Waste - CH	5	17,700	0.0074	0.0016	0.01	0.013	0.024	<0.0001	<0.0001	<0.0001	0.0004
Other Waste - RH	54	240,000	2.5	0.071	0.35	0.44	0.86	<0.0001	0.001	0.0005	0.0055
GTCC-like waste											
Activated metals - RH	38	69,800	0.73	0.017	0.1	0.13	0.25	<0.0001	0.0004	0.0001	0.0035
Sealed sources - CH	1	3,340	0.0014	0.00032	0.0019	0.0024	0.0046	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	69	271,000	0.11	0.029	0.16	0.19	0.38	0.00088	<0.0001	0.0002	0.0055
Other Waste - RH	1,160	4,620,000	48	1.2	6.8	8.5	16	0.0022	0.03	0.01	0.093

TABLE 6.2.9-1 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[c]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
Past BWRs	202	801,000	8.3	0.21	1.2	1.5	2.9	0.0017	0.005	0.002	0.017
Past PWRs	833	3,100,000	32	0.89	4.6	5.7	11	0.0058	0.02	0.007	0.065
Additional commercial waste	1,990	8,160,000	85	2.2	12	15	29	<0.0001	0.05	0.02	0.16
Other Waste - CH	139	570,000	0.24	0.06	0.33	0.41	0.8	0.0029	0.0001	0.0005	0.011
Other Waste - RH	3,790	15,700,000	160	4.3	23	29	56	0.00083	0.1	0.03	0.32
GTCC-like waste											
Other Waste - CH	44	178,000	0.074	0.018	0.1	0.13	0.25	0.00039	<0.0001	0.0001	0.0035
Other Waste - RH	1,400	5,730,000	59	1.5	8.4	11	20	0.0023	0.04	0.01	0.12
Total Groups 1 and 2	12,600	50,300,000	500	13	71	90	170	0.08	0.3	0.1	1

[a] BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

[b] Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

[c] Vehicle-related impacts are impacts independent of the cargo in the shipment.

[d] LCFs were calculated by multiplying the dose by the conversion factor of 6 × 10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

[e] Dose risk is a societal risk and is the product of accident probability and accident consequence.

TABLE 6.2.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at the Hanford Site[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	OffLink	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	7	26,600	0.2	0.064	0.0038	0.084	0.15	0.00039	0.0001	<0.0001	0.0017
Past PWRs	37	131,000	1	0.31	0.019	0.44	0.77	0.0016	0.0006	0.0005	0.0066
Operating BWRs	154	609,000	4.6	1.4	0.089	1.9	3.4	0.0041	0.003	0.002	0.021
Operating PWRs	460	1,850,000	14	4.3	0.25	6	10	0.012	0.008	0.006	0.067
Sealed sources - CH	105	365,000	0.84	0.24	0.015	0.51	0.76	0.0019	0.0005	0.0005	0.0064
Cesium irradiators - CH	120	417,000	0.95	0.27	0.017	0.58	0.87	0.00027	0.0006	0.0005	0.0073
Other Waste - CH	3	10,700	0.024	0.011	0.00078	0.015	0.027	<0.0001	<0.0001	<0.0001	0.00053
Other Waste - RH	27	124,000	0.91	0.3	0.019	0.35	0.67	<0.0001	0.0005	0.0004	0.0038
GTCC-like waste											
Activated metals - RH	11	21,300	0.2	0.042	0.0027	0.092	0.14	<0.0001	0.0001	<0.0001	0.0026
Sealed sources - CH	1	3,480	0.008	0.0023	0.00014	0.0048	0.0073	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	35	140,000	0.31	0.14	0.0089	0.19	0.34	0.00016	0.0002	0.0002	0.0048
Other Waste - RH	579	2,380,000	18	5.5	0.35	7.5	13	0.00039	0.01	0.008	0.08

TABLE 6.2.9-2 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	OffLink	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	54	232,000	1.7	0.5	0.029	0.79	1.3	0.0016	0.001	0.0008	0.0075
New PWRs	227	913,000	6.9	2.1	0.12	3	5.3	0.0046	0.004	0.003	0.03
Additional commercial waste	498	2,080,000	16	4.9	0.31	6.6	12	<0.0001	0.009	0.007	0.072
Other Waste - CH	70	292,000	0.64	0.29	0.019	0.4	0.71	0.00055	0.0004	0.0004	0.01
Other Waste - RH	1,900	8,000,000	60	19	1.2	25	45	0.0001	0.04	0.03	0.27
GTCC-like waste											
Other Waste - CH	22	93,000	0.2	0.092	0.0057	0.12	0.22	<0.0001	0.0001	0.0001	0.003
Other Waste - RH	702	2,940,000	22	6.9	0.43	9.2	1.7	0.00035	0.01	0.01	0.1
Total Groups 1 and 2	5,010	20,600,000	150	46	2.9	63	110	0.028	0.09	0.07	0.7

[a] BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

[b] Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

[c] Vehicle-related impacts are impacts independent of the cargo in the shipment.

[d] LCFs were calculated by multiplying the dose by the health risk conversion factor of 6 × 10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

[e] Dose risk is a societal risk and is the product of accident probability and accident consequence.

provide a range of representative potential exposures. On a site-specific basis, if someone was living or working near the Hanford Site entrance and present for all 12,600 truck or 5,010 rail shipments projected, that individual's estimated dose would be approximately 0.5 or 1.0 mrem, respectively. The individual's associated lifetime LCF risk would then be 3×10^{-7} or 6×10^{-7} for truck or rail shipments, respectively.

6.2.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Because the exact location of such a transportation accident is impossible to predict and thus not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

6.2.10 Cultural Resources

No known cultural resources are located within the project area. However, the reference location has not been examined for the presence of cultural resources. Surveys in the immediate area have found only isolated prehistoric artifacts. No historically significant sites are expected within the project area. The project area is within the viewshed of the historically significant Hanford Site Plant Railroad and the Gable Butte-Gable Mountain traditional cultural property. If the location at the Hanford Site was chosen for development, the NHPA Section 106 process for considering potential project impacts on significant cultural resources would be followed. The Section 106 process requires that the facility location and any ancillary locations that would be affected by the project be investigated for the presence of cultural resources prior to disturbance. Consultation would also take place with the Yakama Indian Nation, CTUIR, Nez Perce Tribe, and Wanapum to ensure that no traditional properties would be affected by the project.

It is expected that most of the impacts on cultural resources would occur during the construction phase. Previous research in the region indicates that some isolated prehistoric artifacts would be found in the project area. If archaeological sites were identified, they would require evaluation for listing on the NRHP. Most impacts on significant cultural resources could be mitigated through documentation. The appropriate mitigation would be determined through consultation with the Washington SHPO and the American Indian tribes mentioned previously.

The borehole method has the greatest potential to affect cultural resources because of its requirements for 44 ha (110 ac) of land. The amount of land needed to employ this method is twice that needed to employ the vault or trench method.

Impacts would likely occur during the ground clearing needed for disposal facilities. The vault method also requires large amounts of soil to cover the waste. Impacts on cultural resources could occur during the removal and hauling of the soil required for this method. Impacts on cultural resources would need to be considered for the soil extraction locations by means of additional NEPA analysis, as appropriate. The NHPA Section 106 process would be followed for all locations. Potential impacts on cultural resources from the operation of a vault facility could be comparable to those expected from the borehole method. While the actual footprint would be smaller for the vault method, the amount of land disturbed for the cover could exceed the land required for the borehole method.

Activities associated with operations and post-closure are expected to have a minimal impact on cultural resources. No new ground-disturbing activities are expected to occur in association with operations and post-closure activities.

6.2.11 Waste Management

The construction of the land disposal facilities would generate small quantities of hazardous and nonhazardous solids and hazardous and nonhazardous liquids. Nonhazardous wastes include sanitary wastes. Waste generated from operations would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable wastes). These waste types would either be disposed of on-site or sent off-site for disposal. It is expected that waste that could be generated from the construction and operations of the land disposal methods would have no impacts on waste management programs at the Hanford Site. Section 5.3.11 provides a summary of the waste handling programs at the Hanford Site for the waste types generated.

6.3 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences presented in Section 6.2 from the disposal of GTCC LLRW and GTCC-like waste under Alternatives 3 to 5 are summarized by resource area as follows:

Air quality. Potential impacts from construction and operations would be negligible or minor at most. It is estimated that during construction and operations, total peak-year emissions of criteria pollutants, VOCs, and CO_2 would be small (see Tables D-15 and D-17 in Appendix D). The highest emissions would be associated with the borehole and vault disposal methods, about 0.20% of the four-county emissions total for SO_2. O_3 levels in the four counties encompassing the Hanford Site are currently in attainment; O_3 precursor emissions from construction and operational activities would be relatively small, less than 0.14% and 0.01% of NO_x and VOC emissions, respectively, and much lower than those for the regional air shed. During construction and operations, maximum CO_2 emissions would be less than 0.00001% of global emissions, a value that is considered negligible. All construction and operational activities would occur at least 6 km (4 mi) from the site boundary and would not contribute significantly to PM concentrations at the boundary or at the nearest residence. Fugitive dust emissions during construction and operations would be controlled by best management practices. Activities for decommissioning would be similar to those for construction but on a more limited scale and for a more limited duration. Potential impacts on ambient air quality would therefore be correspondingly less for decommissioning than for construction.

Noise. The highest composite noise during construction would be about 92 dBA at 15 m (50 ft) from the source. Noise levels at 690 m (2,300 ft) from source would be below the EPA guideline. This distance is well within the Hanford Site boundary, and there are no residences within this distance. No groundborne vibration impacts are anticipated. Noise generated from operations would be less than noise during the construction phase.

Geology. No adverse impacts from the extraction and use of geologic and soil resources are expected, and there would be no significant changes in surface topography or natural drainages. The potential for erosion would be reduced by the low precipitation rates at Hanford and would be further reduced by best management practices.

Water resources. Construction of a vault facility would have the highest water requirement. Water demands for construction at the Hanford Site would be met by using surface water from the Columbia River and the 100-B Area Export Water System. No groundwater would be used at the site during construction; therefore, no direct impacts on groundwater are expected. Indirect impacts on surface water would be reduced by implementing good industry practices and mitigation measures. Construction and operations of the proposed GTCC waste disposal facility would increase the annual water use at the Hanford Site by a maximum of about 0.4% and 0.65%, respectively, both for the vault method (see Tables 5.3.3-2 and 5.3.3-3). Since these increases would be well within the capacity of Hanford's 200 East Area, it is expected that impacts from surface water withdrawals would be negligible. Groundwater could become contaminated with some highly soluble radionuclides during the post-closure period; indirect impacts on surface water could result from aquifer discharges to springs and rivers.

Human health. The impacts on workers from disposal operations would be mainly those from the radiation doses associated with waste handling. The annual doses to the workers would be 2.6 person-rem/yr for the borehole method, 4.6 person-rem/yr for the trench method, and 5.2 person-rem/yr for the vault method. None of these doses are expected to result in any LCFs (see Table 5.3.4.1.1). The maximum dose to any individual worker would not exceed the project (Hanford Site) administrative control level of 500 mrem/yr. It is expected that the maximum dose to any individual worker over the entire project would not exceed a few rem.

The worker impacts from accidents would be associated with the physical injuries and possible fatalities that could result from construction and waste handling activities. It is estimated that the annual number of lost workdays due to injuries and illnesses would range from 1 (for the borehole method) to 2 (for the trench and vault methods) and that there would be no fatalities from construction and waste handling accidents (see Section 5.3.4.1.1). These injuries would not be associated with the radioactive nature of the wastes but would simply be those that are expected to occur in any construction project of this size.

With regard to the general public, no measurable doses are expected to occur during waste disposal operations at the site, given the solid nature of the wastes and the distance of waste handling activities from potentially affected individuals. It is estimated that the highest dose to an individual from an accident involving the waste packages prior to disposal (from a fire affecting an SWB) would be 16 rem and would not result in any LCFs. It is estimated that the collective dose to the affected population from such an event would be 95 person-rem. It is estimated that the peak dose in the first 10,000 years after closure of the disposal facility to a hypothetical nearby receptor (resident farmer) who resided 100 m (330 ft) from the disposal site would be 4.8 mrem/yr for boreholes, 49 mrem/yr for vaults, and 48 mrem/yr for trenches. These peak annual doses would occur at 1,800 years, 3,300 years, and 2,900 years, respectively, after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The peak annual dose for borehole disposal would be mainly from GTCC LLRW activated metals, and the peak annual doses for trench and vault disposal would be mainly from GTCC-like Other Waste - RH.

Ecological resources. Although loss of sagebrush habitat, followed by eventual establishment of low-growth vegetation, would affect species dependent on sagebrush (e.g., black-tailed jackrabbit, pygmy rabbit, sage sparrow, and northern sagebrush lizard), population-level impacts on these species are not expected. Reestablishment of sagebrush after closure could take a minimum of 10 to 20 years. Also, loss of sagebrush would be compensated for by required restoration elsewhere on the Hanford Site. Ground-nesting birds observed in the 200 Area include the horned lark, killdeer, long-billed curlew, and western meadowlark. Ground disturbance during the nesting season could destroy the eggs and young of these species and displace nesting individuals to other areas of the Hanford Site. There are no natural aquatic habitats (including wetlands) within the immediate vicinity of the GTCC reference location. No federally listed species have been reported in the project area.

Socioeconomics. Impacts from constructing a GTCC waste disposal facility would be small. Construction would create direct employment for up to 145 people (vault method) in the peak construction year and 152 indirect jobs (vault method) in the ROI; the annual average employment growth rate would increase by less than 0.1 of a percentage point. The land disposal facilities would produce up to $12.3 million in income in the peak construction year. An estimated 64 people would in-migrate to the ROI as a result of employment on-site; in-migration would have only a marginal effect on population growth and require less than 1% of vacant housing in the peak year. Impacts from operating the facility would also be small; operations would create 51 direct jobs (vault method) annually and an additional 43 indirect jobs (vault method) in the ROI. The land disposal facilities would produce about $5.0 million in income annually during operations (vault method).

Environmental justice. Because health impacts on the general population within the 80-km (50-mi) assessment area during construction and operations would be negligible, no impacts on minority and low-income populations as a result of the construction and operations of a GTCC waste disposal facility are expected.

Land use. The GTCC reference location would be an additional facility to the south of the 200 Area complex; land use patterns at Hanford would not be changed under any of the three land disposal methods.

Transportation. Shipment of all waste to Hanford by truck would result in approximately 12,600 shipments with a total distance of 50 million km (31 million mi) traveled. For shipment of all waste by rail, 5,010 railcar shipments involving 20 million km (12 million mi) of travel would be required. It is estimated that no LCFs would occur to the public or crew members for either mode of transportation, but one fatality from an accident could occur.

Cultural resources. There are no known cultural resources within the project area, although isolated prehistoric artifacts have been found in the surrounding area, and the project area is within the viewshed of the Hanford Site Plant Railroad and the Gable Butte-Gable Mountain traditional cultural property. Section 106 of NHPA would be followed to determine the impact of the project on significant cultural resources. Local tribes would be consulted to ensure that no traditional cultural properties would be affected by the project under the land disposal methods. The trench method has the least potential to affect cultural resources (especially during the construction phase) because it requires the smallest amount of land.

Waste management. The small quantity of wastes that could be generated from the construction and operations of the land disposal methods (see Table 5.3.11-1) are not expected to affect current waste management programs at the Hanford Site.

6.4 CUMULATIVE IMPACTS

Section 5.4 presents the methodology for the cumulative impacts analysis. In the analysis that follows, impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. This section begins with a description of reasonably foreseeable future actions at the Hanford Site, including those that are ongoing, under construction, or planned for future implementation. Past and present actions are generally accounted for in the affected environment section (Section 6.1).

6.4.1 Reasonably Foreseeable Future Actions

Reasonably foreseeable future actions at the Hanford Site are summarized in the following sections. These actions were identified primarily from a review of the *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site* (TC&WM EIS; DOE 2009). The actions listed are planned, under construction, or ongoing. A comprehensive list of the actions and activities considered for the TC&WM EIS cumulative analysis and their source documents is provided in Table R-4 of DOE (2009) and is not reproduced here.

American Indian Text

There is a growing recognition that conventional risk assessment methods do not address all of the things that are "at risk" in communities facing the prospect of contaminated waste sites, permitted chemical or radioactive releases, or other environmentally harmful situations. Conventional risk assessments do not provide enough information to "tell the story" or answer the questions that people ask about risks to their community, health, resource base, and way of life. As a result, cumulative risks, as defined by the community, are often not described, and therefore the remedial decisions may not be accepted. The full span of risks and impacts needs to be evaluated within the risk assessment framework in order for cumulative risks to be adequately characterized. This is in contrast to a more typical process of evaluating risks to human health and ecological resources within the risk assessment phase and deferring the evaluation of risks to sociocultural and socioeconomic resources until the risk management phase.

Within this EIS process, a cumulative risk assessment needs to be developed for the Hanford option. This risk assessment needs to utilize the existing Hanford Tribal risk scenarios (CTUIR, Yakama Indian Nation, DOE default), and include existing Hanford risk values to determine cumulative impacts.

Institutional control boundaries need to be clearly displayed in a map, showing the GTCC proposed repository and the extent it will add to the size, scope, and timeframe of limiting access. For Indian People, a 10,000-year repository extends institutional controls without reasonable compensation or mitigation.

6.4.1.1 DOE Actions at the Hanford Site

Current DOE activities with the potential to contribute to cumulative impacts at the Hanford Site are related to site cleanup, waste disposal, and tank stabilization (DOE 2009). These include:

- Cleanup and restoration activities across all areas of the Hanford Site;

- Changes in land use;

- Decommissioning of the eight surplus reactors and their support facilities in the 100 Areas along the Columbia River;

- Decommissioning of the N Reactor and support facilities;

- Safe storage of surplus plutonium at the Plutonium Finishing Plant in the 200 West Area (until it can be shipped to the SRS for disposition);

- Deactivation of the Plutonium Finishing Plant in the 200 West Area;

- Actions to empty the K Basins in the 100 K Area and to implement dry storage of the fuel rods in the Canister Storage Building in the 200 East Area;

- Completion of the U Plant regional closure;

- Final disposition and cleanup of facilities at the 200 East and West Areas (e.g., canyons, PUREX Plant, PUREX tunnels) to comply with industrial exclusive land use standards;

- Transport of sodium-bonded spent nuclear fuel to INL for treatment;

- Deactivation of the Fast Flux Test Facility in the 400 Area;

- Construction and operations of a PNNL Physical Sciences Facility;

- Excavation and use of geologic materials from existing borrow pits;

- Construction and operations of the Environmental Restoration Disposal Facility near the 200 West Area;

- Implementation of the decisions described in the RODs for the final waste management programmatic EIS;

- Retrieval of suspect TRU waste (buried in 1970);

- Cleanup and protection of groundwater; and

- Transport of TRU waste to WIPP near Carlsbad, New Mexico.

6.4.1.2 Non-DOE Actions at the Hanford Site

Non-DOE activities with the potential to contribute to cumulative impacts at the Hanford site are related to site cleanup, waste disposal, and tank stabilization (DOE 2009). These include:

- Transport of U.S. Navy reactor plants from the Columbia River and their disposal in the 200 East Area,

- Continued operation of the Columbia Generating Station,

- Operation of the U.S. Ecology commercial LLRW disposal site near the 200 East Area,

- Management of the Hanford Reach National Monument and Saddle Mountain National Wildlife Refuge, and

- Operation of the Laser Interferometer Gravitational-Wave Observatory.

6.4.1.3 Off-Site Activities

Off-site activities with the potential to contribute to cumulative impacts relate to land clearing for agriculture and urban development, water diversion and irrigation projects, waste management, industrial and commercial development, mining, power generation, and the development of transportation and utility infrastructure (DOE 2009). Specific off-site activities near the Hanford Site include:

- Changes in regional land use as described in local city and county comprehensive land use plans;

- U.S. Department of Defense base realignment and closure;

- Cleanup of toxic, hazardous, and dangerous waste disposal sites;

- Water management for the Columbia and Yakima River basins, including the proposed Black Rock Reservoir;

- Power generation and transmission projects;

- Pipeline projects; and

- Transportation projects.

6.4.2 Cumulative Impacts from the GTCC Proposed Action at the Hanford Site

Potential impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. The summary of environmental impacts in Section 6.3 indicates that the potential impacts from the GTCC EIS proposed action (construction and operations of a borehole, trench, or vault disposal facility) would be small for all the resource areas evaluated and would not result in a meaningful contribution to overall cumulative impacts, except to human health post-closure impacts (groundwater pathway and resultant dose) from past, present, and reasonably foreseeable future actions at the Hanford Site. To obtain perspective on the cumulative impacts that could occur at the Hanford Site when the potential impacts from this EIS are considered, the cumulative impacts presented in the Hanford TC&WM EIS (DOE 2009) were reviewed for comparison of some of the resource areas evaluated in this EIS. According to the Hanford TC&WM EIS (DOE 2009), the receipt of off-site waste streams that contain specific amounts of certain isotopes, specifically iodine-129 and technetium-99, could cause an adverse impact on the environment. The evaluation presented in the TC&WM EIS indicates that 15 Ci of iodine-129 from off-site waste streams results in impacts above the maximum contaminant levels (MCLs), regardless of whether the waste streams are disposed of in the 200 East Area under Waste Management Alternative 2 or in the

200 West Area under Waste Management Alternative 3. The impacts from the technetium-99 inventory of 1,790 Ci from off-site waste streams evaluated in this Hanford EIS are shown to be less significant than those from iodine-129. However, when the impacts of technetium-99 from past leaks and cribs and trenches (ditches) are combined, DOE believes it may not be prudent to add significant additional technetium-99 to the existing environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of off-site waste streams containing iodine-129 or technetium-99 at Hanford.

The GTCC reference location would be south of the 200 East Area that has been committed to industrial exclusive use; as such, the GTCC proposed action would be consistent with this land use designation. The largest land use impacts at the Hanford Site from Alternatives 3 to 5 as presented in this EIS would result from the use of 44 ha (110 ac) for the borehole method. This amount of land is small when added to the approximately 10,051 ha (24,836 ac) that could be disturbed from cumulative actions at Hanford (DOE 2009).

The vault method could require up to 200,000 m^3 (260,000 yd^3) of soil. The cumulative soil requirements for actions at Hanford would exceed the current soil resource availability (i.e., about 76 million m^3 [99 million yd^3] required versus 58 million m^3 [75 million yd^3] available) (DOE 2009). Hence, the GTCC proposed action could require an additional small amount of soil for which a source has to be identified. Potential impacts from this future borrow area, if needed, would have to be considered in follow-on evaluations.

The relatively small acreage that would be disturbed for the GTCC proposed action would likely not contribute to cumulative impacts for cultural resources at Hanford. The Hanford TC&WM EIS indicates that cultural resources (prehistoric, historic, and paleontological resources) have a low potential of being present for a majority of DOE and non-DOE activities at Hanford (DOE 2009).

Likewise, peak annual employment resulting from the GTCC proposed action (approximately 145 direct jobs) would be small when compared with the possible cumulative total of 14,700 FTEs discussed in the Hanford TC&WM EIS.

A potential long-term impact from the GTCC proposed action would be the groundwater radionuclide concentrations that could result if the integrity of the facility did not remain intact in the distant future. The human health evaluation for the post-closure phase of the proposed action indicates that a dose of up to 48 mrem/yr (trench disposal method) or 49 mrem/yr (vault method) could be incurred by the hypothetical resident farmer assumed to be located 100 m (330 ft) from the edge of the disposal facility. It is estimated that the dose to the hypothetical receptor would be about 10 times lower if the borehole disposal method was used. These doses were calculated to occur about 1,800 years (borehole method), 3,300 years (vault method), and 2,900 years (trench method) after failure of the cover and engineered barriers, which are assumed to retain their integrity for 500 years following the closure of the disposal facility.

These doses would be primarily associated with GTCC-like RH waste, and the primary radionuclide contributors within 10,000 years would be Tc-99 and I-129. The Hanford TC&WM EIS (DOE 2009) cumulative estimates for Alternative Combination 1 indicate that the peak concentrations for Tc-99 and I-129 would be about 350,000 pCi/L and 697 pCi/L, respectively, 2,000 to 3,000 years in the future. The GTCC EIS estimates of the peak concentrations for Tc-99 and I-129 corresponding to the highest dose given above (49 mrem/yr) are about 10,000 pCi/L and 100 pCi/L; these concentrations would occur at approximately the same time as the time reported in the Hanford TC&WM EIS. As stated in the Hanford TC&WM EIS (DOE 2009), when the impacts of technetium-99 from past leaks and cribs and trenches (ditches) are combined, DOE believes it may not be prudent to add significant additional technetium-99 to the existing environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of off-site waste streams containing iodine-129 or technetium-99 at Hanford. Finally, follow-on NEPA evaluations and documents prepared to support any further considerations of siting a new borehole, trench, or vault disposal facility at Hanford would provide more detailed analyses of site-specific issues, including cumulative impacts.

6.5 SETTLEMENT AGREEMENTS AND CONSENT ORDERS FOR THE HANFORD SITE

The TC&WM EIS implements a Settlement Agreement signed on January 6, 2006, by DOE, the Washington State Department of Ecology, and the Washington State Attorney General's Office. The TC&WM EIS includes several preferred alternatives for the actions analyzed, including disposing of Hanford's LLRW and mixed LLRW on-site and deferring Hanford's importation of off-site waste at least until the Waste Treatment Plant (WTP) was operational, consistent with DOE's recently proposed Settlement Agreement with the State of Washington. The WTP is anticipated to be operational in 2022. Off-site waste would be addressed after the WTP was operational, subject to appropriate NEPA reviews. Consistent with its preference regarding receipt at Hanford of LLRW and mixed LLRW, DOE announced in the December 18, 2009, *Federal Register* (74 FR 67189) that DOE would not ship GTCC LLRW to Hanford at least until the WTP was operational. Therefore, disposal of GTCC LLRW and GTCC-like waste in a new trench, vault, or borehole facility at Hanford would be contingent upon the start of WTP operations.

In the ROD (69 FR 39449, June 30, 2004) to the January 2004 *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington* (HSW EIS), DOE announced its decision to limit the amount of off-site LLRW and mixed LLRW received at Hanford to 62,000 m^3 (81,000 yd^3) and 20,000 m^3 (26,000 yd^3), respectively, and to dispose of LLRW and mixed LLRW in lined rather than unlined trenches at Hanford. The GTCC LLRW and GTCC-like waste disposed of at Hanford would be in addition to the 62,000-m^3 (81,000-yd^3) and the 20,000 m^3 (26,000 yd^3) limits established in the ROD to the HSW EIS.

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7 IDAHO NATIONAL LABORATORY: AFFECTED ENVIRONMENT AND CONSEQUENCES OF ALTERNATIVES 3, 4, AND 5

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from the disposal of GTCC LLRW and GTCC-like waste under Alternative 3 (in a new borehole disposal facility), Alternative 4 (in a new trench disposal facility), and Alternative 5 (in a new vault disposal facility) at INL. Alternatives 3, 4, and 5 are described in Section 5.1. Environmental consequences that are common to the sites for which Alternatives 3, 4, and 5 are evaluated (including INL) are discussed in Chapter 5 and not repeated in this chapter. Impact assessment methodologies used for this EIS are described in Appendix C. Federal and state statutes and regulations and DOE Orders relevant to INL are discussed in Chapter 13 of this EIS.

7.1 AFFECTED ENVIRONMENT

This section discusses the affected environment for the various environmental resource areas evaluated for the GTCC reference location at INL. The GTCC reference location is situated to the southwest of the Advanced Test Reactor (ATR) Complex in the south central portion of INL (see Figure 7.1-1.). The reference location was selected primarily for evaluation purposes for this EIS. The actual location would be identified on the basis of follow-on evaluations if and when it is decided to locate a land disposal facility at INL.

7.1.1 Climate, Air Quality, and Noise

7.1.1.1 Climate

At INL and the surrounding area, which are located along the western edge of the Eastern Snake River Plain (ESRP), the climate is characterized as that of a semiarid steppe (DOE 2005). The location of INL and its surrounding area in the ESRP, including their altitude above sea level, latitude, and inter-mountain setting, affects the climate of the site (Clawson et al. 1989). Air masses crossing the ESRP, which gather moisture over the Pacific Ocean and traverse several hundred miles of mountainous terrains, have been responsible for a large percentage of any inherent precipitation. The relatively dry air and infrequent low clouds allow intense solar heating of the surface during the day and rapid radiative cooling at night. Accordingly, the climate exhibits low relative humidity, wide daily temperature swings, and large variations in annual precipitation. Most of the following discussion is extracted from Clawson et al. (1989) for the period 1950–1988. Because of the size and topographic features of the INL site, meteorological data differ from station to station within and around the site. Meteorological data are presented for the Central Facilities Area (CFA), which is the area closest to the GTCC reference location that has an on-site station with comprehensive meteorological data.

As shown in Figure 7.1.1-1, most on-site locations experience the predominant southwest-northeast wind flow of the ESRP, although some discrepancies from this flow pattern

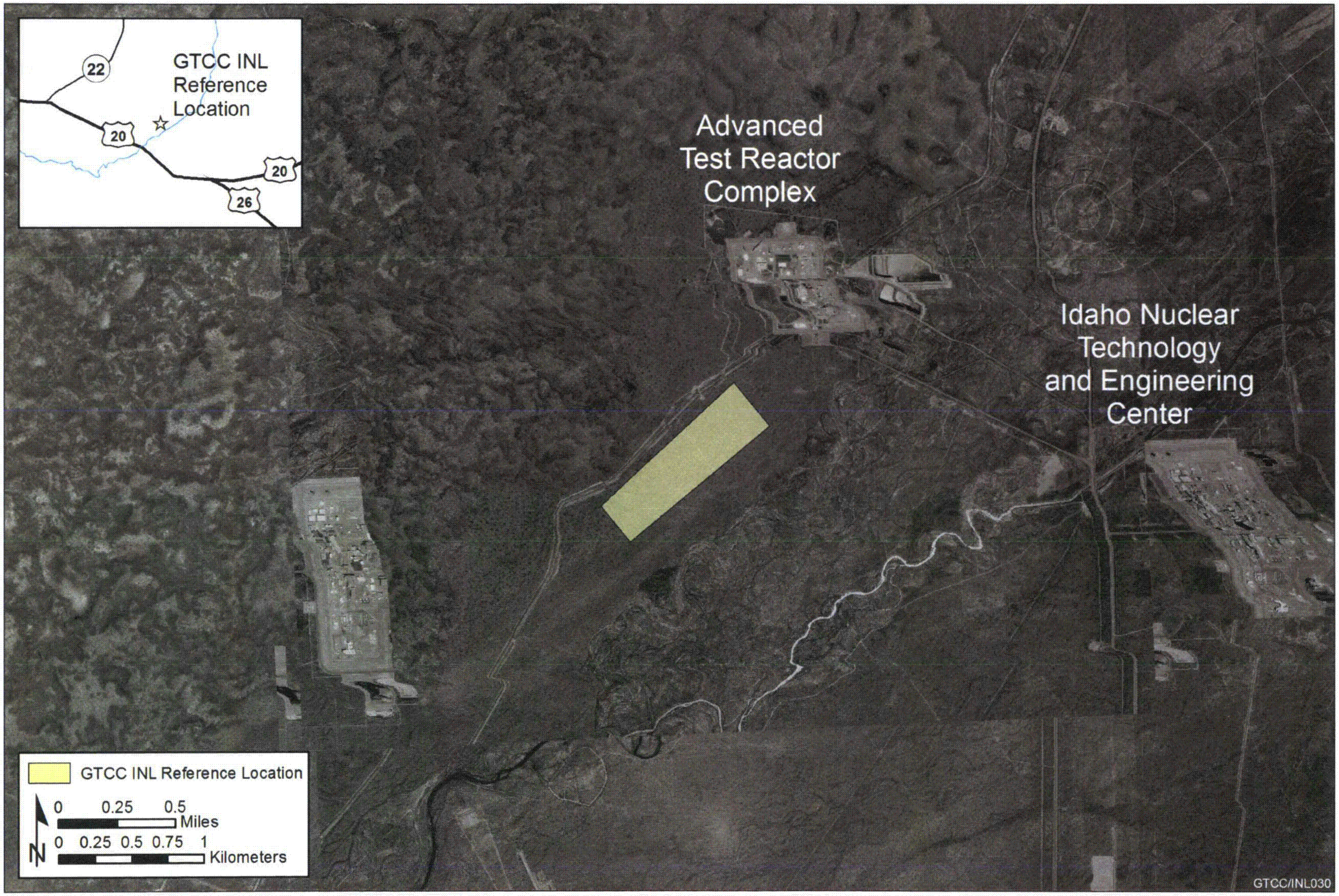
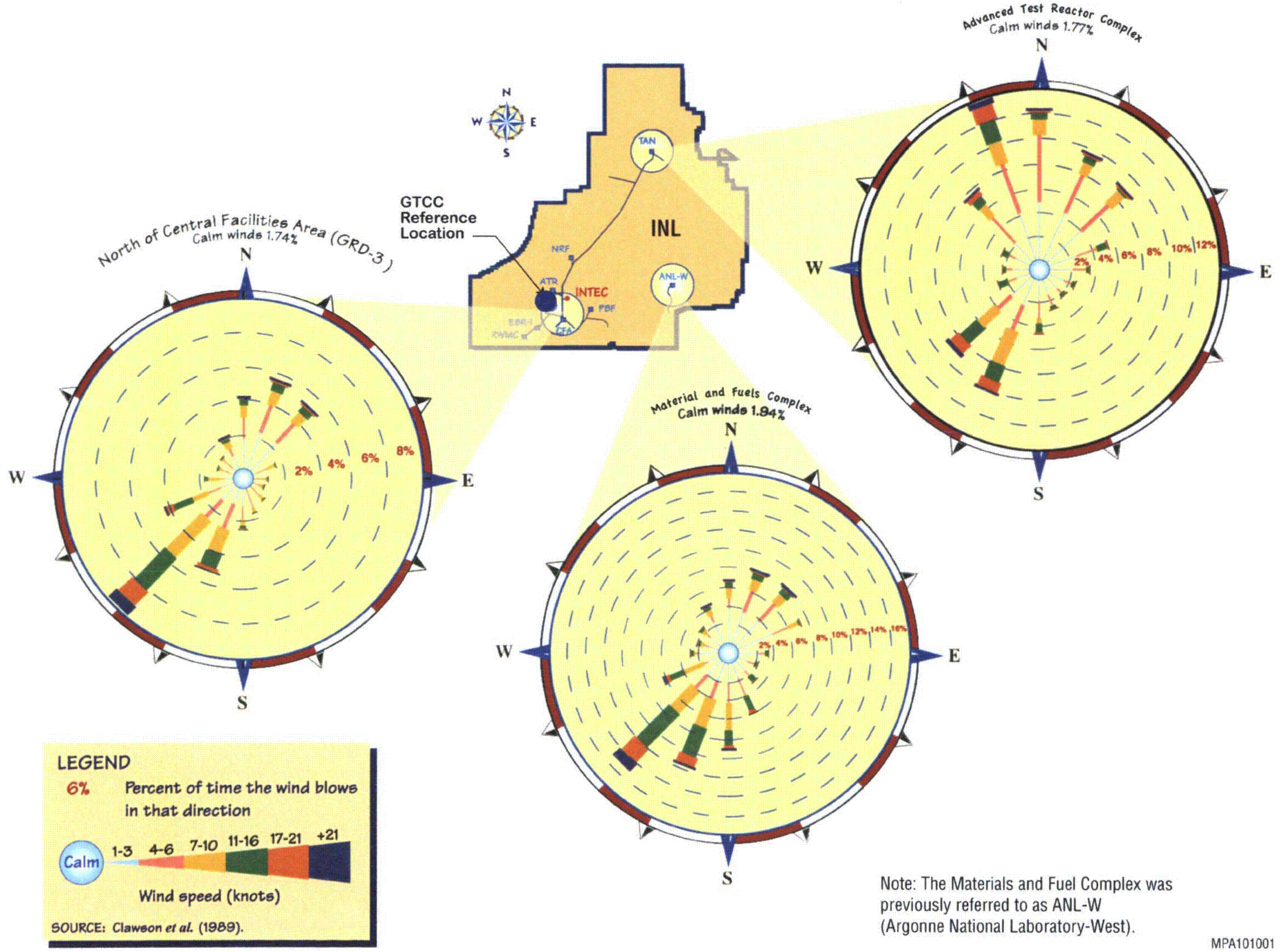


FIGURE 7.1-1 GTCC Reference Location at INL



Note: The Materials and Fuel Complex was previously referred to as ANL-W (Argonne National Laboratory-West).

FIGURE 7.1.1-1 Wind Roses at Meteorological Stations on the INL Site (Source: DOE 2002) exist because of local terrain features (Clawson et al. 1989). The mountains bordering the ESRP act to channel the prevailing west winds into a southwesterly flow. This flow results because of the northeast-southwest orientation of the ESRP between the bordering mountain ranges. The second most frequent wind direction is from the northeast. Average annual wind speeds at the CFA 6-m (20-ft) tower are about 3.4 m/s (7.5 mph). Wind speeds are fastest in spring (4.1 m/s or 9.1 mph), slower in summer and fall, and slowest (2.6 m/s or 5.9 mph) in winter. The highest hourly average near-ground wind speed measured for CFA was 23 m/s (51 mph) from west-southwest, with a maximum instantaneous gust of 35 m/s (78 mph).

For the 1950–1988 period, the annual average temperature for CFA was 5.6°C (42.0°F) (Clawson et al. 1989). January was the coldest month, averaging –8.8°C (16.1°F) and ranging from –13.9 to –1.1°C (7.0 to 30.0°F), and July was the warmest month, averaging 20.0°C (68.0°F) and ranging from 18.3 to 22.2°C (64.9 to 72.0°F). For the same period, temperature extremes for CFA ranged from a summertime maximum of 38.3°C (101°F) to a wintertime minimum of –43.9°C (–47°F). As mentioned above, the average daily average temperature ranges are significant. July and August had an average daily air temperature of 21°C (70°F), while December and January had an average daily air temperature of 13°C (55°F) at CFA.

Although the total amount of precipitation at CFA is light, it can be expected in any month of the year. Annual precipitation at INL averages about 22.1 cm (8.7 in.) for CFA (Clawson et al. 1989). Precipitation is relatively evenly distributed by season, with the pronounced precipitation peak in May and June primarily due to regional major synoptic conditions. The maximum 24-hour precipitation is 4.2 cm (1.6 in.), which is primarily attributable to thunderstorms occurring 2 to 3 days per month in summer. Snow typically occurs from September through May, peaking in December and January. The annual average snowfall in the area is about 70 cm (28 in.), with extremes of 17 cm (6.8 in.) and 150 cm (60 in.).

Other than thunderstorms, severe weather is uncommon because high mountains block air masses from penetrating into the area, although blowing dust occurs during spring and summer, and dust devils are common in summer. INL may experience an average of two or three thunderstorm days during the summer months, with considerable year-to-year variation (Clawson et al. 1989).

Tornadoes in the area surrounding the INL site are much less frequent and destructive than those in the tornado alley in the central United States. For the period 1950–2008, 185 tornadoes were reported in Idaho, with an average of 3.2 tornadoes per year (NCDC 2008). For the period 1950–2008, 45 tornadoes (an average of 0.8 tornado per year) were reported in five counties encompassing the INL site (Bingham, Bonneville, Butte, Clark, and Jefferson). However, most of these tornadoes were relatively weak (i.e., 44 were F0 or F1, and 1 was F2). No deaths and three injuries were associated with these tornadoes. Five funnel clouds and no tornadoes were reported on-site between 1950 and 1997 (DOE 2002).

7.1.1.2 Existing Air Emissions

Title V of the 1990 Clean Air Act Amendments (CAAA) requires the EPA to develop a federally enforceable operating permit program for air pollution sources to be administered by state and/or local air pollution agencies. The EPA promulgated regulations in July 1992 that defined the requirements for state programs. Idaho has promulgated regulations, and the EPA has given interim approval of the Idaho Title V (Tier I) operating permit program. As of 2008, the INL has one Tier I operating permit and 15 active "permits to construct."

Annual emissions for major facility sources and total point and area source emissions (for year 2002) for criteria pollutants and VOCs in the five counties encompassing the INL site are presented in Table 7.1.1-1 (EPA 2009). (Data for 2002 are available on the EPA website). There are few major point sources in the area (INL sources are the major ones in the area); thus, area sources account for most of the emissions of criteria pollutants and VOCs. On-road sources, solvent utilization sources, and miscellaneous sources, respectively, are major contributors to total emissions of NO_x; of VOCs; and of CO, PM_{10}, and $PM_{2.5}$. Nonradiological emissions associated with activities at the INL site are less than 50% of those in Butte County and less than 3.5% of those in the five counties combined, as shown in the table.

The primary source of air pollutants at INL is fuel oil combustion for heating (DOE 2005). Other emission sources include waste burning, industrial processes, stationary diesel engines, vehicles, and fugitive dust from waste burial and construction activities. Table 7.1.1-2 presents emissions for criteria pollutants and VOCs under the Title V permit for the year 2004.

7.1.1.3 Air Quality

Among criteria pollutants (SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$, and lead), the Idaho SAAQS are identical to the NAAQS for SO_2, NO_2, CO, 1-hour O_3, PM_{10}, and lead (EPA 2008a; Idaho Administrative Procedures Act [IDAPA] 58.01.01), as shown in Table 7.1.1-3. However, no standards have been established for 8-hour O_3 and $PM_{2.5}$ in Idaho, and the state has adopted standards for fluorides, as presented in the table.

The INL site is located primarily within Butte County, but portions are also in Bingham, Bonneville, Clark, and Jefferson Counties. Currently, the entire counties encompassing the INL site are designated as being in attainment for all criteria pollutants (40 CFR 81.313). However, parts of Bannock and Power Counties, about 48 km (30 mi) southeast and 56 km (35 mi) south of the INL boundary, respectively, are designated nonattainment for PM_{10}.

In 2006, the environmental surveillance, education, and research contractor sampled ambient air, including 24-hour PM_{10} levels, at communities beyond the INL boundary (DOE 2007). Concentrations at Rexburg ranged from 0.0 to 44.8 $\mu g/m^3$, while those at Blackfoot ranged from 0.3 to 50.1 $\mu g/m^3$. Concentrations at Atomic City ranged from 0.0 to 66.1 $\mu g/m^3$, and thus all 24-hour concentrations were well below the EPA standard of 150 $\mu g/m^3$. In addition, all measurements were less than the EPA standard for annual average concentrations.

TABLE 7.1.1-1 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds from Selected Major Facilities and Total Point and Area Source Emissions in Five Counties Encompassing the INL Site[a]

	Emission Rate (tons/yr)					
Emission Category	SO_2	NO_X	CO	VOCs	PM_{10}	$PM_{2.5}$
Bingham County						
Basic American Foods[b]	*8.5*	*116*	*203*	*7.2*	*98*	*63*
Point sources	32	251	380	16	222	133
Area sources	175	3,614	28,385	7,456	17,102	2,806
Total	207	3,865	28,765	7,472	17,324	2,939
Bonneville County						
Point sources	56	20	0	0.8	13	8.3
Area sources	282	4,200	25,899	8,944	13,318	2,385
Total	338	4,220	25,899	8,945	13,331	2,393
Butte County						
INL	*68*	*117*	*29*	*5.3*	*14*	*7.4*
	75.78%[c]	*27.14%*	*0.87%*	*0.69%*	*0.63%*	*1.55%*
	8.71%	*1.11%*	*0.04%*	*0.02%*	*0.03%*	*0.10%*
Point sources	68	120	29	5.3	14	7.4
Area sources	22	314	3,254	768	2,269	471
Total	90	432	3,283	773	2,283	479
Clark County						
Larsen Farms	*0.9*	*139*	*23*	*3.7*	*34*	*12*
Point sources	0.9	139	23	3.7	34	12
Area sources	15.3	147	6,217	3,269	864	215
Total	16.2	286	6,240	3,273	898	227
Jefferson County						
Point sources	2.0	32	0.0	1.5	50	33
Area sources	129	1,705	13,851	4,154	10,078	1,478
Total	131	1,738	13,851	4,156	10,128	1,511
Five-county total	782	10,541	78,038	24,619	43,964	7,549

[a] Emission data for selected major facilities and total point and area sources are for year 2002. CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 μm, PM_{10} = particulate matter ≤ 10 μm, SO_2 = sulfur dioxide, VOCs = volatile organic compounds.

[b] Data in italics are not added to yield total.

[c] The top row and bottom row with % signs show the above source's emissions as percentages of Butte County total emissions and five-county total emissions, respectively.

Source: EPA (2009)

Nearby urban or suburban measurements are typically used as being representative of background concentrations for the INL site. The highest concentration levels for SO_2, NO_2, CO, and lead around the INL site are less than or equal to 39% of their respective standards in Table 7.1.1-3 (EPA 2009). However, the highest O_3, PM_{10}, and $PM_{2.5}$ concentrations somewhat approach or exceed the applicable standards (maximum of 169% for $PM_{2.5}$ due to recent standard revision) in the area. Relatively high PM levels are attributable to agricultural activities in the region, frequent dust storms, and forest fires.

TABLE 7.1.1-2 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds at INL in 2004

Emission Rate (tons/yr)[a]			
SO_x	NO_x	VOCs	PM_{10}
9.1	63.9	1.7	3.5

Source: DOE (2005)

The INL site and its vicinity are classified as PSD Class II areas. The only Class I area within 100 km (62 mi) is the Crater of the Moon Wilderness Area, about 40 km (25 mi) west-southwest of the GTCC reference location (40 CFR 81.410).

7.1.1.4 Existing Noise Environment

Except for the prohibition of nuisance noise, neither the state of Idaho nor local governments around the INL site have established quantitative noise-limit regulations. For the general area surrounding the INL site, countywide day-night sound levels (L_{dn}) based on population density are estimated to be the highest (at 39 dBA) in Bonneville County. They are around 35 dBA in Bingham and Jefferson Counties, a level that is typical of rural areas (Miller 2002; Eldred 1982). They are less than 30 dBA in Butte and Clark Counties, a level that is similar to the natural background noise level of a wilderness area.

The major noise sources at INL include various industrial activities and equipment (e.g., cooling systems, transformers, engines, pumps, boilers, steam vents, paging systems), construction and material-handling equipment, and vehicles (DOE 2005). Most INL industrial facilities are far enough from the site boundary that noise levels from these sources are not measurable or are barely distinguishable from background levels at the boundary. Existing noise levels related to INL that are of public significance result from the transportation of people and material to and from the site and facilities located in town via buses, private vehicles, and freight trains.

Although no environmental survey data on noise around the site boundaries were available, noise measurement data were available for 15 m (50 ft) from the roadway along U.S. Route 20 (DOE 2005). Traffic noise levels ranged from 64 to 86 dBA,[1] and the primary source was buses (71 to 80 dBA). While few residences exist within 15 m (50 ft) from the roadway, INL-related traffic noise might be objectionable to members of the public residing near

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[1] The levels seem to be peak pass-by measurements, so L_{dn} values that use a 24-hour averaging time would be much lower, except when there are high traffic volumes during the day and night.

TABLE 7.1.1-3 National Ambient Air Quality Standards (NAAQS) or Idaho State Ambient Air Quality Standards (SAAQS) and Highest Background Levels Representative of the GTCC Reference Location at INL, 2003–2007

			Highest Background Level	
Pollutant[a]	Averaging Time	NAAQS/ SAAQS[b]	Concentration[c,d]	Location (Year)
SO_2	1-hour	75 ppb	–[e]	–
	3-hour	0.50 ppm	0.059 ppm (12%)	Pocatello, Bannock Co. (2005)
	24-hour	0.14 ppm	0.024 ppm (17%)	Pocatello, Bannock Co. (2007)
	Annual	0.03 ppm	0.006 ppm (20%)	Pocatello, Bannock Co. (2007)
NO_2	1-hour	0.100 ppm	–	–
	Annual	0.053 ppm	0.008 ppm (16%)	Power Co. (2004)
CO	1-hour	35 ppm	6.0 ppm (17%)	Nampa, Canyon Co. (2003)[f]
	8-hour	9 ppm	3.5 ppm (39%)	Nampa, Canyon Co. (2003)[f]
O_3	1-hour	0.12 ppm[g]	0.078 ppm (65%)	Butte Co. (2007)
	8-hour	0.075 ppm	0.070 ppm (93%)	Butte Co. (2003)
PM_{10}	24-hour	150 μg/m^3	120 μg/m^3 (80%)	Bingham Co. (2003)
	Annual	50 μg/m^3	37 μg/m^3 (74%)	Bingham Co. (2003)
$PM_{2.5}$	24-hour	35 μg/m^3	59 μg/m^3 (169%)	Idaho Falls, Bonneville Co. (2004)
	Annual	15.0 μg/m^3	10.1 μg/m^3 (67%)	Idaho Falls, Bonneville Co. (2004)
Lead[h]	Calendar quarter	1.5 μg/m^3	0.03 μg/m^3 (2.0%)	Kellogg, Shoshone Co. (2002)[f]
	Rolling 3-month	0.15 μg/m^3	–	–
Fluorides	Monthly	80 ppm	–	–
	Bimonthly	60 ppm	–	–
	Annual arithmetic mean	40 ppm	–	–

[a] CO = carbon monoxide, NO_2 = nitrogen dioxide, O_3 = ozone, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, SO_2 = sulfur dioxide.

[b] The more stringent between the NAAQS and the SAAQS is listed when both are available.

[c] Monitored concentrations are the highest arithmetic mean for calendar-quarter lead; second-highest for 3-hour and 24-hour SO_2, 1-hour and 8-hour CO, 1-hour O_3, and 24-hour PM_{10}; fourth-highest for 8-hour O_3; 98th percentile for 24-hour $PM_{2.5}$; arithmetic mean for annual SO_2, NO_2, PM_{10}, and $PM_{2.5}$.

[d] Values in parentheses are monitored concentrations as a percentage of SAAQS or NAAQS.

[e] A dash indicates that no measurement is available.

[f] These locations with highest observed concentrations in the state of Idaho are not representative of the INL site but are presented to show that these pollutants are not a concern over the state of Idaho.

Footnotes continue on next page.

TABLE 7.1.1-3 (Cont.)

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[g] On June 15, 2005, the EPA revoked the 1-hour O_3 standard for all areas except the 8-hour O_3 nonattainment Early Action Compact (EAC) areas (those do not yet have an effective date for their 8-hour designations). The 1-hour standard will be revoked for these areas 1 year after the effective date of their designation as attainment or nonattainment for the 8-hour O_3 standard.

[h] Used old standard because no data in the new standard format are available.

Sources: 40 CFR 52.21; EPA (2008a, 2009); IDAPA 58.01.01 (refer to http://adm.idaho.gov/adminrules/rules/idapa58/0101.pdf)

principal highways or busy bus routes. Noise levels along these routes may have decreased somewhat as a result of reductions in employment and bus service at INL in the last few years. Because noise levels from industrial activities at INL are not measurable or are only barely distinguishable at the INL boundary, the acoustic environment along the INL boundary has relatively low ambient noise levels, ranging from 35 to 40 dBA (DOE 2002).

7.1.2 Geology and Soils

7.1.2.1 Geology

7.1.2.1.1 Physiography. INL sits on a relatively flat area along the northwestern edge of the ESRP, within the ESRP Physiographic Province (Figure 7.1.2-1). The ESRP was built up from multiple eruptions of basaltic lava between 4 million and 2,100 years ago. Four volcanic rift zones, each with a northwestern trend, cut across the plain and have been identified as the source areas for these eruptions. The volcanic rift zone orientations are the result of basalt dikes that intruded perpendicular to the northeast-southwest direction of extension associated with the Basin and Range Physiographic Province. The most recent episode of basalt volcanism occurred 2,000 years ago in the Great Rift volcanic rift zone to the south of INL (DOE 2005; Payne 2006).

Surficial sediments overlying the uppermost basalt consist of unconsolidated clay, silt, sand, and gravel and range in thickness from 0 to 95.4 m (0 to 313 ft). These materials represent alluvial, lacustrine (lake or playa basins), eolian, and colluvial deposits that have accumulated on the plain during the past 200,000 years (Anderson et al. 1996; DOE 2005).

The ESRP is bounded on the north and south by the north-to-northwest trending mountains of the northern Basin and Range Physiographic Province. The mountain peaks, reaching heights of 3,660 m (12,000 ft), are separated by basins filled with terrestrial sediments and volcanic rocks. The basins are 5- to 20-km (3- to 12- mi) wide and grade onto the ESRP. The Yellowstone Plateau lies to the northeast of the ESRP (DOE 2005).

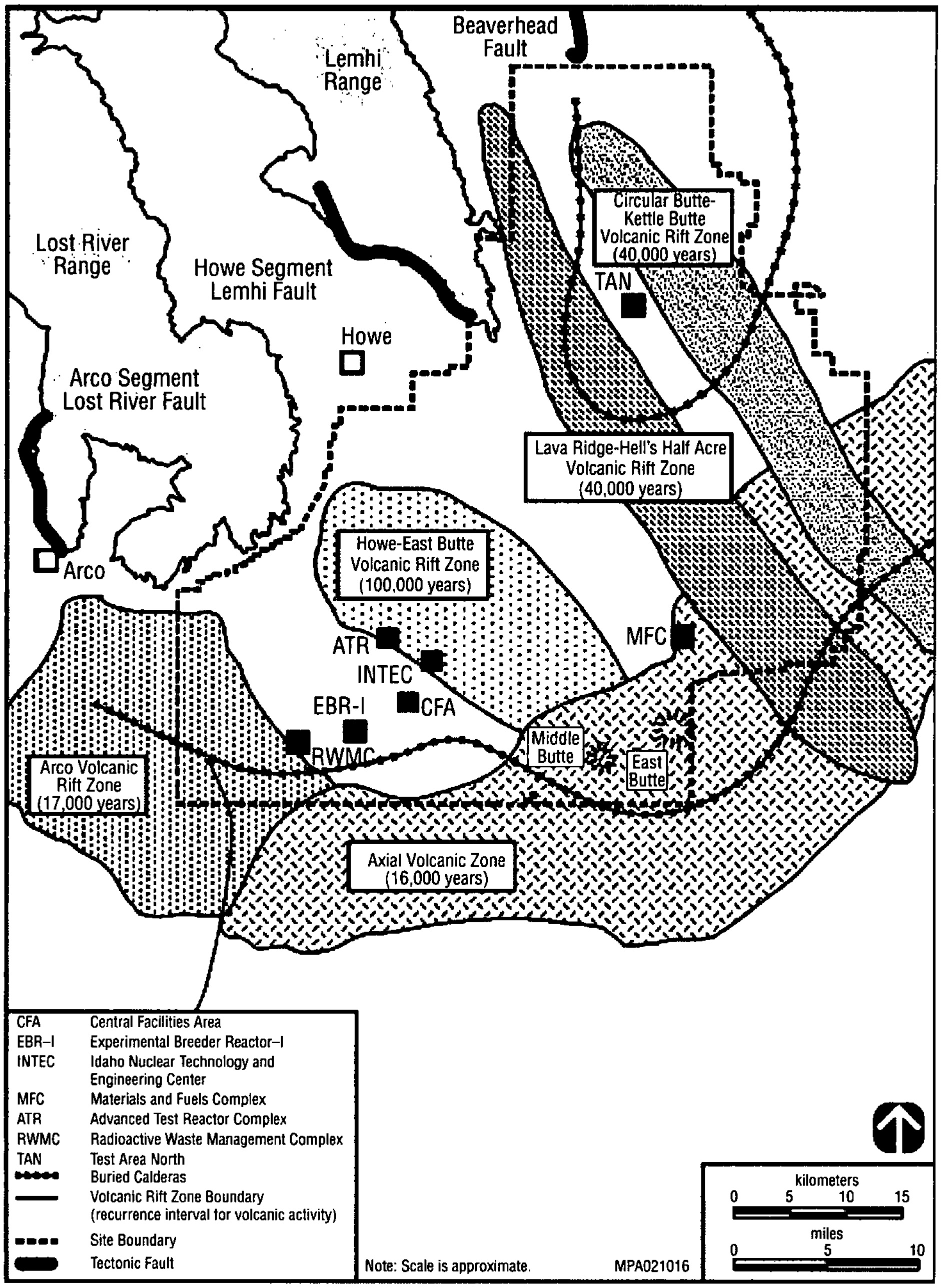


FIGURE 7.1.2-1 Location of INL on the Eastern Snake River Plain (Source: DOE 2005)

7.1.2.1.2 Topography. The land surface in the INL region is relatively flat, with elevations ranging from 1,460 m (4,790 ft) in the south to 1,802 m (5,912 ft) in the northeast. Predominant relief occurs as volcanic buttes or as unevenly surfaced basalt flows or flow vents and fissures. Mountain ranges border the site on the north and west (Mattson et al. 2004).

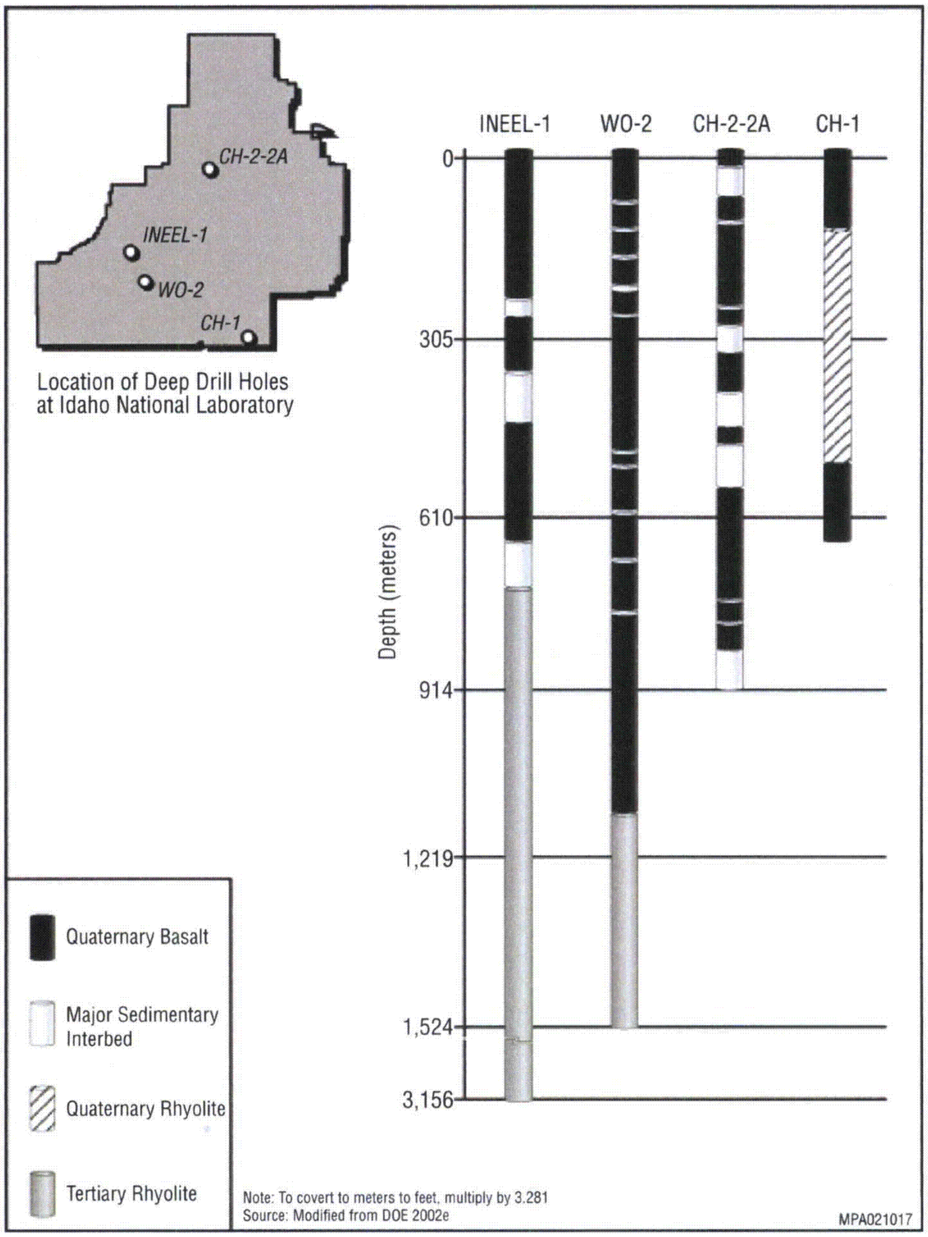
7.1.2.1.3 Site Geology and Stratigraphy. INL is underlain by about 1 to 2 km (0.6 to 1.2 mi) of Quaternary age basaltic lava flows interbedded with poorly consolidated sedimentary materials. Interbedded sediments consist of materials deposited by streams (silts, sands, and gravels), lakes (clays, silts, and sands), and wind (silts) that accumulated on the ESRP between volcanic events. During long periods of inactivity, sediments accumulated to thicknesses greater than 60 m (197 ft). The interbedded basalt flow sequences are collectively known as the Snake River Group (DOE 2005). Stratigraphic data from wells in the vicinity of the GTCC reference location indicate that the first basalt unit is encountered at depths of 13 to 17 m (43 to 57 ft). The average thickness of the basalt unit is about 30 m (100 ft). A layer of sediment material underlies the basalt unit, ranging in thickness from 5.8 to 12 m (19 to 40 ft). One well (USGS 326) drilled within the boundary of the GTCC reference location shows a second basalt unit occurring at a depth of about 62 m (205 ft); the unit is about 3.7-m (12-ft) thick (Anderson et al. 1996).

Underlying the Snake River Group is a thick sequence of Tertiary rhyolitic volcanic rocks that erupted when the area was over the Yellowstone Hotspot, over 4 million years ago.

Several Quaternary rhyolitic domes are located along the Axial Volcanic Zone near the south and southeastern borders of INL. Paleozoic limestones, Late Tertiary rhyolitic volcanic rocks, and large alluvial fans are located in limited areas along the northwestern border. A wide band of Quaternary alluvium extends across the site along the course of the Big Lost River. Ice-age lake deposits (Lake Terreton), eroded by winds in the late Pleistocene and Holocene, were redeposited to form large dune fields in the northeastern portion of INL. The wind-blown loess deposits (silts) may be up to 2.1-m (7-ft) thick on basaltic lava flows throughout INL (DOE 2005).

The GTCC reference location is situated immediately southwest of the ATR Complex in the south-central part of INL. It sits at the southern edge of the Howe-East Butte Volcanic Rift Zone on a thick sequence of Quaternary basalt interbedded with sediments of various textures. Figure 7.1.2-2 presents the lithologic logs of deep drill holes across INL and near the ATR Complex (e.g., INEEL-1).

7.1.2.1.4 Seismicity. The historical earthquake record between 1872 and 2004 shows the ESRP to be aseismic compared to the surrounding Basin and Range Province (Figure 7.1.2-3). Earthquakes within the Basin and Range Province to the northwest of INL indicate extension in a predominantly northeast-southwest direction. Crustal extension began in this area in the Middle Miocene, about 16 million years ago. The southern segments of three northwest-trending Basin and Range normal faults are located along the northwest boundary of INL (Figure 7.1.2-4). The largest normal-faulting earthquakes occurred more than 80 km (50 mi) from INL: in 1959, near Hebgen Lake, Montana (7.3 magnitude), and in 1983, near Borah Peak, Idaho (7.0 magnitude)



Note: To covert to meters to feet, multiply by 3.281
Source: Modified from DOE 2002e

FIGURE 7.1.2-2 Lithologic Logs of Deep Drill Holes at INL (Source: DOE 2005)

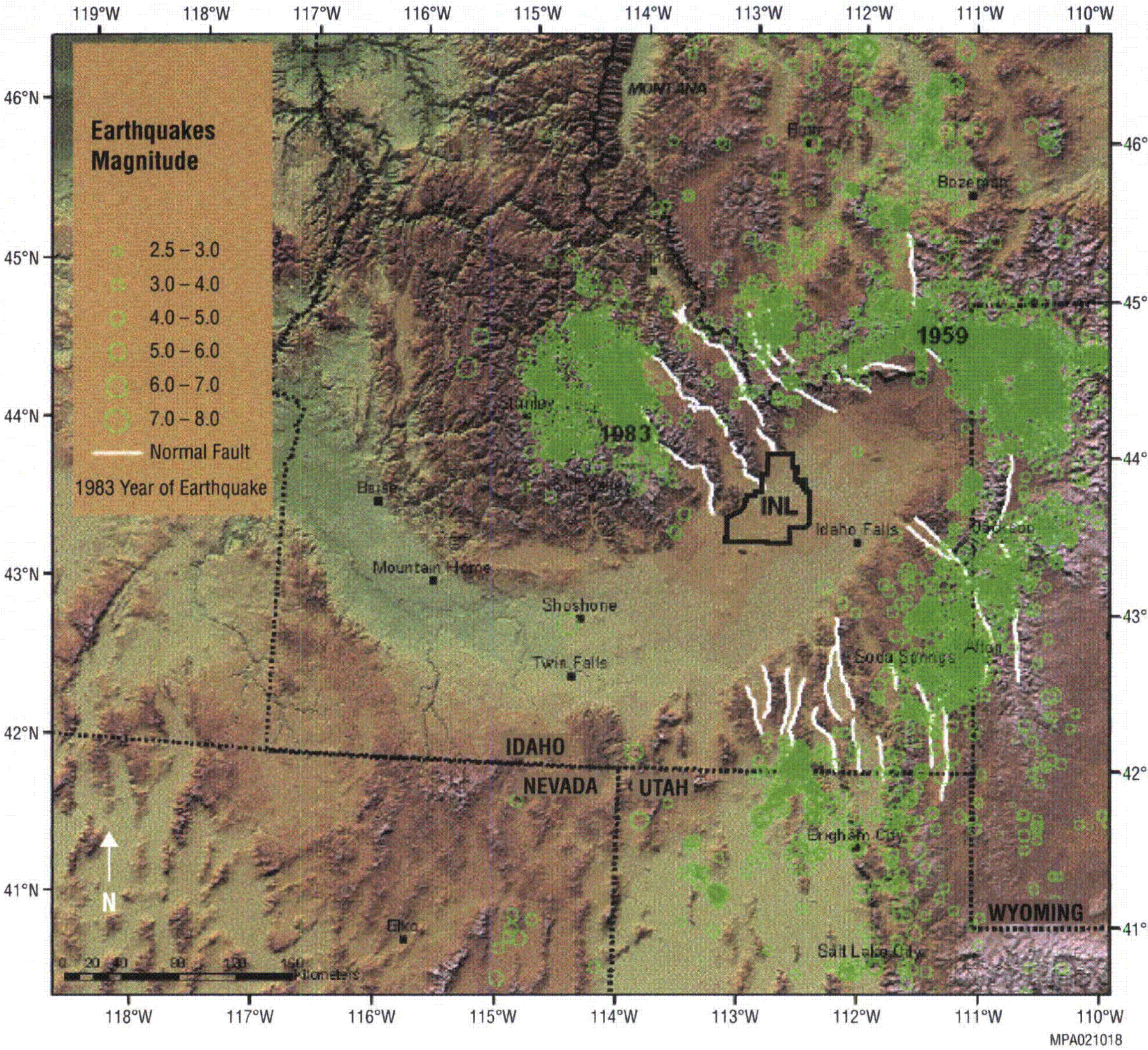


FIGURE 7.1.2-3 Map of Earthquakes with Magnitudes of 2.5 or Greater Occurring from 1872 to 2004 near INL (The Hebgen Lake and Borah Peak earthquakes are indicated as “1959” and “1983” on the map, respectively.) (Source: Payne 2006)

(Figure 7.1.2-3). The earthquakes were felt at INL but caused no significant damage (Payne 2006).

The nearest capable fault to the ATR Complex is the Howe Segment of the Lemhi Fault. The fault terminates near the northwestern INL boundary about 32 km (20 mi) north of the ATR Complex (Figure 7.1.2-1). Other significant faults include the Arco Segment of the Lost River Fault and the Beaverhead Fault. These faults also run along the range front to the northwest of INL.

The INL Seismic Monitoring Program, which began in 1971, has 27 permanent seismic stations to determine the time, location, and size of earthquakes occurring near INL. The

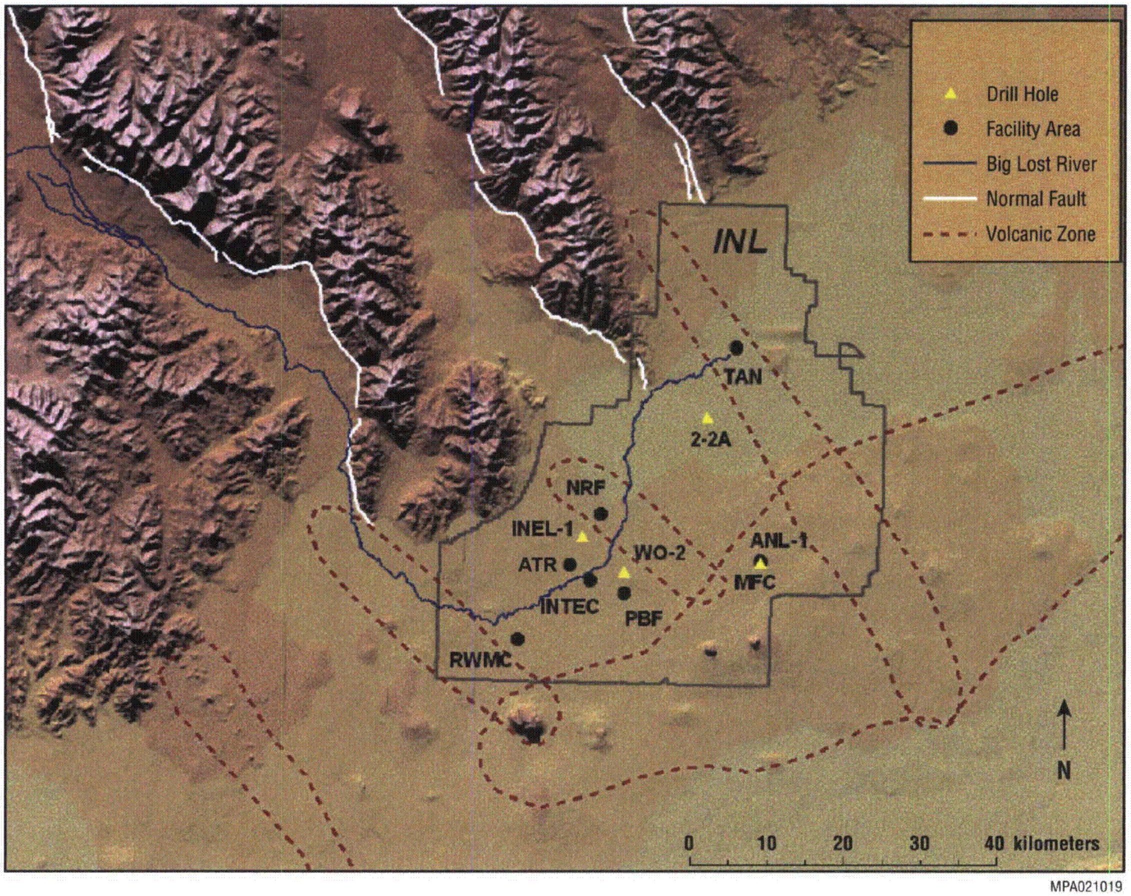


FIGURE 7.1.2-4 Locations of Normal Faults, Volcanic Rift Zones, Deep Drill Holes, and INL Facility Areas (Source: Payne 2006)

program also operates 24 strong-motion accelerographs in INL facility buildings to record strong ground motions from local moderate or major earthquakes. Seismic monitoring provides data for validating current ground motion models and serves as an early detection system for future volcanism, since low-magnitude earthquake swarms accompany the upward movement of magma. The locations of seismic stations and accelerographs are provided in Payne et al. (2007). In 2006, 356 earthquakes occurred within a 161-km (100-mi) radius of INL. Three of these earthquakes had moment magnitudes greater than 3.0 (the largest earthquake had a magnitude of 4.5). The majority of earthquakes were located in areas that are known to be seismically active, along the normal faults of the Basin and Range Province to the northwest of INL. Three earthquakes occurred along the ESRP in 2006. Two of the 2006 earthquakes (magnitude of 2.0 and 0.4) were located within INL boundaries.

Seismic history and geologic conditions indicate that earthquakes with a moment magnitude of more than 5.5 and the associated strong ground shaking and surface rupture would probably not occur within the ESRP; however, moderate to strong ground shaking from earthquakes in the Basin and Range Province could be felt at INL.

A probabilistic assessment of seismic hazard was conducted by Woodward-Clyde Federal Services in 1996 for all INL facility areas, including the Test Reactor Area. It was recomputed in 2000 (WCFS 1996; Payne et al. 2000). The assessments determined that the probabilistic seismic hazard for annual probabilities of once in 2000 years (0.0005) and once in 10,000 years (0.0001) would be 0.11g and 0.18g, respectively, for the ATR Complex, where g is the acceleration of gravity (9.8 m/s/s). These levels are now part of the seismic design criteria for new facilities (Payne 2008). Payne (2007) summarizes the modeling aspects of these assessments, including the modeling of site-specific attenuation relationships.

7.1.2.1.5 Volcanic Activity. Most of the basalt volcanic activity along the ESRP in the vicinity of INL occurred from 4 million to 2,100 years ago. The most recent and closest volcanic eruption occurred at Craters of the Moon National Monument, 44 km (27 mi) southwest of INL.

A volcanic hazard risk assessment by Hackett and Khericha (1993) determined that the major volcanic hazard at INL is the inundation of basaltic lava flows in the event of an eruption within the Great Rift volcanic rift zone. The frequency of a basaltic eruption that could impact areas near the ATR Complex is very low (7.0×10^{-7}), which places it in the "beyond design basis" frequency range (DOE 2002). More explosive rhyolitic volcanism is not expected to occur since the Yellowstone Hotspot is no longer present beneath the site (Payne 2008). The Yellowstone Hotspot currently underlies the Yellowstone National Park area, about 113 km (70 mi) to the northeast.

7.1.2.1.6 Slope Stability, Subsidence, and Liquefaction. No natural factors in the ATR Complex region that would affect the engineering aspects of slope stability have been reported. Ground stability is not expected to be affected by the presence of lava tubes at the site. The potential hazard due to liquefaction is expected to be low (DOE 2005).

7.1.2.2 Soils

Unconsolidated material covers the GTCC reference location and consists of alluvial sediments deposited by the Big Lost River. Sediments are composed mostly of gravel, gravelly sands, and sands ranging in thickness from about 13 to 17 m (43 to 57 ft). A thin layer of silt and clay may underlie the alluvium in places, creating a low-permeability layer at the sediment-basaltic rock contact (Anderson et al. 1996; DOE 2005).

No soils have been designated as prime farmland within INL boundaries (DOE 2005).

7.1.2.3 Mineral and Energy Resources

Mineral resources at INL include sand, gravel, pumice, silt, clay, and aggregate. These resources are extracted at several quarries or pits at the site for use in road construction and maintenance, new facility construction and maintenance, waste burial activities, and landscaping. There is a gravel pit at the ATR Complex.

The geology of the ESRP makes the potential for petroleum production very low. The potential for geothermal energy development exists at INL; however, a study conducted in 1979 found no economic geothermal resources (Mitchell et al. 1980).

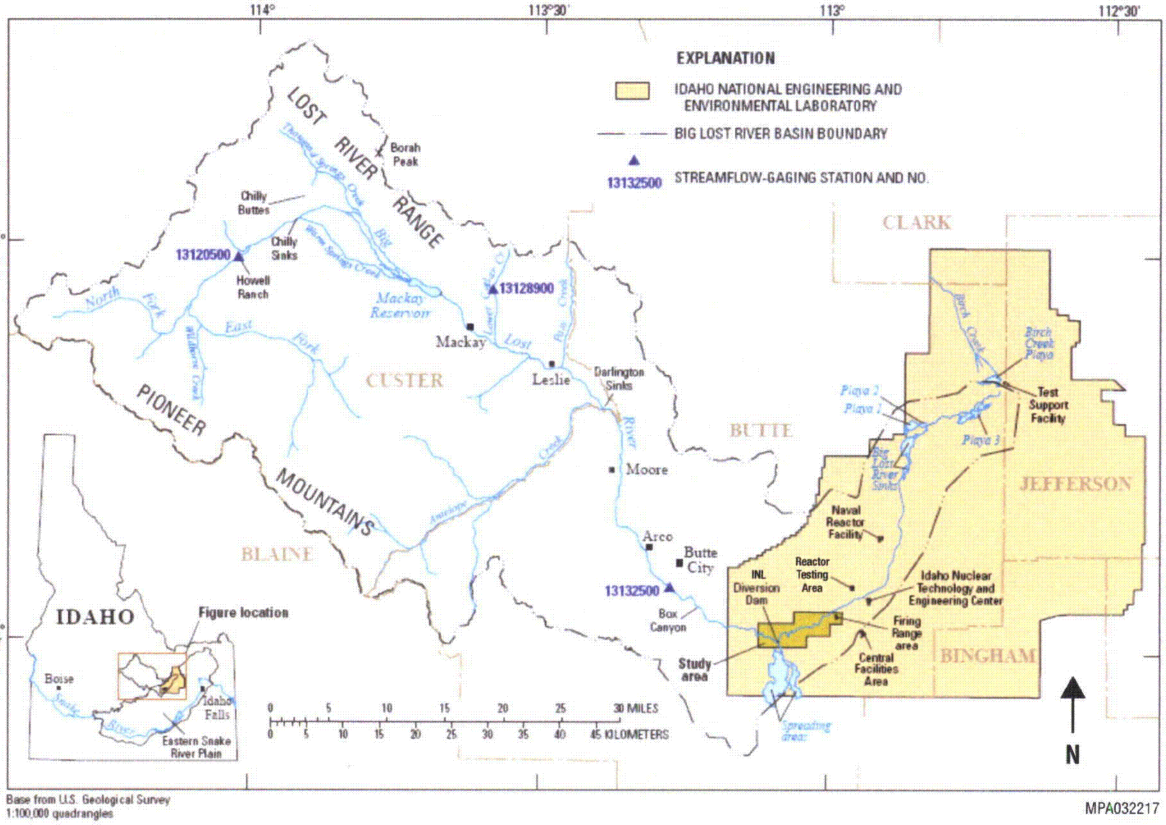
7.1.3 Water Resources

7.1.3.1 Surface Water

7.1.3.1.1 Rivers and Streams. The INL site is located within the Mud Lake-Lost River Basin (also called the Pioneer Basin), a closed drainage basin in which surface water infiltrates the ground surface or is lost through evapotranspiration (DOE 2005). There are three main streams within the basin: the Big and Little Lost Rivers and Birch Creek (Figure 7.1.3-1 and Figure 1.4.3-5). These streams drain the mountain areas to the north and west of INL and are intermittent (DOE 2005).

Stream flow in the Big Lost River is extensively regulated to provide irrigation water for the Big Lost Valley. Water is stored in Mackay Reservoir, a 4.75×10^7-m^3 (38,500 ac-ft) capacity reservoir that is located about 72.4 km (45 mi) upstream of INL, and it is delivered by many large diversion channels throughout the growing season (April through October). The river flows southeast from Mackay Dam, past the towns of Mackay, Leslie, and Arco, and onto the ESRP. It drains more than 3,600 km^2 (1,400 mi^2) of mountainous area, including parts of the Lost River Range and Pioneer Range to the west of INL, as shown in Figure 7.1.3-1 (Berenbrock et al. 2007; Hortness and Rousseau 2003). The average annual discharge for the Big Lost River near Arco (Station 13132500) for 51 years of stream flow data (1947 though 1960, 1967 through 1979, and 1983 through 2006) is highly variable, ranging from zero during several years to 13.82 cms (488 cfs) in 1984. The average annual discharge between 1986 and 2006 was 2.39 cms (84.3 cfs) (USGS 2008a).

Since 1958, a diversion dam near the INL southwestern site boundary has diverted water to a series of natural depressions or spreading centers to the south to prevent flooding of downstream areas during periods of heavy runoff. In summer months, most of the flow in the Big Lost River is diverted for irrigation before it reaches the INL boundary. Stream flow that reaches INL infiltrates the ground surface along the length of the streambeds in the spreading areas and, if stream flow is sufficient, in the ponding areas (playas or sinks) in the northern part of the site (Figure 7.1.3-1). During periods of high flow or low irrigation demand, the Big Lost River continues northeastward past the diversion dam and disappears via infiltration within a series of playas about 32 km (20 mi) northeast of the ATR Complex (Berenbrock et al. 2007; Orr 1997; DOE 2005). The GTCC reference location at INL is situated immediately southwest of the ATR Complex.



Base from U.S. Geological Survey
1:100,000 quadrangles

MPA032217

FIGURE 7.1.3-1 Location of the Big Lost River Basin and INL (Source: Berenbrock et al. 2007)

The Little Lost River and Birch Creek flow southeast from the mountains to the north. In summer months, flow from these streams is diverted for irrigation and rarely reaches the INL boundary. During periods of high precipitation or rapid snow melt, however, stream flow may enter the site and infiltrate the ground surface (DOE 2005).

7.1.3.1.2 Other Surface Water. Other surface water bodies within the INL boundaries include natural wetland-like ponds and several man-made percolation and evaporation ponds used for wastewater management. Wastewater discharge to the land surface is permitted and monitored (DOE 2005).

7.1.3.1.3 Surface Water Quality. The Big and Little Lost Rivers and Birch Creek have been designated for cold water aquatic communities, salmonid spawning, and primary contact recreation, with the Big Lost River sinks and channel and lowermost Birch Creek also classified for domestic water supply and as special resource waters. Water quality in these streams is similar, reflecting the carbonate mineral compositions of the mountain ranges they drain and the quality of irrigation water return flows. No surface waters are used for drinking water at INL, nor is effluent discharged directly to them. No streams have been classified as Wild and Scenic (DOE 2005).

Surface water locations just outside the INL boundary are sampled by the contractor for environmental surveillance, education, and research twice a year for gross alpha, gross beta, and tritium. In 2005, 12 surface water samples were collected from five off-site locations along the Snake River, downgradient from the INL site. No gross alpha activity was detected in these samples. Gross beta activity was detected in 11 of the 12 samples, ranging from 3.22 ±0.90 pCi/L (Hagerman) to 7.09 ± 0.96 pCi/L (Bliss), well below the EPA screening level of 50 pCi/L. Tritium (H-3) was detected at Idaho Falls, about 65 km (40 mi) to the southeast, with a concentration of 231.0 ±31.0 pCi/L in a November sample. It was also detected in a November sample from the Hagerman area to the southwest, with a concentration of 384.0 ±32.9 pCi/L. These concentrations were well below Idaho's primary constituent standards (PCSs) and the EPA maximum contaminant level (MCL) of 20,000 pCi/L (DOE 2006).

7.1.3.2 Groundwater

7.1.3.2.1 Unsaturated Zone. Groundwater at INL occurs under unsaturated (vadose) and saturated conditions. The thickness of the unsaturated zone varies across the site. Along the southwestern boundary of the site, the thickness is on the order of 240 m (800 ft); along the northeastern boundary, the thickness is less (on the order of 120 m [400 ft]) (Ackerman et al. 2006).

In the vicinity of the GTCC reference location, the total thickness of the unsaturated zone is about 142.5 m (468 ft). The unsaturated zone can be divided into five layers. The first layer (i.e., layer at the ground surface) is composed of alluvium (surficial sediment predominantly consisting of coarse-grained sand and gravel) with a thickness of about 9.1 m (30 ft). The second unsaturated zone layer has a thickness of about 94.6 m (310 ft). This thickness corresponds with the sum of thicknesses of thick-flow basalt layers. According to the stratigraphic profile for Well USGS-51, thick-flow basalts constitute about 90% of the total thickness of all basalt layers above the groundwater table. The third unsaturated zone layer has a thickness of about 7.5 m (25 ft). The fourth unsaturated layer at the reference site has a thickness of 16 m (52 ft). The fifth and deepest layer of the unsaturated zone has a thickness of about 15 m (50 ft) (DOE 2003).

7.1.3.2.2 Aquifer Units. The basaltic lava flows and interbedded sedimentary material underlying INL together form the Snake River Plain aquifer, one of the most productive aquifers in the United States. (The Eastern Snake River Plain aquifer provides the sole source of drinking water for nearly 200,000 people in southeast and south central Idaho; it was designated as a sole source aquifer in 1991 [IDEQ 2009c].) Groundwater below INL occurs at depths of 61 m (200 ft) in the northern part of the site to about 274 m (900 ft) in the southern part. Groundwater at the ATR Complex occurs at about 140 m (460 ft). The aquifer itself extends to depths greater than 1,067 m (3,500 ft); however, the most active part of the aquifer at INL ranges in depth from 75 to 250 m (250 to 820 ft). Sedimentary interbeds occur in an alternating sequence with the relatively thin basalt flows (with thicknesses of 6.1 to 7.6 m [20 to 25 ft]). The continuity of the sedimentary units is controlled by basalt flow topography, the rate of sediment deposition, and the subsidence rate. In some areas, sediment accumulation resulted in discontinuous distributions of relatively impermeable material, creating localized perching of groundwater. Perched water has been detected beneath the ATR Complex (DOE 2005).

The basaltic lava flows composing the vadose zone are very porous and permeable. The rubble between lava flows and cooling fractures allow very rapid infiltration and flow of water into the saturated zone. Saturated thickness ranges from 183 m (600 ft) in the northeast portion of the site to more than 366 m (1,200 ft) in the southwest. Interbedded sediments serve as aquitards and have an important influence on infiltration rates (DOE 2006; Orr 1997).

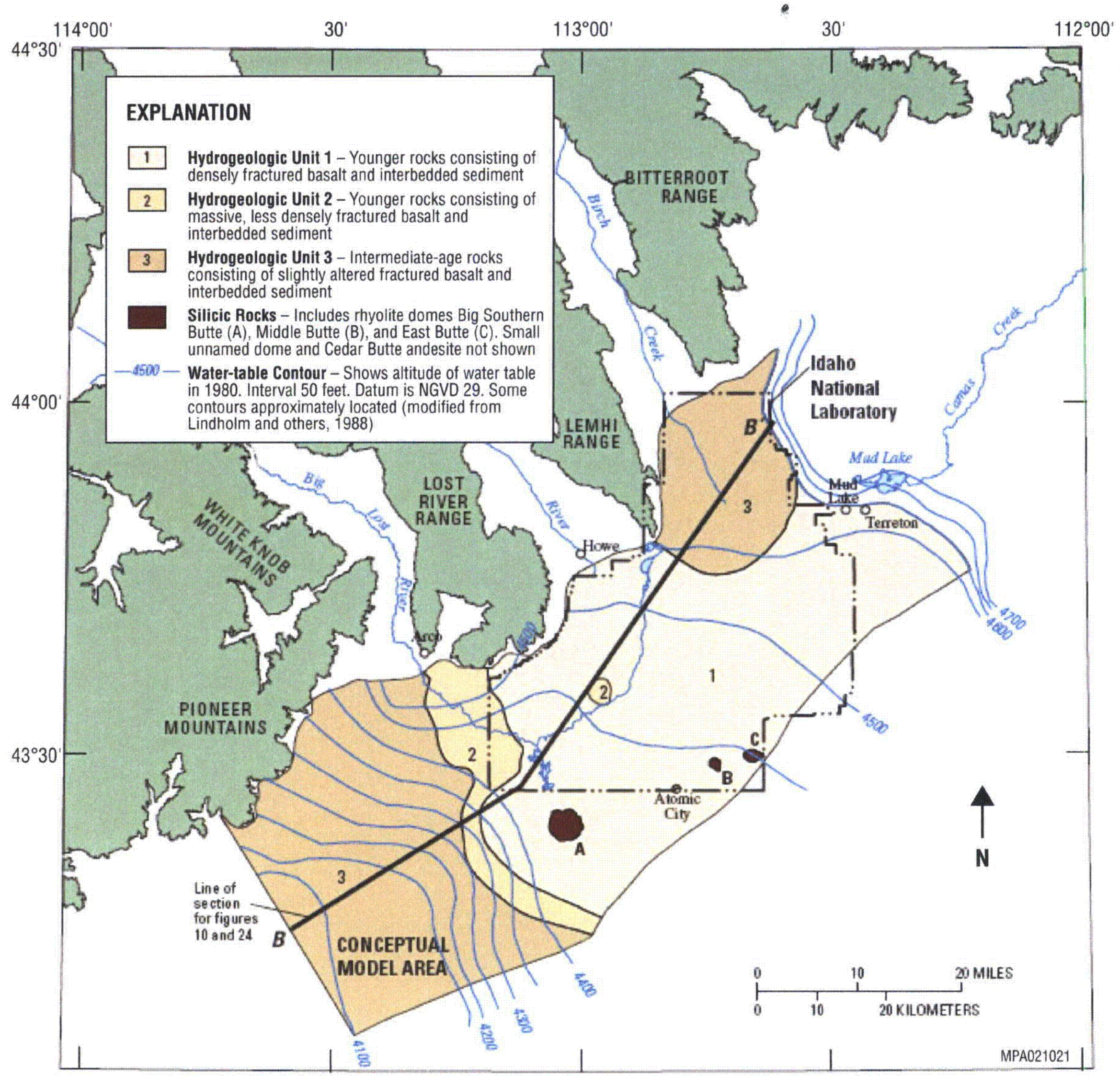
The stratigraphic column for INL can be conceptualized as having 14 layers between the ground surface and rocks of the underlying Snake River Plain aquifer. Units 1 through 7 include unaltered basalt and sediment. Locally, these units contain andesite and rhyolite. Units 8 through 14 contain unaltered to altered basalt and sediment and contain andesite and rhyolite (Ackerman et al. 2006).

7.1.3.2.3 Groundwater Flow. Groundwater in the Snake River Plain aquifer flows to the south-southwest (Figure 7.1.3-2), with flow velocities ranging from 1.5 to 6.1 m/d (4.9 to 20 ft/d) (DOE 2006). Water mainly moves horizontally through highly permeable basalt interflow zones (Figure 7.1.3-3); vertical movement occurs through joints and interfingering edges of interflow zones. Movement of groundwater is affected locally by various natural conditions (infiltration, seasonal fluxes in recharge and discharge) and man-made conditions (heavy pumpage) (Knobel et al. 2005).

Groundwater is discharged through large spring flows to the Snake River about 110 km (70 mi) south of the INL site and pumped for irrigation. Major areas of springs and seeps occur near the American Falls Reservoir (southwest of Pocatello) and the Thousand Springs area (near Twin Falls) between Milner Dam and King Hill. It is estimated that the aquifer discharges 8.8 billion m^3 (7.1 million ac-ft) annually to springs and rivers (DOE 2005).

Aquifer recharge occurs mainly through the surface of the ESRP from flow in the channel of the Big Lost River and its diversion area to the south. Melting of snowpacks, valley underflow from adjacent mountains, and infiltration of applied irrigation water are important local sources of recharge across the plain. Recharge from direct infiltration of precipitation is considered to be minimal because of the small annual precipitation on the plain, evapotranspiration, and the great depth to groundwater (Orr 1997; DOE 2002, 2005).

7.1.3.2.4 Groundwater Quality. Groundwater quality at INL is monitored by the USGS using a network of 178 observation or production wells and auger holes. Drinking water is also monitored via 17 production wells and 10 distribution systems. Historical waste disposal practices at INL have created localized plumes of radiochemical contamination within the Snake River Plain aquifer. Of particular concern are tritium and Sr-90. The extent of tritium and Sr-90 plumes at INL is shown in Figure 7.1.3-4. Monitoring wells downgradient of the ATR Complex



Base from U.S. Geological Survey digital data, 1:24,000 and 1:100,000
Universal Transverse Mercator projection Zone 12
Datum in North American Datum of 1927

FIGURE 7.1.3-2 Water Table Contours for 1980 (hydrogeologic units at the water table also shown) (Source: Ackerman et al. 2006)

have continually shown the highest tritium concentrations in the aquifer over time; however, maximum tritium concentrations in these wells dropped below the Idaho PCS and the EPA MCL of 20,000 pCi/L in 1997 and remained below these standards as of 2005 (DOE 2006).

The SR-90 contamination originated from the Idaho Nuclear Technology and Engineering Center (INTEC) as a result of wastewater injection. Sr-90 was not detected in groundwater in the vicinity of the ATR Complex in 2005. Instead, it was retained in surficial sediments, interbeds, and perched groundwater zones. Concentrations of Sr-90 have remained

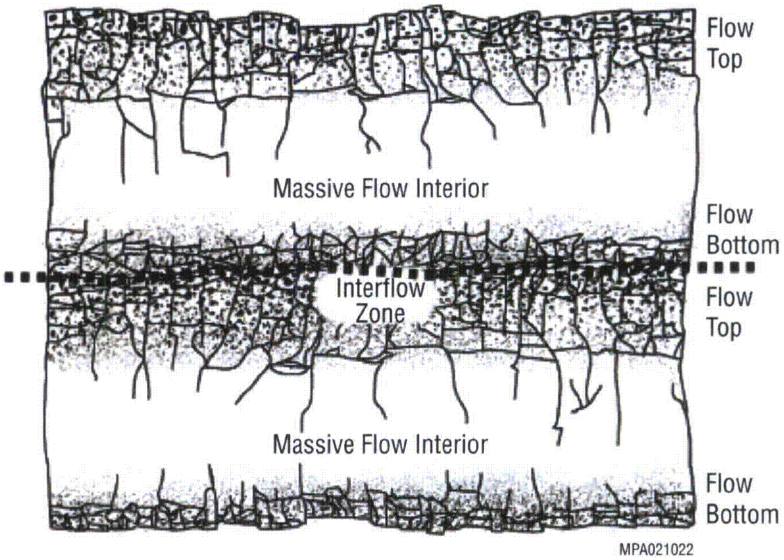


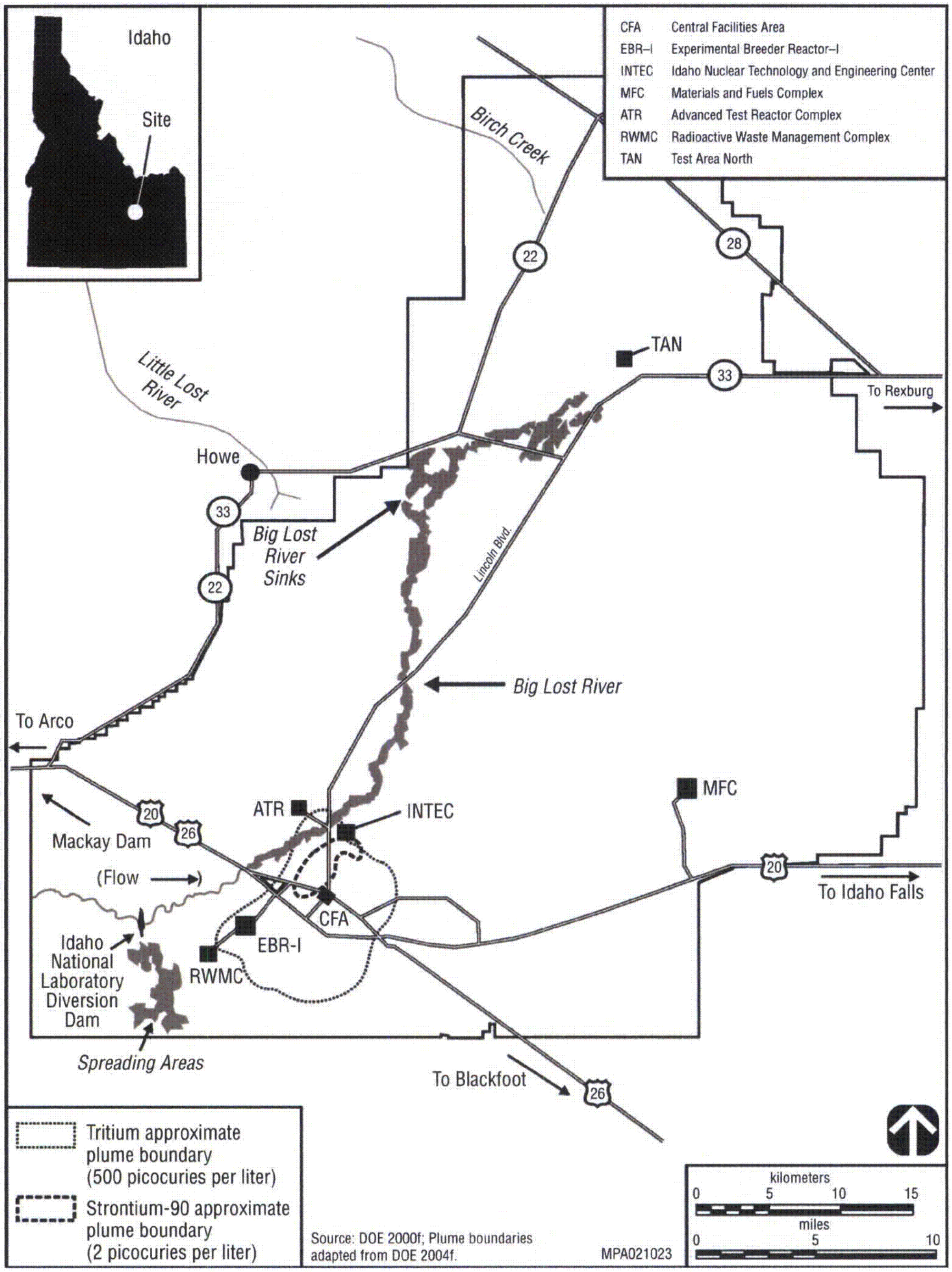
FIGURE 7.1.3-3 Diagram Showing Permeable Interflow Zone (Source: Wood et al. 2007)

constant at about 1.0 ± 0.6 pCi/L since 1989, which is below the PCS and MCL of 8 pCi/L for drinking water.

7.1.3.2.5 INL Water Use. The entire water supply for INL, including drinking water, is obtained from the Snake River Plain aquifer (USGS 2007). The water is provided by a system of about 30 wells, together with pumps and storage tanks. The system is administered by DOE, which holds the Federal Reserved Water Right of 43 billion L (11.4 billion gal) per year for the site. INL sitewide groundwater production and usage is approximately 4.2 billion L (1.1 billion gal) annually. INL discharges result in a much smaller net water use than what is pumped from the aquifer.

In the past, INL used percolation ponds, drain fields, ditches, and deep-well injection for discharging liquid wastes. This practice led to contamination in the underlying aquifer. Currently, most liquid sewage, chemical, and radioactive wastes are discharged to evaporation ponds; deep-well injection has ceased. The soil and rocks beneath the ponds filter some of the pollutants from the water as it passes through, but not all of the pollutants adhere to the soil and rocks, and some end up in the aquifer. DOE used percolation ponds to dispose of radioactive and chemical wastes at the ATR Complex from 1952 to the 1990s. These ponds are known contributors to groundwater contamination beneath INL. In the 1990s, the percolation ponds at the Test Reactor Area were capped and replaced with lined evaporation ponds. With this change, water quality near the Test Reactor Area improved over time (IDEQ 2008).

Current groundwater use in nearby Butte County falls into four categories: public supply, domestic, livestock, and irrigation. In 2005, total water deliveries were estimated to



Source: DOE 2000f; Plume boundaries adapted from DOE 2004f.

FIGURE 7.1.3-4 Extent of Tritium and Strontium-90 Plumes within the Snake River Plain Aquifer (Source: DOE 2005)

be about 440 million L (116 million gal). The greatest demand was for irrigation (about 99% or 435 million L [115 million gal]). The net per capita use was 156,800 million L/d (42,000 million gal/d). Butte County has a population of only 2,808 (USGS 2008b).

7.1.4 Human Health

Exposures of the off-site general public to radiation can occur as a result of exposure to airborne releases of radionuclides during normal operations from current site activities. Because these exposures are too low to be measured by available monitoring techniques, the reported amounts of radionuclides released from INL site facilities and appropriate air dispersion computer codes were used to calculate potential radiation doses to the public. Table 7.1.4-1 summarizes the calculated results. The maximum individual dose to the off-site public from airborne releases of radionuclides was calculated to be 0.13 mrem/yr. Inhalation accounts for most of the exposure. Other pathways considered included direct radiation from deposition, immersion, and ingestion of leafy vegetables (DOE 2009). The maximum dose is 1.3% of the dose limit (10 mrem/yr) set for airborne release (40 CFR Part 61). The collective dose to the population residing within 80 km (50 mi) of the INL site from airborne releases was estimated to be about 0.78 person-rem/yr, which is very small compared with the collective dose to the same population from natural background and man-made sources (186,000 person-rem/yr) (DOE 2009).

According to air monitoring data, on-site air concentrations for radionuclides were either less than or about the same as those measured at the site boundary or distant off-site locations (DOE 2009). An estimate of the potential inhalation dose for workers was made by scaling the off-site dose to the individual receiving the highest impact of 0.13 mrem/yr from airborne releases by the exposure duration (8,760 h/yr for the general public and 2,000 h/yr for workers). The resulting estimate for inhalation exposure for an on-site worker is 0.030 mrem/yr.

Potential radiation doses could also occur as a result of ingestion. Game animals are hunted in this area, and the maximum dose from eating contaminated meat and waterfowl is estimated to be 0.28 mrem/yr. This value is based on data from sampling the tissue of mule deer and ducks in 2008 (DOE 2009). Potential exposure for workers from drinking on-site contaminated water is estimated to be 0.30 mrem/yr (DOE 2009), which is less than 10% of the EPA standard of 4 mrem/yr for drinking water.

Direct radiation throughout the site was monitored by placing thermoluminescent dosimeters (TLDs) at locations likely to show the highest gamma radiation readings. The maximum reading recorded during 2008 was 647 mR (i.e., 666 mrem) after applying a dose equivalent conversion factor of 1.03 mrem/mR (NRC 1997) at the Radioactive Waste Management Complex (RWMC) near active waste storage and management areas. After the average reading at distant off-site (background) locations (122 mrem) was subtracted, the maximum on-site reading was determined to be 544 mrem above background levels. Applying the reading to estimate the direct radiation dose to a worker at the TLD location with the highest reading gives a dose of 120 mrem for an exposure duration of 2,000 hours per year. For most on-site workers, the potential direct radiation exposure dose would be much lower than this value

TABLE 7.1.4-1 Estimated Annual Radiation Doses to Workers and the General Public at INL

Receptor	Radiation Source	Exposure Pathway	Dose to Individual (mrem/yr)	Dose to Population (person-rem/yr)
On-site workers	Groundwater contamination	Water ingestion	0.30[a]	
	Air contamination	Inhalation	0.030[b]	
	Soil contamination and waste storage	Direct radiation	120[c]	
General public	Airborne release	Immersion, inhalation, ingestion of leafy vegetables, direct radiation from deposition	0.13[d]	0.78[e]
	Routine site operations	Game ingestion (waterfowl)	0.052[f]	
		Game ingestion (antelope)	0.237[g]	
Worker/public	Natural background radiation and man-made sources		620[h]	186,000[i]

[a] The drinking water dose was estimated on the basis of the mean tritium concentration measured at the Central Facilities Area (CFA) and the assumption that the maximally exposed worker obtained all the water he or she drank from an on-site well (DOE 2009). The CFA had the highest concentration of tritium in 2008.

[b] The inhalation dose was obtained by scaling the dose (0.13 mrem/yr) for the highest exposed individual in the general public from an airborne release (see text).

[c] Estimated by using the maximum TLD reading at the Radioactive Waste Management Complex (RWMC), subtracting the reading at distant off-site (background) locations, then scaling with an exposure duration of 2,000 h/yr.

[d] Estimated dose is to an individual residing at Frenchman's Cabin at the southern boundary of the INL site. The estimate was made by using the reported amount of radionuclides released during 2008 from the INL site facilities and the air dispersion computer code CAP88-PC (DOE 2009).

[e] The collective dose was estimated for the population residing within 80 km (50 mi) of an INL site facility. The collective population dose was calculated by using the air dispersion code MDIFF. The population size is reported to be 300,656 (DOE 2009).

[f] Maximum potential dose estimated for consuming 225 g (8 oz) of edible (muscle) waterfowl tissue (DOE 2009).

[g] Maximum potential dose estimated for consuming the entire muscle (27,000 g [952 oz]) and liver mass (500 g [17.6 oz]) of a mule deer with the highest levels of radioactivity (DOE 2009).

[h] Average dose to a member of the U.S. population as estimated in Report No. 160 of the National Council on Radiation Protection and Measurements (NCRP 2009).

[i] Collective dose to the reported population of 300,656 within 80 km (50 mi.) of an INL site facility from natural background radiation and man-made sources.

because they would not be radiation workers and would not work near waste storage and management areas. In addition, application of DOE's ALARA program would ensure that all worker doses would be below DOE's administrative control level of 2 rem/yr.

7.1.5 Ecology

INL is located within a cool desert ecosystem dominated by relatively undisturbed shrub-steppe and grassland vegetation (DOE 2002; Vilord 2004). The climate is arid, with about 22 cm/yr (8.7 in./yr) average annual precipitation. About 29,950 ha (74,000 ac) in the north-central portion of INL is designated as the INL Sagebrush Steppe Ecosystem Reserve. This area represents some of the last relatively undisturbed, contiguous sagebrush steppe habitat in the United States and provides habitat for many rare and sensitive plants and animals (DOE 2000). More than 400 species of plants have been identified within the 20 plant communities that occur on INL (Anderson et al. 1996). The plant communities can be grouped into six basic types: juniper woodland, grassland, shrub-steppe (including sagebrush-steppe and salt desert shrubs), lava, bareground-disturbed, and wetlands. Shrub-steppe vegetation, covering about 90% of INL, is dominated by big sagebrush (*Artemisia tridentata*) and saltbush (*Atriplex* spp.), with other common shrubs including green rabbitbrush (*Chrysothamnus viscidiflorus*), shadscale (*Atriplex confertifolia*), prickly phlox (*Leptodactylon pungens*), spineless horsebrush (*Tetradymia canescens*), spiny hopsage (*Grayia spinosa*), and winterfat (*Krascheninnikovia lanata*) (Anderson et al. 1996).

Wildland fires at INL generally result in a loss of big sagebrush, but most of the other native perennial plant species resprout the next spring to initiate recovery. Although recovery of herbaceous perennials and resprouting shrubs is complete in two to three years, big sagebrush must return to the burned area by seed, and it may take decades for sagebrush to return to pre-burn conditions.

Sensitive habitats at INL include the big sagebrush communities throughout the site and the low sagebrush communities in the northern portion of the site, which provide critical winter and spring range for greater sage-grouse (*Centrocercus urophasianus*) and pronghorn (*Antilocapra americana*), and the juniper communities in the northwestern and southeastern portions of the site, which are important for nesting raptors and songbirds. Vegetative communities in the vicinity of the ATR Complex include one community dominated by big sagebrush, a grassland community dominated by crested wheatgrass (*Agropyron cristatum*), and native perennial grasslands resulting from a 2000 fire. The developed portions of the ATR Complex area are either unvegetated or contain little native vegetation (e.g., lawns and ornamental vegetation).

Wetlands do not occur in the area of the ATR Complex (DOE 2005). The major wetlands at INL are associated with the Big Lost River, the Big Lost River spreading areas, and the Big Lost River sinks, which are located about 2.0 km (1.2 mi) southeast, 13 km (8 mi) southwest, and 21 km (13 mi) north-northeast of the ATR Complex, respectively (DOE 2000). The Big Lost River sinks are the only wetlands on INL that may be jurisdictional wetlands (DOE 2002).

More than 270 wildlife species have been observed at INL (DOE 2002), including 46 species of mammals, 225 species of birds, and 13 species of reptiles and amphibians (DOE 2002, 2005). Common mammal species include the black-tailed jackrabbit (*Lepus californicus*) and Townsend's ground squirrel (*Spermophilus townsendii*). Game species include the mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), and pronghorn (Reynolds et al. 1986). Up to 6,000 pronghorn (about 30% of Idaho's pronghorn population) may winter at INL during some years (DOE 2005). About 100 elk and 500 pronghorn summer at INL (Blew et al. 2006). Carnivores such as the mountain lion (*Puma concolor*) and coyote (*Canis latrans*) also occur at INL (Reynolds et al. 1986). Bats use INL throughout the year, with the western small-footed myotis (*Myotis ciliolabrum*) being the most abundant species at INL (Reynolds et al. 1986). During the spring and summer, it roosts in sagebrush, junipers, buildings, and rocky outcroppings (Blew et al. 2006). Mammals have been observed at disposal ponds at INL despite perimeter fences, and amphibians have been reported at industrial waste and sewage disposal ponds.

INL qualifies as an Important Bird Area in Idaho because it (1) supports bird species in greatest need of conservation, (2) is an exceptional representative of a natural habitat, and (3) supports long-term research or monitoring programs. The goal of the Important Bird Area program is to identify, monitor, and conserve key sites for birds (Moulton 2007). Among the bird species observed during the 2006 breeding bird survey at INL, 62% were shrub-steppe/grassland species; 28% were sagebrush obligates; 4% were urban and exotic species; 3% were raptors and corvids; and 2% were waterfowl, shorebirds, and wading birds (Vilord 2007). The most abundant bird species observed at INL included the horned lark (*Eremophila alpestris*), western meadowlark (*Sturnella neglecta*), Brewer's sparrow (*Spizella breweri*), sage sparrow (*Amphispiza belli*), sage thrasher (*Oreoscoptes montanus*), mourning dove (*Zenaida macroura*), and greater sage-grouse (Vilord 2007).

Since greater sage-grouse depend on sagebrush for habitat, INL is one of the most important wintering areas for the species in Idaho. Loss of sagebrush from wildfires may be having a detrimental impact on the greater sage-grouse. Juniper communities occurring in the northwestern and southeastern portions of INL and riparian areas with cottonwoods (*Populus* spp.) and willows (*Salix* spp.) provide important nesting habitats for raptors and songbirds.

Bird species that would not normally be observed in the sagebrush steppe or grassland habitats of INL have been found in altered or man-made habitats within these areas because of the addition of permanent water, different food resources, buildings, and planted trees. The ponds in and around the ATR Complex are frequented by waterfowl, shorebirds, swallows, passerines, and some raptors such as the American kestrel (*Falco sparverius*), ferruginous hawk (*Buteo regalis*), and northern harrier (*Circus cyaneus*) (DOE 2000).

The gopher snake (*Pituophis catenifer*), western rattlesnake (*Crotalus viridis*), sagebrush lizard (*Sceloporus graciosus*), and short-horned lizard (*Phrynosoma hernandesi*) are among the common reptile species (Reynolds et al. 1986).

The main aquatic habitats that occur on INL are the Big Lost River, Little Lost River, and Birch Creek. All three are intermittent water bodies. Flow in Big Lost River that reaches INL infiltrates into the ground along the streambeds at the southern end of INL or, if the flow is sufficient, it infiltrates into the playas or sinks in the northern portion of the site. The Big Lost River is located southeast of the GTCC reference location (1.9 km [1.2 mi] southeast of the ATR Complex). During dry years, little or no surface water flows on the INL site. During periods of high precipitation or rapid snowmelt, water from Little Lost River enters INL and infiltrates into the ground. Flows from Birch Creek seldom enter INL during summer because of its off-site use for irrigation, but flows from Birch Creek do enter INL during winter months when agricultural diversions cease. The only other aquatic habitats on INL are natural wetland-like ponds and man-made percolation and evaporation ponds. Six fish species have been observed on INL (Reynolds et al. 1986). The evaporation ponds in the vicinity of the ATR Complex do not support fish but are inhabited by aquatic invertebrates and amphibians.

Seventeen federally listed and state-listed threatened, endangered, and other special-status species have been identified on the INL site (Table 7.1.5-1). No federally listed threatened or endangered species and no critical habitat for any federally listed threatened or endangered species occur on INL (DOE 2005). Both the greater sage-grouse (a candidate species) and the pygmy rabbit (*Brachylagus idahoensis*, under review for listing) are considered to be common on the INL site. No threatened, endangered, or other special-status species have been recorded in the vicinity of the ATR Complex. However, the bald eagle (*Haliaeetus leucocephalus*), greater sage-grouse, pygmy rabbit, and Townsend's big-eared bat (*Dorynorhinus townsendii*) may potentially occur in the area (DOE 2005). Several state species of special concern have been observed in the area surrounding the ATR Complex area, including the northern goshawk (*Accipiter gentilis*), loggerhead shrike (*Lanius ludovicianus*), black tern (*Chlidonias niger*), and trumpeter swan (*Cygnus buccinator*). Among these, only the loggerhead shrike is commonly observed in the surrounding areas (Vilord 2004, 2007).

7.1.6 Socioeconomics

Socioeconomic data for INL covers an ROI composed of four Idaho counties surrounding the site: Bannock County, Bingham County, Bonneville County, and Jefferson County. More than 80% of INL workers reside in these counties (DOE 1997).

7.1.6.1 Employment

In 2005, total employment in the ROI stood at 95,514 and was expected to reach 102,433 by 2008. Employment grew at an annual average rate of 2.9% between 1995 and 2005 (U.S. Bureau of the Census 2008a). The economy of the ROI is dominated by the trade and service industries, with employment in these activities currently contributing nearly 70% of all employment (see Table 7.1.6-1). Agriculture and manufacturing are both smaller employers in the ROI, each contributing less than 9% of total ROI employment. Employment at INL stood at 8,452 in 2006 (Black et al. 2006).

TABLE 7.1.5-1 Federally and State-Listed Threatened, Endangered, and Other Special-Status Species at INL

Common Name (Scientific Name)	Status[a] Federal/State
Plants	
Cushion milk vetch (*Astragalus gilviflorus*)	–/SS
Painted milkvetch (*Astragalus ceramicus* var. *apus*)	SC/–
Puzzling halimolobos (*Halimolobos perplexa* var. *perplexa*)	–/SM
Narrowleaf oxytheca (*Oxytheca dedroidea*)	–/SS
Spreading gilia (*Iponopsis polycladon*)	–/SP2
Winged-seed evening primrose (*Camissonia pterosperma*)	–/SS
Reptiles	
Northern sagebrush lizard (*Sceloporus graciosus graciosus*)	SC/–
Birds	
Bald eagle (*Haliaeetus leucocephalus*)	–/ST
Ferruginous hawk (*Buteo regalis*)	SC/–
Greater sage-grouse (*Centrocercus urophasianus*)	C/–
Long-billed curlew (*Numemius americanus*)	SC/–
Mammals	
Gray wolf (*Canis lupus*)	EXPN/–
Long-eared myotis (*Myotis evotis*)	SC/–
Merriam's shrew (*Sorex merriami*)	SC/–
Pygmy rabbit (*Brachylagus idahoensis*)	UR/–
Townsend's big-eared bat (*Dorynorhinus townsendii*)	SC/–
Western small-footed myotis (*Myotis ciliolabrum*)	SC/–

[a] C (candidate): A species for which USFWS or NOAA Fisheries has on file sufficient information on biological vulnerability and threats to support a proposal to list as endangered or threatened.

EXPN (experimental population): A population (including its offspring) of a listed species designated by rule published in the *Federal Register* that is wholly separate geographically from other populations of the same species. An experimental population may be subject to less stringent prohibitions than are applied to the remainder of the species to which it belongs.

SC (species of concern): An informal term referring to a species that might be in need of conservation action. This may range from a need for periodic monitoring of populations and threats to the species and its habitat to a need for listing as threatened or endangered. Such species receive no legal protection under the ESA, and use of the term does not necessarily imply that a species will eventually be proposed for listing.

SM (state monitor): A species that is common within a limited range or a species that is uncommon but has no identified threats.

Footnote continues on next page.

TABLE 7.1.5-1 (Cont.)

SP2 (state priority 2): A species likely to be classified as state priority 1 within the foreseeable future in Idaho, if factors contributing to its population decline, habitat degradation, or loss continue. State priority 1 refers to species in danger of becoming extinct from Idaho in the foreseeable future, if factors contributing to their population decline, habitat degradation, or loss continue.

SS (state sensitive): A species with small populations or localized distributions within Idaho that presently do not meet the criteria for classification as priority 1 or 2, but whose populations and habitats may be jeopardized without active management or removal of threats.

ST (state threatened): A native species likely to be classified as state endangered within the foreseeable future throughout all or a significant portion of its Idaho range.

UR (under review): A species undergoing a status review to determine if listing of the species as threatened or endangered is warranted.

–: Not listed.

Sources: DOE (2005); IDFG (2008a,b)

TABLE 7.1.6-1 INL County and ROI Employment by Industry in 2005

Sector	Bannock County	Bingham County	Bonneville County	Jefferson County	ROI Total	% of ROI Total
Agriculture[a]	753	4,298	1,711	1,613	8,375	8.8
Mining	60	0	10	10	80	0.1
Construction	1,478	894	2,920	536	5,828	6.1
Manufacturing	2,750	1,954	2,491	867	8,062	8.4
Transportation and public utilities	800	266	1,457	114	2,637	2.8
Trade	5,276	2,682	9,448	893	18,299	19.2
Finance, insurance, and real estate	2,031	281	1,609	125	4,046	4.2
Services	15,236	3,620	28,101	1,206	48,163	50.4
Other	4	10	10	0	24	0.0
Total	28,388	14,005	47,757	5,364	95,514	–

[a] USDA (2008).

Source: U.S. Bureau of the Census (2008a)

7.1.6.2 Unemployment

Unemployment rates varied across the counties in the ROI (Table 7.1.6-2). Over the 10-year period 1999–2008, average rates were 4.4% in Bannock County and 4.0% in Bingham County, with lower rates in Bonneville County (3.2%) and Jefferson County (3.4%). The average rate in the ROI over this period was 3.7%, which was lower than the average rate for the state of 4.4%. Unemployment rates for the first two months of 2009 contrasted markedly with rates for 2008 as a whole; in Jefferson County, the unemployment rate increased to 6.5%, while in Bingham County, the rate reached 6.3%. The average rates for the ROI (5.9%) and for the state (6.8%) during this period were both higher than the corresponding average rates for 2008.

7.1.6.3 Personal Income

Personal income in the ROI stood at almost $6.3 billion in 2005 and was expected to reach $6.7 billion in 2008, growing at an annual average rate of growth of 2.5% over the period 1995–2005 (Table 7.1.6-3). ROI personal income per capita also rose over the same period and was expected to reach $27,226 in 2008 compared to $26,817 in 2005. Per capita incomes were higher in Bonneville County ($30,599 in 2005) and Bannock County ($26,257) than elsewhere in the ROI.

7.1.6.4 Population

The population of the ROI in 2006 stood at 239,474 (U.S. Bureau of the Census 2008b) and was expected to reach 246,176 by 2008 (Table 7.1.6-4). In 2006, 94,630 people were living in Bonneville County (40% of the ROI total), and 78,443 people (33% of the total) resided in Bannock County. Over the period 1990–2006, the population in the ROI as a whole grew slightly, with an average growth rate of 1.4%, while higher-than-average growth occurred in Jefferson County (1.9%) and Bonneville County (1.7%). The population of Idaho as a whole grew at a rate of 2.3% over the same period.

7.1.6.5 Housing

Housing stock in the ROI as a whole grew at an annual rate of 1.4% over the period 1990–2000 (Table 7.1.6-5), with total housing units expected to reach 90,042 in 2008. A total of 10,416 new units were added to the existing housing stock in the ROI between 1990 and 2000. On the basis of annual population growth rates, it was expected that there would be 5,608 vacant housing units in the ROI in 2008, of which 1,405 would be rental units available to construction workers at the proposed facility.

TABLE 7.1.6-2 INL Average County, ROI, and State Unemployment Rates (%) in Selected Years

Location	1999–2008	2008	2009[a]
Bannock County	4.4	3.9	6.1
Bingham County	4.0	3.4	6.3
Bonneville County	3.2	2.9	5.5
Jefferson County	3.4	3.1	6.5
ROI	3.7	3.3	5.9
Idaho	4.4	4.9	6.8

[a] Rates for 2009 are the average for January and February.

Source: U.S. Department of Labor (2009a–d)

TABLE 7.1.6-3 INL County, ROI, and State Personal Income in Selected Years

Income	1995	2005	Average Annual Growth Rate (%), 1995–2005	2008[a]
Bannock County				
Total personal income (2006 $ in millions)	1,661	2,043	2.1	2,148
Personal income per capita (2006 $)	22,572	26,257	1.5	26,804
Bingham County				
Total personal income (2006 $ in millions)	861	975	1.3	1,000
Personal income per capita (2006 $)	21,179	22,265	0.5	22,256
Bonneville County				
Total personal income (2006 $ in millions)	2,056	2,806	3.2	3,045
Personal income per capita (2006 $)	25,851	30,599	1.7	31,110
Jefferson County				
Total personal income(2006 $ in millions)	366	476	2.7	509
Personal income per capita (2006 $)	20,040	22,003	0.9	21,920
ROI total				
Total personal income (2006 $ in millions)	4,944	6,299	2.5	6,702
Personal income per capita (2006 $)	23,317	26,817	1.4	27,226
Idaho				
Total personal income (2006 $ in millions)	30,255	42,019	3.3	45,840
Personal income per capita (2006 $)	25,698	29,397	1.4	29,844

[a] Argonne National Laboratory estimates.

Source: DOC (2008)

TABLE 7.1.6-4 INL County, ROI, and State Population in Selected Years

Location	1990	2000	2006	Average Annual Growth Rate (%), 1990–2006	2008[a]
Bannock	66,026	75,565	78,443	1.1	80,151
Bingham	37,583	41,735	44,051	1.0	44,934
Bonneville	72,207	82,522	94,630	1.7	97,884
Jefferson	16,543	19,155	22,350	1.9	23,207
ROI total	192,359	218,977	239,474	1.4	246,176
Idaho	1,012,384	1,293,953	1,466,465	2.3	1,535,987

[a] Argonne National Laboratory projections.

Sources: U.S. Bureau of the Census (2008b); estimated data for 2006

7.1.6.6 Fiscal Conditions

Construction and operations of a GTCC waste disposal facility could result in increased expenditures for local government jurisdictions, including counties, cities, and school districts. Revenues to support these expenditures would come primarily from state and local sales tax revenues associated with employee spending during construction and operations and would be used to support additional local community services currently provided by each jurisdiction. Table 7.1.6-6 presents information on expenditures by the various local government jurisdictions and school districts in the ROI.

7.1.6.7 Public Services

Construction and operations of a GTCC waste disposal facility could require increases in employment to provide public safety, fire protection, community, and educational services in the counties, cities, and school districts likely to host relocating construction workers and operations employees. Additional demands could also be placed on local physician services. Table 7.1.6-7 presents data on employment and levels of service (number of employees per 1,000 population) for public safety. Table 7.1.6-8 provides data on staffing and levels of service for school districts. Table 7.1.6-9 covers physicians.

7.1.7 Environmental Justice

Figures 7.1.7-1 and 7.1.7-2 and Table 7.1.7-1 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer around INL from Census data for the year 2000 and from CEQ) guidelines (CEQ 1997. Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or multi-racial (with at least one race designated as a minority race under CEQ). Individuals identifying themselves as

TABLE 7.1.6-5 INL County, ROI, and State Housing Characteristics in Selected Years

Housing	1990	2000	2008[a]
Bannock County			
Owner occupied	16,082	19,215	20,381
Rental	7,330	7,977	8,461
Vacant units	2,282	1,910	2,026
Total units	25,694	29,102	30,868
Bingham County			
Owner occupied	8,830	10,564	11,374
Rental	2,683	2,753	2,964
Vacant units	1,151	986	1,062
Total units	12,664	14,303	15,400
Bonneville County			
Owner occupied	17,371	21,467	25,463
Rental	6,918	7,286	8,642
Vacant units	1,760	1,731	2,053
Total units	26,049	30,484	36,158
Jefferson County			
Owner occupied	3,920	5,008	6,067
Rental	951	893	1,082
Vacant units	482	386	468
Total units	5,353	6,287	7,617
ROI total			
Owner occupied	46,203	56,254	63,285
Rental	17,882	18,909	21,149
Vacant units	5,675	5,013	5,608
Total units	69,760	80,176	90,042
Idaho			
Owner occupied	252,734	339,960	430,962
Rental	107,989	129,685	164,400
Vacant units	52,604	58,179	73,753
Total units	413,321	527,824	669,115

[a] Argonne National Laboratory projections.

Source: U.S. Bureau of the Census (2008b)

TABLE 7.1.6-6 INL County, ROI, and State Public Service Expenditures in 2006 ($ in millions)

Location	Local Government	Schools
Bannock County	41.1	51.4
Bingham County	10.6	37.7
Bonneville County	45.8	67.0
Jefferson County	5.9	19.1
ROI total	103.4	175.3
Idaho	4,580	1,599

Source: U.S. Bureau of the Census (2008c)

TABLE 7.1.6-7 INL County, ROI, and State Public Service Employment in 2006

	Bannock County		Bingham County		Bonneville County	
Service	No.	Level of Service[a]	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	151	1.9	67	1.5	143	1.5
Fire protection[b]	71	0.9	23	0.5	95	1.0
General	675	8.6	381	8.6	726	7.7

	Jefferson County		ROI		Idaho	
Service	No.	Level of Service[a]	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	25	1.1	386	1.6	2,432	1.7
Fire protection	1	0.1	190	0.8	1,179	0.8
General	158	7.1	1,940	8.0	53,543	36.5

[a] Level of service represents the number of employees per 1,000 persons in each county.

[b] Does not include volunteers.

Source: U.S. Bureau of the Census (2008b,c)

TABLE 7.1.6-8 INL County, ROI, and State Education Employment in 2006

Location	No. of Teachers	Level of Service[a]
Bannock	1,244	15.9
Bingham	548	12.4
Bonneville	963	10.2
Jefferson	296	13.2
ROI	3,051	12.7
Idaho	14,521	9.9

[a] Level of service represents the number of teachers per 1,000 persons in each county.

Sources: National Center for Educational Statistics (2008); U.S. Bureau of the Census (2008b,c)

TABLE 7.1.6-9 INL County, ROI, and State Medical Employment in 2006

Location	No. of Physicians	Level of Service[a]
Bannock	262	3.3
Bingham	44	1.0
Bonneville	249	2.6
Jefferson	7	0.3
ROI	562	2.3
Idaho	2,645	1.8

[a] Level of service represents the number of physicians per 1,000 persons in each county.

Sources: AMA (2006); U.S. Bureau of the Census (2008b)

Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals who also identified themselves as being part of one or more of the population groups listed in the table.

7.1.8 Land Use

INL is owned by the federal government and is administered, managed, and controlled by DOE. The mission of INL has evolved from energy development and the safety testing of nuclear reactors to radioactive waste management and cleanup, national security, and energy research and development.

INL occupies about 230,670 ha (570,000 ac), but only about 4,610 ha (11,400 ac) have been developed to support facility and program operations associated with energy research and waste management activities (DOE 2002). These facilities are located within a 93,080-ha (230,000-ac) central core of INL (DOE 2000). An 18,200-ha (45,000-ac) security and safety buffer zone surrounds the developed area. About 13,760 ha (34,000 ac) of INL are devoted to utility ROWs and public roads (DOE 2002).

Fifty-two research and test reactors have been used over the years at INL to test reactor systems, fuel and target designs, and overall safety. Other INL facilities support reactor operations. These facilities include low-level and high-level radioactive waste processing, storage, and disposal sites; hot cells; analytical laboratories; machine shops; and laundry, railroad, and administrative facilities.

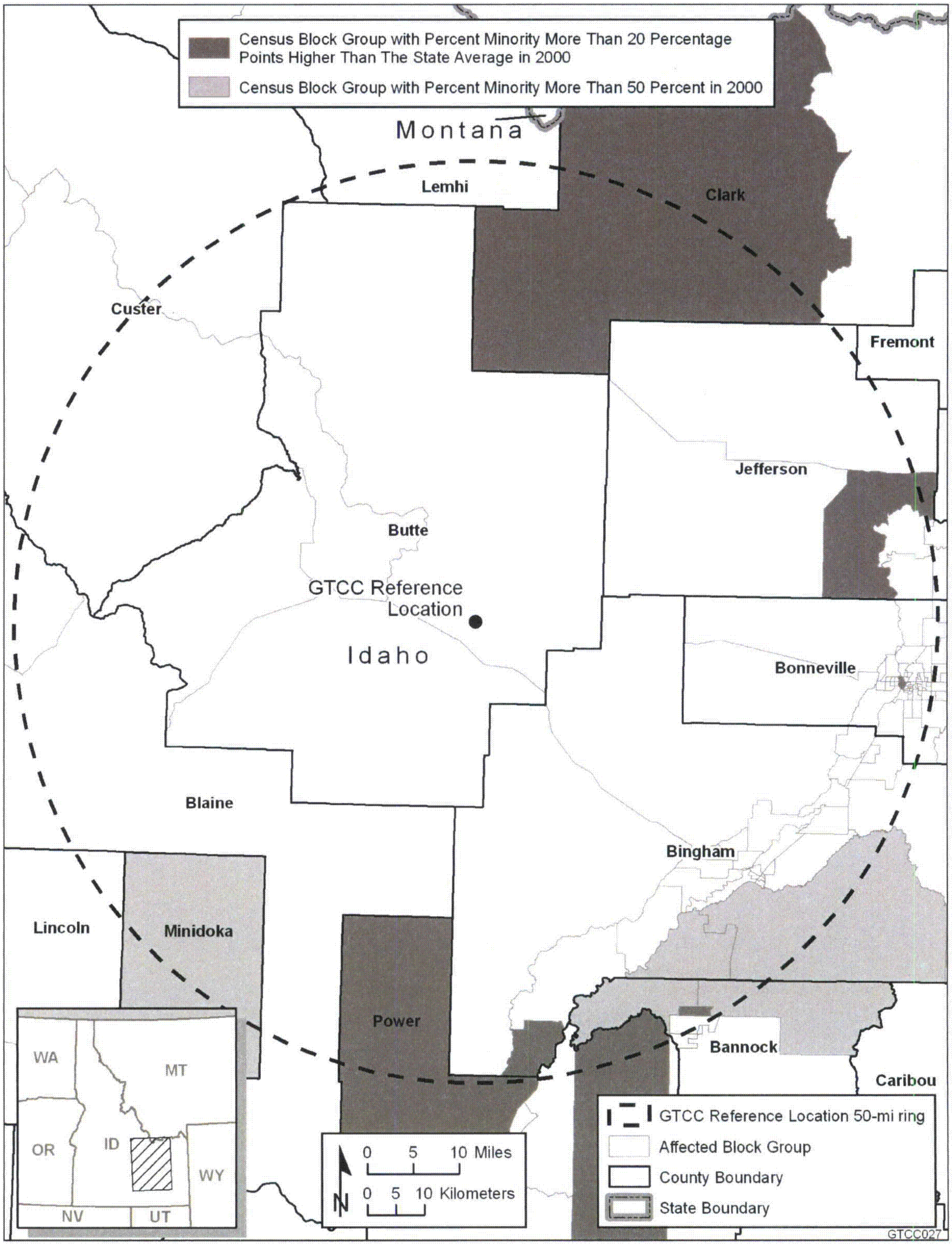


FIGURE 7.1.7-1 Minority Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at INL (Source: U.S. Bureau of the Census 2008b)

FIGURE 7.1.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at INL (Source: U.S. Bureau of the Census 2008b)

TABLE 7.1.7-1 Minority and Low-Income Populations in an 80-km (50-mi) Radius of INL

Population	Idaho Block Groups
Total population	144,821
White, non-Hispanic	123,510
Hispanic or Latino	13,888
Non-Hispanic or Latino minorities	7,423
One race	5,927
Black or African American	421
American Indian or Alaskan Native	4,424
Asian	939
Native Hawaiian or other Pacific Islander	65
Some other race	78
Two or more races	1,496
Total minority	21,311
Percent minority	14.7%
Low-income	16,531
Percent low-income	11.4%
State percent minority	9.0%
State percent low-income	11.8%

Source: U.S. Bureau of the Census (2008b)

Land use categories at INL include facility operations, grazing, general open space, and infrastructure (e.g., roads). Much of INL is open space and is not designated for a specific use (DOE 2000). Up to 137,590 ha (340,000 ac) of INL are leased for livestock grazing, with the grazing permits administered by the BLM. No livestock grazing is allowed within 0.8 km (0.5 mi) of any primary facility boundary and within 3.7 km (2 mi) of any nuclear facility. A 364-ha (900-ac) winter feedlot for sheep used by the U.S. Sheep Experiment Station is located at the intersection of Idaho State Highways 28 and 33 (DOE 2002). Through a Memorandum of Agreement (MOA) with the Shoshone-Bannock tribes, tribal members are allowed access to the Middle Butte on INL to perform sacred or religious ceremonies or other educational or cultural activities (DOE 2000).

Land use at INL is moving toward radioactive and hazardous waste management, environmental restoration and remedial technologies, and technology transfer (DOE 2002).

Recreational use of INL includes public tours of general facility areas and the EBR-I (a National Historic Landmark) and controlled hunting that is restricted to specific locations. INL was designated as a NERP in 1975, functioning as a field laboratory that is set aside for ecological research and evaluation of the environmental impacts from nuclear energy development (DOE 2002). About 29,540 ha (74,000 ac) of open space in the north-central portion of INL was designated as the INL Sagebrush Steppe Ecosystem Reserve.

The GTCC reference location is located within a general open space land use area. The location is primarily sagebrush habitat that is situated near the ATR Complex on the south-central portion of INL (Figure 7.1-1). Land in the ATR Complex is mostly disturbed and is designated for reactor operations. Located within the ATR Complex are the Materials Testing Reactor and Engineering Test Reactor (both shut down), the ATR Complex hot cells, and the ATR itself. There are also numerous support facilities in the area, including storage tanks, maintenance buildings, warehouses, laboratories, and sanitary and radioactive waste treatment facilities. The ATR Complex includes about 15 ha (37 ac) within a security fence, plus several sewage and evaporation ponds located outside the fenced area (DOE 2000).

About 75% of the lands surrounding INL are public lands administered by the BLM that provide wildlife habitat and are managed for multiple uses, such as mineral and energy production, grazing, and recreation. About 1% is owned by the state of Idaho and is used for the same purposes. The rest of the surrounding lands are privately owned and used for livestock grazing and crop production (DOE 2002). Irrigated farmlands make up about 25% of the land bordering INL. Several small rural communities are scattered around the borders of INL (i.e., Howe, Mud Lake, Atomic City, Butte City, and Arco). Recreational and agricultural uses are expected to increase in the surrounding areas, with agricultural use resulting from the conversion of rangeland to cropland (DOE 2002). Since INL is remote from most developed areas, the lands adjacent to it are not likely to experience residential and commercial development, and no new development is planned near the site (DOE 2000).

7.1.9 Transportation

Major highway access to the region is via Interstate 15, which runs north-south through Idaho Falls, Idaho, roughly parallel to the eastern edge of the site. The eastern edge of INL is located approximately 40 km (25 mi) to the west of Idaho Falls along US 20, which passes through the southern portion of the site and continues on to Arco, Idaho, to the west. Access to the southern boundary of the site is from Blackfoot, Idaho, which is 50 km (31 mi) to the southeast along US 26. State Route (SR) 22 and SR 28, from Dubois and Salmon, respectively, provide access to the northern portion of INL, along with SR 33 from the east, from Rexburg. Approximately 145 km (90 mi) of paved highways are used by the general public on the site (Cahn et al. 2006). Average daily traffic counts in the vicinity of INL are provided in Table 7.1.9-1.

Rail service is available on-site. About 23 km (14 mi) of Union Pacific Railroad tracks cross the southern portion of the site. A government-owned spur off these tracks passes through the CFA to INTEC (Cahn et al. 2006), passing by the ATR Complex on its way to the Naval Reactors Facility.

7.1.10 Cultural Resources

INL is a science-based, applied engineering laboratory with its roots extending back to World War II. Battelle Energy Alliance maintains the INL Cultural Resource Management

TABLE 7.1.9-1 Annual Average Daily Traffic (AADT) Counts in the Vicinity of INL

Location		AADT[a]	Commercial AADT[b]
US 26	South of junction with US 20 north of Atomic City	1,100	260
US 20	East of junction with US 26 north of Atomic City	1,900	270
US 20/26	East of US 20/26 junction north of Atomic City	2,200	250
	East of junction with SR 22/33	1,500	250
SR 22/33	North of junction with US 20/26	620	120
	West of Howe	650	120
	East of Howe	670	120
	West of SR 22/33 split	600	120
SR 22	North of SR 22/33 split before SR 28 junction	250	90
	North of junction with SR 28	200	60
SR 33	East of SR 22/33 split	380	90
	West of junction with SR 28	680	90
SR 28/33	East of SR 28/33 split	1,800	120
SR 28	North of split with SR 33	1,200	70
	South of SR 22 junction	530	50
	North of SR 22 junction	600	50

[a] Source: ITD (2007a)

[b] Source: ITD (2007b)

Office (CRMO) to monitor cultural resource reviews and compliance issues. Cultural resource compliance efforts are guided by a Cultural Resource Management Plan and a programmatic agreement among the DOE Idaho Operations Office (DOE-ID), the Idaho SHPO, and the ACHP. Compliance activities at INL include the review of all major undertakings to determine if there could be effects on cultural resources. Compliance with the various cultural resource laws is the ultimate responsibility of DOE-ID, which relies heavily on the INL CRMO for implementing the cultural resource program at INL. The DOE-ID and INL CRMO work closely with the Shoshone-Bannock tribes. The three groups have entered into an Agreement in Principle (AIP) that allows the Shoshone-Bannock to oversee INL environmental programs, transportation safety, and cultural resource management (DOE-ID 2002).

Cultural resource surveys have identified 2,250 archaeological sites on INL property (Braun et al. 2007). They represent 9% of the total land managed by the INL. These sites show that people have been using the INL property for the last 13,000 years. Most sites are located close to water sources. The INL property once contained a large, shallow lake, Lake Terreton.

When rainfall volumes decreased 13,000 years ago, the lake began to dry up. Remnant wetlands are all that remain of Lake Terreton. Several rivers, including the Big and Little Lost Rivers and Birch Creek, are found on the INL property. Because of the soil characteristics, much of the water at INL is held underground, rendering it inaccessible for much of the history of the facility. Only in the last 100 years has technology allowed this water to be used. No large Native American villages have been found on INL property. Transient hunting and gathering activities were the primary activities supported by the INL landscape throughout the prehistoric period and into the contact period.

Historic use of the property began in the early 1800s when trappers came into the area to collect beaver skins. More frequent use of the land began in 1852 with the establishment of Goodale's Cutoff in the northern portion of the INL property. The cutoff began as a northern extension of the Oregon Trail. By 1860, the route began to be used for moving cattle and sheep from Oregon and Washington to eastern markets. During the 1860s to 1880, numerous mines began to open in central Idaho, which led to increased traffic on Goodale's Cutoff and the creation of numerous other roads and trails through the area. Ranches were established along the Big Lost River by the 1880s; here livestock were raised and then transported across what would become INL. Populations began to rise steadily with passage of the Carey Land Act of 1894 and the Desert Reclamation Act of 1902.

By the early 20th century, the town of Powell had been established on INL property near the intersection of the Oregon Shortline Railroad (now the Union Pacific Railroad) and the Big Lost River. The town was located near the current location of the RWMC. Most of the homesteads failed by the 1920s because of the water use that was occurring upstream of the INL property and were abandoned. Roughly 100 historic archaeological sites from the homesteading era have been recorded on INL property. Numerous others are known but have yet to be recorded.

Ten main facilities are scattered across the laboratory's land. The first government facility constructed at INL was the Arco Naval Proving Ground, which was built in 1942 for the testing of naval ordnance. The facility was expanded in 1949 and renamed the National Reactor Testing Station. The site was renamed several times between 1949 and 2008. Roughly 52 reactors were constructed at INL over the last 57 years. Major reactors constructed at INL include EBR-I and naval propulsion reactors. Throughout much of its existence, INL was linked with Argonne National Laboratory, located in Illinois; that is, the past Argonne-West was a small part surrounded by the laboratory, then called Idaho National Engineering Laboratory (INEL). In 2007, INL became a stand-alone laboratory. The facility is managed and operated by Battelle Energy Alliance for DOE-ID.

INL was the location for numerous one-of-a-kind test reactors. Many of the early reactors constructed at INL are located in the ATR Complex. Facilities in the ATR Complex include the Materials Testing Reactor built in 1950, the Engineering Test Reactor built in 1957, and the Advanced Test Reactor built in 1967. Each of these reactors represented the pinnacle of reactor design when it was constructed. These reactors, together with the ancillary structures used to support the research (such as the Hot Cell Facility), formed a core research center for the AEC's research on nuclear reactor design and the basic properties of nuclear materials.

7.1.11 Waste Management

Site management of the waste types generated by the land disposal methods for Alternatives 3 to 5 are discussed in Section 5.3.11. Waste management programs at INL are operated by the Office of Nuclear Energy.

7.2 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

The following sections address the potential environmental and human health consequences for each resource area discussed in Section 7.1.

7.2.1 Climate and Air Quality

This section presents potential climate and air quality impacts from the construction and operations of each of the disposal facilities (borehole, trench, and vault) at INL. Noise impacts are discussed in Section 5.3.1.

7.2.1.1 Construction

During the construction period, emissions of criteria pollutants (e.g., SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$), VOCs, and the primary greenhouse gas CO_2 would be caused by fugitive dust emissions from earth-moving activities and engine exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Typically, the potential impacts from exhaust emissions on ambient air quality would be smaller than those from fugitive dust emissions.

Air emissions of criteria pollutants, VOCs, and CO_2 from construction activities are estimated for the peak year when site preparation and construction of the support facility and some disposal cells would take place. Estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. These estimates are provided in Table 7.2.1-1 for each disposal method. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in the table, total peak-year emission rates are estimated to be rather small when compared with emission totals for all five counties encompassing INL (Bingham, Bonneville, Butte, Clark, and Jefferson Counties). Peak-year emissions for all criteria pollutants and VOCs would be the highest for the vault method because it would involve more soil handling (i.e., for the cover system) than the other two methods. Peak-year emissions of all criteria pollutants and VOCs would be the lowest for the trench method, because it would disturb the smallest area among the disposal methods. In terms of their contribution to the emissions total, peak-year emissions of SO_2 from the vault method would be the highest, about 0.41% of the five-county emissions total, while emissions of other criteria pollutants and VOCs would be 0.30% or less of the five-county emissions total.

Background concentration levels for PM_{10} and annual $PM_{2.5}$ at INL are below the standards (less than 80%), but those for 24-hour $PM_{2.5}$ are about 169% of the standard (Table 7.1.1-3). All construction activities at INL would occur at least 11 km (7 mi) from the site

TABLE 7.2.1-1 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction of the Three Land Disposal Facilities at INL

Pollutant	Total Emissions (tons/yr)[a]	Construction Emissions (tons/yr)					
		Trench (%)		Borehole (%)		Vault (%)	
SO_2	784	0.90	(0.11)[b]	3.0	(0.38)	3.2	(0.41)
NO_x	10,540	8.1	(0.08)	26	(0.25)	31	(0.29)
CO	78,038	3.3	(<0.01)	11	(0.01)	11	(0.01)
VOCs	24,619	0.90	(<0.01)	2.7	(0.01)	3.6	(0.01)
PM_{10}[c]	43,964	5.0	(0.01)	13	(0.03)	8.6	(0.02)
$PM_{2.5}$[c]	7,549	1.5	(0.02)	4.1	(0.05)	3.6	(0.05)
CO_2		670		2,200		2,300	
County[d]	1.99×10^6		(0.03)		(0.11)		(0.12)
Idaho[e]	1.74×10^7		(0.004)		(0.013)		(0.013)
U.S.[e]	6.54×10^9		(0.00001)		(0.00003)		(0.00004)
World[e]	3.10×10^{10}		(0.000002)		(0.000007)		(0.000007)

[a] Total emissions in 2002 for all five counties encompassing INL (Bingham, Bonneville, Butte, Clark, and Jefferson Counties). See Table 7.1.1-1 for criteria pollutants and VOCs.

[b] Numbers in parentheses are percent of total emissions.

[c] Estimates for GTCC construction include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, CO_2 emissions at county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of the population distribution.

[e] Annual CO_2 emissions in Idaho, the United States, and the world in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

boundary and thus would not contribute much to concentrations at the boundary or at the nearest residence. Construction activities would be conducted so as to minimize potential impacts from construction-related emissions on ambient air quality, and construction permits typically require fugitive dust control by established, standard, dust control practices, primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles.

Although O_3 levels in the area approached the standard (about 93%) (Table 7.1.1-3), the five counties encompassing INL are currently in attainment for O_3 (40 CFR 81.313). Ozone precursor emissions from the proposed facility for all methods would be relatively small, less than 0.29% and 0.01% of five-county total NO_x and VOC emissions, respectively, and would be much lower than those for the regional air shed in which emitted precursors are transported and formed into O_3. Accordingly, potential impacts of O_3 precursor releases from construction on regional ozone would not be of concern.

The major air quality concern with respect to emissions of CO_2 is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. The combustion of fossil fuels makes CO_2 the most widely emitted greenhouse gas worldwide. CO_2 concentrations in the atmosphere have continuously increased, from about 280 ppm in preindustrial times to 379 ppm in 2005, a 35% increase, and most of this increase has occurred in the last 100 years (IPCC 2007).

The climatic impact of CO_2 does not depend on the geographic location of sources because CO_2 is stable in the atmosphere and is essentially uniformly mixed; that is, the global total is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the construction of a disposal facility is useful in understanding whether CO_2 emissions from the site are significant with respect to global warming. As shown in Table 7.2.1-1, the highest peak-year amount of CO_2 emissions from construction would be under 0.12%, 0.013%, and 0.00004% of 2005 five-county total, state, and U.S. CO_2 emissions. In 2005, national CO_2 emissions were about 21% of worldwide emissions (EIA 2008); emissions from construction would thus be less than 0.00001% of global emissions. Potential impacts on climate change from construction emissions would be small.

The period over which major land clearing and the construction of surface facilities would occur is assumed to be 3.4 years (see Appendix D). In fact, the disposal units would likely be constructed as the waste would become available for disposal. The construction phase would be extended over more years; thus, emission levels for nonpeak years would be lower than peak-year levels in the table. In addition, construction activities would occur only during daytime hours, when air dispersion is most favorable. Accordingly, potential impacts from construction activities on ambient air quality would be minor and intermittent.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and is not applicable to the proposed action at INL because the area is classified as being in attainment for all criteria pollutants (40 CFR 81.313).

7.2.1.2 Operations

Criteria pollutants, VOCs, and CO_2 would be released into the atmosphere during operations. These emissions would include fugitive dust emissions from emplacement activities and exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Estimated annual emissions of criteria pollutants, VOCs, and CO_2 at the facility are presented in Table 7.2.1-2. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. Annual emission levels for the trench method would be the highest because of the use of forklifts. The annual emission levels for the borehole method would be the lowest. Compared with annual emissions for counties encompassing the INL, the annual emissions of SO_2 for the trench and vault methods would be the highest, about 0.42% of the total emissions, while emissions of all the other criteria pollutants and VOCs would be about 0.25% or less.

It is expected that emission concentration levels from operational activities for PM_{10} and $PM_{2.5}$ (which include diesel particulate emissions) would remain below the standards, except for the 24-hour $PM_{2.5}$ level, which is already above the standard. As discussed in the construction

TABLE 7.2.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations of the Three Land Disposal Facilities at INL

	Total Emissions	Operation Emissions (tons/yr)					
Pollutant	(tons/yr)[a]	Trench (%)		Borehole (%)		Vault (%)	
SO_2	784	3.3	(0.42)[b]	1.2	(0.16)	3.3	(0.42)
NO_x	10,540	27	(0.26)	10	(0.09)	27	(0.26)
CO	78,038	15	(0.02)	6.7	(0.01)	15	(0.02)
VOCs	24,619	3.1	(0.01)	1.2	(<0.01)	3.1	(0.01)
PM_{10}[c]	43,964	2.5	(0.01)	0.91	(<0.01)	2.5	(0.01)
$PM_{2.5}$[c]	7,549	2.2	(0.03)	0.81	(0.01)	2.2	(0.03)
CO_2		3,200		1,700		3,300	
County[d]	1.99×10^6		(0.16)		(0.09)		(0.17)
Idaho[e]	1.74×10^7		(0.018)		(0.010)		(0.019)
U.S.[e]	6.54×10^9		(0.00005)		(0.00003)		(0.00005)
World[e]	3.10×10^{10}		(0.00001)		(0.00001)		(0.00001)

[a] Total emissions in 2002 for all five counties encompassing INL (Bingham, Bonneville, Butte, Clark, and Jefferson Counties). See Table 7.1.1-1 for criteria pollutants and VOCs.

[b] Numbers in parentheses are percent of total emissions.

[c] Estimates from GTCC operations include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, CO_2 emissions at county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

[e] Annual CO_2 emissions in Idaho, the United States, and the world in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

section, established fugitive dust control measures (primarily watering of unpaved roads, disturbed surfaces, and temporary stockpiles) would be implemented to minimize potential impacts on ambient air quality.

With regard to regional O_3, precursor emissions of NO_x and VOCs would come from operational activities (about 0.26% and 0.01% of the five-county emission totals, respectively), and it is not anticipated that they would contribute much to regional O_3 levels. The highest CO_2 emissions among the disposal methods would be comparable to the highest construction-related emissions; thus, their potential impacts on climate change would also be small.

PSD regulations are not applicable to the proposed action because the proposed action is not a major stationary source.

7.2.2 Geology and Soils

Direct impacts from land disturbance would be proportional to the total area of land disturbed during site preparation activities (e.g., grading and backfilling) and construction of the waste disposal facility and related infrastructure (e.g., roads). Land disturbance would include the surface area covered by each disposal method and the vertical displacement of geologic materials for the borehole and trench disposal methods. The increased potential for soil erosion would be an indirect impact of land disturbance at the construction site. Indirect impacts would also result from the consumption of geologic materials (e.g., aggregate) to construct the facility and new roads. The impact analysis also considers whether the proposed action would preclude the future extraction and use of mineral materials or energy resources.

7.2.2.1 Construction

Land surface area disturbance impacts would be a function of the disposal method implemented at the site (Table 5.1-1). Of the three land disposal methods, the borehole facility layout would result in the greatest impact in terms of land area disturbed (44 ha or 110 ac). It also would result in the greatest disturbance with depth (40 m or 130 ft), with boreholes completed in an alternating sequence of unconsolidated sediment and basalt (with the first basalt layer encountered at depths of 13 to 17 m [43 to 57 ft]). A trench might also penetrate the upper basalt layer.

Geologic and soil material requirements are provided in Table 5.3.2-1. Of the three disposal methods, the vault facility would require the most material since it would involve the installation of interim and final cover systems. This material would be considered permanently lost. However, none of the three disposal methods are expected to result in adverse impacts on geologic and soil resources at INL, since these resources are in abundant supply at the site and in the surrounding area.

No significant changes in surface topography or natural drainages are anticipated in the construction area. However, the disturbance of soil during the construction phase would increase the potential for erosion in the immediate vicinity. This potential would be greatly reduced, however, by the low precipitation rates at INL. Mitigation measures also would be implemented to avoid or minimize the risk of erosion.

The GTCC waste disposal facility would be sited, designed, and constructed to meet existing site design criteria (including safeguards to avoid or minimize the risks associated with seismic and volcanic hazards). Although ground shaking has been reported at INL, the ESRP on which INL is situated is a region of relatively low seismicity. The annual probability of a volcanic event (basaltic eruption) is considered low; the risk of silicic volcanism is negligible. The potential for other hazards (e.g., subsidence, liquefaction) is also considered to be low.

7.2.2.2 Operations

The disturbance of soil and the increased potential for soil erosion would continue throughout the operations phase as waste would be delivered to the site for disposal over time. The potential for soil erosion would be greatly reduced by the low precipitation rates at INL. Mitigation measures also would be implemented to avoid or minimize the risk of erosion.

Impacts related to the extraction and use of valuable geologic materials would be low, since only the area within the facility itself would be unavailable for mining, and the potential for oil production and geothermal energy development at the site is considered to be low.

7.2.3 Water Resources

Direct and indirect impacts on water resources could occur as a result of water use at the proposed GTCC waste disposal facility during construction and operations. Table 5.3.3-1 provides an estimate of the water consumption and discharge volumes for the three land disposal methods; Tables 5.3.3-2 and 5.3.3-3 summarize the water use impacts (in terms of change in annual water use) to water resources from construction and normal operations, respectively. A discussion of potential impacts during each project phase is presented in the following sections. In addition, contamination due to potential leaching of radionuclides into groundwater from the waste inventory could occur, depending on the post-closure performance of the land disposal facilities discussed in Section 7.2.4.2.

7.2.3.1 Construction

Of the three land disposal methods considered for INL, construction of a vault facility would have the highest water requirement (Table 5.3.3-1).Water demands for construction at INL would be met by using groundwater from on-site wells completed in the Snake River Plain aquifer. No surface water would be used at the site during construction. As a result, no direct impacts on surface water resources are expected. The potential for indirect surface water impacts on the Big Lost River (to the south of the GTCC reference location) related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures. The GTCC reference location at INL is not located within the 100-yr floodplain.

Currently, INL uses about 4.2 billion L/yr (1.1 billion gal/yr) of groundwater, about 10% of its Federal Reserved Water Right of 43.1 billion L/yr (11.4 billion gal/yr). Construction of the proposed GTCC waste disposal facility would increase the annual water use at INL by a maximum of about 0.08% (vault method) over the 20-year period that construction would occur. This increase would be well within INL's water right. Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at INL. As a result, impacts due to groundwater withdrawals are expected to be small.

Construction activities could potentially change the infiltration rate at the site of the proposed GTCC waste disposal facility, first by increasing the rate as ground would be disturbed in the initial stages of construction and then later by decreasing the rate as impermeable materials (e.g., the clay material and geotextile membrane assumed for the cover or cap for the land disposal facility designs) would cover the surface. These changes are expected to be negligible since the area of land associated with the proposed GTCC waste disposal facility (up to 44 ha [110 ac], depending on the disposal method) is small relative to the INL site.

Disposal of waste (including sanitary waste) generated during construction of the land disposal facilities would have a negligible impact on the quality of water resources at INL (see Sections 5.3.11 and 7.2.11).

The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

7.2.3.2 Operations

Of the three land disposal methods considered for INL, operation of a vault or trench facility would have the highest water requirement (Table 5.3.3-1).Water demands for operations at INL would be met by using groundwater from on-site wells completed in the Snake River Plain aquifer. No surface water would be used at the site during operations. As a result, no direct impacts on surface water resources are expected. The potential for indirect surface water impacts related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures.

Operations of the proposed GTCC waste disposal facility would increase the annual water use at INL by a maximum of about 0.13% (vault or trench method). This increase would be well within INL's water right. Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at INL. As a result, impacts due to groundwater withdrawals are expected to be small.

Disposal of wastes (including sanitary waste) generated during operations of the land disposal facilities would have a negligible impact on the quality of water resources at INL (see Sections 5.3.11 and 7.2.11).

The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

7.2.4 Human Health

Potential impacts on members of the general public and the involved workers from the construction and operations of the waste disposal facilities are expected to be comparable for all of the sites evaluated in this EIS for the three land disposal methods, and these impacts are described in Section 5.3.4. The following sections discuss the impacts from hypothetical facility accidents associated with waste handling activities and the impacts during the long-term post-closure phase. They address impacts on members of the general public who might be affected by these waste disposal activities at the INL GTCC reference location, since these impacts would be site dependent.

7.2.4.1 Facility Accidents

Data on the estimated human health impacts from hypothetical accidents at a GTCC land waste disposal facility located on the INL site are provided in Table 7.2.4-1. A description of the accident scenarios is provided in Section 5.3.4.2.1 and Appendix C. A reasonable range of accidents that considered both operational events and natural causes was analyzed. The impacts presented for each accident scenario are for the sector with the highest impacts and with no protective measures assumed; thus, they are the maximum impacts expected from such an accident.

The collective population dose includes exposure from inhalation of airborne radioactive material, external exposure from radioactive material deposited on the ground, and ingestion of contaminated crops. The exposure period is considered to last for 1 year immediately following the accidental release. It is recognized that interdiction of food crops would likely occur if a significant release did occur, but many stakeholders are interested in what could happen without interdiction. For the accidents involving CH waste (Accidents 1–9, 11, 12), the ingestion dose made up about 20% of the collective population dose shown in Table 7.2.4-1. External exposure was found to be negligible in all cases. All exposures were dominated by the inhalation dose from the passing plume of airborne radioactive material downwind of the hypothetical accident immediately following release.

The highest estimated impact on the general public, 13 person-rem, would be from a hypothetical release from an SWB caused by a fire in the Waste Handling Building (Accident 9). Such a dose is not expected to lead to any additional LCFs in the population. This dose would be to the 65,300 people living to the east of the facility, resulting in an average dose of about 0.0002 rem per person. Because this dose would be from internal intake (primarily inhalation, with some ingestion) and because the DCFs used in this analysis are for a 50-year CEDE, this dose would be accumulated over the course of 50 years.

The dose to an individual (expected to be a noninvolved worker because there would be no public access within 100 m [330 ft] of the GTCC reference location) includes exposure from inhalation of airborne radioactive material and 2 hours of exposure to radioactive material deposited on the ground. As shown in Table 7.2.4-1, the highest estimated dose to an individual, 11 rem, is for Accident 9 from inhalation exposure immediately after the postulated release. This estimated dose is for a hypothetical individual located 100 m (330 ft) to the west-northwest of the accident location. As discussed above, the estimated dose of 11 rem would be accumulated over a 50-year period after intake. Thus, it is not expected to result in acute radiation syndrome. A maximum annual dose of about 5% of the total dose would occur in the first year. The increased lifetime probability of a fatal cancer for this individual is approximately 0.7% on the basis of a total dose of 11 rem.

TABLE 7.2.4-1 Estimated Radiological Human Health Impacts from Hypothetical Facility Accidents at INL[a]

		Off-Site Public		Individual[b]	
Accident Number	Accident Scenario	Collective Dose (person-rem)	Latent Cancer Fatalities[c]	Dose (rem)	Likelihood of LCF[b]
1	Single drum drops, lid failure in Waste Handing Building	0.00028	<0.0001	0.00025	<0.0001
2	Single SWB drops, lid failure in Waste Handing Building	0.00063	<0.0001	0.00055	<0.0001
3	Three drums drop, puncture, lid failure in Waste Handling Building	0.0005	<0.0001	0.00045	<0.0001
4	Two SWBs drop, puncture, lid failure in Waste Handling Building	0.00088	<0.0001	0.00077	<0.0001
5	Single drum drops, lid failure outside	0.28	0.0002	0.25	0.0001
6	Single SWB drops, lid failure outside	0.63	0.0004	0.55	0.0003
7	Three drums drop, puncture, lid failure outside	0.5	0.0003	0.45	0.0003
8	Two SWBs drop, puncture, lid failure outside	0.88	0.0005	0.77	0.0005
9	Fire inside the Waste Handling Building, one SWB assumed to be affected	13	0.008	11	0.007
10	Single RH waste canister breach	<0.0001	<0.0001	<0.0001	<0.0001
11	Earthquake affects 18 pallets, each with four CH drums	7.9	0.005	7.1	0.004
12	Tornado, missile hits one SWB, contents released	2.5	0.001	2.2	0.001

[a] CH = contact-handled, RH = remote-handled, LCF = latent cancer fatality, SWB = standard waste box.

[b] The individual receptor is assumed to be 100 m (330 ft) downwind from the release point. This individual is expected to be a noninvolved worker because there would be no public access within 100 m (330 ft) of the GTCC reference location.

[c] LCFs are calculated by multiplying the dose by the health risk conversion factor of 0.0006 fatal cancer per person-rem (see Section 5.2.4.3). Values are rounded to one significant figure.

7.2.4.2 Post-Closure

The potential radiation dose from airborne releases of radionuclides to the off-site members of the public after the closure of a waste disposal facility would be small. RESRAD-OFFSITE calculation results indicate that there would be no measurable exposure from this pathway for the borehole method. Small radiation exposures are estimated for the trench and vault methods. The potential inhalation dose at a distance of 100 m (330 ft) from the disposal facility is estimated to be less than 1.8 mrem/yr for trench disposal and 0.52 mrem/yr for vault disposal. The potential radiation exposures would be caused mainly by inhalation of radon gas and its short-lived progeny.

The use of boreholes would provide better protection against potential exposures from airborne releases of radionuclides because of the greater depth of cover material involved. The top of the waste placement zone for the boreholes would be 30 m (100 ft) bgs, and this depth of overlying soil would inhibit the diffusion of radon gas, CO_2 gas (containing C-14), and tritium (H-3) water vapor to the atmosphere above the disposal area. However, because the distance to the groundwater table would be closer under the borehole method than under the trench and vault methods, radionuclides that leached out from wastes in the boreholes would reach the groundwater table in a shorter time than would radionuclides that leached out from a trench or vault disposal facility.

Within 10,000 years, C-14, Tc-99, and I-129 could reach the groundwater table and a well installed by a hypothetical resident farmer located at a distance of 100 m (330 ft) from the downgradient edge of the disposal facility. All three of these radionuclides are highly soluble in water, a quality that could lead to potentially significant groundwater concentrations and subsequently to a measurable radiation dose to the resident farmer. The peak annual dose associated with the use of contaminated groundwater from disposal of the entire GTCC waste inventory at INL was calculated to be 820 mrem/yr for the borehole method, 2,300 mrem/yr for the vault method, and 2,100 mrem/yr for the trench method.

Although radionuclides would reach the groundwater table sooner under the borehole method, the peak annual dose within 10,000 years would occur later than it would under the other two disposal methods because of uranium isotopes from the disposal facility that would reach the groundwater table near the end of the 10,000-year time frame. The uranium isotopes would produce a radiation dose to the hypothetical resident farmer that would be slightly higher than the dose resulting from the C-14, Tc-99, and I-129 that would reach the groundwater table sooner under the borehole disposal method. Calculations indicate that the uranium isotopes would not reach the groundwater table within 10,000 years under the trench and vault disposal methods.

Tables 7.2.4-2 and 7.2.4-3 present the peak annual doses and LCF risks, respectively, to the hypothetical resident farmer (from use of potentially contaminated groundwater within the first 10,000 years after closure of the disposal facility) when the disposal of the entire GTCC waste inventory by using the land disposal methods evaluated is considered. In these tables, the doses contributed by each waste type (i.e., dose for each waste type at the time or year when the peak dose for the entire inventory is observed) to the peak dose reported are also tabulated. The

TABLE 7.2.4-2 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at INL[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual Dose for Entire Inventory
Borehole									820[b]
Group 1 stored	2.6	-	0.0	0.45	0.21	0.0	48	17	
Group 1 projected	39	32	-	0.013	0.52	0.0	8.4	580	
Group 2 projected	21	0.0	5.6	24	-	-	17	26	
Vault									2,300[b]
Group 1 stored	1.5	-	0.0	2.3	0.0	0.0	0.59	2,200	
Group 1 projected	24	0.0	-	0.069	0.0	0.0	0.22	6.4	
Group 2 projected	12	0.0	1.4	86	-	-	0.33	12	
Trench									2,100[b]
Group 1 stored	1.7	-	0.0	2.0	0.0	0.0	0.65	1,900	
Group 1 projected	28	0.0	-	0.0	0.0	0.0	0.24	5.7	
Group 2 projected	14	0.0	1.5	77	-	-	0.37	11	

[a] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual doses to the hypothetical resident farmer at the time of peak annual dose for the entire GTCC waste inventory. These contributions do not represent the maximum doses that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses that could result from each of the waste types are presented in Tables E-22 through E-25 in Appendix E.

[b] The times for the peak annual doses of 820 mrem/yr for boreholes, 2,300 mrem/yr for vaults, and 2,100 mrem/yr for trenches were calculated to be about 9,200 years, 220 years, and 190 years, respectively, for disposal of the entire GTCC waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual doses for the specific waste types at the time of these peak doses. The primary contributor to the dose in all cases is GTCC-like Other Waste - RH. For borehole disposal, the primary radionuclides causing the dose would be uranium isotopes; and C-14, Tc-99, and I-129 would be the primary radionuclides causing this dose for the vault and trench disposal methods.

TABLE 7.2.4-3 Estimated Peak Annual LCF Risks from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at INL[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual LCF Risk for Entire Inventory
Borehole									5E-04[b]
Group 1 stored	2E-06	-	0E+00	3E-07	1E-07	0E+00	3E-05	1E-05	
Group 1 projected	2E-05	2E-05	-	8E-09	-	-	5E-06	3E-04	
Group 2 projected	1E-05	0E+00	3E-06	1E-05	0E+00	0E+00	1E-05	2E-05	
Vault									1E-03[b]
Group 1 stored	9E-07	-	0E+00	1E-06	0E+00	0E+00	4E-07	1E-03	
Group 1 projected	1E-05	0E+00	-	4E-08	0E+00	0E+00	1E-07	4E-06	
Group 2 projected	7E-06	0E+00	8E-07	5E-05	-	-	2E-07	7E-06	
Trench									1E-03[b]
Group 1 stored	1E-06	-	0E+00	1E-06	0E+00	0E+00	4E-07	1E-03	
Group 1 projected	2E-05	0E+00	-	0E+00	0E+00	0E+00	1E-07	3E-06	
Group 2 projected	8E-06	0E+00	9E-07	5E-05	-	-	2E-07	6E-06	

[a] These annual LCF risks are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to one significant figure, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual LCF risks to the hypothetical resident farmer at the time of peak annual LCF risk for the entire GTCC waste inventory. These contributions do not represent the maximum LCF risks that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum LCF risks that could result from each waste type individually generally occur at different times than the peak annual LCF risk from the entire inventory.

[b] The times for the peak annual LCF risks of 5E-04 for boreholes, 1E-03 for vaults, and 1E-03 for trenches were calculated to be about 9,200 years, 220 years, and 190 years, respectively, for disposal of the entire GTCC waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual LCF risks for the specific waste types at the time of peak LCF risks. The primary contributor to the LCF risk in all cases is GTCC-like Other Waste - RH. For borehole disposal, the primary radionuclides causing the risk would be uranium isotopes; and C-14, Tc-99, and I-129 would be the primary radionuclides causing this risk for the vault and trench disposal methods.

doses presented from the various waste types do not necessarily represent the peak dose and LCF risk of the waste type itself when it is considered on its own.

For borehole disposal, it is estimated that the peak annual dose and LCF risks would occur about 9,200 years after disposal, and calculations indicate that the peak annual dose and LCF risks would occur 220 years after disposal for the vault method and 190 years after disposal for the trench method. These times represent the time after failure of the engineered barriers (including the cover), which is assumed to begin 500 years after closure of the disposal facility. The GTCC-like Other Waste - RH would be the primary contributor to the dose in all cases. C-14, Tc-99, and I-129 would be the primary radionuclides of concern within a time frame of 10,000 years after closure of the disposal facility for all the three disposal methods. As noted above, under the borehole method, uranium isotopes would also reach the groundwater table within 10,000 years and contribute to the maximum dose at 9,200 years. These radionuclides contribute more than 90% of the total dose.

Tables E-22 through E-25 in Appendix E present peak doses for each waste type when considered on its own. Because these peak doses generally occur at different times, the results should not be summed to obtain total doses for comparison with those presented in Table 7.2.4-2 (although for some cases, these sums might be close to those presented in the site-specific chapters).

Figure 7.2.4-1 is a temporal plot of the radiation doses associated with the use of contaminated groundwater for a period extending to 10,000 years, and Figure 7.2.4-2 shows these results to 100,000 years for the three land disposal methods. Note that the time scale is logarithmic in Figure 7.2.4-1 and linear in Figure 7.2.4-2. A logarithmic time scale was used in the first figure to better illustrate the projected radiation doses to a hypothetical resident farmer in the first 1,000 years.

Although C-14, Tc-99, and I-129 would result in measurable radiation doses in the first 10,000 years, the inventory of these radionuclides in the disposal areas would be depleted rather quickly. Under the three land disposal options, various isotopes of uranium as well as Np-237 and Am-241 would reach the groundwater table after about 9,000 to 16,000 years and contribute to radiation exposures. At that time, the radiation doses from these radionuclides could greatly exceed those from C-14, Tc-99, and I-129, and the magnitude of the calculated annual doses to the hypothetical resident farmer would be comparable to those that are predicted to occur in the first 10,000 years. However, there is a high degree of uncertainty associated with results like these, which are for such a long time of analysis.

The results given here are assumed to be conservative because the location selected for the residential exposure was 100 m (330 ft) from the edge of the disposal facility. Use of a longer distance, which might be more realistic for the sites being evaluated, would significantly lower these estimated doses (i.e., by as much as 70%). A sensitivity analysis performed to determine the effect of a distance longer than 100 m (330 ft) is presented in Appendix E.

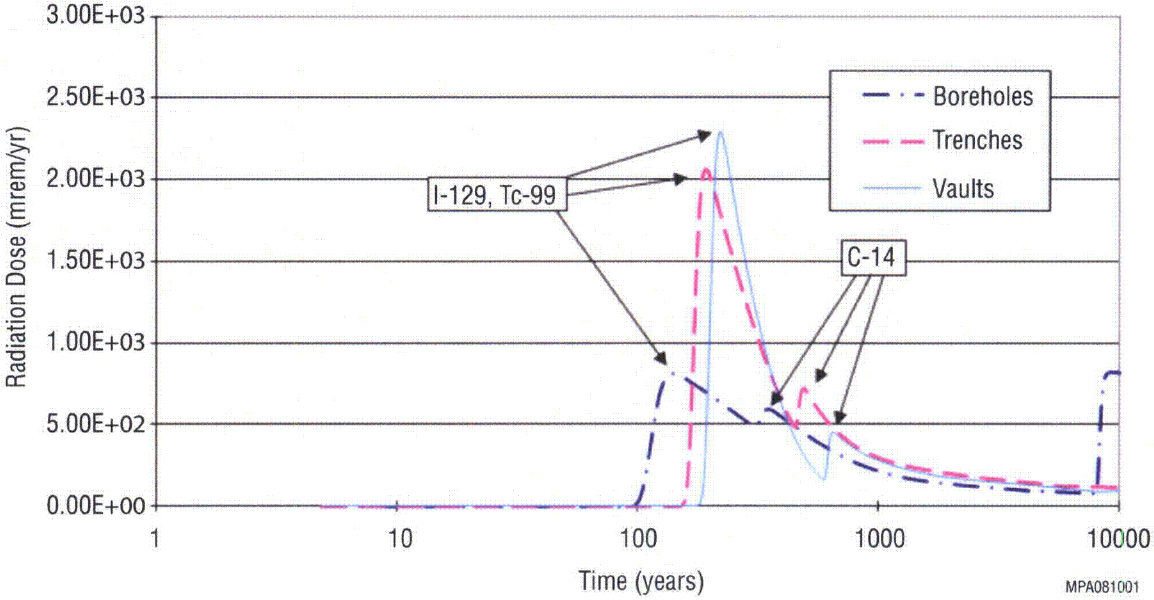


FIGURE 7.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal for the Three Land Disposal Methods at INL

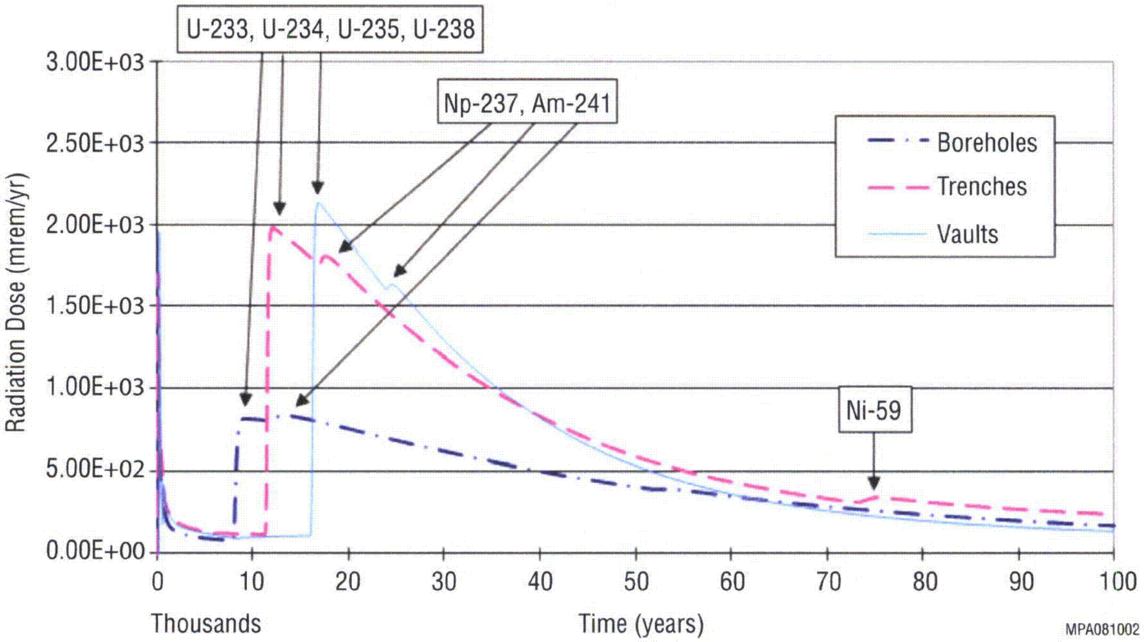


FIGURE 7.2.4-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Three Land Disposal Methods at INL

These analyses assume that engineering controls would be effective for 500 years following closure of the disposal facility. This means that essentially no infiltrating water would reach the wastes from the top of the disposal units during the first 500 years. It is assumed that after 500 years, the engineered barriers would begin to degrade, allowing infiltrating water to come in contact with the disposed-of wastes. For purposes of analysis in the EIS, it is assumed that the amount of infiltrating water that would contact the wastes would be 20% of the site-specific natural infiltration rate for the area, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate for the area. This approach is conservative because it is expected that the engineered systems (including the disposal facility cover) would last significantly longer than 500 years, even in the absence of active maintenance measures.

It is assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. Consistent with the assumptions used for engineering controls, no credit was taken for the effectiveness of this stabilizing agent after 500 years in this analysis. That is, any water that would contact the wastes after 500 years would be able to leach radioactive constituents from the disposed-of materials. These radionuclides could then move with the percolating groundwater to the underlying groundwater system. This assumption is conservative because grout or other stabilizing materials could retain their integrity for longer than 500 years.

Sensitivity analyses performed relative to these assumptions indicate that if a higher infiltration rate to the top of the disposal facilities was assumed, the doses would increase in a linear manner from those presented. Conversely, the doses would decrease in a linear manner with lower infiltration rates. This finding indicates that there is a need to ensure a good cover over the closed disposal units. Also, the doses would be lower if the grout was assumed to last for a longer time. Because of the long-lived nature of the radionuclides associated with the GTCC LLRW and GTCC-like waste, any stabilization effort (such as grouting) would have to be effective for longer than 5,000 years in order to substantially reduce doses that could result from potential future leaching of the disposed-of waste (particularly that from GTCC-like Other Waste - RH).

The radiation doses presented in the post-closure assessment in this EIS are intended to be used for comparing the performance of each of the land disposal methods at each site evaluated. The results indicate that the use of robust engineering designs and redundant measures (e.g., types and thicknesses of covers and long-lasting grout) in the disposal facility could delay the potential release of radionuclides and could reduce the release to low levels, thereby minimizing the potential groundwater contamination and associated human health impacts in the future. DOE will consider the potential doses to the hypothetical farmer and other factors in developing the preferred alternative as discussed in Section 2.9.

7.2.5 Ecology

It is expected that the initial loss of sagebrush habitat would not create a long-term reduction in the local or regional ecological diversity. After closure of the waste disposal facility, the cover would initially become vegetated with annual and perennial grasses and forbs. Reestablishment of mature sagebrush stands would be difficult because of the arid climate and could take a minimum of 10 to 20 years (Poston and Sackschewsky 2007). As appropriate, regionally native plants would be used to landscape the disposal site in accordance with "Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscape Grounds" (EPA 1995). An aggressive revegetation program would be necessary so that nonnative cheatgrass (*Bromus tectorum*) and halogeton (*Halogeton glomeratus*) would not become established. These species are quick to colonize disturbed sites and are difficult to eradicate because they produce large amounts of seeds yearly that remain viable for long periods of time (Blew et al. 2006).

Because wetlands do not occur within the area of the ATR Complex (DOE 2005), impacts on INL wetlands from construction, operations, and post-closure of the waste disposal facility would not occur. Wetland plants could develop along the borders of the waste facility retention pond, and depending on the slope of the pond margins and amount and length of time that the pond would retain water, the shoreline areas of the pond might function in a manner similar to that of a natural emergent wetland.

At the GTCC reference location, species such as pygmy rabbit, greater sage-grouse, sage thrasher, loggerhead shrike, sage sparrow, and Brewer's sparrow, which depend on sagebrush, would be replaced by species that thrive in grasslands, such as mountain cottontail, western meadowlark, horned lark, grasshopper sparrow, and vesper sparrow (Vilord et al. 2005; Blew et al. 2006).

Because no natural aquatic habitats occur within the immediate vicinity of the GTCC reference location, impacts on aquatic biota are not expected. DOE would use appropriate erosion control measures to minimize off-site movement of soil. It is expected that the waste disposal facility retention pond would not become a highly productive aquatic habitat. However, depending on the amount of water and length of time that water would be retained within the pond, aquatic invertebrates could become established within it. Waterfowl, shorebirds, and other birds might also make use of the retention pond, as would mammal species that might enter the site.

No federally or state-listed or special-status species have been reported from the vicinity of the ATR Complex (DOE 2005). However, several species that inhabit sagebrush habitats (e.g., greater sage-grouse and pygmy rabbit) could be affected by the habitat loss that would result from construction of a waste disposal facility. Since only a small proportion of the sagebrush habitat on INL would be affected by the waste disposal facility, it is not expected that it would have a population-level impact on these species.

Among the goals of the waste management mission at INL is to design, construct, operate, and maintain disposal facilities in a manner that protects the environment and complies with regulations (DOE 2002). Therefore, impacts on ecological resources that could result from the disposal facility for GTCC LLRW and GTCC-like waste would be minimized and mitigated.

7.2.6 Socioeconomics

7.2.6.1 Construction

The potential socioeconomic impacts from constructing a GTCC waste disposal facility and support buildings at INL would be relatively small for all disposal methods. Construction activities would create direct employment for 62 people (trench method) to 145 people (vault method) in the peak construction year and an additional 70 indirect jobs (trench method) to 184 indirect jobs (borehole method) in the ROI (Table 7.2.6-1). Construction activities would increase the annual average employment growth rate by less than 0.1 of a percentage point over the duration of construction. A GTCC facility would produce between $4.6 million in income (trench method) and $12.1 million in income (vault method) in the peak year of construction.

In the peak year of construction, between 27 people (trench method) and 64 people (vault method) would in-migrate to the ROI (Table 7.2.6-1) as a result of employment on-site. In-migration would have only a marginal effect on population growth and would require no more than 2% of vacant rental housing in the peak year. No significant impact on public finances would occur as a result of in-migration, and no more than one new local public service employee would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small to moderate impact on levels of service in the local transportation network surrounding the site.

7.2.6.2 Operations

The potential socioeconomic impacts from operating a GTCC waste disposal facility would be small for all disposal methods. Operational activities would create 38 direct jobs (borehole method) to 51 direct jobs (vault method) annually and an additional 42 indirect jobs (borehole method) to 50 indirect jobs (vault method) in the ROI (Table 7.2.6-1). A GTCC facility would also produce between $3.9 million in income (borehole method) and $4.9 million in income (vault method) annually during operations.

Two people would move to the area at the beginning of operations (Table 7.2.6-1). In-migration would have only a marginal effect on population growth and would require less than 1% of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur as a result of in-migration, and no new local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small impact on levels of service in the local transportation network surrounding the site.

TABLE 7.2.6-1 Effects of GTCC Waste Disposal Facility Construction and Operations on Socioeconomics at the ROI for INL[a]

	Trench		Borehole		Vault	
Impact Category	Construction	Operation	Construction	Operation	Construction	Operation
Employment (number of jobs)						
Direct	62	48	72	38	145	51
Indirect	70	48	197	42	184	50
Total	132	96	269	80	329	101
Income ($ in millions)						
Direct	2.4	3.2	3.3	2.6	6.3	3.4
Indirect	2.2	1.5	5.5	1.3	5.8	1.5
Total	4.6	4.7	8.8	3.9	12.1	4.9
Population (number of new residents)	27	2	32	2	64	2
Housing (number of units required)	14	1	16	1	32	1
Public finances (% impact on expenditures)						
Cities and counties[b]	<1	<1	<1	<1	<1	<1
Schools[c]	<1	<1	<1	<1	<1	<1
Public service employment (number of new employees)						
Local government employees[d]	0	0	0	0	1	0
Teachers	0	0	0	0	1	0
Traffic (impact on current levels of service)	Small	Small	Small	Small	Moderate	Small

[a] Impacts shown are for waste facility and support buildings in the peak year of construction and the first year of operations.

[b] Includes impacts that would occur in the cities of Arimo, Chubbock, Downey, Inkom, Lava Hot Springs, McCammon, Pocatello, Aberdeen, Basalt, Blackfoot, Firth, Shelley, Ammon, Idaho Falls, Iona, Irwin, Swan Valley, Ucon, Lewisville, Menan, Rigby, Ririe, and Roberts and in the counties of Bannock, Bingham, Bonneville, and Jefferson.

[c] Includes impacts that would occur in the school districts of Marsh Valley, Pocatello, Aberdeen, Blackfoot, Firth, Shelley, Snake River, Idaho Falls, Bonneville, Swan Valley, Jefferson County, Ririe, and West Jefferson.

[d] Includes police officers, paid firefighters, and general government employees.

7.2.7 Environmental Justice

7.2.7.1 Construction

No radiological risks and only very low chemical exposure and risk are expected during construction of the trench, borehole, or vault facility. Chemical exposure during construction would be limited to airborne toxic air pollutants at less than standard levels and would not result in any adverse health impacts. Because the health impacts of each facility on the general population within the 80-km (50-mi) assessment area during construction would be negligible, impacts from construction of each facility on the minority and low-income population would not be significant.

7.2.7.2 Operations

Because incoming waste containers would only be consolidated for placement in trench, borehole, and vault facilities with no repackaging necessary, there would be no radiological impacts on the general public during normal operations, and no adverse health effects on the general population. Because the health impacts of routine operations on the general public would be negligible, it is expected that there would be no disproportionately high and adverse impact on minority and low-income population groups within the 80-km (50-mi) assessment area. Subsequent NEPA analysis to support any GTCC implementation would consider any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well water use) to determine any additional potential health and environmental impacts.

7.2.7.3 Accidents

A radiological release at any of the three facilities could cause LCFs in the surrounding area, but it is highly unlikely such a release would occur. Therefore, the risk to any population, including low-income and minority communities, is considered to be low. In the unlikely event of a release at a facility, the communities most likely to be affected could be minority or low-income, given the demographics within 80 km (50 mi) of the GTCC reference location.

In the event that an accident producing significant contamination occurred, appropriate measures would be taken to ensure that the impacts on low-income and minority populations would be minimized. The extent to which low-income and minority population groups would be affected would depend on the amount of material released and the direction and speed at which airborne material was dispersed from any of the facilities by the wind. Although the overall risk would be very small, the greatest short-term risk of exposure following an airborne release and the greatest one-year risk would be to the population groups residing to the southwest of the site. Airborne releases following an accident would likely have a larger impact on the area than would an accident that released contaminants directly into the soil surface. A surface release entering local steams could temporarily interfere with subsistence activities being carried out by low-income and minority populations within a few miles downstream of the site.

Monitoring of contaminant levels in soil and surface water following an accident would provide the public with information on the extent of any contaminated areas. Analysis of these contaminated areas would reduce the likelihood for exposures and potential impacts on local residents.

7.2.8 Land Use

Section 5.3.8 presents an overview of the potential land use impacts that could occur from the construction, operations, and post-closure maintenance of a waste disposal facility regardless of the location selected for it. This section evaluates the potential impacts on land use at INL.

The disposal of GTCC waste at the reference location would be consistent with DOE policy on land use and facility planning and existing INL land use plans. The Comprehensive Facility and Land Use Plan (Sperber et al. 1998) for INL anticipates that future industrial development would most likely be concentrated in the central portion of INL within existing major complex areas. The land use classification of the reference location for the GTCC waste disposal facility would change from general open space to facility operations. Land use on areas surrounding INL would not be affected.

7.2.9 Transportation

The transportation impacts from shipments that would be required to dispose of all GTCC LLRW and GTCC-like waste at INL were evaluated. No impacts from transportation are assumed for the wastes generated at INL, which consist of GTCC-like waste that is stored, projected activated metal wastes, and projected Other Waste - CH and Other Waste - RH. As discussed in Section 5.3.9, transportation of all cargo by the truck mode and rail mode as separate options is considered for the purposes of this EIS. Transportation impacts are expected to be the same for disposal in boreholes, trenches, or vaults because the same type of transportation packaging would be used regardless of the disposal method.

As discussed in Appendix C, three impacts from transportation were calculated: (1) collective population risks during routine conditions and accidents (Section 7.2.9.1), (2) radiological risks to individuals receiving the highest impacts during routine conditions (Section 7.2.9.2), and (3) consequences to individuals and populations after the most severe accidents involving a release of radioactive or hazardous chemical material (Section 7.2.9.3).

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rates for CH waste shipments to INL are assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rate is assumed to be 2.5 and 5.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. These assignments are based on shipments of similar types of waste. Dose rates from rail shipments are approximately double those for truck shipments because rail shipments are assumed to have twice the number of waste packages as a truck shipment. Impacts from accidents are dependent on the amount of radioactive material in a shipment and on the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

7.2.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group; no individual receptors are specified. Exposures to four different groups are considered: (1) persons living and working along the transportation routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for cargo-related risks from routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and are only calculated for traffic accidents (fatalities caused by physical trauma).

Estimated impacts from the truck and rail options are summarized in Tables 7.2.9-1 and 7.2.9-2, respectively. For the truck option, it is estimated that about 12,600 shipments involving about 42 million km (26 million mi) of travel would cause no LCFs in both truck crew members and the public. One fatality directly related to accidents could result. For the rail option, potentially one physical fatality from accidents and no LCFs are estimated from the approximately 4,980 railcar shipments and about 17 million km (11 million mi) of travel that would be involved.

7.2.9.2 Highest-Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals might be exposed to radiation in the vicinity of a shipment. Risks to these individuals for a number of hypothetical exposure-causing events were estimated. The receptors include transportation workers, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living and/or working near a destination site. The assumptions about exposure are given in Appendix C, and transportation impacts are discussed in Section 5.3.9. The scenarios for exposure are not meant to be exhaustive; they were selected to provide a range of representative potential exposures. On a site-specific basis, if someone was living or working near the INL entrance and present for all 12,600 truck or 4,980 rail shipments projected, that individual's estimated dose would be approximately 0.5 or 1.0 mrem, respectively, over the course of more than 50 years. The individual's associated lifetime LCF risk would then be 3×10^{-7} or 6×10^{-7} for truck or rail shipment, respectively.

TABLE 7.2.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at INL[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	20	67,000	0.7	0.02	0.1	0.12	0.24	0.00016	0.0004	0.0001	0.0014
Past PWRs	143	413,000	4.3	0.12	0.62	0.76	1.5	0.00076	0.003	0.0009	0.0082
Operating BWRs	569	1,830,000	19	0.51	2.7	3.4	6.6	0.003	0.01	0.004	0.037
Operating PWRs	1,720	5,520,000	57	1.6	8.2	10	20	0.011	0.03	0.01	0.11
Sealed sources - CH	209	559,000	0.23	0.056	0.32	0.4	0.78	0.036	0.0001	0.0005	0.01
Cesium irradiators - CH	240	642,000	0.27	0.064	0.36	0.46	0.89	0.0055	0.0002	0.0005	0.012
Other Waste - CH	5	14,400	0.006	0.0013	0.0083	0.01	0.02	<0.0001	<0.0001	<0.0001	0.00032
Other Waste - RH	54	204,000	2.1	0.064	0.3	0.37	0.74	<0.0001	0.001	0.0004	0.0046
GTCC-like waste											
Activated metals - RH	11	36,600	0.38	0.01	0.053	0.067	0.13	<0.0001	0.0002	<0.0001	0.0027
Sealed sources - CH	1	2,670	0.0011	0.00027	0.0015	0.0019	0.0037	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	65	224,000	0.094	0.025	0.13	0.16	0.31	0.00074	<0.0001	0.0002	0.0043
Other Waste - RH	1,120	3,840,000	40	1.1	5.6	7.1	14	0.002	0.02	0.008	0.074

TABLE 7.2.9-1 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[c]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	202	666,000	6.9	0.18	0.99	1.2	2.4	0.0016	0.004	0.001	0.014
New PWRs	833	2,600,000	27	0.8	3.9	4.8	9.5	0.0053	0.02	0.006	0.052
Additional commercial waste	1,990	6,840,000	71	1.9	10	13	25	<0.0001	0.04	0.01	0.13
Other Waste - CH	139	478,000	0.2	0.053	0.27	0.34	0.67	0.0025	0.0001	0.0004	0.0092
Other Waste - RH	3,790	13,200,000	140	3.8	19	24	47	0.00074	0.08	0.03	0.26
GTCC-like waste											
Other Waste - CH	44	148,000	0.062	0.016	0.085	0.11	0.21	0.00034	<0.0001	0.0001	0.0028
Other Waste - RH	1,400	4,800,000	49	1.4	7.1	8.8	17	0.002	0.03	0.01	0.092
Total Groups 1 and 2	12,600	42,000,000	410	12	60	75	150	0.072	0.2	0.09	0.83

[a] BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

[b] Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

[c] Vehicle-related impacts are impacts independent of the cargo in the shipment.

[d] LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

[c] Dose risk is a societal risk and is the product of accident probability and accident consequence.

TABLE 7.2.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at INL[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	7	23,300	0.18	0.057	0.0034	0.082	0.14	0.00036	0.0001	<0.0001	0.0015
Past PWRs	37	109,000	0.89	0.26	0.017	0.4	0.68	0.0014	0.0005	0.0004	0.0053
Operating BWRs	154	506,000	4	1.2	0.074	1.9	3.1	0.003	0.002	0.002	0.015
Operating PWRs	460	1,530,000	12	3.6	0.21	5.5	9.3	0.01	0.007	0.006	0.05
Sealed sources - CH	105	263,000	0.66	0.16	0.011	0.48	0.66	0.0012	0.0004	0.0004	0.0043
Cesium irradiators - CH	120	300,000	0.75	0.19	0.012	0.55	0.75	0.00017	0.0005	0.0004	0.005
Other Waste - CH	3	9,480	0.022	0.0063	0.0005	0.014	0.021	<0.0001	<0.0001	<0.0001	0.00038
Other Waste - RH	27	104,000	0.8	0.28	0.013	0.36	0.65	<0.0001	0.0005	0.0004	0.0027
GTCC-like waste											
Activated metals - RH	3	10,400	0.081	0.024	0.0013	0.037	0.062	<0.0001	<0.0001	<0.0001	0.0021
Sealed sources - CH	1	2,500	0.0063	0.0016	0.0001	0.0046	0.0062	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	33	115,000	0.26	0.12	0.0077	0.18	0.31	0.00013	0.0002	0.0002	0.0036
Other Waste - RH	562	1,960,000	15	4.8	0.3	7	12	0.00031	0.009	0.007	0.058

TABLE 7.2.9-2 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	54	189,000	1.5	0.43	0.025	0.71	1.2	0.0014	0.0009	0.0007	0.0057
New PWRs	227	747,000	5.9	1.8	0.097	2.8	4.7	0.0035	0.004	0.003	0.022
Additional commercial waste	498	1,730,000	14	4.3	0.27	6.2	11	<0.0001	0.008	0.006	0.054
Other Waste - CH	70	244,000	0.56	0.26	0.016	0.38	0.65	0.00046	0.0003	0.0004	0.0076
Other Waste - RH	1,900	6,680,000	52	17	1	24	41	<0.0001	0.03	0.02	0.2
GTCC-like waste											
Other Waste - CH	22	76,500	0.17	0.077	0.0046	0.12	0.2	<0.0001	0.0001	0.0001	0.0021
Other Waste - RH	702	2,440,000	19	5.9	0.38	8.8	15	0.00029	0.01	0.009	0.074
Total Groups 1 and 2	4,980	17,000,000	130	40	2.4	59	100	0.022	0.08	0.06	0.52

[a] BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

[b] Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

[c] Vehicle-related impacts are impacts independent of the cargo in the shipment.

[d] LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

[e] Dose risk is a societal risk and is the product of accident probability and accident consequence.

7.2.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Because the exact location of such a transportation accident is impossible to predict, and thus not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

7.2.10 Cultural Resources

The GTCC reference location evaluated for land waste disposal facilities at INL is situated southwest of the ATR Complex. No known cultural resources are located within the project area. However, the reference location has not been examined for the presence of cultural resources. In the event that this location at INL is considered for development, the NHPA Section 106 process would be followed for considering potential project impacts on significant cultural resources, as necessary. The Section 106 process requires that the location and any ancillary locations that would be affected by the project be investigated for the presence of cultural resources prior to disturbance.

On the basis of previous research in the region, it is expected that some small prehistoric archaeological sites and also possibly some more substantial historic homesteads that were using the nearby Big Lost River for irrigation would be found in the project area. If archaeological sites were identified, they would require evaluation for listing on the NRHP. Most impacts on significant cultural resources could be mitigated through documentation. The appropriate mitigation would be determined through consultation with the Idaho SHPO and the appropriate Native American tribes.

The borehole method has the greatest potential to affect cultural resources because of its requirements for 44 ha (110 ac) of land. The amount of land needed to employ this option is about twice that needed to construct either the trench or vault disposal facility. It is expected that the majority of the impacts on cultural resources would occur during the construction phase. Visual impacts from the borehole method would be minimal compared with those from the trench or vault method because the majority of the borehole disposal facility would be below grade. Activities associated with operations and post-closure are expected to have a minimal impact on cultural resources. No new ground-disturbing activities are expected to occur in association with operational and post-closure activities.

Northeast of the GTCC reference location is the ATR Complex. A radiological release from the GTCC reference location could have an impact on the ATR, which is considered a historically significant reactor.

Unlike the other two methods being considered, the vault method would require large amounts of soil to cover the waste. Potential impacts on cultural resources could occur during the removal and hauling of the soil required for the vault method. Impacts on cultural resources would need to be considered for the soil extraction locations. The NHPA Section 106 process would be followed for all locations. Potential impacts on cultural resources from the operation of a vault facility could be comparable to those expected from the borehole and trench methods. While the actual footprint of a vault facility would be smaller, the amount of land disturbed for the vault cover could mean that the land requirements for the vault method might exceed those for the borehole method.

7.2.11 Waste Management

The construction of the land disposal facilities would generate small quantities of waste in the form of hazardous and nonhazardous solids and hazardous and nonhazardous liquids. Nonhazardous wastes include sanitary waste. Waste generated from operation would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable waste). These waste types would either be disposed of on-site or sent off-site for disposal. No impacts on waste management programs at INL are expected from the waste that could be generated from the construction and operation of the land disposal methods. Section 5.3.11 provides a summary of the waste handling programs at INL for the waste types generated.

7.3 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences from the disposal of GTCC LLRW and GTCC-like waste under Alternatives 3 and 4 are summarized by resource area as follows:

Air quality. Potential impacts from construction and operations of a disposal facility at INL on the ambient air quality would be negligible or minor, at most. The highest emissions associated with the vault method would be about 0.42% of the five-county emissions total for SO_2. O_3 levels in the five counties encompassing INL are currently in attainment; O_3 precursor emissions from construction and operational activities would be relatively small, less than 0.30% and 0.02% of NO_x and VOC emissions, respectively, and much lower than those for the regional airshed. During construction and operations, maximum CO_2 emissions would about 0.00001% of global emissions (negligible). All construction and operation activities would occur at least 11 km (7 mi) from the site boundary and would not contribute much to concentrations at the boundary or at the nearest residence. Fugitive dust emissions during construction and operations would be controlled by best management practices.

Noise. The highest composite noise level during construction would be about 92 dBA at 15 m (50 ft) from the source. Noise levels at 690 m (2,300 ft) from the source would be below the EPA guideline of 55 dBA as L_{dn}. This distance would be well within the INL boundary, and there are no residences within this distance. Noise generated during operations would be less than noise during the construction phase. No impacts from groundborne vibration are anticipated because the generating equipment would not be high-vibration equipment and because there are no residences or vibration-sensitive buildings nearby.

Geology. During the construction phase, the borehole facility footprint would result in the greatest impact in terms of the amount of land disturbed (44 ha or 110 ac). It also would result in the greatest degree of disturbance, with disturbance reaching a depth of 40 m (130 ft) as a result of boreholes completed in unconsolidated material interlayered with basalt. No adverse impacts from the extraction or use of geologic and soil resources are expected. No significant changes in surface topography or natural drainages would occur. The potential for erosion would be reduced by low precipitation rates and further reduced by best management practices.

Water resources. Construction of a vault facility would have the highest water requirement. Water demands for construction at INL would be met by using groundwater from on-site wells completed in the Snake River Plain aquifer. No surface water would be used at the site during construction; therefore, no direct impacts on surface water are expected. Indirect impacts on surface water would be reduced by implementing good industry practices and mitigation measures. Construction and operations of the proposed GTCC waste disposal facility would increase the annual water use at INL by a maximum of about 0.08% and 0.13%, respectively (both from the vault method). Since these increases are well within INL's water right and would not significantly lower the water table or change the direction of groundwater flow, impacts due to groundwater withdrawals are expected to be negligible. There would be no water demands during the post-closure period. Groundwater could become contaminated with some highly soluble radionuclides during the post-closure period; indirect impacts on surface water could result from aquifer discharges to springs and rivers.

Human health. The impacts on workers from operations would mainly be those associated with the radiation doses resulting from handling of the wastes. The annual radiation doses would be 2.6 person-rem/yr for the borehole method, 4.6 person-rem/yr for the trench method, and 5.2 person-rem/yr for the vault method. The worker doses would result in less than one LCF (see Section 5.3.4.1.1). The maximum dose to any individual worker would not exceed the DOE administrative control level of 2 rem/yr for site operations. It is expected that the maximum dose to any individual worker over the entire project would not exceed a few rem. The worker impacts from accidents would be associated with the physical injuries and possible fatalities that could result from construction and waste handling activities. It is estimated that the annual number of lost workdays due to injuries and illnesses during disposal operations would range from 1 (for use of boreholes) to 2 (for the trench and vault methods) and that no fatalities would occur from construction and waste handling accidents (see Section 5.3.4.2.2). These injuries would not be associated with the radioactive nature of the wastes but would simply be those expected to occur during any construction project of this size.

With regard to the general public, no measurable doses are expected to occur during waste disposal at the site, given the solid nature of the wastes and the distance of waste handling activities from potentially affected individuals. It is estimated that the highest dose to an individual from an accident involving the waste packages prior to disposal (from a fire affecting an SWB) would be 11 rem and would not result in any LCFs. The collective dose to the affected population from such an event would be 13 person-rem. It is estimated that the peak annual dose in the first 10,000 years after closure of the disposal facility to a hypothetical nearby receptor (resident farmer) who resided 100 m (330 ft) from the disposal site would be 2,300 mrem/yr for the vault method. This dose would result mainly from the GTCC-like Other Waste - RH and would occur about 220 years in the future. The peak annual doses for the borehole and trench methods within the first 10,000 years after closure are somewhat lower: 820 mrem/yr and 2,100 mrem/yr, respectively. These doses would occur 9,200 years in the future for the borehole method and 190 years for the trench method. These times represent the length of time after failure of the engineered barriers (including the cover), which is assumed to begin 500 years after closure of the disposal facility.

Ecology. Although the loss of sagebrush habitat, followed by eventual establishment of low-growth vegetation, would affect the species that depend on sagebrush (pygmy rabbit, greater sage-grouse, sage thrasher, loggerhead shrike, sage sparrow, and Brewer's sparrow), population-level impacts on these species are not expected. Reestablishment of sagebrush after closure could take a minimum of 10 to 20 years. There are no natural aquatic habitats or wetlands within the immediate vicinity of the GTCC reference location; however, depending on the amount of water in the retention pond and the length of the retention time, certain species (e.g., aquatic invertebrates, waterfowl, shorebirds, amphibians, and mammals) could become established. No federally or state listed or special-status species have been reported in the project area. However, the greater sage-grouse (candidate species for federal listing as threatened or endangered) and the pygmy rabbit (under review for federal listing) are common on the INL site and could be expected to occur in the vicinity of the GTCC reference location.

Socioeconomics. Impacts associated with construction and operations of the land disposal facilities would be small. Construction would create direct employment for up to 145 people (vault method) in the peak construction year and 197 indirect jobs (borehole method) in the ROI; the annual average employment growth rate would increase by less than 0.1 of a percentage point. The waste facility would produce up to $12.1 million in income in the peak construction year (vault method). Up to 64 people would in-migrate to the ROI as a result of employment on-site; in-migration would have only a marginal effect on population growth and require less than 0.5% of vacant housing in the peak year. Impacts from operating the facility would also be small, creating up to 51 direct jobs annually (vault method) and up to 50 additional indirect jobs (vault method) in the ROI. The disposal facility would produce up to $4.9 million in income annually during operations.

Environmental justice. Because the health impacts on the general population within the 80-km (50-mi) assessment area during construction and operations would be negligible, no impacts from construction and operations on minority and low-income population are expected.

Land use. The GTCC reference location is located within existing major complex areas and would not conflict with the area's land use designation. Land use on areas surrounding INL would not be affected.

Transportation. Shipment of all waste to INL by truck would result in about 12,600 shipments, with the total distance covered being 42 million km (26 million mi). For shipment of all waste by rail, 4,980 railcar shipments totaling 17 million km (11 million mi) of travel would be required. It is estimated that no LCFs would occur to the public or crew members for either mode of transportation, but one fatality from an accident could occur.

Cultural resources. There are no known cultural resources within the GTCC reference location, although prehistoric archeological sites and a substantial number of historic homestead sites could be located there. The borehole method has the greatest potential to affect cultural resources because of its 44-ha (110-ac) land requirement. It is expected that the majority of the impacts on cultural resources would occur during the construction phase. The amount of land needed to employ the borehole method is twice the amount needed to construct a vault or trench. Activities associated with operations and post-closure are expected to have a minimal impact on cultural resources since no new ground-disturbing activities would occur during these phases. Section 106 of the NHPA would be followed to determine the impact of disposal facility activities on significant cultural resources, as needed. Local tribes would be consulted to ensure that no traditional cultural properties were affected by the project.

Waste management. The wastes that could be generated from the construction and operations of the land disposal methods (i.e., nonhazardous solid and liquid waste, hazardous solid and liquid waste, and small quantities of solid LLRW, such as spent HEPA filters) are not expected to affect the current waste management programs at INL.

7.4 CUMULATIVE IMPACTS

Section 5.4 presents the methodology for the cumulative impacts analysis. In the analysis that follows, impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. This section begins with a description of reasonably foreseeable future actions at INL, including those that are ongoing, under construction, or planned for future implementation. Past and present actions are generally accounted for in the affected environment section (Section 7.1).

7.4.1 Reasonably Foreseeable Future Actions

Reasonably foreseeable actions at INL are summarized in the following sections. These actions were identified primarily from a review of the Idaho Department of Environmental Quality (IDEQ) and INL websites, as cited below. The actions listed are planned, under construction, or ongoing and may not be inclusive of all actions at the site. However, they should provide an adequate basis for determining potential cumulative impacts at INL.

7.4.1.1 Idaho Nuclear Technology and Engineering Center

INTEC was established in the 1950s as a location for extracting reusable uranium from SNF. Until 1992, reprocessing efforts recovered more than $1 billion worth of highly enriched uranium (HEU). The highly radioactive liquid created in this process was turned into a solid through a process known as calcining. Calcining converted more than 30 million L (8 million gal) of liquid waste to a solid granular material that is now stored in bins awaiting a final disposal location outside Idaho. Past activities at INTEC also included the storage of SNF in water basins to cool it prior to reprocessing. Ongoing activities at INTEC include storage of SNF in a modern water basin and in dry storage facilities, management of high-level waste calcine and sodium-bearing liquid waste (some of which was shipped from the Hanford Site), and the operation of the INL CERCLA Disposal Facility (ICDF), which includes a landfill, evaporation ponds, and a storage and treatment facility (IDEQ 2009a).

7.4.1.2 Advanced Mixed Waste Treatment Project

The Advanced Mixed Waste Treatment Project (AMWTP) was constructed by British Nuclear Fuel Limited to prepare TRU waste now buried or stored at INL for permanent disposal at WIPP in New Mexico. Most of the waste processed at the AMWTP resulted from the manufacture of nuclear components at the Rocky Flats Plant in Colorado and was shipped to INL in the 1970s and early 1980s. The waste contains industrial debris, such as rags, work clothing, machine parts, and tools, as well as soil and sludge, and it is contaminated with TRU elements (primarily plutonium). Most of the waste is mixed waste (i.e., it is contaminated with radioactive and nonradioactive hazardous chemicals, such as oil and solvents) (INL 2008a, IDEQ 2009b).

The retrieval enclosure houses about 53,300 m^3 (69,714 yd^3) of waste and occupies an area of about 2.8 ha [7 ac]). After the containers are characterized, they are sent either to the loading facilities for packaging and shipment or to the AMWTP treatment facility for further processing. Characterized waste containers that need further treatment before they can be shipped are sent to the treatment facility, where the waste can be reduced in size, sorted, and repackaged. Waste sent to the treatment facility is transported to different areas within the facility by an intricate system of conveyers, and all waste handling is done remotely. The treatment facility houses the supercompactor, which can compact a 208-L (55-gal) drum to roughly one-fifth of its original size. Approximately 70% of the waste to be processed is sent through the supercompactor to be reduced in size. Following treatment, waste containers go through two major steps at the two AMWTP loading areas: payload assembly and TRUPACT II loading. During payload assembly, waste is separated into payloads that are then individually loaded into TRUPACT II containers for certification and shipping (INL 2008a, IDEQ 2009b).

7.4.1.3 Radioisotope Power Systems Project

In the Radioisotope Power Systems (RPS) Project, radioisotope power systems for space exploration and national security missions are developed. DOE is currently supporting RPS production, testing, and delivery operations for a national security mission and for the National Aeronautics and Space Administration (NASA) Mars Science Laboratory mission. The INL Space and Security Power Systems Facility was dedicated in 2004 for the assembly, testing, and delivery of RPSs in support of space and defense programs. The Facility began operations in FY 2005 (DOE 2008b). The Facility is expected to grow considerably over the coming decade, from $18 million in 2005 to $70 million by 2015 (INL 2009).

7.4.1.4 Remote-Handled Waste Disposition Project

The Remote-Handled Waste Disposition Project would accept RH wastes stored at INL that currently lack a treatment and disposition plan. The types of waste include TRU, mixed TRU, LLRW, mixed low-level waste, SNF, and unirradiated fuel. Primary waste streams are the 317 m^3 (11,200 ft^3) of RH waste stored at the Materials and Fuels Complex and the RWMC. Under this project, the wastes would be moved to INTEC for characterization and treatment. Treated wastes would then be packaged and shipped for final disposal. Approximately 1,000 canisters would be processed over a 10-year period; the total project would span 16 years (Jines 2007). On April 3, 2008, DOE posted a "Request for Expression of Interest" for the RH waste processing capability at INL (DOE 2008a).

7.4.1.5 AREVA Uranium Enrichment Plant

The French-based company, AREVA, is proposing to build the Eagle Rock Enrichment Facility in Bonneville County, about 32 km (20 mi) west of Idaho Falls, near INL. The facility would use centrifuge technology to enrich uranium for use in manufacturing fuel for commercial nuclear power plants. AREVA has indicated its intention to submit a license application to the NRC by the end of December 2008 (NRC 2008). The project is expected to inject about $2 billion into Idaho's economy. AREVA plans to begin construction in 2011 and to have the plant operational by 2014 (Wheeler 2008).

7.4.2 Cumulative Impacts from the GTCC Proposed Action at INL

Potential impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. The impacts from Alternatives 3 to 5 at INL are described in Section 7.2 and summarized in Section 7.3. These sections indicate that the potential impacts from the proposed action (construction and operation of a borehole, trench, or vault facility) would be small for all the resource areas evaluated. With the exception of potential post-closure long-term human health impacts, on the basis of the total impacts (including the reasonably foreseeable future actions summarized in Section 7.4.1), the incremental potential impacts from the GTCC proposed action are not expected to contribute substantially to cumulative impacts on the various resource areas evaluated for INL. However, the estimated human health impacts from the GTCC proposed action could add an annual dose of up to 2,300 mrem/yr or result in an annual LCF risk of 1E-03 (under the vault disposal method) 220 years after closure of the disposal facility at INL. This dose would be primarily from GTCC-like Other Waste - RH. The composite analysis for the RWMC low-level waste disposal facility at INL estimated that a maximum dose of 48 mrem/yr would occur about 75,000 years after the institutional control period (INL 2008b).

To provide additional perspective, the data on the potential impacts given in this EIS were compared to values provided in the *Draft EIS for the Proposed Consolidation of Nuclear Operations Related to Production of Radioisotope Power Systems* (DOE 2005). For example, the maximum amount of land affected by the disposal of GTCC LLRW and GTCC-like waste would be about 44 ha (110 ac), compared to about 5,300 ha (13,000 ac) of total land use committed to various activities at INL. The total amount of available land at INL is about 230,000 ha (570,000 ac). The GTCC EIS socioeconomic evaluation indicates that about 51 additional (direct) jobs would be created by the operation of any of the facilities considered. This number is small relative to the 9,000 or so jobs estimated to be needed to carry out the various activities at INL. For potential worker doses, the GTCC EIS estimate of about 5.2 person-rem/yr is lower than the estimate of 420 person-rem/yr as the total from various other activities at INL.

Finally, follow-on NEPA evaluations and documents prepared to support any further considerations of siting a new borehole, trench, or vault disposal facility at Hanford would provide more detailed analyses of site-specific issues, including cumulative impacts.

7.5 SETTLEMENT AGREEMENTS AND CONSENT ORDERS FOR INL

A review of existing settlement agreements and consent orders for INL was conducted to identify if any of them contained requirements that would be triggered by Alternatives 3 to 5 for this EIS. Table 7.5-1 lists those that were identified.

TABLE 7.5-1 INL Settlement Agreements and Consent Orders Relevant to the GTCC EIS Proposed Action

Settlement Agreement/ Consent Order	Date	Description	Rationale
Settlement Agreement: United States of America v. Philip E. Batt and Consent Order	10/16/95	Specifies that DOE shall ship TRU waste now located at INL to WIPP or some other such facility designated by DOE by a target date of December 31, 2015. Specifies timetables for the removal of SNF and high-level radioactive waste from INL and for the shipments of SNF to INL. Specifies that DOE will treat SNF, high-level radioactive waste, and TRU at INL that require treatment so that they can ultimately be disposed of outside the state of Idaho. Specifies that any and all treatable waste shipped into Idaho for treatment at the Mixed Waste Treatment Facility shall be shipped outside Idaho for storage or disposal within 6 months after treatment.	Potential non-defense TRU waste at INL is included in the inventory of GTCC-like waste analyzed in the GTCC EIS. This INL TRU waste may be subject to the Settlement Agreement for removal from INL. The Agreement requires that TRU waste received from off-site generators be shipped out of Idaho for storage or disposal within 6 months of treatment. (The GTCC EIS includes alternatives that would involve the disposal at INL of TRU waste generated off-site.)

TABLE 7.5-1 (Cont.)

Settlement Agreement/ Consent Order	Date	Description	Rationale
INEL Consent Order	6/1/95	Resolves RCRA Land Disposal Restriction (LDR) storage violations and approves a modified "INEL Site Treatment Plan." Establishes an enforceable framework by which DOE will meet RCRA LDRs for mixed waste to be generated or received in the future.	Potential hazardous constituents in waste are included in the inventory of GTCC-like waste analyzed in the GTCC EIS.
Agreement-in-Principle (AIP) between the Shoshone-Bannock Tribes and the U.S. Department of Energy	12/3/2007	Promotes increased interaction, understanding, and cooperation on issues of mutual concern. DOE acknowledges its trust responsibility to the tribes and will strive to fulfill this responsibility through this AIP, DOE American Indian and Alaska Native Tribal Government policy, and other American Indian program initiatives.	This AIP dictates consultation with the Shoshone-Bannock tribes. DOE has initiated the consultation process for the GTCC EIS with the Shoshone-Bannock tribes.
Environmental Oversight and Monitoring Agreement between the U.S. Department of Energy and the State of Idaho	10/12/2005	Goals of the Agreement are to: • Maintain an independent, impartial, and qualified State of Idaho INL Oversight Program to assess the potential impacts of present and future DOE activities in Idaho; • Assure the citizens of Idaho that all present and future DOE activities in Idaho are protective of the health and safety of Idahoans and the environment; and • Communicate the findings to the citizens of Idaho in a manner that gives them the opportunity to evaluate potential impacts of present and future DOE activities in Idaho.	The Agreement requires the assessment of the potential impacts from future DOE activities in Idaho. The GTCC EIS includes an assessment of potential future impacts from DOE activity in Idaho.

Source: DOE (2008a)

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8 LOS ALAMOS NATIONAL LABORATORY: AFFECTED ENVIRONMENT AND CONSEQUENCES OF ALTERNATIVES 3, 4, AND 5

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from the disposal of GTCC LLRW and GTCC-like waste under Alternative 3 (in a new borehole disposal facility), Alternative 4 (in a new trench disposal facility), and Alternative 5 (in a new vault disposal facility) at LANL. Alternatives 3, 4, and 5 are described in Section 5.1. Environmental consequences that are common to the sites for which Alternatives 3, 4, and 5 are evaluated (including LANL) are discussed in Chapter 5 and not repeated in this chapter. Impact assessment methodologies used for this EIS are described in Appendix C. Federal and state statutes and regulations and DOE Orders relevant to LANL are discussed in Chapter 13 of this EIS. This chapter also includes tribal narrative text that reflects the views and perspectives of the Nambe Pueblo, Santa Clara Pueblo, Pueblo de San Ildefonso, and the Pueblo de Cochiti.

The tribal text is included in text boxes in Section 8.1. Full narrative texts provided are in Appendix G. The perspectives and views presented are solely those of the tribes. When tribal neutral language is used (e.g., Indian People, Native People, Tribes) within the tribal text, it reflects the input from these tribes unless otherwise noted. DOE recognizes that American Indians have concerns about protecting traditions and spiritual integrity of the land in the LANL region, and that these concerns extend to the propriety of the Proposed Action. Presenting tribal views and perspectives in this EIS does not represent DOE's agreement with or endorsement of such views. Rather, DOE respects the unique and special relationship between American Indian tribal governments and the Government of the United States, as established by treaty, statute, legal precedent, and the U.S. Constitution. For this reason, DOE has presented tribal views and perspectives in this Draft EIS to ensure full and fair consideration of tribal rights and concerns before making decisions or implementing programs that could affect tribes.

8.1 AFFECTED ENVIRONMENT

This section discusses the affected environment for the various resource areas evaluated for the GTCC reference location at LANL. In order to have enough acreage to evaluate for Alternatives 3 to 5, the GTCC reference location at LANL is composed of three undeveloped and relatively undisturbed areas within Technical Area 54 (TA-54) and TA-51, on Mesita del Buey: Zone 6, North Site, and North Site expanded (Figure 8.1-1). The reference location was selected primarily for evaluation purposes for this EIS. The actual location would be identified on the basis of follow-on evaluations if and when it is decided to locate a land disposal facility at LANL.

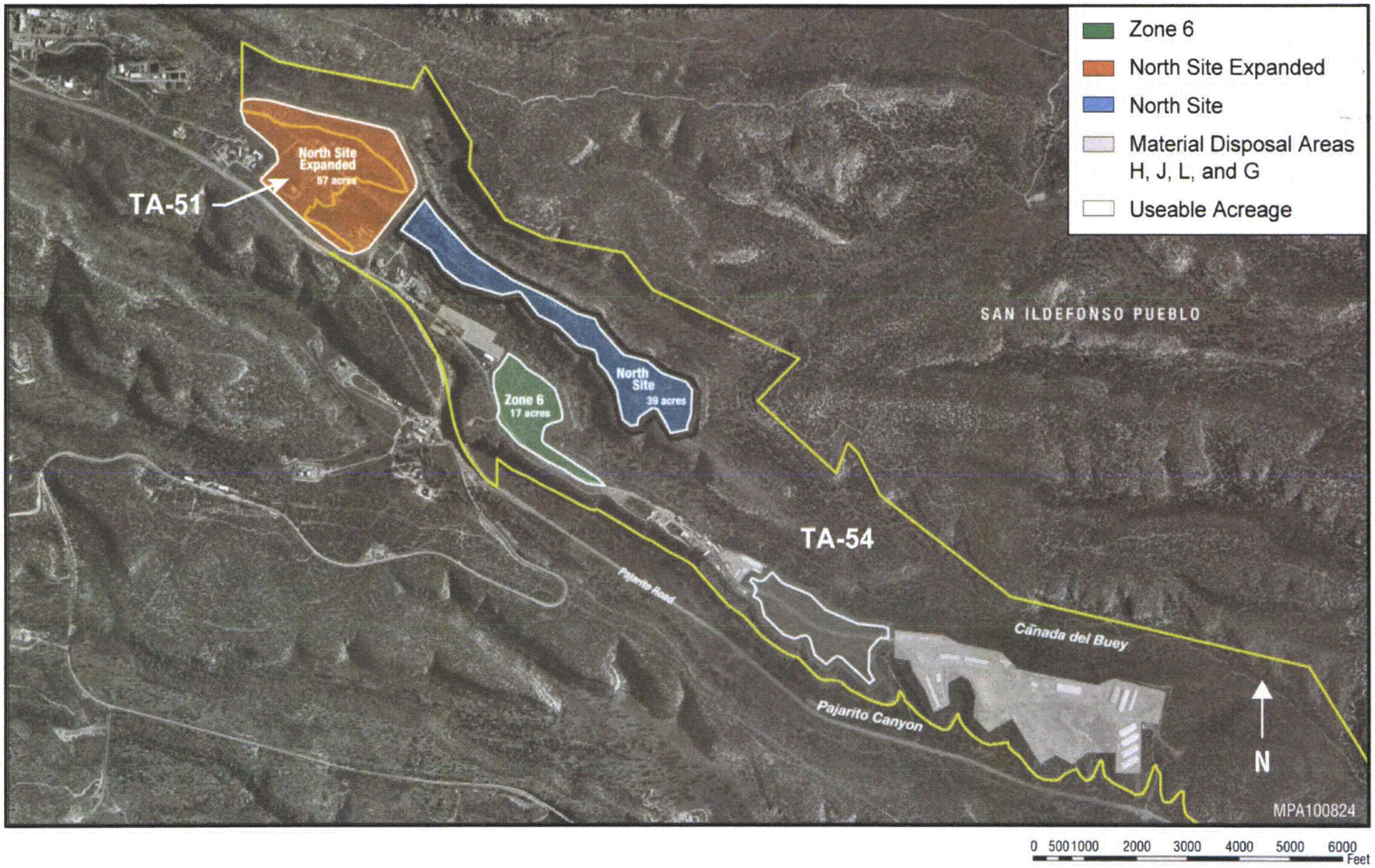

FIGURE 8.1-1 GTCC Reference Locations at LANL: North Site, North Site Expanded, and Zone 6

8.1.1 Climate, Air Quality, and Noise

8.1.1.1 Climate

The LANL site has a temperate, semiarid mountain climate with four distinct seasons (Bowen 1992). Winters are generally mild, with occasional winter storms. Spring tends to be windy and dry, and summer begins with warm, often dry, conditions, followed by a two-month rainy season. Fall has typically drier, cooler, and calmer weather. Because of the complex topography around the site (e.g., 300-m [1,000-ft] elevation changes), there are large differences in locally observed temperature and precipitation.

The complex topography of the LANL site influences local wind patterns, notably in the absence of large-scale disturbances. Surface winds often vary dramatically with time of day, location, and elevation (Bowen 1992). Daytime winds at the four Pajarito Plateau meteorological towers are predominantly from the south, consistent with the typical upslope flow of heated daytime air moving up the Rio Grande Valley, as shown in the wind roses in Figure 8.1.1-1 (LANL 2007). On the other hand, nighttime winds are lighter and more variable than daytime winds from the west. This condition results from a combination of the prevailing westerly winds and the downslope flow of cooled mountain air. Winds atop Pajarito Mountain, which are much faster than those over the Pajarito Plateau, are more representative of upper-level flows, reflecting the prevailing westerly winds in the area. In general, winds at LANL are light, averaging about 2.8 m/s (6.3 mph) in a year, and prevailing directions are from the south during the day and west-northwest at night (Bowen 1992). Wind speeds are the fastest in spring, slower in summer and fall, and the slowest in winter.

For the 1910–2010 period, the annual average temperature at the LANL site was 8.9°C (48.0°F) (WRCC 2010). January is the coldest month, averaging –1.8°C (28.7°F) and ranging from –7.7 to 4.1°C (18.1 to 39.3°F), and July is the warmest month, averaging 20.0°C (68.0°F) and ranging from 12.8 to 27.1°C (55.1 to 80.8°F). During the years 1910–2010, the highest temperatures reached 35.0°C (95°F), and the lowest reached –27.8°C (–18°F). Daily temperature ranges are large (as high as 14°C [57°F]) at Los Alamos, because of the thin, dry air and frequent clear skies (about three-quarters of the time), which allow strong solar heating during the day and rapid radiative cooling at night (Bowen 1992). Unlike other DOE facilities, LANL is located on high ground: 2,250 m (7,380 ft) above sea level. Atmospheric pressure averages 776 mbar (22.9 in. of Hg), which is about 76% of standard sea-level pressure.

For the 1910–2010 period, annual precipitation at the LANL site averages about 47 cm (18 in.) (WRCC 2010). Winter is the driest season and summer is the wettest; about 36% of the annual precipitation falls from convective storms during July and August (Bowen 1992). Because of the eastward slope of the terrain, there is a large east-to-west gradient in precipitation across the plateau. For example, in a year, White Rock often receives 13 cm (5 in.) less precipitation, and the eastern flanks of the Jemez Mountains often receive 13 cm (5 in.) more. Snow typically occurs from September through May, peaking in December through March. The annual average snowfall in the area is about 134 cm (53 in.) but is quite variable from year to year (WRCC 2010). The highest recorded snowfall for one season was 389 cm (153 in.), and the

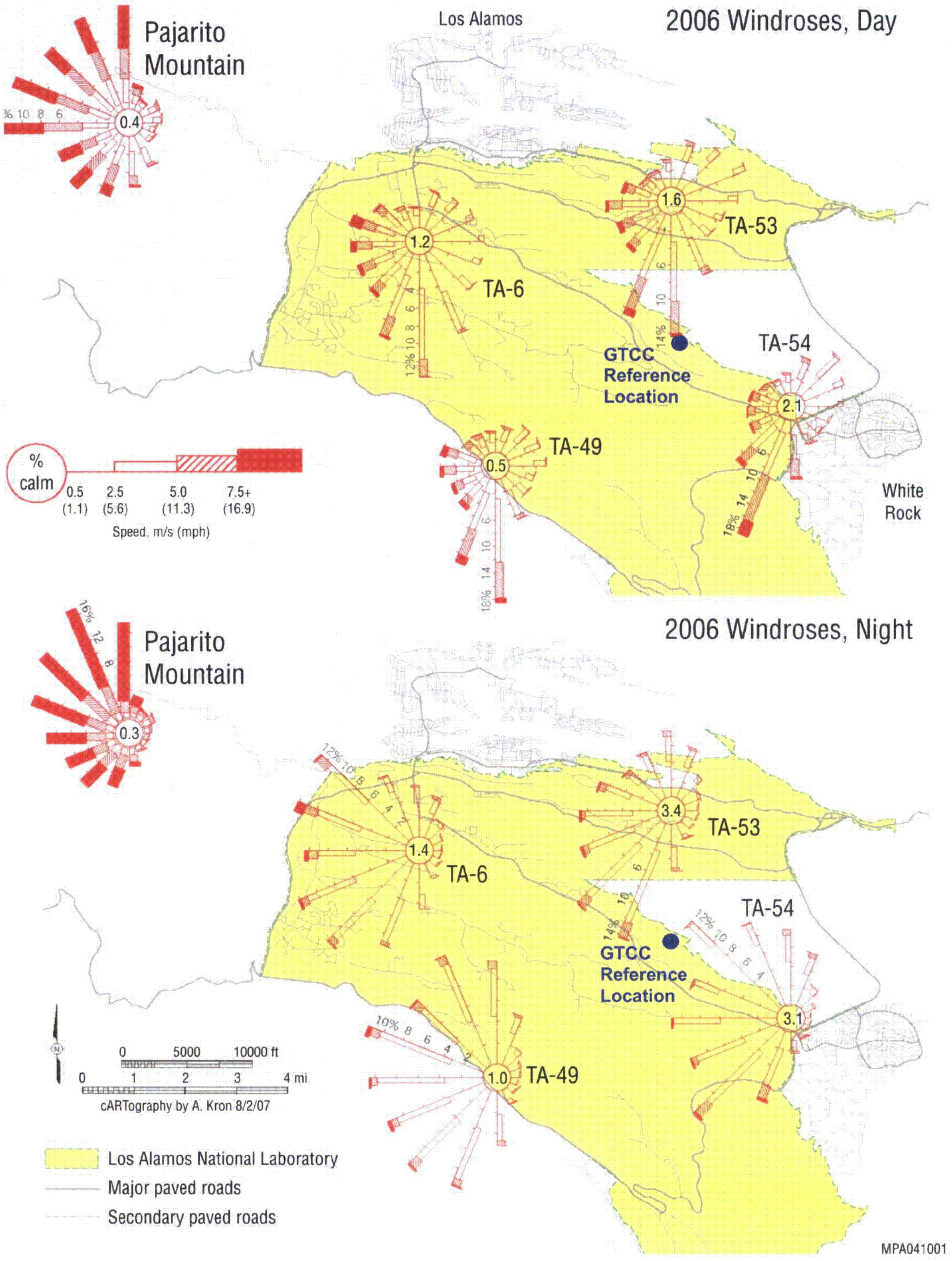

FIGURE 8.1.1-1 Daytime and Nighttime Wind Roses at and around the LANL Site in 2006 (Source: LANL 2007)

maximum daily snowfall was 56 cm (22 in.). Large snowfalls may occur locally as a result of orographic lifting of the storms by the high terrain.

Thunderstorms are common at the LANL site, with 61 occurring in an average year (Bowen 1992). Most thunderstorms occur during July and August. The combination of moist air from the Gulf of Mexico and the Pacific Ocean, strong sunshine, and warm surface temperatures promote the formation of afternoon and evening thunderstorms, especially over the Jemez Mountains. The thunderstorms yield short, heavy downpours and an abundance of lightning.

Tornadoes in the area surrounding the LANL site are much less frequent and destructive than those in the tornado alley in the central United States. For the period 1950–2008, 512 tornadoes were reported in New Mexico, with an average of 8.8 tornadoes per year. Most tornadoes occurred at lower elevations in eastern New Mexico next to Texas (NCDC 2008). Historically, no tornadoes have ever been reported in Los Alamos County. For the period 1950–2008, a total of 18 tornadoes with an average of 0.3 tornado per year were reported in Santa Fe County, which encompasses the LANL site. However, most tornadoes occurring in Santa Fe County were relatively weak (i.e., there were fourteen F0 and four F1 tornadoes on the Fujita scale). No deaths and no substantial property damage (in excess of $250,000) were associated with any of these tornadoes.

American Indian Text

The Pueblo people, having lived since the beginning of time in the region of the proposed GTCC waste disposal site, are concerned about meteorological climate shifts occurring over hundreds of years and longer term climate changes occurring over thousands of years. Such shifts impact vegetation. During dryer periods vegetation burns increase and post-burn erosion is accelerated. The Cerro Grande fire increased post-fire storms' runoff flows in some drainages more than 1,000 times the pre-fire levels. These higher runoff flows increased erosion and moved radioactive and hazardous materials downstream towards the Pueblo people.

During warmer periods, more intense rainfall episodes occur and less snow falls in winter, thus increasing erosion. Tree ring data document shifts in annual rainfall between 1523 and today, with a rainfall high in 1597 of 40 inches to a low in 1685 of 2.4 inches.

During the Holocene, major shifts occurred in this region, and the GTCC disposal is to be evaluated for a duration of 10,000 years. These climate shifts are both culturally important to the Pueblo people who conduct ceremonies to balance climate and pertinent to the consideration of GTCC proposal.

8.1.1.2 Existing Air Emissions

Pursuant to the federal CAAA and Title 20, Chapter 2, Part 70, "Operating Permits," of the *New Mexico Administrative Code* (20.2.70 NMAC), Los Alamos National Security LLC (LANS) is authorized to operate applicable air emission sources at LANL per the terms and conditions as defined in Operating Permit No. P100–M1 (LANL 2007). Emission sources specified in the permit include multiple boilers, two steam plants, a data disintegrator, carpenter shops, three degreasers, and asphalt production. LANL also reports emissions from chemical use associated with R&D and permitted beryllium activities. In 2006, LANL demonstrated full compliance with all other permit applicable terms and conditions and met all reporting requirement deadlines, except for an excess emission at the Asphalt Plant, which slightly exceeded the smoke opacity limit.

Annual emissions for major facility sources and total point and area sources for year 2002 for criteria pollutants and VOCs in Los Alamos and Santa Fe Counties, New Mexico, which encompass the LANL site, are presented in Table 8.1.1-1 (EPA 2009). Area sources consist of nonpoint and mobile sources. Data for 2002 are the most recent data available on the EPA website. There are few major point sources in the area; LANL is one of the major sources in Los Alamos County. Area sources account for most of the emissions of criteria pollutants and VOCs.

TABLE 8.1.1-1 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds from Selected Major Facilities and Total Point and Area Source Emissions in Los Alamos and Santa Fe Counties Encompassing the LANL Site[a]

	Emission Rate (tons/yr)					
Emission Category	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Los Alamos County						
Los Alamos National Laboratory[b]	*1.3*	*65*	*28*	*40*	*10*	*9.6*
	2.2%[c]	*12%*	*0.82%*	*8.0%*	*0.47%*	*3.4%*
	0.31%	*0.90%*	*0.04%*	*0.47%*	*0.02%*	*0.15%*
Point sources	1.3	65	28	40	10	9.6
Area sources	60	480	3,400	460	2,200	280
Total	61	540	3,400	500	2,200	290
Santa Fe County						
Point sources	0.0	54	72	33	40	27
Area sources	370	6,600	62,000	7,900	53,000	6,000
Total	370	6,700	62,000	7,900	53,000	6,000
Two-county total	430	7,200	65,000	8,400	55,000	6,300

[a] Emission data for selected major facilities and total point and area sources are for year 2002. CO = carbon monoxide, NO_x = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 µm, PM_{10} = particulate matter ≤ 10 µm, SO_2 = sulfur dioxide, VOCs = volatile organic compounds. Values have been rounded to two significant figures. Totals may not add up because of the independent rounding of values within the table. Traffic at LANL is the primary contributor to air quality impacts at the site.

[b] Data in italics are not added to yield total.

[c] The top row and bottom row with % signs show emissions as percentages of Los Alamos County and two-county total emissions, respectively.

Source: EPA (2009)

On-road sources are major contributors to the total emissions of SO_2, NO_x, CO, and VOCs; miscellaneous sources are major contributors to emissions of PM_{10} and $PM_{2.5}$. Nonradiological emissions associated with activities at the LANL site are 12% or less of those in Los Alamos County and 1% or less of those in the two counties combined, as shown in the table.

Under the Title V Operating Permit program, LANL is classified as a major source on the basis of its potential to emit NO_x, CO, and VOCs (LANL 2007). In 2006, the TA-3 steam plant and boilers located across the LANL site were the major contributors of NO_x, CO, and PM. R&D activities were responsible for most of the VOCs and hazardous air pollutant emissions. Stationary standby generators are major contributors to sulfur oxides (SO_x) emissions. Table 8.1.1-2 presents a five-year (2002–2006) history of criteria pollutant and VOC emissions for emissions inventory reporting to the New Mexico Environment Department (NMED). Emissions for 2005 and 2006 were very similar and remained relatively constant following the sharp decline in 2004 emissions from the higher emissions in 2002 and 2003. The sharp decline in 2004 may have resulted from air curtain destructors being taken out of service in October of 2003.

American Indian Text

Contaminated air emissions either from fugitive dust, violent storms, dust devils, emission stacks, bomb testing, burn pits, or from the Cerro Grande fire have spread to surrounding Pueblo lands and communities. A Santa Clara Pueblo wind monitor meteorological station recorded a wind of 70 miles per hour. Dust devils have been recorded by LANL at 73 miles per hour. Santa Clara, Pueblo de San Ildefonso, Pueblo de Cochiti, and Jemez perceive that they have received contaminated ash and air from the Cerro Grande fire, from more than 110 historic and active LANL emission stacks, and bomb testing detonations. Nambe, Pojoaque, and the surrounding Pueblos perceive that they too received contaminated ash from the Cerro Grande fire. The contaminations from these events exposed natural resource users ranging from hunters of animals to gatherers of clay for pots. Even normal Pueblo residents were exposed in many ways from farming to outdoor activities to everyday life.

The Pueblo de Cochiti is situated within Sandoval County, and emissions rates here were not compared in the GTCC to emission rates of LANL. The Pueblo de Cochiti is located south of LANL and adjacent to the PSD [Prevention of Significant Deterioration] Class I Bandelier National Monument. The Pueblo de Cochiti could thus be considered a PSD Class I area as well and all emissions pose a threat to this classification.

All the Accord Pueblos (Pueblo de San Ildefonso, Pueblo de Cochiti, Santa Clara, and Jemez Pueblo) are currently conducting independent studies of air emissions from LANL. These studies have been ongoing for about ten years. Some Pueblos have their findings evaluated by independent laboratories. These studies are monitoring tritium, plutonium, uranium, americium, and other radionuclides and metals. Some of the studies have documented contaminated air emissions on Pueblo lands.

TABLE 8.1.1-2 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds at LANL during 2002–2006 for Emissions Inventory Reporting to the New Mexico Environment Department[a]

	Emission Rate (tons/yr)				
Year	SO_2	NO_x	CO	VOCs	PM
2002	1	65	28	40	15
2003	2	50	32	50	22
2004	0.3	25	17	10	3
2005	0.2	24.5	18	13	3.3
2006	0.4	24.5	18	14	4.4

[a] CO = carbon monoxide, NO_x = nitrogen oxides, PM = particulate matter, SO_2 = sulfur dioxide, VOCs = volatile organic compounds.

Source: LANL (2007)

8.1.1.3 Air Quality

Among criteria pollutants (SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$, and lead), the New Mexico SAAQS are identical to the NAAQS for NO_2 (EPA 2008a; 20.2.3 NMAC), as shown in Table 8.1.1-3. The State of New Mexico has established more stringent standards for SO_2 and CO, but there are no standards for O_3, PM, and lead. In addition, the State has adopted standards for hydrogen sulfide (H_2S) and total reduced sulfur and has retained the standard for total suspended particulates (TSP), which used to be one of criteria pollutants but was replaced by PM_{10} in 1987.

The GTCC reference location within LANL is situated mostly in Los Alamos County, with a small section (northeast) being in Santa Fe County. These two counties that encompass LANL are designated as being in attainment for all criteria pollutants (40 CFR 81.332).

Currently, the Nonradiological Air Sampling Network (NonRadNet), which was implemented in 2001, conducts monitoring to (1) develop a database of typical background levels for selected nonradiological species in the communities nearest LANL and (2) measure LANL's potential contribution to nonradiological air pollution in the surrounding communities (LANL 2007). The program consists of six ambient PM (PM_{10} and $PM_{2.5}$) monitoring units at three locations, plus selected Ambient Air Monitoring Network (AIRNET) samples, which are analyzed for three nonradiological constituents: aluminum, calcium, and beryllium.

Because of the lack of on-site monitoring, nearby urban or suburban measurements are typically used as being representative of background concentrations for LANL. The highest concentration levels of all criteria pollutants except for O_3 and $PM_{2.5}$ around LANL are less than or equal to 60% of their respective standards in Table 8.1.1-3 (EPA 2009; LANL 2004–2006,

TABLE 8.1.1-3 National Ambient Air Quality Standards (NAAQS) or New Mexico State Ambient Air Quality Standards (SAAQS) and Highest Background Levels Representative of the GTCC Reference Location at LANL, 2003–2007

			Highest Background Level	
Pollutant[a]	Averaging Time	NAAQS/ SAAQS[b]	Concentration[c,d]	Location (Year)
SO_2	1-hour	75 ppb	–[e]	–
	3-hour	0.5 ppm[d]	0.079 ppm (16%)	San Juan Co. (2003)[f]
	24-hour	0.10 ppm	0.013 ppm (13%)	San Juan Co. (2005)[f]
	Annual	0.02 ppm	0.003 ppm (15%)	San Juan Co. (2004)[f]
NO_2	1-hour	0.100 ppm	–	–
	24-hour	0.10 ppm	–	–
	Annual	0.053 ppm	0.019 ppm (38%)	Albuquerque, Bernalillo Co. (2004)[f]
CO	1-hour	13.1 ppm	3.0 ppm (23%)	Santa Fe, Santa Fe. Co. (2005)
	8-hour	8.7 ppm	1.9 ppm (22%)	Santa Fe, Santa Fe. Co. (2003)
O_3	1-hour	0.12 ppm[g]	0.070 ppm (58%)	Santa Fe, Santa Fe. Co. (2007)
	8-hour	0.075 ppm	0.063 ppm (84%)	Santa Fe, Santa Fe. Co. (2007)
TSP	24 hours	150 $\mu g/m^3$	–	–
	7 days	110 $\mu g/m^3$	–	–
	30 days	90 $\mu g/m^3$	–	–
	Annual geometric mean	60 $\mu g/m^3$	–	–
PM_{10}	24-hour	150 $\mu g/m^3$	90 $\mu g/m^3$ (60%)	White Rock, Los Alamos Co. (2003)
$PM_{2.5}$	24-hour	35 $\mu g/m^3$	28 $\mu g/m^3$ (80%)	Los Alamos, Los Alamos Co. (2003)
	Annual	15 $\mu g/m^3$	8.0 $\mu g/m^3$ (53%)	Los Alamos, Los Alamos Co. (2005)
Lead	Calendar quarter	1.5 $\mu g/m^3$ [h]	0.03 $\mu g/m^3$ (2.0%)	Albuquerque, Bernalillo Co. (2004)[f]
	Rolling 3-month	0.15 $\mu g/m^3$	–	–
H_2S	1 hour	0.010 ppm	–	–
Total reduced sulfur	1/2 hour	0.003 ppm	–	–

[a] CO = carbon monoxide, H_2S = hydrogen sulfide, NO_2 = nitrogen dioxide, O_3 = ozone, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, SO_2 = sulfur dioxide, TSP = total suspended particulates.

[b] The more stringent standard between the NAAQS and the SAAQS is listed when both are available.

[c] Monitored concentrations are the highest arithmetic mean for calendar-quarter lead; the highest for 24-hour PM_{10} and $PM_{2.5}$; second-highest for 3-hour and 24-hour SO_2, 1-hour and 8-hour CO, and 1-hour O_3; 4th-highest for 8-hour O_3; arithmetic mean for annual SO_2, NO_2, and $PM_{2.5}$.

[d] Values in parentheses are monitored concentrations as a percentage of SAAQS or NAAQS.

[e] A dash indicates that no measurement is available.

[f] These locations with the highest observed concentrations in the state of New Mexico are not representative of the LANL site but are presented to show that these pollutants are not a concern over the state of New Mexico.

Footnotes continue on next page.

TABLE 8.1.1-3 (Cont.)

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[g] On June 15, 2005, the EPA revoked the 1-hour O_3 standard for all areas except the 8-hour O_3 nonattainment Early Action Compact (EAC) areas (those do not yet have an effective date for their 8-hour designations). The 1-hour standard will be revoked for these areas 1 year after the effective date of their designation as attainment or nonattainment for the 8-hour O_3 standard.

[h] Used old standard because no data in the new standard format are available.

Sources: EPA (2008a, 2009); LANL (2004–2006, 2007); 20.2.3 NMAC (refer to http://www.nmcpr.state.nm.us/nmac/parts/title20/20.002.0003.pdf)

2007). The highest O_3 and $PM_{2.5}$ concentrations are 84% and 80% of their standards, respectively. Overall, background concentration levels around the LANL site are below the standards for all criteria pollutants.

LANL and its vicinity are classified as PSD Class II areas. The nearest Class I area is Bandelier National Monument, about 5 km (3 mi) southwest of the GTCC reference location (40 CFR 81.421). Three more Class I areas are within 100 km (62 mi) of the GTCC reference location, including (in order of distance) the Pecos, San Pedro Parks, and Wheeler Peak Wilderness Areas. Currently, there are no facilities operating at LANL that are subject to PSD regulations.

8.1.1.4 Existing Noise Environment

Noise, air blasts (also known as air pressure waves or over pressures), and ground vibrations are intermittent aspects of the LANL site environment (DOE 1999).

Although the State of New Mexico has established no quantitative noise-level regulations, Los Alamos County has promulgated a local noise ordinance that establishes noise level limits for residential land uses. Noise levels that affect residential receptors are limited to a maximum of 65 dBA during daytime hours and 53 dBA during nighttime hours (i.e., 9 p.m. to 7 a.m.). Between 7 a.m. and 9 p.m., the permissible noise level can be increased to 75 dBA in residential areas, provided that the noise is limited to 10 minutes in any one hour. Activities that do not meet the noise ordinance limits require a permit (DOE 1999).

Noise levels around the LANL site are combined effects from LANL-related activities and activities unrelated to LANL. LANL-related noise sources include the movement of vehicles to and from LANL, activities at technical areas, aboveground testing of high explosives, and security guards' firearms practice sessions (DOE 1999). Noise sources within Los Alamos County unrelated to LANL include predominantly traffic movements and, to a much lesser degree, other residential-, commercial-, and industrial-related activities within Los Alamos and White Rock communities. Detailed noise and vibration sources at LANL and noise measurements are presented in the 1999 LANL Site-Wide EIS (SWEIS) (DOE 1999). The 2008 SWEIS (DOE 2008c) also refers to the data in the 1999 SWEIS.

Currently, data on the levels of routine background noise, air blasts, and ground vibrations generated by LANL operations (including explosives detonations) are limited (DOE 1999). Measurements of nonspecific background ambient noise in the LANL area have been taken at a couple of locations near LANL boundaries next to public roadways. Background noise levels ranged from 31 to 35 dBA at the vicinity of the entrance to Bandelier National Monument and New Mexico State Route (SR) 4. At White Rock, background noise levels ranged from 38 to 51 dBA; this is slightly higher than the level found near Bandelier National Monument, probably because of the higher levels of traffic and the presence of a residential neighborhood as well as the different physical setting. These noise levels are typical of rural or quiet suburban residential areas (Eldred 1982).

For the general area surrounding the LANL site, the countywide L_{dn} (based on population density) is estimated to be 40 dBA for Santa Fe County and 44 dBA for Los Alamos County — typical of rural areas (Miller 2002; Eldred 1982).

American Indian Text

The Sacred Area is currently monitored for noise by Pueblo de San Ildefonso. Noise, which from a Pueblo perspective is an unnatural sound, does disturb ceremony and the place itself. Currently non-Indian voices, machinery, and processing equipment have been recorded by Pueblo de San Ildefonso monitors as coming from Area G to the Sacred Area.

8.1.2 Geology and Soils

8.1.2.1 Geology

8.1.2.1.1 Physiography. LANL is located on the Pajarito Plateau, within the Rio Grande rift zone, in the Southern Rocky Mountain physiographic province (and immediately adjacent to the eastern edge of the Colorado Plateau), in north-central New Mexico. The east-sloping Pajarito Plateau is composed predominantly of volcanic material (tuffs) and covers an area of about 620 km^2 (240 mi^2). LANL is situated on about 100 km^2 (40 mi^2 or 25,600 ac) in its central part. The plateau overlies the western portion of the Española Basin, extending to the southeast from the Sierra de los Valles on the eastern rim of the Jemez Mountains to White Rock Canyon and the Española Valley (Figure 8.1.2-1). The plateau was formed by the deposition of volcanic ash from calderas in the central part of the Jemez Mountains. Surface water flow across the Pajarito Plateau has created a mesa and canyon landscape. Its surface is deeply dissected, consisting of narrow, flat mesas separated by deep, narrow, east- to southeast-trending canyons. The canyon bottoms are covered with a thin layer of alluvium; mesa tops show little soil formation. Drainage is by ephemeral and intermittent streams that discharge to the Rio Grande, which lies just to the east of the plateau (Purtymun 1995; Broxton and Vaniman 2005; DOE 2008c).

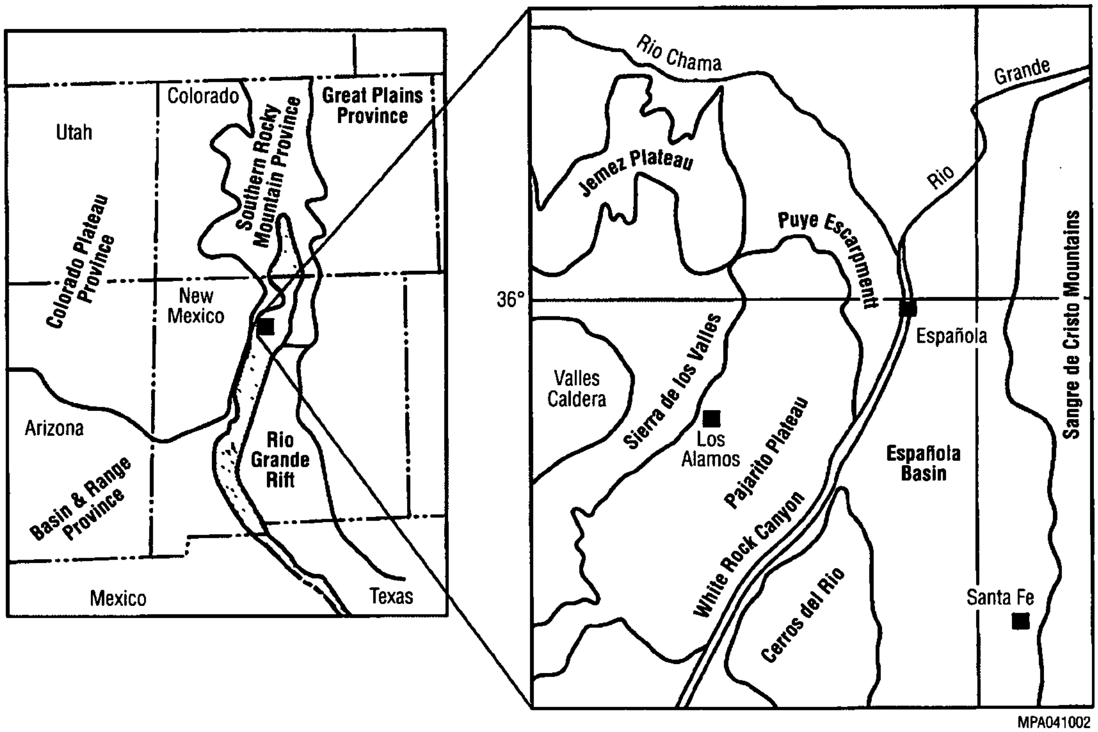
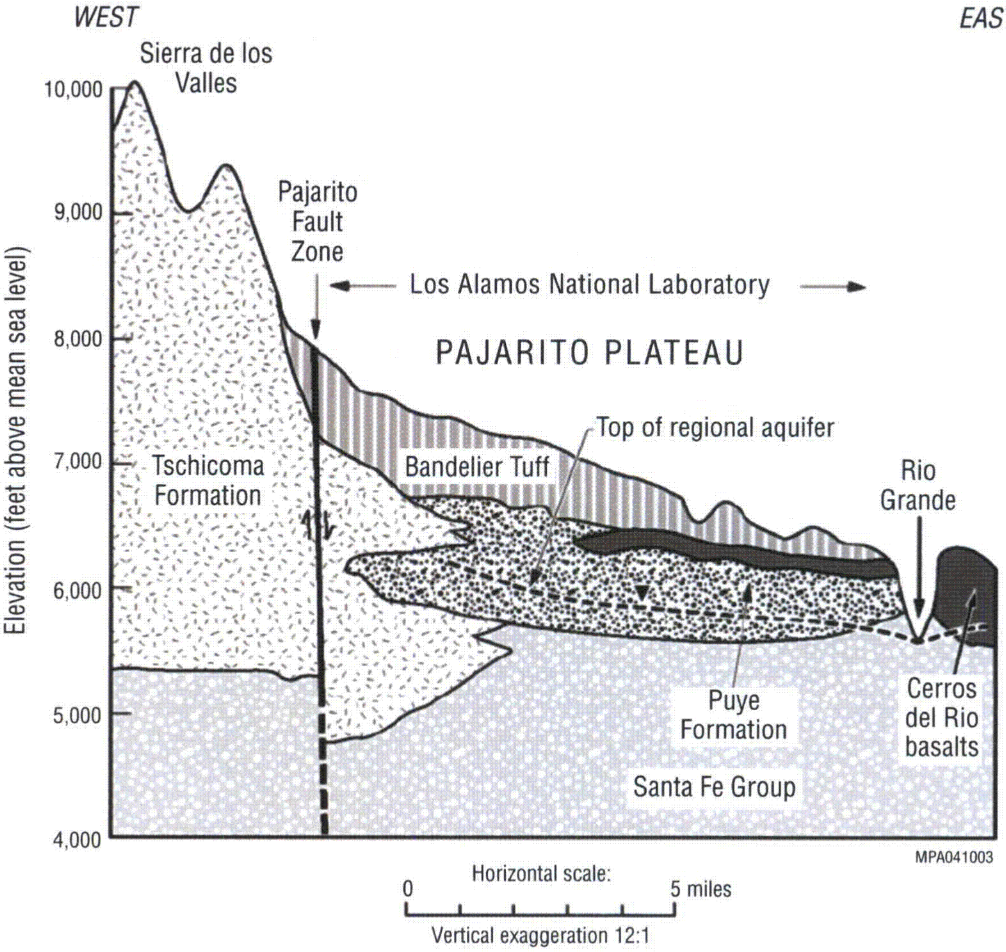


FIGURE 8.1.2-1 Location of LANL in the Southern Rocky Mountain Physiographic Province (Source: Purtymun 1995)

8.1.2.1.2 Topography. The maximum elevation in the Sierra de los Valles is 3,505 m (11,500 ft) MSL. The Pajarito Plateau forms an apron 13- to 26-km (8- to 16-mi) wide and 48- to 64-km (30- to 40-mi) long around the eastern flanks of the Sierra de los Valles (Purtymun 1995). Elevations on the plateau range from 2,377 m (7,800 ft) MSL on the slopes of the Sierra de los Valles to 1,900 m (6,200 ft) MSL along the eastern edge, where it terminates at the Puye Escarpment and White Rock Canyon (Figure 8.1.2-1). The mesa top elevation at TA-54 is about 1,768 m (5,800 ft) MSL.

Running along the east side of the plateau, the Rio Grande drops from an elevation of about 1,676 m (5,500 ft) MSL to about 1,634 m (5,360 ft) MSL as it flows from Los Alamos Canyon to Frijoles Canyon (Purtymun 1995; DOE 2008c).

8.1.2.1.3 Site Geology and Stratigraphy. The Pajarito Plateau consists of a complex sequence of rocks of volcanic and fluvial origins that together form a vertical intergradation of wedge-shaped strata (Figure 8.1.2-2). Volcanic units consist of volcaniclastics and volcaniclastic-derived sediments from the Jemez Mountain volcanic field to the west. Fluvial deposits are associated with alluvial fan development from Precambrian basement rock in the highlands to the north and east of the site (DOE 2008c).



Notes:
1. The thickness of geologic units has been exaggerated on this figure to illustrate unit relationships and topography.
2. Offset of the Tschicoma formation on the Pajarito Fault zone is schematic due to the variation along the trace of the fault.
3. To convert feet to meters, multiply by 0.3048.

Source: LANL 2005j.

FIGURE 8.1.2-2 Generalized Cross Section of Pajarito Plateau (Source: DOE 2008c)

The GTCC reference locations are situated on the northwest end of TA-54. TA-54 is an elongated area with a northwest-southeast trend that sits on the narrow part of Mesita del Buey (Figure 8.1-1). It is bounded to the south by Pajarito Canyon and to the north by Cañada del Buey. The boundary between LANL and the San Ildefonso Indian Pueblo is on the far side of Cañada del Buey. The Bandelier Tuff makes up the majority of surface exposures and near surface rocks; it is composed of nonwelded to moderately welded rhyolitic ash-flow and ash-fall tuffs deposited during eruptions of the Valles caldera, about 18 km (11 mi) west of TA-54 (Krier et al. 1997).

The following summary of stratigraphy for Mesita del Buey is based on the work of Purtymun (1995), Krier et al. (1997), Reneau et al. (1998), Gardner et al. (1999), and Broxton and Vaniman (2005) and on material presented in the latest SWEIS (DOE 2008c). A generalized cross section of the plateau is shown in Figure 8.1.2-2. Figure 8.1.2-3 presents a stratigraphic column of the Pajarito Plateau.

Middle to Upper Tertiary (Oligocene to Miocene) Rocks.

Santa Fe Group. The Santa Fe Group encompasses the sediments of the Española Basin. It is subdivided into several formations (from oldest to youngest): the Tesuque Formation, the older fanglomerate deposits of the Jemez Mountain volcanic field, the Totavi Lentil, and the Puye Formation.

The Miocene Tesuque Formation is composed of fluvial deposits derived from Precambrian granite, pegmatite, sedimentary rocks from the Sangre de Cristo Range, and Tertiary volcanic rocks from northern New Mexico. Beds are typically greater than 3-m (10-ft) thick, massive to planar- and cross-bedded, light pink to buff siltstone and sandstone, with minor lenses of pebbly conglomerate. There are no exposures of this formation within LANL site boundaries; however, exposures may be found on the eastern margins of the Pajarito Plateau and along the canyon walls to the north (e.g., Los Alamos Canyon).

Older fanglomerate deposits are widespread on the Pajarito Plateau. Deposits are composed of volcanic detritis and dark lithic sandstone with gravel and cobbles. The unit is up to 500-m (1,650-ft) thick and interfingers with the Tschicoma Formation.

The Totavi Lentil consists of poorly consolidated and well rounded sands, gravels, and cobbles deposited by the ancestral Rio Grande. The unit is highly variable in thickness (from 10 to 30 m [30 to 100 ft]) and rests conformably on top of the older fanglomerate deposits.

The Puye Formation is composed of large alluvial fans made up of volcanic material and alluvium; its source rocks are the domes and flows in the Sierra de los Valles. The formation has two facies: fanglomerate and lacustrine. The fanglomerate is an intertonguing mixture of stream flow, sheet flow, debris flow, block and ash fall, pumice fall, and ignimbrite deposits, up to 330-m (1,100-ft) thick. The lacustrine facies may be up to 9-m (30-ft) thick and include lake and river deposits in the upper part of the section, consisting of fine sand, silt, and clay. The Puye Formation is well exposed on the Pajarito Plateau and unconformably overlies the Santa Fe Group.

The total thickness of the Santa Fe Group is as much as 1,460 m (4,800 ft) in the eastern and northern part of the basin. Prebasin strata are exposed along the basin margins; they include Upper Paleozoic (Mississippian to Permian), Mesozoic marine, terrestrial sedimentary rocks, and Upper Tertiary Laramide synorogenic deposits.

Cerros del Rio Basalts. The thick, dense-fractured mafic lava flows and rubbly flow breccias of the Cerros del Rio Basalts underlie and interfinger with the sedimentary

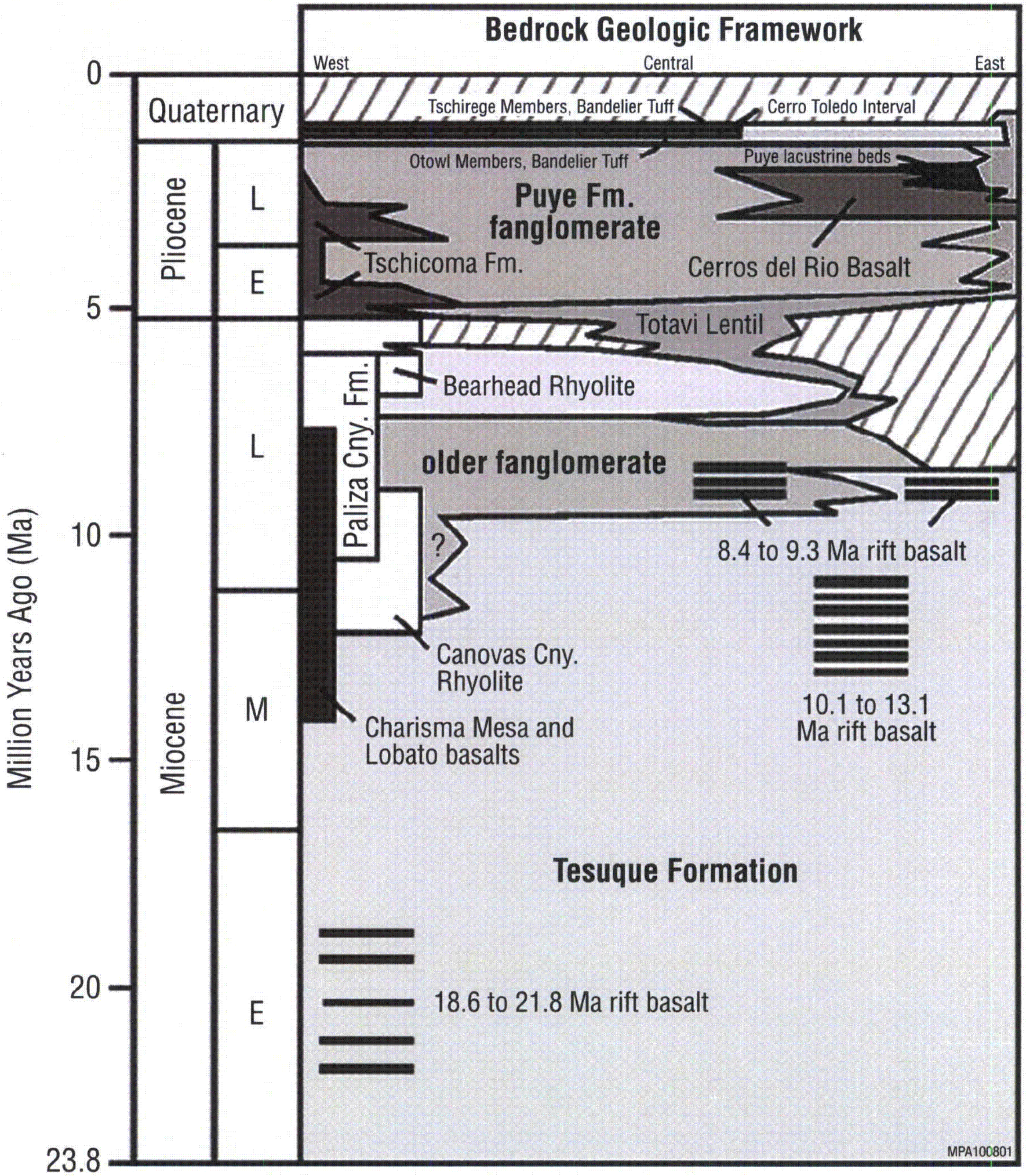


FIGURE 8.1.2-3 Stratigraphic Column for the Pajarito Plateau at LANL (Source: Modified from DOE 2008c)

conglomerates and fanglomerates of the Puye Formation (Figures 8.1.2-2 and 8.1.2-3). Their thicknesses beneath T-54 are unknown but are at least 82 m (269 ft) in places.

Tschicoma Formation. The Tschicoma Formation interfingers with the deposits of the Puye Formation. It consists of thick dacite and low-silica rhyolite lava flows erupted from the Sierra del los Valles. The unit has a thickness of up to 762 m (2,500 ft) in the Sierra del los Valles (Figure 8.1.2-1). Beneath the Pajarito Plateau surface, the formation is lenticular. It extends broadly across the plateau, thinning eastward.

Quaternary Deposits.

Bandelier Tuff. The Bandelier Tuff forms the upper surface of the Pajarito Plateau, lapping up onto the Tschicoma Formation along its western edge (Figure 8.1.2-2). The tuff is thickest to the west of LANL (near its source) and gets thinner as it goes eastward across the plateau. The upper two members of the Bandelier Tuff, the Tshirege Member (upper) and the Otowi Member (lower), are separated by an ash-fall/fluviatile sedimentary interval (referred to as the Cerro Toledo interval) (Figure 8.1.2-4). The lowest member, the Guaje Member, underlies the Cerro Toledo interval and rests conformably on rocks of the Puye Formation. All three members are present on Mesita del Buey.

The following discussion uses the nomenclature originally adopted by Baltz et al. (1963) to describe the stratigraphic units of the Bandelier Tuff (e.g., Units 1a, 1b, 2a, 2b, and 3) because investigators such as Krier et al. (1997) have used it, both for simplicity and to maintain continuity with previous investigations related to waste disposal and hydrologic issues in TA-54.

The Tshirege Member at Mesita del Buey consists of (from youngest to oldest) Units 2b, 2a, 1b, and 1a and the basal Tsankawi pumice bed. According to Krier et al. (1997), Units 2b through 1b crop out on the tops and sides of Mesita del Buey; units older than 1b have only been observed in borehole samples deeper than the base of the mesa. Unit 2b is the brittle and resistant caprock that forms the tops of mesas, including Mesita del Buey. It is about 12-m (40-ft) thick in the southeastern portion of TA-54 and is composed of crystal-rich devitrified pumice fragments in a matrix of ash, shards, and abundant phenocrysts. It is extensively fractured as a result of contraction due to cooling after deposition. Fractures are typically filled with smectite clays to a depth of about 3 to 4 m (10 to 13 ft), with opal and calcite below this depth. Opal and calcite deposition is associated with the presence of tree root molds; live tree roots have been observed at depths of up to 20 m (66 ft). The base of this unit is commonly marked by a thin interval (less than 10 cm or 4 in.) of crystal-rich material that is the size of fine-grained sand (called surge beds) that represents deposition from the basal surge associated with violent eruptions. The surge beds on Mesita del Buey have been displaced by small faults.

Unit 2a underlies Unit 2b; it consists of devitrified ash-fall and ash-flow tuff. The unit is about 14-m (46-ft) thick in the southeastern portion of TA-54 and is slightly welded at its base, becoming moderately welded further up the section. Some of the more prominent cooling

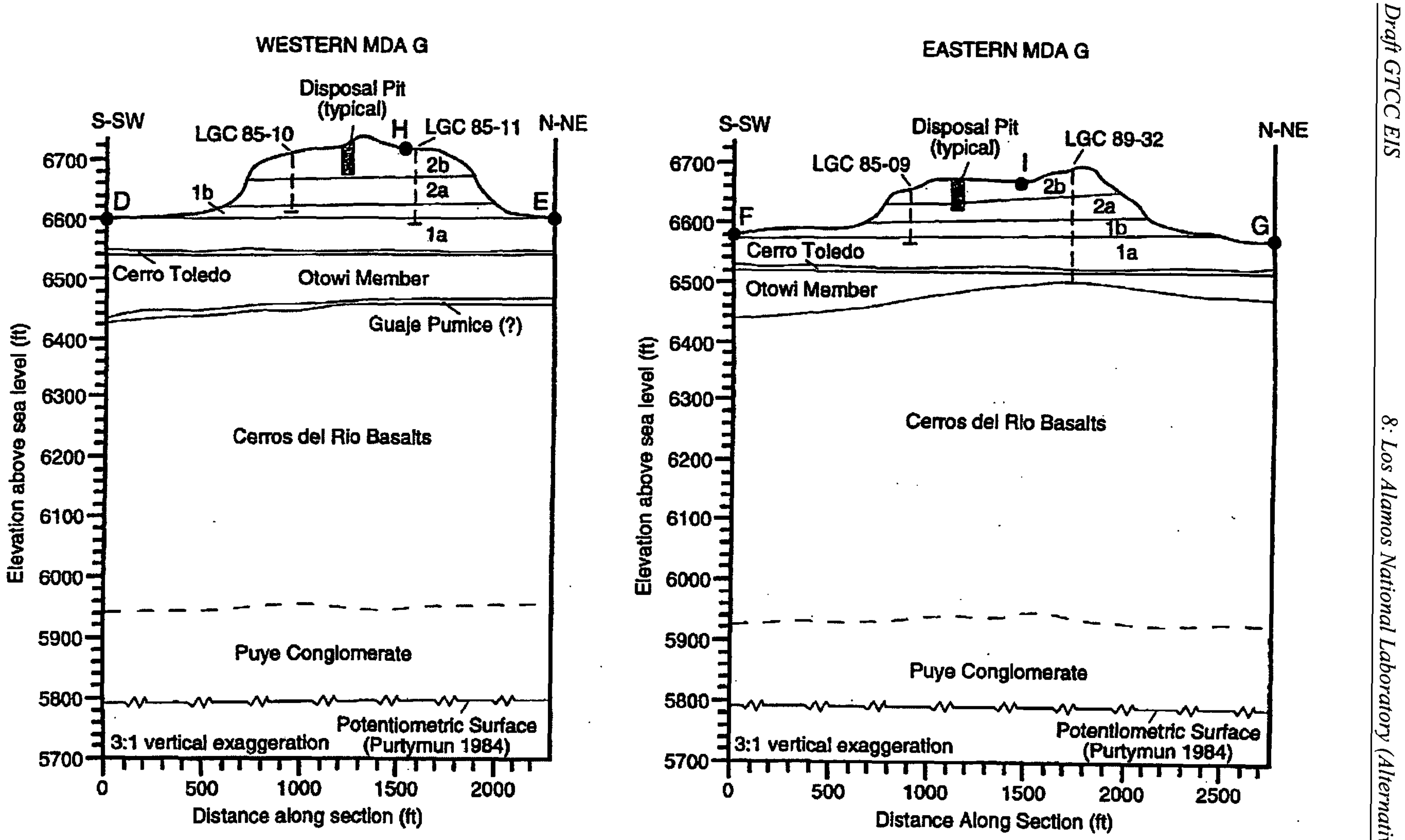


FIGURE 8.1.2-4 Stratigraphy of the Bandelier Tuff at Material Disposal Area G, to the Southeast of the GTCC Reference Location (Source: Krier et al. 1997)

fractures originating in Unit 2b extend down into Unit 2a. Attempts to retrieve core samples from this unit invariably result in unconsolidated material.

Unit 1b underlies Unit 2a; it is a slightly welded to welded, devitrified ash-flow tuff that becomes increasingly welded toward its center. It has a greater content of unwelded pumice lapilli than the overlying Unit 2b, and it exhibits little of its fracturing characteristics. Unit 1b ranges from 7- to 15-m (23- to 49-ft) thick in the southeastern portion of TA-54.

Unit 1a is the oldest unit of the Tshirege Member. It is a vitric, pumiceous, nonwelded ash-flow tuff with a thickness of up to 15 m (50 ft) in the southeastern portion of TA-54. Because of its weak matrix properties, this unit likely has few fractures.

The Tsankawi Pumice Bed is fairly thin (i.e., less than 0.30 m or 1 ft) at TA-54. It consists of a layer of gravel-sized, vitric, nonwelded pumice. The bed is extensive on the Pajarito Plateau and marks the base of the Tshirege Member. Underlying this basal unit is the Cerro Toledo interval, which is composed of sedimentary deposits, including tuffaceous sandstones, siltstones, and gravel and cobbles of mafic to intermediate lavas. It also contains deposits of ash and pumice. The Cerro Toledo interval has a thickness of about 5 m (16 ft) in the southeastern portion of TA-54; it typically gets thinner to the east across the Pajarito Plateau.

The Otowi Member at Mesita del Buey is a massive, nonwelded, pumiceous rhyolite tuff. It has a fine-grained ash matrix that contains an unsorted mix of phenocrysts (e.g., quartz and sanidine), glass shards, mafic minerals, and various rock fragments (e.g., latite, rhyolite, quartz latite, and pumice). The unit is about 30-m (100-ft) thick in the southeastern portion of TA-54 and typically gets thinner to the east. It rests conformably on the Guaje Member, the basal unit of the Bandelier Tuff. The Guaje Member is composed of nonwelded pumice fragments that are silicified and brittle. The bed is about 3.7-m (12-ft) thick.

Mesa Top Alluvium. Silts, sands, gravels, soils, and reworked pyroclastic deposits overlie the Bandelier Tuff in many mesa-top localities, including Mesita del Buey. These deposits generally sit on the erosional surface that cuts the upper units of the Tshirege Formation. Alluvial gravels, deposited by a fluvial system that predates the incision of canyons on the Pajarito Plateau, contain abundant pumice and dacite clasts. The age of these deposits has been estimated to be several hundred thousand years old.

Canyon Alluvium. Canyon alluvium is derived from the weathering and erosion of rocks from the Sierra de los Valles and the Pajarito Plateau. The thickness of the alluvium varies but is typically less than 6 m (20 ft) and increases as it goes eastward. Alluvial deposits are composed of unconsolidated silty to coarse sands of quartz and sanidine (feldspar), crystal fragments, and fragments of pumice. Occasional fragments of latite or latite-composition lava and welded tuff are also present.

8.1.2.1.4 Seismicity. LANL is located in the Española Basin within the Rio Grande rift zone. The Rio Grande rift is a north-trending, active tectonic feature that extends from central Colorado to northern Mexico (Figure 8.1.2-5). Basins in the rift zone are bounded by normal faulting that occurs along the rift zone margins and within the basins. The Española Basin is a west-tilting half-graben bounded on the west edge by north-trending normal faults of the Pajarito fault zone, bounded on the north by northeast-trending transverse faults of the Embudo fault zone, and bounded on the south by northwest-trending transverse faults of the Bajada fault zone (LANL 2007; Broxton and Vaniman 2005; Gardner et al. 1999).

The seismicity of north central New Mexico is concentrated along the rift structures within the Rio Grande rift — stretching from Socorro to Albuquerque — and tends to be shallow (i.e., less than 20 km [12 mi]). It is absent in areas of high heat flow, as in the calderas in the Jemez Mountains, because of the increased ductility of rocks; this situation reduces the likelihood of brittle fracture and faulting even at shallow depths (Cash and Wolff 1984).

The main strand of the Pajarito fault system, a major structural element of the Rio Grande rift, lies along the western boundary of LANL (Figures 8.1.2-5 and 8.1.2-6). The fault system is a north-northeast trending series of en echelon faults; it consists of the Pajarito fault zone and the related Guaje Mountain and Rendija Canyon faults (Figure 8.1.2-6). Activity along the fault system has been recurrent, with abundant evidence at the surface showing that Quaternary vertical displacement has taken place (e.g., stream gradient discontinuities and topographic scarps of up to 125 m [410 ft] in the Bandelier Tuff). Horizontal movement is also evident, particularly along the segment north of LANL. For these reasons, the fault system is considered capable[1] and has the potential to generate earthquakes in the region (Dransfield and Gardner 1985; Gardner and House 1987; Wachs et al. 1988; Wong 1990). It is considered to be the primary source of seismic risk at LANL (LANL 2007; DOE 2008c).

As many as 37 faults with vertical displacements of 5 to 65 cm (0.5 to 25 in.) have been observed in the surge beds of the Tshirege Member in outcrops of Mesita del Buey along Pajarito Canyon. Fault planes are steeply dipping, indicating normal displacement, and most displacements are down to the west. Lateral movement may also have occurred along these faults. Faults are thought to be no more than 1.2 million years old. Fracture studies have characterized the fractures in Unit 2 of the Tshirege Member in TA-54 (Area G) as steeply dipping, with preferential dips to the north and east. Fractures become more closely spaced with depth (Reneau and Vaniman 1998; Reneau et al. 1998; DOE 2008c). These faults are likely secondary effects associated with large earthquakes in the main Pajarito fault system, and the principal faults likely experience small amounts of movement during earthquakes (DOE 2008c).

The record of earthquakes in the vicinity of LANL goes back only to the 1940s when the town of Los Alamos was first established. Reports of earthquakes felt before 1950 are rare. Earthquakes of particular note that were felt in Los Alamos occurred on August 17, 1952 (magnitude estimate of 4); February 17, 1971 (magnitude estimate of 3.4); December 5, 1971

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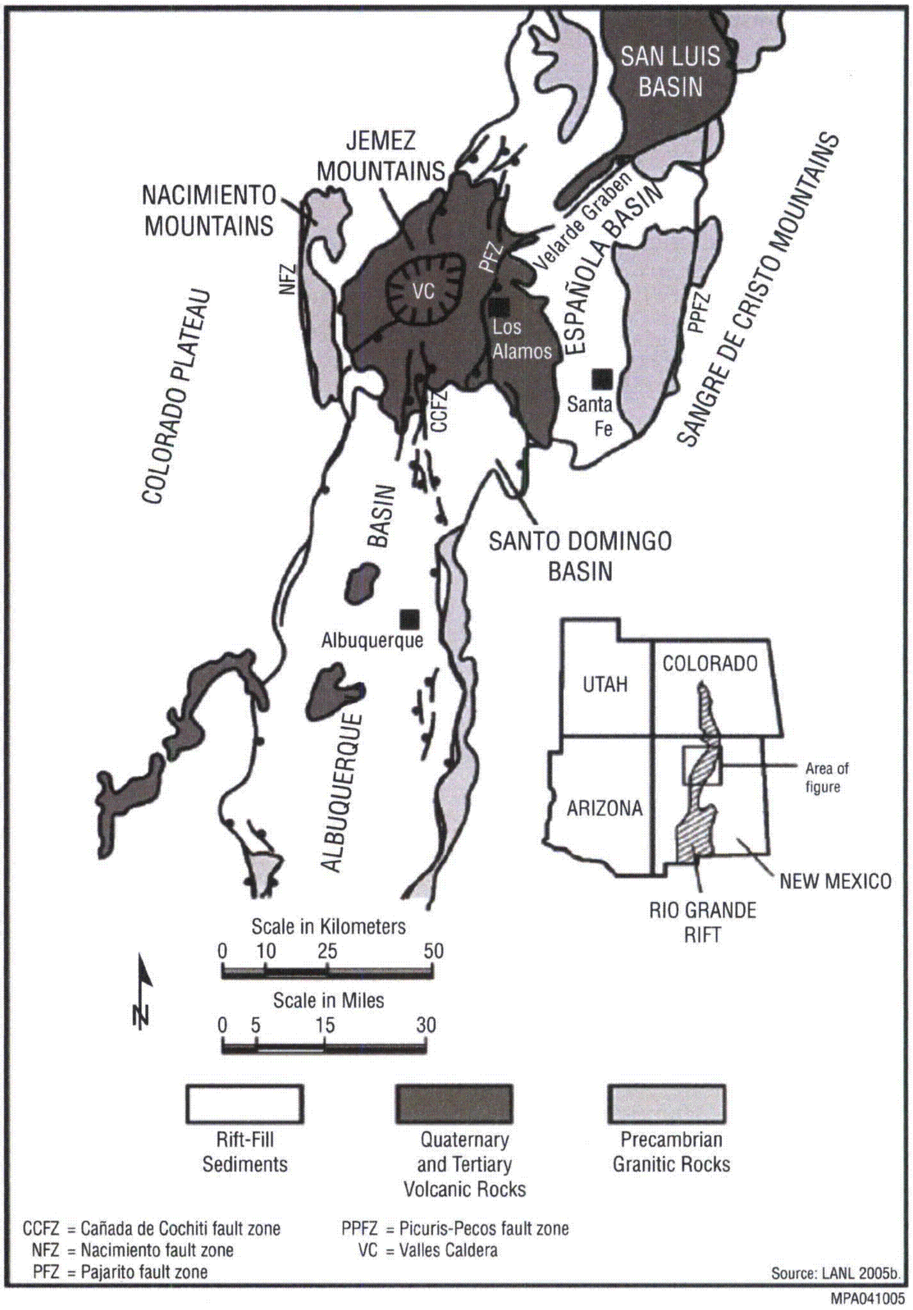
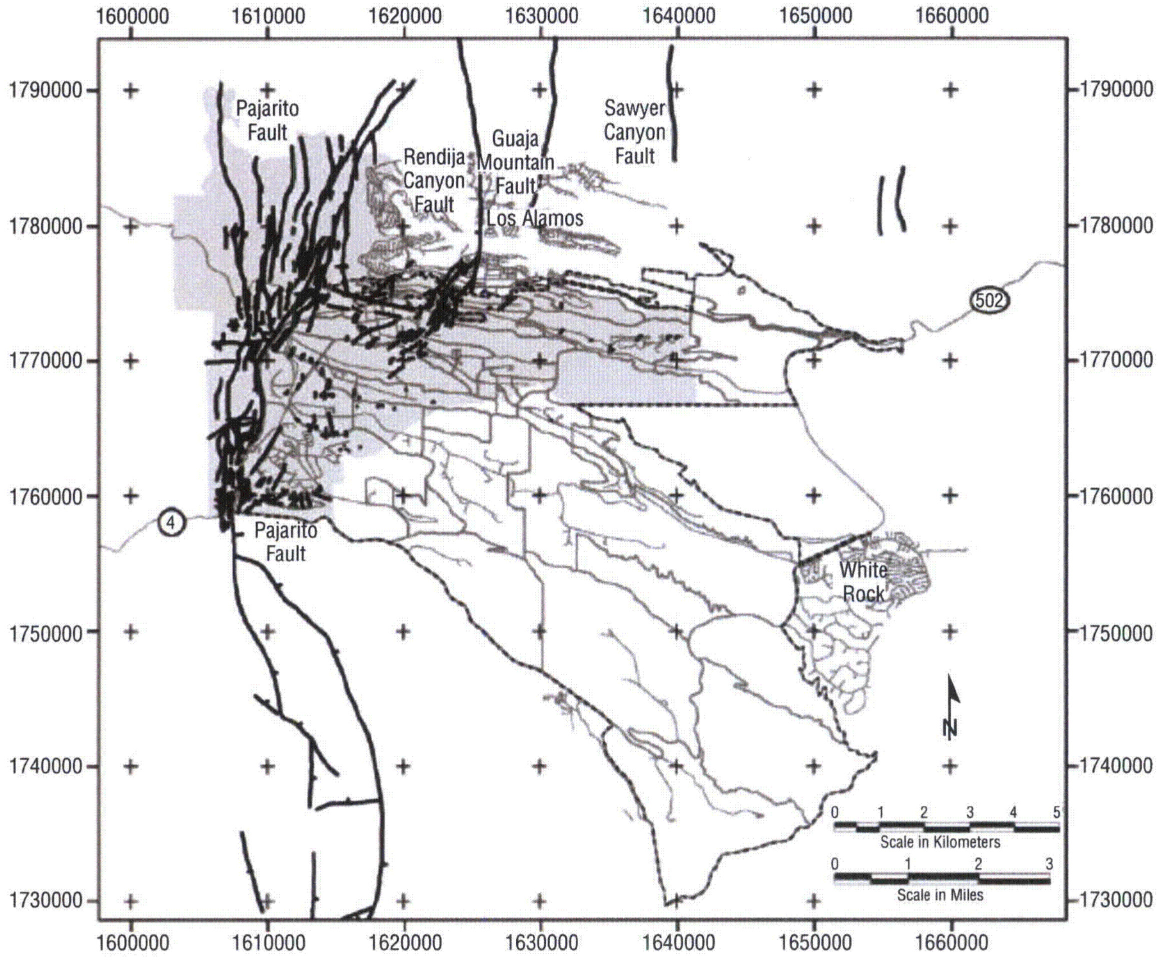
[1] The NRC defines a capable fault as a fault with demonstrable historic macroseismicity, recurrent movements within the last 500,000 years, and/or one movement within the last 35,000 years (10 CFR Part 100, Appendix A).



Source: LANL 2005b.

FIGURE 8.1.2-5 Structural Elements of the Rio Grande Rift Zone (Source: DOE 2008c)



Source: LANL 2004e.

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FIGURE 8.1.2-6 Mapped Faults in the LANL Area (Source: DOE 2008c)

(magnitude estimate of 3.3); and March 17, 1973 (magnitude estimate of 3.3). The largest reported earthquake in the region occurred in Cerrillos in 1918, about 50 km (31 mi) to the southeast of LANL; it had an estimated magnitude of 5.5 (House and Cash 1988; DOE 1999).

As many as 2,000 earthquakes have been recorded since the inception of the Los Alamos Seismograph Network in 1973. The largest event occurred in 1976, about 60 km (37 mi) to the west of LANL (near Gallup, New Mexico), with a magnitude of 5.2 (Cash and Wolff 1984; House and Cash 1988). A catalog of earthquakes occurring in the vicinity of LANL from 1893 to 1991 has been compiled by Wong et al. (1995). The latest SWEIS (DOE 2008c) documents more recent seismic events. Since 1991, five small earthquakes (with magnitudes of 2 or less on the Richter scale) have been recorded along the Pajarito fault (DOE 2008c).

The 2008 SWEIS (DOE 2008c) reports the findings of a seismic hazard study conducted in 2007. This study was based on more recent geological studies that characterize the faults within the Pajarito fault system and their relationships in the LANL area. The study determined that a 0.0004-per-year earthquake (with a return frequency of 2,500 years) would produce peak horizontal accelerations of about 0.47 to 0.52g for a surface facility in technical areas to the west of TA-54 (where the principal faults, and thus the principal seismic risks at LANL, are located). A 0.001-per-year earthquake (with a return frequency of 1,000 years) would produce peak horizontal accelerations of about 0.25 to 0.27g (DOE 2008c).

American Indian Text

The Pueblo people are aware of the occurrence of major earthquakes in the GTCC study area (up to 2000 have been recorded in recent times). These cause vertical displacements, large fissures, and small fractures. Water seeps into these fissures and plant roots follow them to great depths (up to 66 feet). Pueblo people believe that plant roots will eventually penetrate the GTCC facility.

8.1.2.1.5 Volcanic Activity. Most of the volcanic activity in the vicinity of LANL has occurred in the Jemez Mountains, just to the west of the Pajarito Plateau (Figure 8.1.2-1). Volcanic activity dates to 16.5 million years ago. The oldest activity was concentrated to the southwest of the plateau and was dominated by basaltic to andesitic lavas (with minor dacites and rhyolites). About 3 to 7 million years ago, the activity shifted to the north and became dominated by dacites and rhyolites. Two major eruptions about 1.6 to 1.2 million years ago produced the ash fall material making up the Otowi and Tshirege Members of the Bandelier Tuff and formed the Valles Caldera, about 8 km (5 mi) to the west of LANL. The most recent volcanic activity within Valles Caldera is estimated to have occurred about 150,000 years ago (although some suggest activity occurred as recently as 50,000 to 60,000 years ago), creating rhyolitic lava domes and minor pyroclastic deposits. Currently, the Jemez Mountains show little seismic or volcanic activity (DOE 1999; Rosenberg and Turin 1993).

The low seismic activity is attributed to the adsorption of seismic energy deep in the subsurface due to elevated temperatures and high heat flow, thus masking the movement of magma and adding to the difficulty of predicting a volcanic event in the LANL area (although a large Bandelier-Tuff-type eruption would give years of warning, as regional uplift and doming occurred). The Jemez Mountains continue to be considered a zone of potential volcanic activity (DOE 1999, 2008c).

The Cerros del Rio basaltic field to the southeast of the Pajarito Plateau represents other volcanic activity in the vicinity of LANL (Figure 8.1.2-1). These basalts range in age from 1.1 to 1.4 million years (Rosenberg and Turin 1993).

8.1.2.1.6 Slope Stability, Subsidence, and Liquefaction. Steep canyon walls within LANL are susceptible to rock falls and landslides. The potential for these processes to occur is related to wall steepness, canyon depth, and stratigraphy. At greatest risk are facilities near a cliff edge or in a canyon bottom. Slope instability may be triggered by excessive rainfalls, erosion, and seismic activity (DOE 1999). However, a study conducted for TA-3 indicated that rock spalling near canyon walls was determined not to be of concern even in an earthquake (Bradley et al. 2007). Fires, such as the Cerro Grande fire that occurred in 2000, also contribute to slope instability because they cause a loss of vegetative cover and the formation of hydrophobic soil, increasing soil erosion in localized areas. This risk is reduced as vegetation returns (DOE 2008c).

Subsidence and soil liquefaction are less likely to affect areas within LANL than are rock falls or landslides. The potential for subsidence is reduced by the firm rock beneath LANL. The potential for liquefaction is minimal, since bedrock, soils, and other unconsolidated materials at LANL tend to be unsaturated (DOE 1999).

8.1.2.2 Soils

The undisturbed soils within the study area were formed from material weathered from tuff on the nearly level surface (with slopes of 1% to 5%) of Mesita del Buey. These soils are shallow to moderately deep and well drained, with low to moderate permeability and a small to moderate erosion hazard. At the surface (to a depth of 10 cm [4 in.]), soils are predominantly brown loam to sandy loam. They become clay loam to clay with increasing depth (up to 50 cm [20 in.]). The substratum is a gravelly sandy loam, containing up to 30% pumice, with a thickness of about 40 cm (16 in.). The depth to tuff bedrock is from 30 to 100 cm (12 to 40 in.) (DOE 1999; Nyhan et al. 1978).

8.1.2.3 Mineral and Energy Resources

Mineral resources at LANL consist of rock and soil that are excavated for use as backfill or borrow material for construction of remedial structures, such as waste unit caps. Most borrow materials are taken from sedimentary deposits of the Santa Fe Group and Pliocene-age volcanic rocks (e.g., the Bandelier Tuff) and from Quaternary alluvium along stream channels (in limited volumes). The only borrow pit currently in use at LANL is the East Jemez Road Borrow Pit in TA-61 to the northwest of TA-54. The pit is cut into the Bandelier Tuff and is used for soil and rubble storage and retrieval. There are at least 11 commercial borrow pits and quarries within 48 km (30 mi) of LANL; these produce mostly sand and gravel (DOE 2008c). Pumice has been mined on U.S. Forest Service (USFS) land in Guaje Canyon (DOE 1999).

LANL has conducted extensive research on geothermal energy systems throughout the United States (including the Valles Caldera in New Mexico) and in other countries. This research involves both conventional and dry hot rock geothermal energy. There are currently seven experimental geothermal (gradient) wells at LANL. Currently, there are no geothermal production wells on-site.

American Indian Text

The Pueblo people who visited the proposed GTCC disposal site note the likelihood of traditionally used minerals occurring there. They assess that this is a medium to high probability. There is a need for a cultural mineral assessment and study to identify the existence of minerals of cultural significance and use.

Although there is no current Pueblo ethnogeology studies for the LANL, one was recently developed for Bandelier National Monument. That study, which was approved by the participating pueblos, documented that 96 geological resources were found to have specific uses by Pueblo people, which is estimated to be the bulk of the occurring minerals in Bandelier NM. The following are the ten most frequently cited mineral resources, presented in order of frequency of reference. Included also is the number of pueblos that were documented to have used the named resource (1) Clay 17 times mentioned for 7 pueblos; (2) Turquoise 15 times mentioned for 7 pueblos; (3) Basalt 15 times mentioned for 5 pueblos; (4) Obsidian 9 times mentioned for 4 pueblos; (5) Gypsum 8 times mentioned for 5 pueblos; (6) Rock Crystal 8 times mentioned for 5 pueblos; (7) Salt 7 times mentioned for 4 pueblos; (8) Mica 6 times mentioned for 5 pueblos; (9) Sandstone 6 times mentioned for 5 pueblos; and (10) Hematite 6 times mentioned for 4 pueblos. Just as there are certain minerals that are more frequently documented, certain pueblos were more often the subject of observations and ethnographies.

8.1.3 Water Resources

8.1.3.1 Surface Water

8.1.3.1.1 Rivers and Streams. LANL covers 100 km^2 (40 mi^2) of the Pajarito Plateau in north-central New Mexico, approximately 56 km (35 mi) northwest of Santa Fe. The surface of the Pajarito Plateau is deeply dissected, consisting of narrow, flat mesas separated by deep, narrow, east- to southeast-trending canyons. There are about 140 km (85 mi) of drainage courses within LANL boundaries, of which only about 3.2 km (2 mi) are naturally perennial. About 5 km (3 mi) of streams flow perennially because they are supplemented by wastewater discharge. Most streams, however, are dry for most of the year and flow only in response to storm runoff or snowmelt.[2] Surface water also flows from shallow groundwater discharging as springs into canyons. Figure 8.1.3-1 shows the 16 watersheds in the vicinity of LANL; 12 of them cross LANL boundaries. The watersheds are named for the canyons that receive their runoff. TA-54 is situated on Mesita del Buey, between Pajarito Canyon to the south and Cañada del Buey to the north (LANL 2005; DOE 2008c). The GTCC reference sites at LANL are situated on Mesita del Buey.

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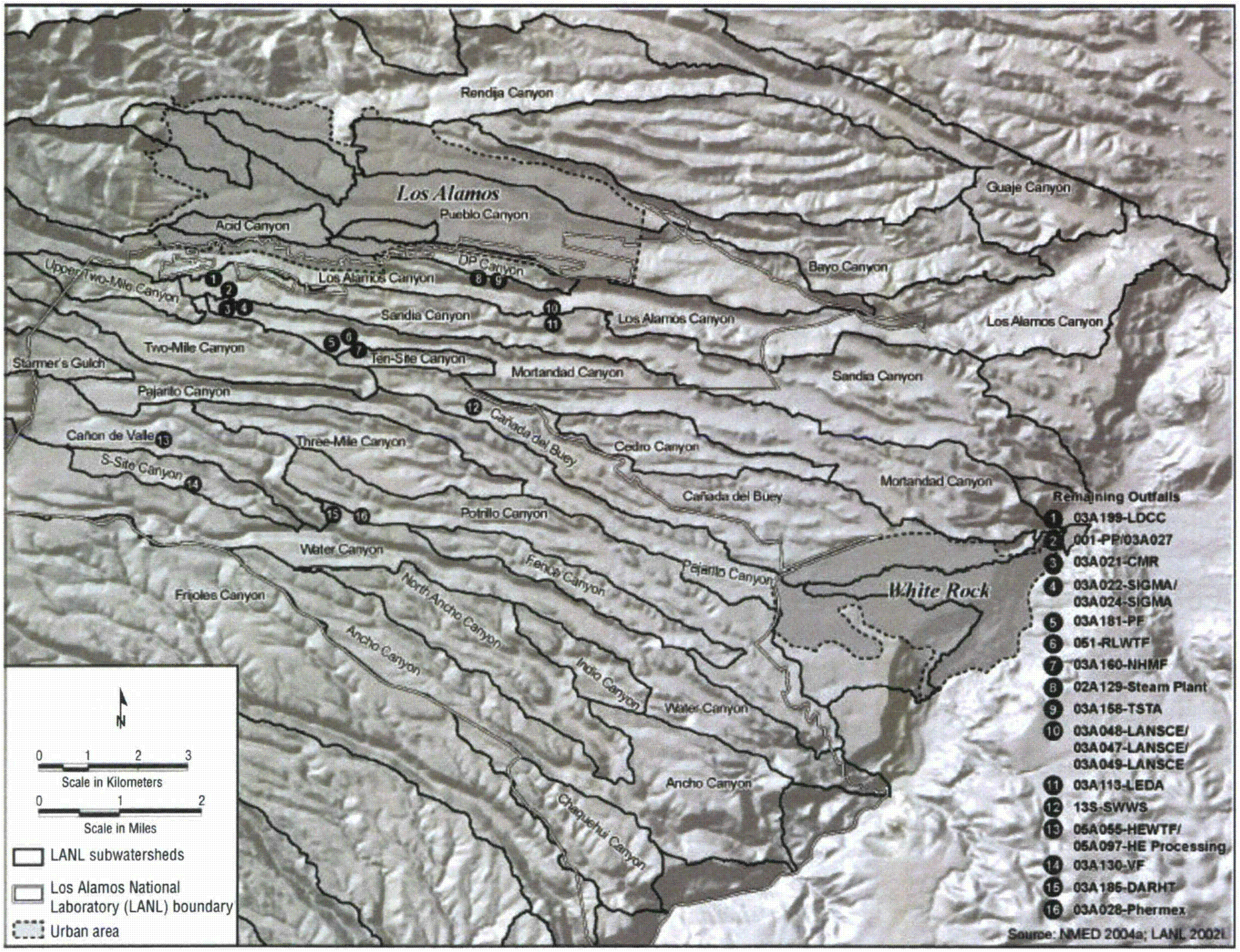
[2] Environmental surveillance reports distinguish between streams that are ephemeral (always above the water table) and those that are intermittent (sometimes below the water table) because of the different biological communities they support.



Source: NMED 2004a; LANL 2002i

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FIGURE 8.1.3-1 Watersheds in the LANL Region (Source: DOE 2008c)

Stream flow is monitored at six locations in Pajarito Canyon and three locations in Cañada del Buey (Figure 8.1.3-2; Table 8.1.3-1). Gauges monitoring the Pajarito Canyon during water year 2006 were dry for most of the year, with recorded average annual flows of less than 0.028 cms (1 cfs) and maximum flows of up to 12 cms (425 cfs) on August 25. Similarly, gauges monitoring Cañada del Buey were dry for most of the year, with average annual flows of less than 0.028 cms (1 cfs) and maximum flows of up to 6.4 cms (228 cfs) on August 25 (Table 8.1.3-1).

American Indian Text

Pueblo people know that drainages in LANL flow during major runoff and storm events. These flows, though at times low in volume, have a potential to reach the Rio Grande and lower water bodies. In 1996, the Pueblo of Cochiti conducted a cooperative sediment study with LANL and the USGS in which Pre-1960s Legacy Waste was identified using the Thermal Ionization Mass Spectroscopy (TIMS) method. This Pre-1960s Legacy Waste has been recorded on the up-river portion of the Cochiti Reservoir, which is on the Rio Grande as it passes through the Cochiti Reservation.

There exists high potential for continuing pollution flows as indicated in the GTCC text above, and now the Cerro Grande fire has increased the potential for constituent movement as indicated in the Site-Wide EIS. Evidence of radioactivity and hazardous waste (PCBs) movement from LANL has led to fish consumption warnings on eating fish from the Rio Grande.

At LANL, perennial streams are not a source of municipal, industrial, irrigation, or recreational water; however, they have the designated uses of coldwater aquatic life use, livestock watering use, and wildlife habitat use (secondary contact). None of LANL perennial streams have been designated as Wild and Scenic. Ephemeral and intermittent streams, such as those within the Pajarito Canyon and Cañada del Buey, have designated uses of limited aquatic life use, livestock watering use, and wildlife habitat use (secondary contact). Beyond the site boundaries, water is used by tribal members of the San Ildefonso Pueblo for traditional or ceremonial purposes. Water may discharge to the Rio Grande River, which lies just to the east of the Pajarito Plateau (DOE 2008c; LANL 2007).

8.1.3.1.2 Other Surface Water. There are approximately 14 ha (34 ac) of wetlands within LANL boundaries. Most wetlands are associated with canyon stream channels; some are located on mesas and are associated with springs, seeps, and effluent outfalls. A 2005 survey found that about 45% of the site's wetlands are located in Pajarito Canyon. The acreage of wetlands at LANL has decreased since 1999 as effluent outfalls have been closed or rerouted. About 3.6 ha (9 ac) of wetlands were transferred to Los Alamos County and the DOI to be held in trust for the San Ildefonso Pueblo and are no longer under DOE's control (DOE 2008c).

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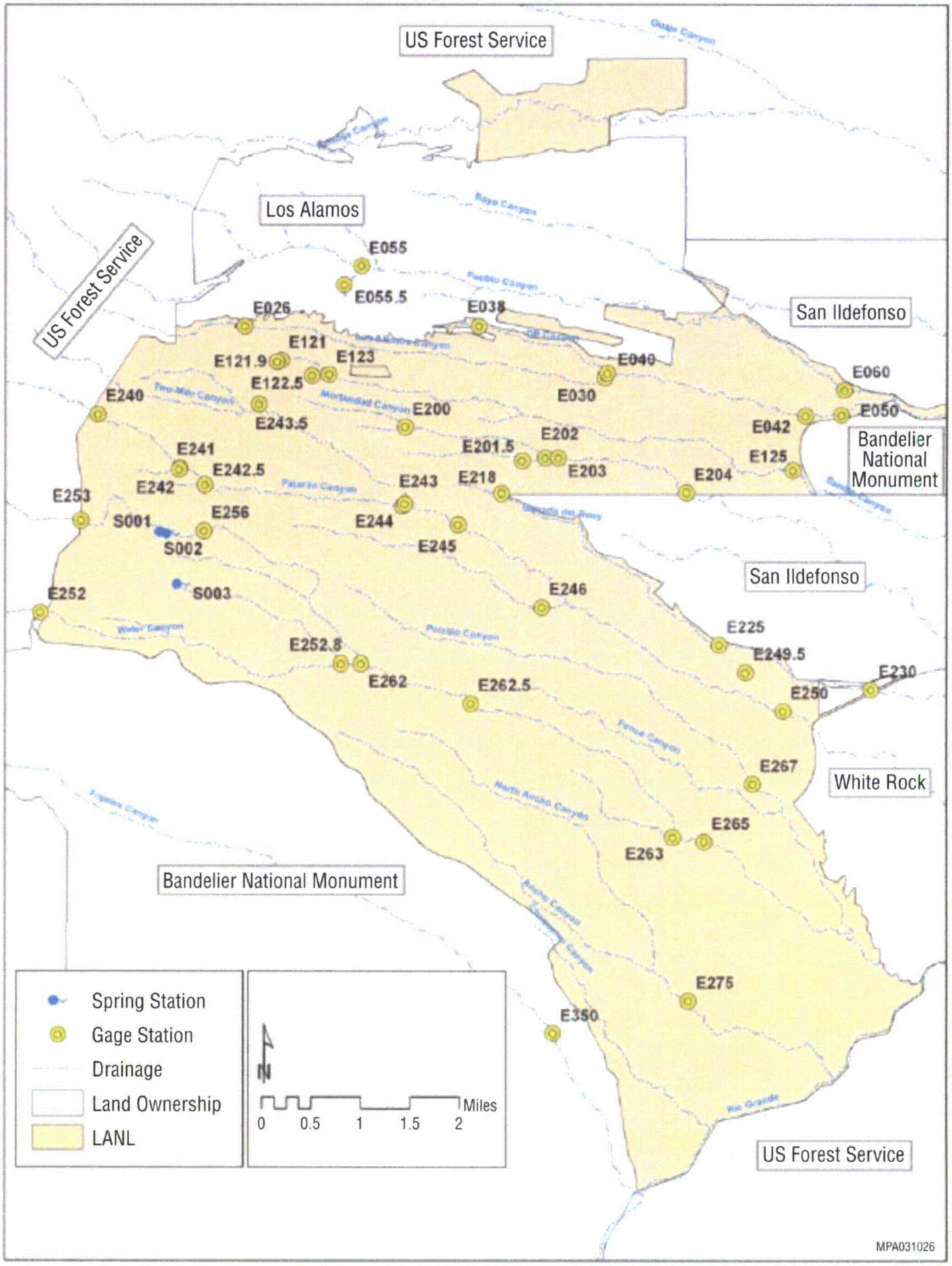

FIGURE 8.1.3-2 LANL Stream Gauging Stations (Source: Romero et al. 2007)

TABLE 8.1.3-1 Stream Flow at U.S. Geological Survey Gauging Stations Monitoring Pajarito Canyon and Cañada del Buey in Water Year 2006[a]

Gauge Station	Maximum Stream Flow in cfs (Date)	Annual Mean
Pajarito Canyon		
E240	16 (Aug. 8)	0.0030
E241	20 (Aug. 8)	0.014
E242.5	12 (Aug. 25)	0.024
E243	101 (Aug. 8)	0.081
E245	425 (Aug. 25)	0.16
E250	206 (Aug. 25)	0.043
Cañada del Buey		
E218	228 (Aug. 25)	0.028
E225	0.49 (Aug. 8)	0
E230	54 (Aug. 6)	0.0090

[a] Water year 2006 is from Oct. 2005 through Sept. 2006.

Source: Romero et al. (2007)

8.1.3.1.3 Surface Water Quality. Potential sources of surface water contamination at LANL include industrial effluents discharged through NPDES permitted outfalls, stormwater runoff, dredge and fill activities, isolated spills, former photographic processing facilities, highway runoff, residual Cerro Grande fire ash (the fire occurred in May 2000), and sediment transport (DOE 2008c). LANL samples surface water within the major canyons that cross the site and at locations along the site perimeter. Stormwater runoff is sampled along the site boundary and at discreet mesa-top sites (including two near North Site at TA-54). Sediment samples are also collected at stations along the canyons and from drainages downstream of two material disposal areas (MDAs), including nine stations just outside the perimeter fence of MDA G at TA-54. Exceedances between 2000 and 2005 were generally of excess total residual chlorine (LANL 2007).

Although every major watershed at LANL shows some effect from site operations, the overall quality of surface water is considered good. Environmental monitoring at NPDES-permitted outfalls indicates that levels of dissolved solutes are low and that levels of most analytes are below regulatory standards or risk-based levels (LANL 2007).

Past discharges of radioactive liquid effluents into Pueblo Canyon (including its tributary in Acid Canyon), and Los Alamos Canyons and current releases from the Radioactive Liquid Waste Treatment Facility into Mortandad Canyon have introduced Am-241, Cs-137, Pu-238, Pu-239, Pu-240, Sr-90, and tritium into both surface waters and canyon sediments. Table 8.1.3-2 summarizes radionuclide concentrations in Pueblo and Mortandad Canyons (DOE 2008c).

During New Mexico's summer rainy season, a large volume of stormwater runoff can flow over LANL facilities and construction sites, picking up pollutants. The most common pollutants transported in stormwater flows are radionuclides, polychlorinated biphenyls (PCBs), and metals. Recent data from stormwater runoff monitoring detected some contaminants on and off-site, but the exposure potential for these contaminants is limited. Radionuclides have been detected in runoff at higher-than-background levels in Pueblo, DP, Los Alamos, and Mortandad Canyons, with sporadic detections extending off-site in Pueblo and Los Alamos Canyons. Stormwater runoff has exceeded the wildlife habitat standard for gross alpha activity of 15 pCi/L since the Cerro Grande fire that occurred in nearly all of the canyons in 2000. Los Alamos Canyon and Sandia Canyon runoff and base flows contain PCBs at levels above New Mexico human health stream standards. Dissolved copper, lead, and zinc have been detected above the New Mexico acute aquatic life stream standards in many canyons, and these metals were detected off-site in Los Alamos Canyon. Some of these PCB and metal detections were upstream of LANL facilities, indicating that non-LANL urban runoff was one source of the contamination. Mercury was detected slightly above wildlife habitat stream standards in Los Alamos and Sandia Canyons (DOE 2008c).

TABLE 8.1.3-2 Summary of Surface Water Radionuclide Concentrations in Pueblo and Mortandad Canyons in 2005

Radionuclide	DOE 100-mrem Derived Concentration Guide for Public Exposure (pCi/L)[a]	Biota Concentration Guide (pCi/L)	Concentration in Lower Pueblo Canyon at SR (pCi/L) 502	Concentration in Mortandad Canyon below TA-50 Radioactive Liquid Waste Treatment Facility Outfall (pCi/L)
Am-241	30	400	0.4	5.1
Cs-137	3,000	20,000	ND[b]	20
Tritium	NR[b]	300,000,000	ND	237
Pu-238	40	200	ND	2.1
Pu-239 and Pu-240	30	200	11	2.9
Sr-90	1,000	300	0.4	3.4
U-234	NR	200	1.7	2.0
U-235 and U-236	NR	200	0.1	1.1
U-238	NR	200	1.6	1.9

[a] Source for the Derived Concentration Guide: DOE (2006).

[b] NR means not reported and ND means not detected.

Source: DOE (2008c)

Dissolved aluminum concentrations exceeded the acute aquatic life standard for some locations in 2006; however, it is thought that these concentrations resulted from particulate (colloidal) aluminum passing through the filter, because LANL surface waters, which are slightly alkaline, rarely contain aluminum in solution. Selenium levels, which had been high following the Cerro Grande fire in 2000 (likely due to ash from the fire), were found to be below the wildlife habitat standard in 2006.

PCBs have also been detected in streams and sediment at LANL. Surface water was analyzed for PCBs in 14 water courses, and PCBs were detected in 6 of them. Consistent with previous years, multiple PCB detections were reported in Sandia, Los Alamos, and Mortandad Canyons. Sandia Canyon accounted for about half of the detections, and Los Alamos Canyon accounted for an additional one-third.

In Los Alamos Canyon, PCBs were detected in sediments throughout the watershed and extending to the confluence with the Rio Grande River near Otowi. The highest sediment concentration for total PCBs in Los Alamos Canyon, approximately 0.5 μg/g, occurred at the confluence with DP Canyon. PCB concentrations tend to decrease with distance from the source; at the LANL boundary, the maximum total PCB sediment concentration was about 0.2 μg/g. The main sources of PCBs on LANL lands are probably from past spills and leaks of transformers rather than from current effluent discharges (LANL 2007).

PCBs were detected throughout the Sandia Canyon watershed from near LANL's main technical area at TA-3 to LANL's downstream boundary at SR 4. Unlike the Los Alamos Canyon watershed, however, there is minimal off-site stream flow in Sandia Canyon. Although most PCBs were detected in stormwater samples, they were also detected in three base flow samples collected near the Sandia Canyon wetlands. Sediment samples collected in the upper portion of Sandia Canyon contained PCB concentrations. The highest PCB concentration was approximately 7 μg/g. Concentrations of PCBs in downstream sediment decline quickly with distance and usually are not detected at the site's boundary (LANL 2007).

In 2006, approximately 50 surface water samples were collected from water-course and hillside sites and analyzed for PCBs within Mortandad Canyon and its tributaries: Cañada del Buey, Ten Site Canyon, and Pratt Canyon. In only two samples were concentrations of PCBs detected; both were from middle Mortandad Canyon. These results indicate that PCB concentrations in the drainage are occasionally detected but are relatively small (LANL 2007).

8.1.3.2 Groundwater

8.1.3.2.1 Unsaturated Zone. Groundwater occurs in both the unsaturated (vadose) and saturated (phreatic) zones at LANL. Groundwater was encountered in characterization Well R-22 (located near MDA G on Mesita del Buey to the southeast of the North Site and Zone 6 in TA-54) at a depth of 270 m (890 ft). However, intermediate-depth perched groundwater also occurs within the vadose zone beneath wet canyons (e.g., within the more-porous breccia zones in basalt) and along the western portion of the site. The unsaturated zone varies in thickness from about 183 m (600 ft) to more than 366 m (1,200 ft), decreasing in thickness with increasing distance down the canyon to the southeast.

8.1.3.2.2 Aquifer Units. Saturated groundwater at LANL occurs in three hydrologic settings. It is perched at shallow depths in canyon bottom alluvium; it is perched at intermediate depths below canyon bottoms; and it is found at greater depths within units that make up the regional aquifer beneath the Pajarito Plateau. Figure 8.1.3-3 shows the hydrogeologic units at LANL and their relationship to the lithologic units of the Pajarito Plateau described in Section 8.1.2.1.3.

The following descriptions are taken from the SWEIS (DOE 2008c), Birdsell et al. (2005b), and LANL (2005, 2007) and include information specific to characterization Well R-22 and municipal water supply Wells PM-2 and PM-4. Well R-22, on the mesa above Pajarito Canyon, penetrates the Bandelier Tuff and Cerros del Rio lavas and is completed in the lower Puye Formation. Wells PM-2 and PM-4 are more than 451-m (1,500-ft) deep. Table 8.1.3-3 lists the hydrostratigraphic data for Well R-22.

Perched Alluvial Groundwater. Alluvial aquifers at the bottoms of canyons are made up of fluvial deposits interbedded with deposits of alluvial fans and colluvium from the adjacent mesas. The primary source of sediment is the Bandelier Tuff and other units, such as the Tschicoma Formation. The Bandelier Tuff produces sand-sized alluvium; colluvial deposits are more coarse-grained. The interbedded units range in thickness from a few meters (feet) to up to 30 m (100 ft) and serve as conduits for groundwater movement both laterally and with depth. The alluvial aquifers are perched on top of the less permeable Bandelier Tuff (Figure 8.1.3-4).

Many of the canyons are dry, with little surface water flow and little or no alluvial groundwater. In wet canyons, surface water flows along the canyon bottoms and infiltrates downward until it hits the less permeable tuff or other rocks, creating shallow zones of perched groundwater within the alluvium. Infiltration rates beneath the alluvial systems of wet canyons are estimated to be the highest across the plateau, approaching several meters per year. The water table slopes toward the east, as do the canyon floors. Because of water losses due to evapotranspiration and infiltration, alluvial groundwater is generally not sufficiently extensive for domestic use.

Intermediate-Depth Perched Groundwater. Intermediate-depth perched groundwater aquifers are associated with wet canyons. These systems occur within the unsaturated portion of the Bandelier Tuff and the underlying Puye Formation and Cerros del Rio basalt (Figure 8.1.3-4) and are recharged by the overlying perched alluvial groundwater. Depths vary among canyons, ranging from 36.6 m (120 ft) in Pueblo Canyon to 230 m (750 ft) in Mortandad Canyon. It has been estimated that the rate of movement of the intermediate perched groundwater is about 18 m/d (60 ft/d), or about 6 months from recharge to discharge (LANL 2003a).

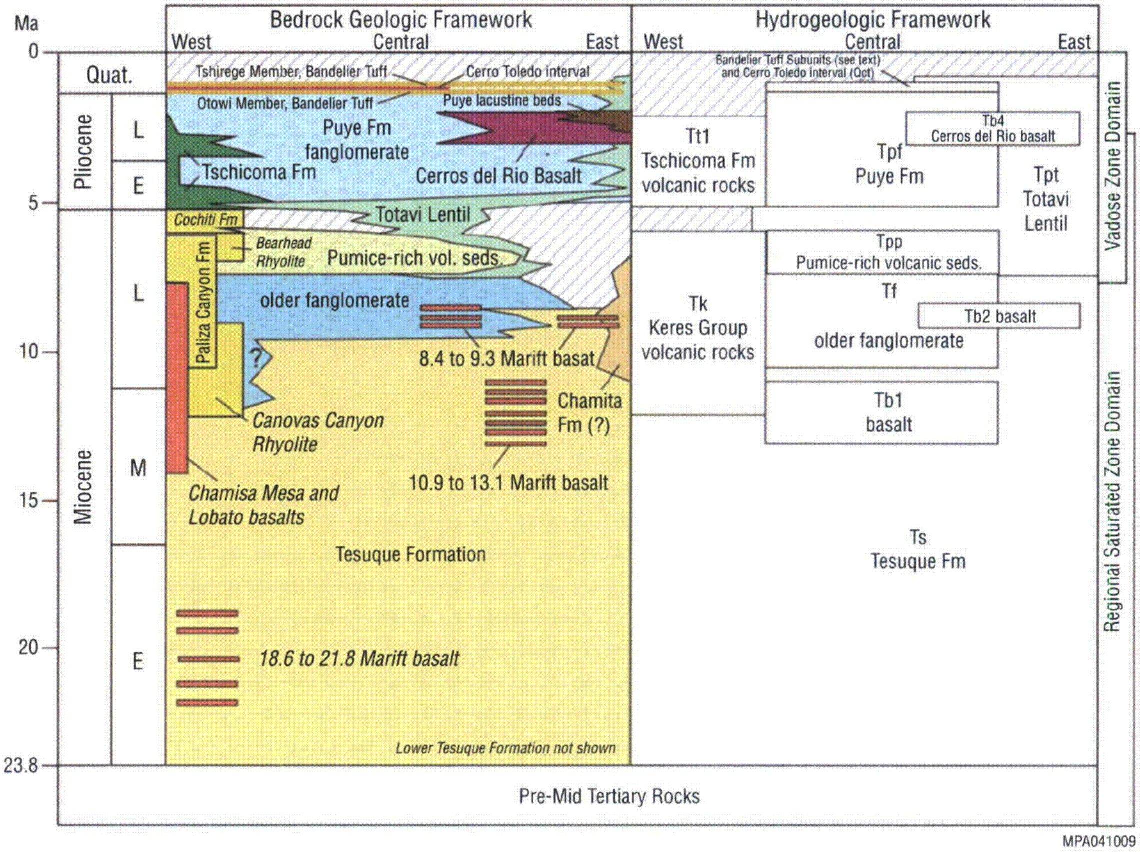

FIGURE 8.1.3-3 Hydrogeologic Units at LANL (Source: Birdsell et al. 2005b)

TABLE 8.1.3-3 Hydrostratigraphic Data from Well R-22 at LANL[a]

Hydrostratigraphic Unit	Top Depth	Base Depth	Top Elevation	Unit Thickness
Depth to groundwater/vadose zone	0	883	6,650.5	883
Tshirege ash flows	0	128	6,650.5	128
Otowi ash flows	128	179	6,522.5	51
Guaje pumice bed	179	190	6,471.5	11
Cerros del Rio lavas	190	1,173	6,460.5	983
Upper Puye Formation	1,173	1,338	5,477.5	165
Older basalt unit (Santa Fe Group)	1,338	1,406	5,312.5	68
Lower Puye Formation	1,406	1,489[b]	5,244.5	>83

[a] All thicknesses and depths are in feet; all elevations are in feet relative to MSL.

[b] Value represents the total depth of the borehole and not the depth or thickness of the unit.

Source: Ball et al. (2002)

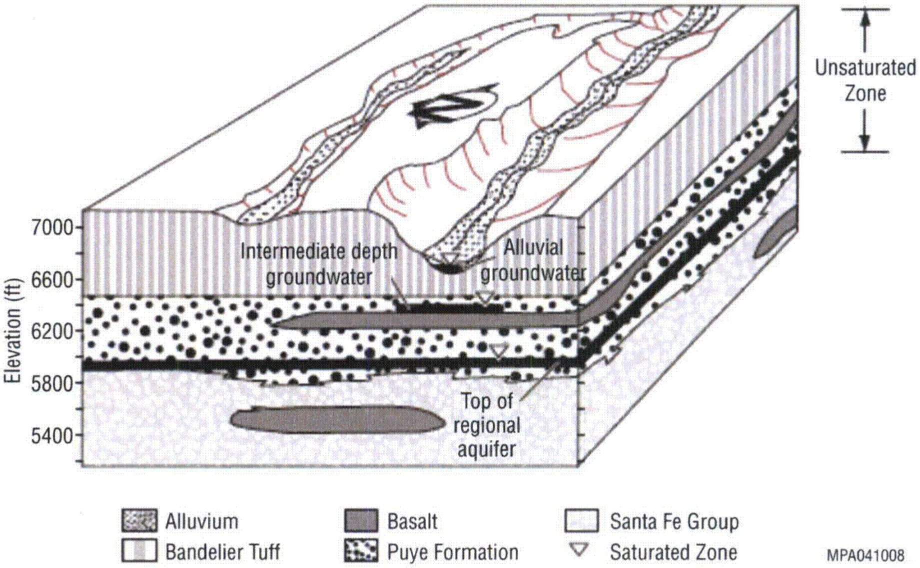

FIGURE 8.1.3-4 Three Modes of Groundwater Occurrence at LANL (Source: DOE 2008c)

Regional Aquifer. The regional aquifer (known as the Española Basin aquifer system) is the only aquifer in the LANL vicinity that can serve as a municipal water supply. It is a major source of drinking and agricultural water for northern New Mexico, and, in January 2008, it was designated by EPA Region 6 as a sole source aquifer (EPA 2008c). The regional aquifer extends throughout the Española Basin and consists of both sedimentary and volcanic units that have vastly different hydrologic properties. Sedimentary units include the Puye Formation, pumice-rich volcaniclastic rocks, Totavi Lentil, older fanglomerate rocks, Santa Fe Group sands, and sedimentary deposits between basalt flows. These units are highly heterogeneous and strongly anisotropic, with lateral conductivity (parallel to the sedimentary beds) as much as 100 to 1,000 times higher than vertical conductivity.

Correlation (and therefore lateral continuity) between individual beds in the Puye Formation is difficult to find because of the complex arrangement of channel and overbank deposits in the alluvial fans that make up this unit. Pumice-rich volcaniclastic rocks are expected to have high porosity, which may, in turn, translate into high permeability, depending on the degree of clay alteration. The Totavi Lentil is thought to be the most transmissive of the sedimentary units, since it consists of unconsolidated sands and gravels. It also contains fine-grained sediments.

Volcanic rocks on the plateau include the lavas of the Tschicoma Formation and various basalt units (Cerros del Rio, Bayo Canyon, and the Miocene basalts within the Santa Fe Group). These rocks consist of stacked lava flows separated by interflow zones of highly porous breccias, clinker, cinder deposits, and sedimentary deposits. Lava flow interiors are made up of dense impermeable rock with varying degrees of fracture. Beneath Mesita del Buey, the Cerros del Rio basalt is 300-m (1,000-ft) thick, indicating fill within a paleocanyon (Ball et al. 2002).

North-south trending fault zones on the Pajarito Plateau — including the Pajarito fault zone and the Guaje Mountain and Rendija Canyon faults — may facilitate or impede groundwater flow in the north-south direction, depending on whether they are open or clay-filled.

Elevations of the regional aquifer water table decrease to the east-southeast and range from 1,780 m (5,850 ft) MSL near North Site to about 1,750 m (5,750 ft) MSL at Area G on Mesita del Buey (Figure 8.1.3-5). Vadose zone thickness ranges from about 183 m (600 ft) to more than 366 m (1,200 ft), decreasing with increasing distance down canyon (to the east-southeast). Groundwater was encountered at a depth of 269 m (883 ft) in characterization Well R-22 when it was installed in 2000 (Ball et al. 2002). Intermediate-depth perched aquifers occur within the vadose zone beneath major (wet) canyons (e.g., within the more porous, breccia zones in basalt) and along the western portion of the LANL site. In the vicinity of TA-54, the thickness of the saturated zone (Cerro del Rio basalts saturated zone) is about 37 m (120 ft).

8.1.3.2.3 Groundwater Flow. Unsaturated flow is through the welded and nonwelded units of the Bandelier Tuff and the basalt flow interior and interflow units of the Cerros del Rio lavas. Flow within the densely welded tuffs (which occur on the western edge of the plateau) and the dense, basalt flow interiors of the Cerros del Rio basalt is predominantly through fractures. Downward movement is thought to be more rapid in the basalt than through moderately welded tuff (Birdsell et al. 2005b). Matrix flow likely occurs within the nonwelded and moderately welded tuffs (with porosities of 40% to 50%) and within the more porous brecciated interflow zones in the basalt (Birdsell et al. 2005a).

Groundwater takes decades to move from the surface to perched groundwater zones. Movement within perched zones is not well characterized, but it is, in general, controlled by factors such as the topography of the perching layer, bedding features, and the orientation of interconnected fractures (LANL 2005; Birdsell et al. 2005b).

Saturated flow in the upper 90 m (300 ft) of the regional aquifer beneath Mesita del Buey (at Well R-22) is within the fractures and interflow zones of the Cerros del Rio basalt. Flow direction in the perched alluvial and regional aquifer systems is to the east-southeast, toward the Rio Grande; the direction of groundwater flow in the intermediate perched zones is less certain. Flow within deeper parts of the regional aquifer (i.e., deeper than 150 m [500 ft]) is currently unknown, but it could be different than the flow occurring at shallower depths. Groundwater flow is anisotropic, with preferential flow parallel to bedding planes.

The Rio Grande River is the principal discharge point for the alluvial and regional aquifers. Discharge to the river may occur as lateral flow or upward flow or as flow from springs in White Rock Canyon (LANL 2005; Birdsell et al. 2005b).

8.1.3.2.4 Groundwater Quality. Natural groundwater chemistry at LANL varies with the acidity of the water and the chemistry of local rock. Natural constituents, including uranium, silicon, and sodium, are common in the volcanic rocks of the region. Since the 1940s, liquid

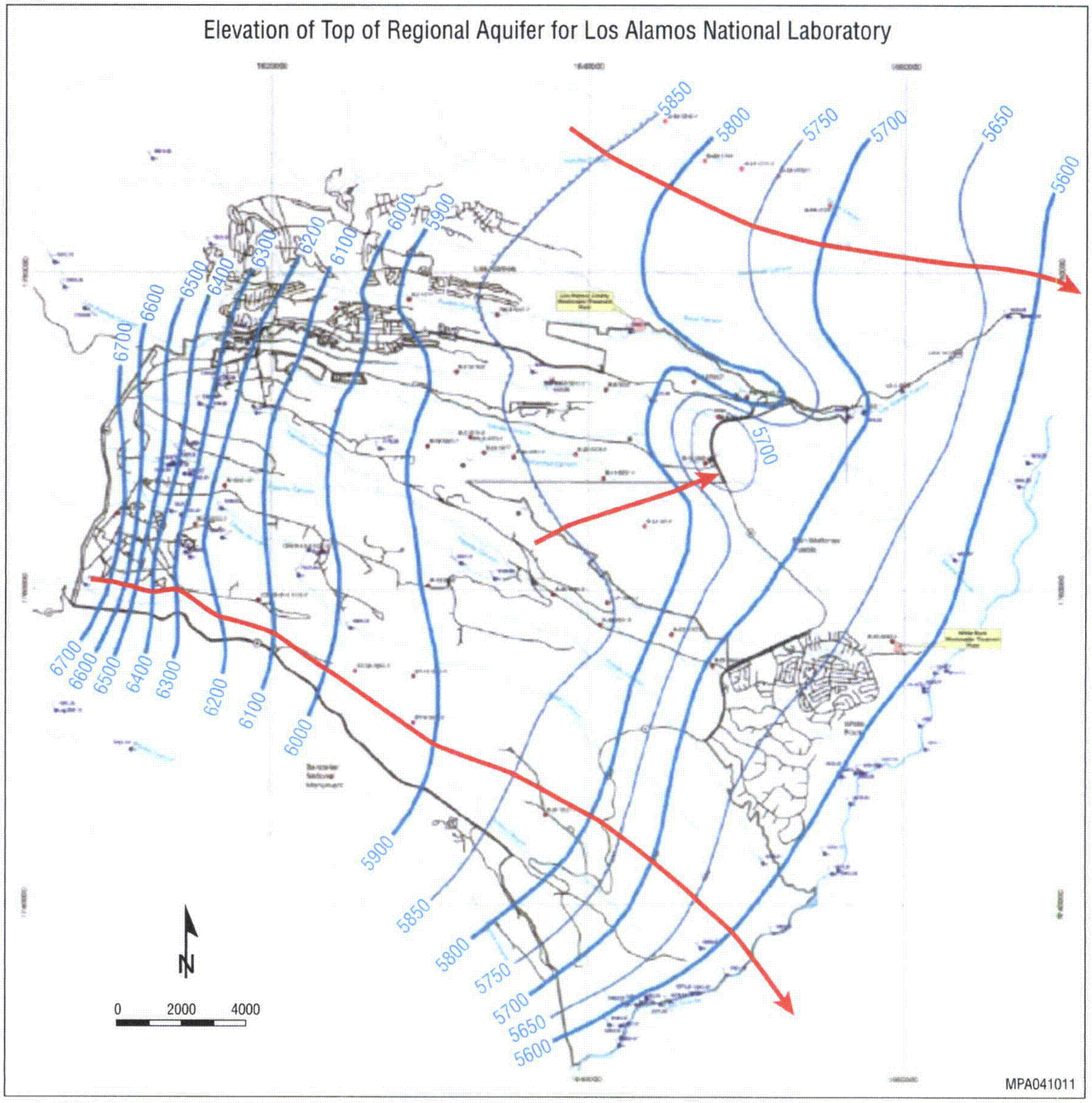

FIGURE 8.1.3-5 Water Table Elevation of LANL Regional Aquifer (Source: Birdsell et al. 2005b)

effluents from operations at LANL have degraded the water quality in the perched alluvial groundwater beneath the floor of several canyons. In some cases, impacts extend to the intermediate perched aquifers (particularly below wet canyons). Water quality impacts on the regional aquifer are minimal, since several hundred feet of dry rock separate the regional aquifer from the shallow perched groundwater. Although there is evidence that some contaminants (tritium, perchlorate, cyclonite or RDX, trinitrotoluene or TNT, perchloroethylene or PCE, and trichloroethylene) are reaching the regional aquifer, none of the drinking water wells in the regional aquifer have been contaminated to date. Table 8.1.3-4 lists the major contaminants found in groundwater sampled beneath Pajarito Canyon and Cañada del Buey in 2006. Details of

TABLE 8.1.3-4 Summary of Groundwater Contamination in Pajarito Canyon and Cañada del Buey at LANL in 2006

		Groundwater Contaminants[a]		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Pajarito Canyon	Major dry sources, past major but minor present liquid sources	Chloride above and nitrate at 50% of NMGWS	1,1-DCE and 1,1,1-TCA above NMGWS, RDX above EPA excess cancer risk level, TCE, 1,1-dichloroethane, 1,4-dioxane	Trace RDX
Cañada del Buey	Major dry, minor liquid sources	None, little alluvial groundwater	No intermediate groundwater	None

[a] DCE = dichloroethene, NMGWS = New Mexico groundwater standards, RDX = the explosive cyclonite, TCA = trichloroethane, TCE = trichloroethene.

Source: LANL (2007)

the monitoring program at LANL can be found in the Laboratory's annual surveillance reports (DOE 2008c; LANL 2007).

The lower Pajarito Canyon has a saturated alluvium that does not extend past LANL's east boundary. Past discharges to the canyon via its tributaries include small amounts of wastewater from TA-9. A nuclear materials experimental facility was located on the floor of the canyon at TA-18. Mesita del Buey, to the north of the canyon, is the site of several waste management areas, including MDA G, used for the disposal of LLRW. In 2006, several organic compounds (including chlorinated solvents) were detected in the intermediate-depth perched aquifer below the canyon. Traces of RDX were detected in the regional aquifer (LANL 2007).

Cañada del Buey has a shallow alluvial groundwater system of limited extent and is monitored by a network of five shallow wells and two moisture monitoring wells. Most of these wells are dry at any given time. Past discharges include accidental releases from experimental reactors and laboratories at TA-46. Treated effluent from LANL's sanitary wastewater system is also discharged to the canyon at times. As of 2006, no contamination had been detected in any of the aquifer systems below the canyon (LANL 2007).

8.1.3.2.5 Groundwater Use. All water used at LANL is derived from groundwater drawn from the regional aquifer (the Española Basin aquifer system) in three well fields: Otowi, Pajarito, and Guaje. The Guaje, Pajarito, and Otowi Well Fields are located in the mesas and canyons of the Pajarito Plateau. The 12 deep wells that supply water are all completed within the regional aquifer, located beneath the Pajarito Plateau. This sole source aquifer is the only local aquifer capable of supplying municipal and industrial water in the Los Alamos area. The piezometric surface of the regional aquifer ranges in depth from about 6 m (20 ft) above ground level (artesian water conditions) in portions of lower Los Alamos Canyon near the confluence with Guaje Canyon, to about 230 m (750 ft) bgs along the eastern edge of LANL property, to more than 375 m (1,230 ft) bgs near the center of the Pajarito Plateau (LANL 2003b). Water levels in the wells are declining by 30 to 60 cm/yr (1 to 2 ft/yr) (LANL 2003a).

Potable groundwater is pumped from the wells into the distribution system. Yields from individual production wells ranged from about 1,400 to 5,600 L/min (370 to 1,480 gpm) from 1998 through 2001 (LANL 2003a). Booster pumps lift the water to terminal storage for distribution to LANL and the community. The entire water supply is disinfected with mixed-oxidant solution before it is distributed to Los Alamos, White Rock, Bandelier National Monument, and LANL areas. Potable water storage tanks at Los Alamos have a combined terminal storage of 132 to 150 million L (35 to 40 million gal). Under drought-like conditions, daily water production alone may not be sufficient to meet water demands, and Los Alamos County relies on the terminal storage supply to make up the difference. The firm rated capacity[3] of the Los Alamos water production system is 7,797 gpm (42 million L/d or 11 million gal/d) (LANL 2003b).

Water use by LANL between 1998 and 2001 ranged from 1,430 million L (380 million gal) in 2000 to 1,745 million L (460 million gal) in 1998. LANL water use in 2001 was 1,490 million L (390 million gal), or 27% of the total water use at Los Alamos. Water use by Los Alamos County ranged from 3,300 million L (870 million gal) in 1999 to 4.2 billion L (1.1 billion gal) in 2000, and it averaged 3.8 billion L/yr (1.0 billion gal/yr) (LANL 2003b).

In September 1998, DOE leased the Los Alamos water supply system to Los Alamos County, and in September 2001, ownership of the water supply system was officially transferred to Los Alamos County. The water rights owned by DOE from all permitted sources (surface water and groundwater) in 1998 were about 5,500 ac-ft/yr or about 6.8 billion L/yr (1.8 billion gal/yr). In September 1998, these water rights were leased to Los Alamos County. DOE retained ownership of 30% of the water rights; this amount of water has been established as a maximum "target quantity" for water use by LANL. Transfer of ownership of the water supply system and water rights was completed in September 2001. LANL now purchases water from Los Alamos County. Water meters were installed at all delivery points to LANL, and water now provided to LANL is metered for documentation and billing (LANL 2003b).

Current water use in Los Alamos County falls into five categories: residential, commercial/institutional, industrial, public landscape irrigation, and other (e.g., firefighting, main flushing, swimming pools, construction projects, schools). In 2004, total water deliveries were estimated to be 3,920 million L (1,035 million gal). The greatest demand was for single-family use (62% or 2,400 million L [630 million gal]). The net per capita use was 572 L/d (151 gal/d). Water demand is expected to be about 8,285 million L (2,189 million gal) in 2020 (Daniel B. Stephens and Associates, Inc. 2006).

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[3] The firm rated capacity is the maximum amount of water that can be pumped immediately to meet peak demand.

Water demand by LANL as a percentage of the total diversions varied from 34% in 1999 to 21% in 2002. Demand at LANL increases about 35% in the summer months because of its increased use of water in its cooling towers. In 2004, its per capita demand was 191 L/d (50 gal/d) (Daniel B. Stephens and Associates, Inc. 2006).

American Indian Text

Pueblo people know that extensive work has been completed to map and determine flow rates, direction, and quality of groundwater systems. There are independent studies published which challenge these findings. These other studies maintain that monitoring at sites is inadequate and that the drilling practices influence the results.

Santa Clara Pueblo is concerned that their groundwater is being contaminated by LANL – especially from TA 54 waste deposits. Even though Santa Clara Pueblo is upstream when only surface water is considered, known faults between LANL and SCP are suspected to connect reservation groundwater and TA 54 wastes in LANL groundwater. Current investigations by Santa Clara Pueblo science teams and funded by the Pueblo are on-going to determine if Santa Clara Pueblo groundwater is connected through water bearing faults.

8.1.4 Human Health

Potential radiation exposures to the off-site general public residing in the vicinity of LANL would be only a very small fraction of the dose limit of 100 mrem/yr set by DOE to protect the public from the operations of its facilities (DOE Order 5400.5). The pathways of potential exposure include ingestion of contaminated soil, groundwater, and fish and respiration of air emissions. In 2008, the dose from each of these pathways was estimated to be less than 1 mrem/yr (LANL 2009), as shown in Table 8.1.4-1.

In 2008, the highest dose to a member of the general public was determined to be at the boundary of the Pueblo de San Ildefonso Sacred Area north of Area G, where TRU waste was stacked awaiting shipment to WIPP (LANL 2009). The dose at this location was estimated to be 0.9 mrem/yr over a time period of 550 hours in the year (or about 1/16 of the entire year) and was mainly from neutron radiation emitted by the waste (LANL 2009). The location of the individual receiving the highest dose from airborne emissions was determined to be the East Gate AIRNET station, and the dose at this location was reported to be 0.55 mrem/yr. Potential radiation exposure from airborne emissions is expected to remain low in the future. The collective dose for the 280,000 people living within 80 km (50 mi) around the LANL site was estimated to be 0.79 person-rem, which is less than 0.00046% of the collective dose that the same population would receive from natural background and man-made sources.

Among all the on-site workers who were monitored for radiation exposure, 1,985 had measurable doses in 2006. (The total number of employees at LANL exceeded 10,000.) The collective total dose was 164 person-rem (DOE 2008b), which gives an average individual dose of 83 mrem/yr to the radiation workers at the site. Among the workers who registered

TABLE 8.1.4-1 Estimated Annual Radiation Doses to Workers and the General Public at LANL

Receptor	Radiation Source	Exposure Pathway	Dose to Individual (mrem/yr)	Dose to Population (person-rem/yr)
On-site workers	Groundwater contamination	Water ingestion	2.6[a]	
	Radioactive materials handled in operations	Inhalation and ingestion	38[b]	1.376[b]
	Radioactive materials handled in operations	Direct radiation	81.9[c]	162.6[c]
General public	Airborne release	Submersion, inhalation, ingestion of plant foods (contaminated through deposition), direct radiation from deposition	0.55[d]	0.79[e]
	Groundwater contamination	Water ingestion	0.002[f]	
	Soil contamination	External radiation, dust inhalation, soil ingestion	< 0.1[g]	
	Surface water contamination	Fish ingestion	0.03[h]	
	On-site waste storage and shipment	Direct radiation	0.9[i]	
Worker/public	Natural background radiation and man-made sources		620[j]	174,000[k]

[a] Dose corresponds to drinking 1 L/d (0.3 gal/d) of alluvium spring water in middle Los Alamos Canyon for a year. However, the spring water is not a drinking water source (LANL 2009).

[b] In 2006, among the workers monitored for internal exposure, 36 had measurable doses. A collective dose of 1.376 person-rem was recorded, which would give an average internal dose of 38 mrem per worker (DOE 2008b).

[c] In 2006, 1,985 workers monitored for radiation exposures received measurable doses (DOE 2008b). The total collective dose for these workers was 164 person-rem (DOE 2008b). When the collective dose for internal exposure is subtracted from the total collective dose, and the remainder is distributed evenly among the workers, an average individual external dose of 81.9 mrem/yr is obtained.

[d] The radiation dose was conservatively estimated as the sum of the dose calculated with CAP88-PC for airborne emissions and the dose calculated for ambient air monitoring data for tritium, which is also included in the CAP88-PC modeling results. In 2008, the location of the highest-exposed individual was determined to be the East Gate AIRNET station (LANL 2009). The dose to an individual receiving the highest impacts estimated for 2008 was comparable to the dose reported for 2006 and 2007. The potential dose to this individual is expected to remain low.

Footnotes continue on next page.

TABLE 8.1.4-1 (Cont.)

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[e] The collective dose was estimated with CAP88-PC for the population residing within 80 km (50 mi) of LANL. The collective dose estimated for 2008 was somewhat larger than that estimated for 2006 and 2007. The population size is about 280,000 (LANL 2009).

[f] The dose corresponds to drinking 730 L/yr (190 gal/yr) of water from the Otowi-1 well located in Pueblo Canyon. However, this well was not used as a drinking water source by Los Alamos County in 2008.

[g] The dose was calculated on the basis of measured surface soil concentrations and was attributed to on-site operations. Except for those measured at a few locations, soil concentrations measured within or off the site were indicative of background sources or indistinguishable from background levels (LANL 2009).

[h] Dose from ingesting 25 g (0.055 lb) of bottom-feeding fish from the Rio Grande River downstream from the LANL site (LANL 2009).

[i] Dose corresponds to spending about 550 hours each year at the boundary of the Pueblo de San Ildefonso Sacred Area north of Area G, where TRU waste waiting for shipment to WIPP is stored (LANL 2009).

[j] Average dose to a member of the general public (NCRP 2009).

[k] Collective dose to the population of 280,000 within 80 km (50 mi) of the LANL site from natural background radiation and man-made sources.

measurable doses, most received only external radiation; only 36 workers had measurable internal doses. The collective internal dose was 1.376 person-rem; if distributed evenly among the 36 workers, the average individual dose was 38 mrem/yr (DOE 2008b). According to DOE records (DOE 2008b), no radiation worker received a dose greater than the DOE administrative control level of 2 rem/yr in 2006. Use of DOE's ALARA program ensures that worker doses are kept well below applicable standards.

Most of the radiation dose to LANL workers was from managing radioactive wastes at the site. In addition to radiation exposure from these activities, the potential exposure from the groundwater ingestion pathway was analyzed for on-site workers (LANL 2009). Groundwater monitoring data indicate that only the alluvium spring water in the middle Los Alamos Canyon had radionuclide concentrations above background levels. However, this spring water is not a drinking water source for on-site workers. If a worker drank 1 L (0.3 gal) per day of this contaminated spring water for a year, the potential radiation dose would be 2.6 mrem/yr, which is less than the EPA drinking water standard of 4 mrem/yr.

American Indian Text

Standard calculations of human heath exposure as used for the General Public are not applicable to Pueblo populations. The concept General Public is an EPA term that is a generalization that derives from studies of average adult males. Residency time for the General Public tends to be a short period of an individual's lifetime and exposure is voluntary. Pueblo people live here in their Sacred Home Lands for their entire lives and will continue to reside here forever.

Pueblo people use their resources differently than average US citizens so standard dosing rates do not apply. For ceremonial purposes, for example, water is consumed directly from surface water sources and natural springs. Potters, for example, have direct and intimate contact with stream and surface clay deposits. Natural pigment paints, for example, are placed on people's bodies and kept there through long periods of time during which strenuous physical activities opens the pores.

8.1.5 Ecology

LANL consists of five vegetation zones: (1) grassland, (2) ponderosa pine (*Pinus ponderosa*) forest, (3) pinyon-juniper (*P. edulis-Juniperus monosperma*) woodland, (4) juniper savannah, and (5) mixed conifer forest (Douglas fir [*Pseudotsuga menziesii*], ponderosa pine, and white fir [*Abies concolor*]) (DOE 2008c). The GTCC reference location at LANL would be located mostly within the pinyon-juniper woodland, although a portion might be located within the ponderosa pine forest zone. More than 900 species of plants occur on LANL. About 150 of them are nonnative plants (DOE 1999). Exotic plant species of concern on LANL include salt-cedar (*Tamarix ramosissima*), tree-of-heaven (*Ailanthus altissima*), cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola kali*) (DOE 1999). The vegetation that is planted as disposal pits are closed includes native grasses, such as blue grama grass (*Bouteloua gracilis*), buffalo grass (*Buchloe dactyloides*), western wheatgrass (*Pascopyrum smithii*), and dropseed (*Sporobolus* spp.), as well as alfalfa (*Medicago sativa*) (Shuman et al. 2002).

Most wetlands in the LANL area are associated with canyon stream channels or occur on mountains or mesas as isolated meadows containing ponds or marshes, often associated with springs or seeps (DOE 2008c). About 14 ha (34 ac) of wetlands have been identified within LANL, and about 6.1 ha (15 ac) of these occur within Pajarito Canyon (DOE 2008c). Lake-associated wetlands occur at Cochiti Lake and near LANL Fenton Hill site (TA-57), while spring-associated wetlands occur within White Rock Canyon (DOE 1999). No wetlands occur in the TA-54 area, although wetlands and floodplains exist in the lower portion of Pajarito Canyon.

American Indian Text

A Pueblo Writers' GTCC site visit and a draft LANL LLRW study for Area G documented the presence of the following plants:

Plants From LLRW Areas	Listed in Area G LLRW Study	Observed by Pueblo Writer's Group
Blue Grama (*Bouteloua gracilis*)	X	P
Indian Rice Grass (*Oryzopsis hymenoides*)		P
Cutleaf evening primrose (*Oenothera caespitosa*	X	
Mullein Amaranth (*Verbascum thapsus*)	X	P
Indian Paintbrush (*Castilleja sp.*)		P
4-O'clock (*Mirabilis jalapa*)		P
Narrowleaf Yucca (*Yucca angustissima*)	X	P
Penstemon spp.		P
Prickly Pear (*Opuntia polyacantha*)	X	P
Small Barrel (*Sclerocactus*)		P
Sunflower (*Helianthus petiolaris*)	X	P
Apache Plume (*Fallugia paradoxa*)	X	P
Big Sage (*Artemisia tridentate*)	X	P
Chamisa (*Chrysothamnus nauseosus*)	X	P
Four-wing Saltbush (*Atriplex canescens*)	X	P
Mountain Mahogany (*Cercocarpus montanus*)	X	
New Mexico Locust (*Robinia neomexicana*)	X	
Oak (*Quercus spp.*)	X	
Snakeweed (*Gutierresia sarthrae*)	X	
Squawberry (*Rhus trilobata*)	X	
Wax Currant (*Ribes cereum*)	X	
Wolfberry (*Lycium barbarum*)		P
One-seed Juniper(*Juniperus monosperma*)	X	P
Pinon Pine (*Pinus edulis*)	X	P
Ponderosa Pine (*Pinus ponderosa*)	X	P

While a full list of the traditional use animals was not available at the time of this analysis, a recent study conducted on the adjacent Bandelier National Monument identified 76 Pueblo use animals there. The use animals represent 76% of the animals on the official animal inventory.

American Indian Text

Pueblo People know that they have many traditional plants and animals located on and near to the GTCC proposal area. During a brief visit to the proposed GTCC site, Pueblo EIS writers identified traditional use plants, which include medicinal, ceremonial, and domestic use plants. These plants were identified in a brief period and it was noted that many plants could be identified were a full ethnobotany of the site to be conducted. During this site visit the Pueblo EIS writers identified the presence of traditional animals, but noted that more could easily be identified during a full ethnozoological study.

While a full list of the traditional use plants was not available at the time of this analysis, a recent study conducted on the adjacent Bandelier National Monument identified 205 Pueblo use plants there. These use plants represent 59% of the known plants on the official plant inventory of Bandelier.

American Indian Text

A Pueblo GTCC site visit and a LANL LLRW study for Area G documented the presence of the following animals: Deer; Elk; Lizards; Harvester Ants; Rattlesnake; Cicadas; Mocking Bird; Pocket Mice and Kangaroo Rats; Pocket Gophers; Chipmunks and Ground Squirrels.

Only about 5% of LANL is developed and unavailable for use by wildlife (e.g., due to security fencing) (DOE 2008c). Within LANL, 57 species of mammals, 200 species of birds, and 37 species of reptiles and amphibians have been reported (DOE 2008c). Mammals that occur in the area of the GTCC reference location (e.g., Pajarito Plateau) include a number of rodent species (e.g., North American deermouse, pinyon mouse [*Peromyscus truei*], western harvest mouse [*Reithrodontomys megalotis*], brush mouse [*P. boylii*], silky pocket mouse [*Perognathus flavus*], Colorado chipmunk [*Neotamias quadrivittatus*], and woodrats [*Neotoma* spp.]), mountain cottontail (*Sylvilagus nuttallii*), mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), American black bear (*Ursus americanus*), mountain lion (*Puma concolor*), bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), and coyote (*Canis latrans*). Common bird species include Cassin's kingbird (*Tyrannus vociferans*), cliff swallow (*Petrochelidon pyrrhonota*), ash-throated flycatcher (*Myiarchus cinerascens*), and brown-headed cowbird (*Molothrus ater)*. Common reptile species include fence lizard (*Sceloporus undulatus*), plateau striped whiptail (*Cnemidophorus velux*), gophersnake (*Pituophis catenifer*), and terrestrial garter snake (*Thamnophis elegans*) (DOE 1999; Shuman et al. 2002).

The streams on LANL drain into the Rio Grande River, the major aquatic habitat in the area of LANL. Many of the streams on LANL are intermittent and flow in response to precipitation or snowmelt. Of the 140 km (85 mi) of water courses on LANL, about 3.2 km (2 mi) are naturally occurring perennial streams and another 5 km (3 mi) are perennial waters supported by supplemental wastewater discharge flows (DOE 1999). No fish species have been reported within LANL boundaries (DOE 2008c).

The federally and state-listed species identified on or in the immediate vicinity of LANL are listed in Table 8.1.5-1. DOE and LANL coordinate with the USFWS and New Mexico Department of Game and Fish to locate and conserve these species (DOE 2008c). LANL has developed a *Threatened and Endangered Species Habitat Management Plan* (LANL 1998) whose goals are to (1) develop a comprehensive management plan that protects undeveloped portions of LANL that are suitable or potentially suitable habitat for threatened or endangered species, while allowing current operations to continue and future development to occur with a minimum of project or operational delays or additional costs related to protecting species or their habitats; (2) facilitate DOE compliance with the Endangered Species Act and related federal regulations by protecting and aiding in the recovery of threatened or endangered species; and (3) promote good environmental stewardship by monitoring and managing threatened and endangered species and their habitats using sound scientific principles. The plan identifies areas of environmental interest for federally listed species that have suitable habitat within LANL. In 1998, these species included the peregrine falcon (*Falco peregrinus*), Mexican spotted owl (*Strix occidentalis lucida*), Southwestern willow flycatcher (*Empidonax tcallii extimus*), and bald eagle (*Haliaeetus leucocephalus*). (The peregrine falcon and bald eagle have since been delisted.) These areas of environmental interest consist of core areas that contain important breeding or wintering habitat and buffer areas that protect the core area from disturbance (LANL 1998).

8.1.6 Socioeconomics

The socioeconomic data for LANL describe an ROI surrounding the site composed of three counties: Los Alamos County, Rio Arriba County, and Santa Fe County in New Mexico. More than 85% of LANL workers reside in these counties (DOE 2008c).

8.1.6.1 Employment

In 2005, total employment in the ROI stood at 63,985 and was expected to reach 67,348 by 2008. Employment grew at an annual average rate of 1.8% between 1995 and 2005 (U.S. Bureau of the Census 2008a). The economy of the ROI is dominated by the trade and service industries, with employment in these activities currently contributing nearly 80% of all employment (see Table 8.1.6-1). Construction is a smaller employer in the ROI, contributing 7% of total ROI employment. Employment at LANL in New Mexico was reported as being 12,584 in 2004 (DOE 2008c).

8.1.6.2 Unemployment

Unemployment rates have varied across the counties in the ROI (Table 8.1.6-2). Over the 10-year period 1999–2008, the average rate in Rio Arriba County was 5.9%, with lower rates in Santa Fe County (3.7%) and Los Alamos County (2.5%). The average rate in the ROI over this period was 4.0%, lower than the average rate for the state of 5.0%. Unemployment rates for the first two months of 2009 can be contrasted with rates for 2008 as a whole; in Rio Arriba County,

TABLE 8.1.5-1 Federally and State-Listed Threatened, Endangered, and Other Special-Status Species on or in the Immediate Vicinity of LANL

Common Name (Scientific Name)	Status[a] Federal/State
Plants	
Santa Fe stickyleaf *(Mentzelia springeri)*	-/SSC
Sapello Canyon larkspur *(Delphinium sapellonis)*	-/SSC
Wood lily (*Lilium philadelphicum* L. var. *anadinum*)	-/SE
Yellow lady's slipper orchid (*Cyprepedium calceolus* L. var. *pubescens*)	-/SE
Insects	
New Mexico silverspot butterfly (*Speyeria nokomis nitocris*)	SC/-
Fish	
Rio Grande chub (*Gila pandora*)	-/SS
Amphibians	
Jemez Mountain salamander (*Plethodon neomexicanus*)	SC/ST
Birds	
American peregrine falcon (*Falco peregrinus anatum*)	SC/ST
Arctic peregrine falcon (*Falco peregrinus tundrius*)	SC/ST
Bald eagle (*Haliaeetus leucocephalus*)	-/ST
Gray vireo (*Vireo vicinior*)	-/ST
Loggerhead shrike (*Lanius ludovicianus*)	-/SS
Mexican spotted owl (*Strix occidentalis lucida*)	T/SS
Northern goshawk (*Accipiter gentiles*)	SC/SS
Southwestern willow flycatcher (*Empidonax traillii extimus*)	E/SE
Yellow-billed cuckoo (*Coccyzus americanus*)	C/SS
Mammals	
Big free-tailed bat (*Nyctinomops macrotis*)	-/SS
Black-footed ferret (*Mustela nigripes*)	E/-
Fringed myotis (*Myotis thysanodes*)	-/SS
Goat Peak pika (*Ochotona princeps nigrescens*)	SC/SS
Long-eared myotis (*Myotis* evotis)	-/SS
Long-legged myotis (*Myotis volans*)	-/SS
New Mexico meadow jumping mouse (*Zapus hudsonius luteus*)	SC/ST
Ringtail (*Bassariscus astulus*)	-/SS
Spotted bat (*Euderma maculatum*)	-/ST
Townsend's big-eared bat (*Plecotus townsendii*)	SC/SS
Western small-footed myotis (*Myotis ciliolabrum*)	-/SS
Yuma myotis (*Myotis yumanensis*)	-/SS

Footnote on next page.

TABLE 8.1.5-1 (Cont.)

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[a] C (candidate): A species for which the USFWS or NOAA Fisheries has on file sufficient information on biological vulnerability and threats to support a proposal to list as endangered or threatened.

E (endangered): A species in danger of extinction throughout all or a significant portion of its range.

SC (species of concern): An informal term referring to a species that might be in need of conservation action. This may range from a need for periodic monitoring of populations and threats to the species and its habitat, to a need for listing as threatened or endangered. Such species receive no legal protection under the Endangered Species Act, and use of the term does not necessarily imply that a species will eventually be proposed for listing.

SE (state endangered): An animal species or subspecies whose prospects of survival or recruitment in New Mexico are in jeopardy; or a plant species that is listed as threatened or endangered under the Endangered Species Act, or is considered proposed under the Act, or is a rare plant across its range within New Mexico, and of such limited distribution and population size that unregulated taking could adversely impact it and jeopardize its survival in New Mexico.

SS (state sensitive): Species that, in the opinion of a qualified New Mexico Department of Game and Fish biologist, deserve special consideration in management and planning and are not listed as threatened or endangered by the state of New Mexico.

SSC (state species of concern): A New Mexico plant species that should be protected from land use impacts when possible because it is a unique and limited component of the regional flora.

ST (state threatened): A native species likely to be classified as state endangered within the foreseeable future throughout all or a significant portion of its New Mexico range.

T (threatened): A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

-: Not listed.

Source: DOE (2008c)

the unemployment rate increased to 6.2%, while in Santa Fe County the rate reached 4.8%. The average rates for both the ROI (5.1%) and the state (5.4%) during this period were higher than the corresponding average rates for 2008.

8.1.6.3 Personal Income

Personal income in the ROI stood at almost $7.5 billion in 2005 and was expected to reach $8.3 billion in 2008, growing at an annual average rate of growth of 3.7% over the period 1995–2005 (Table 8.1.6-3). ROI personal income per capita also rose over the same period and was expected to reach $39,642 in 2008, compared to $37,647 in 2005. Per capita incomes were much higher in Los Alamos County ($55,883 in 2005) than elsewhere in the ROI.

TABLE 8.1.6-1 LANL County and ROI Employment by Industry in 2005

	New Mexico				
Sector	Los Alamos County	Rio Arriba County	Santa Fe County	ROI Total	% of ROI Total
Agriculture[a]	191	1,078	437	1,706	2.7
Mining	0	96	60	156	0.2
Construction	0	571	3,955	4,526	7.1
Manufacturing	60	192	1,253	1,505	2.4
Transportation and public utilities	60	260	747	1,067	1.7
Trade	549	1,777	10,806	13,132	20.5
Finance, insurance, and real estate	380	285	3,199	3,864	6.1
Services	4,717	4,564	28,728	38,009	59.4
Other	0	10	10	20	0.0
Total	5,957	8,833	49,195	63,985	–

[a] USDA (2008).

Source: U.S. Bureau of the Census (2008a)

TABLE 8.1.6-2 LANL Average County, ROI, and State Unemployment Rates (%) in Selected Years

Location	1999–2008	2008	2009[a]
Los Alamos County	2.5	2.8	2.8
Rio Arriba County	5.9	5.0	6.2
Santa Fe County	3.7	3.4	4.8
ROI	4.0	3.7	5.1
New Mexico	5.0	4.2	5.4

[a] Rates for 2009 are the average for January and February.

Source: U.S. Department of Labor (2009a–d)

TABLE 8.1.6-3 LANL County, ROI, and State Personal Income in Selected Years

Income	1995	2005	Average Annual Growth Rate (%), 1995–2005	2008[a]
Los Alamos County				
Total personal income (2006 $ in millions)	844	1,054	2.3	1,114
Personal income per capita (2006 $)	45,005	55,883	2.2	58,186
Rio Arriba County				
Total personal income (2006 $ in millions)	643	973	4.2	1,089
Personal income per capita (2006 $)	16,835	23,951	3.6	26,025
Santa Fe County				
Total personal income (2006 $ in millions)	3,740	5,513	4.0	6,123
Personal income per capita (2006 $)	31,568	39,157	2.2	41,085
ROI total				
Total personal income (2006 $ in millions)	5,227	7,540	3.7	8,326
Personal income per capita (2006 $)	29,795	37,647	2.4	39,642
New Mexico				
Total personal income (2006 $ in millions)	41,935	55,447	2.8	59,603
Personal income per capita (2006 $)	24,375	28,789	1.7	29,554

[a] Argonne National Laboratory estimates.

Source: DOC (2008)

8.1.6.4 Population

The population of the ROI in 2006 stood at 202,378 (U.S. Bureau of the Census 2008b) and was expected to reach 210,037 by 2008 (Table 8.1.6-4). In 2006, 142,407 people were living in Santa Fe County (70% of the ROI total), and 40,949 people (20% of the total) resided in Rio Arriba County. Over the period 1990–2006, the population in the ROI as a whole grew slightly, with an average growth rate of 1.8%, with higher-than-average growth occurring in Santa Fe County (2.3%). The population in New Mexico as a whole grew at a rate of 1.6% over the same period.

8.1.6.5 Housing

Housing stock in the ROI as a whole grew at an annual rate of 2.2% over the period 1990–2000 (Table 8.1.6-5), with total housing units expected to reach 93,106 in 2008. A total of 20,268 new units were added to the existing housing stock in the ROI between 1990 and 2000. On the basis of annual population growth rates, there were expected to be 9,496 vacant housing units in the county in 2008, of which 2,396 were expected to be rental units available to construction workers at the proposed facility.

TABLE 8.1.6-4 LANL County, ROI, and State Population in Selected Years

Location	1990	2000	2006	Average Annual Growth Rate (%), 1990–2006	2008[a]
Los Alamos County	18,115	18,343	19,022	0.3	19,139
Rio Arriba County	34,365	41,191	40,949	1.1	41,856
Santa Fe County	98,928	129,287	142,407	2.3	149,042
ROI	151,408	188,821	202,378	1.8	210,037
New Mexico	1,521,574	1,818,046	1,954,599	1.6	2,016,755

[a] Argonne National Laboratory projections.

Sources: U.S. Bureau of the Census (2008b), estimated data for 2006

8.1.6.6 Fiscal Conditions

Construction and operations of a GTCC waste disposal facility could result in increased expenditures for local government jurisdictions, including counties, cities, and school districts. Revenues to support these expenditures would come primarily from state and local sales tax revenues associated with employee spending during construction and operations and would be used to support additional local community services currently provided by each jurisdiction. Table 8.1.6-6 presents information on expenditures by the various jurisdictions and school districts.

8.1.6.7 Public Services

Construction and operations of a GTCC waste disposal facility could require increases in employment in order to provide public safety, fire protection, and community and educational services in the counties, cities, and school districts likely to host relocating construction workers and operations employees. Additional demand could also be placed on local physician services. Table 8.1.6-7 presents data on employment and levels of service (number of employees per 1,000 population) for public safety and general local government services. Table 8.1.6-8 provides data on staffing and levels of service for school districts. Table 8.1.6-9 does the same for the medical field.

TABLE 8.1.6-5 LANL County, ROI, and State Housing Characteristics in Selected Years

Type of Housing	1990	2000	2008[a]
Los Alamos County			
Owner occupied	5,367	5,894	6,150
Rental	1,846	1,603	1,673
Vacant units	352	440	459
Total units	7,565	7,937	8,281
Rio Arriba County			
Owner occupied	9,218	12,281	12,479
Rental	2,243	2,763	2,808
Vacant units	2,896	2,972	3,020
Total units	14,357	18,016	18,307
Santa Fe County			
Owner occupied	25,621	35,985	41,483
Rental	12,219	16,497	19,018
Vacant units	3,624	5,219	6,016
Total units	41,464	57,701	66,518
ROI total			
Owner occupied	40,206	54,160	60,112
Rental	16,308	20,863	23,498
Vacant units	6,872	8,631	9,496
Total units	63,386	83,654	93,106
New Mexico			
Owner occupied	365,965	474,445	583,960
Rental	176,744	203,526	250,505
Vacant units	89,349	102,608	126,293
Total units	632,058	780,579	960,758

[a] Argonne National Laboratory projections.

Source: U.S. Bureau of the Census (2008b)

TABLE 8.1.6-6 LANL County, ROI, and State Public Service Expenditures in 2006 ($ in millions)

Location	Jurisdiction	School District
Los Alamos County	40.0	18.8
Rio Arriba County	12.1	29.3
Santa Fe County	91.5	60.9
ROI total	143.6	109.0
New Mexico	6,754	2,500

Source: U.S. Bureau of the Census (2008c)

8.1.7 Environmental Justice

Figures 8.1.7-1 and 8.1.7-2 and Table 8.1.7-1 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer around LANL from Census data for the year 2000 and from CEQ guidelines (CEQ 1997). Persons whose incomes fall below the federal poverty threshold are designated as low income. Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or multi-racial (with at least one race designated as a minority race under CEQ). Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number includes individuals who also identified themselves as being part of one or more of the population groups listed in the table. The most affected population in the 80-km (50-mi) assessment area could be the adjacent Pueblos.

8.1.8 Land Use

LANL covers 10,360 ha (25,600 ac) and is divided into 48 technical areas or TAs. Developed areas make up only a small portion of LANL as a result of the physical constraints of the geological setting, such as steep slopes and canyons. No agriculture occurs on LANL (DOE 2008c). The GTCC reference location would be situated within TA-54 (Figure 8.1-1).

The land use categories at LANL include service and support, experimental science, R&D on high explosives, testing of high explosives, R&D on nuclear materials, physical and technical support, public and corporate interface, reserve (areas not otherwise included within other categories and that may include environmental core and buffer areas, vacant land, and proposed land transfer areas), theoretical and computational science, and waste management (DOE 2008c). The land use categories within TA-54 are (1) reserve and (2) waste management (areas that provide for activities related to handling, treatment, and disposal of all generated solid, liquid, and hazardous waste products [chemical, radiological, and explosive]). During the late 1950s, LANL, with the approval of the AEC and upon recommendation of the USGS,

TABLE 8.1.6-7 LANL County, ROI, and State Public Service Employment in 2006

	Los Alamos County		Rio Arriba County		Santa Fe County		ROI		New Mexico	
Type of Service	No.	Level of Service[a]	No.	Level of Service[a]	No.	Level of Service[a]	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	63	3.3	23	0.6	80	0.6	166	0.3	3,882	2.0
Fire protection[b]	136	7.2	0	0.0	163	1.1	299	2.1	2,121	1.1
General	583	30.6	267	6.5	2,519	17.7	3,369	16.6	71,143	36.4

[a] Level of service represents the number of employees per 1,000 persons in each county.

[b] Does not include volunteers.

Source: U.S. Bureau of the Census (2008b,c)

TABLE 8.1.6-8 LANL County, ROI, and State Education Employment in 2006

Location	No. of Teachers	Level of Service[a]
Los Alamos County	255	13.4
Rio Arriba County	440	10.7
Santa Fe County	1,053	7.4
ROI	1,748	8.6
New Mexico	22,021	11.3

[a] Level of service represents the number of teachers per 1,000 persons in each county.

Sources: National Center for Educational Statistics (2008); U.S. Bureau of the Census (2008b,c)

TABLE 8.1.6-9 LANL County, ROI, and State Medical Employment in 2006

Location	No. of Physicians	Level of Service[a]
Los Alamos County	64	3.4
Rio Arriba County	46	1.1
Santa Fe County	605	4.2
ROI	715	3.5
New Mexico	4,421	2.3

[a] Level of service represents the number of physicians per 1,000 persons in each county.

Sources: AMA (2006); U.S. Bureau of the Census (2008b)

American Indian Text

As Indian peoples culturally affiliated with land currently occupied by LANL, the Pueblo people would like to expand the definition of Environmental Justice so that it reflects the unique burdens borne by them. This definition is defined more fully below.

Pueblo people and their lands have been encroached upon by Europeans since the 1500s. During this time they have experienced loss of control over many aspects of their lives including (1) loss of traditional lands, (2) damage to Sacred Home Lands, (3) negative health effects due to European diseases and shifting diet, and (4) lack of access to traditional places. Negative encroachments that occurred during the Spanish period were continued after 1849 under the United States of America's federal government. The removal of lands for the creation of LANL in 1942 were a major event causing great damage to Pueblo peoples. Resulting pollution to the natural environment and ground disturbances from LANL activities constitute a base-line of negative Environmental Justice impacts. The GTCC proposal needs to be assessed in terms how it would continue these Environmental Justice impacts and thus further increase the differential emotional, health, and cultural burdens borne by the Pueblo peoples.

The Congress of the United States recognized this violation of their human, cultural, and national rights when the American Indian Religious Freedom Act (AIRFA) was passed in 1978. In the AIRFA legislation Congress told all Federal agencies to submit plans which would assure they would no longer violate the religious freedom of American Indian peoples. Subsequent legislation like the Native American Graves Protection and Repatriation Act (NAGPRA) and Executive Order 13007 – Sacred Sites Access have further defined their rights to Sacred Home Lands and traditional resources. The Federal Government also has a Trust Responsibility to American Indian peoples which is recognized in the DOE American and Alaska Native policy (http://www.em.doe.gov/pages/emhome.aspx). Environmental Justice is one point of analysis where these concerns can be expressed by Pueblo peoples and the obligations addressed by Federal Agencies during the NEPA EIS process.

Pueblo people believe that their health has been adversely affected by LANL operations including different types of cancers. These concerns were publicly recorded in videos produced with Closing the Circle grants provided by the National Park Service and the DOE. Documentation of these adverse health affects is difficult because post-mortem analysis is not normal due to cultural rules regarding the treatment of the deceased and burial practices.

selected TA-54 for underground disposal of LANL-derived waste. Since that time, TA-54 has functioned as a major storage and disposal facility, with some treatment permitted for wastes generated by LANL operations (DOE 2008c).

LANL was designated as a National Environmental Research Park (NERP) in 1977. The 405-ha (1,000-ac) White Rock Canyon Reserve, located on the southeast perimeter of LANL, was dedicated in 1999. The reserve is jointly managed by DOE and the National Park Service (NPS) for its significant ecological and cultural resources and research potential (DOE 2008c).

Communities in the region are generally small, supporting residential, commercial, light industrial, and recreational land uses. American Indian tribal communities also occur in the area,

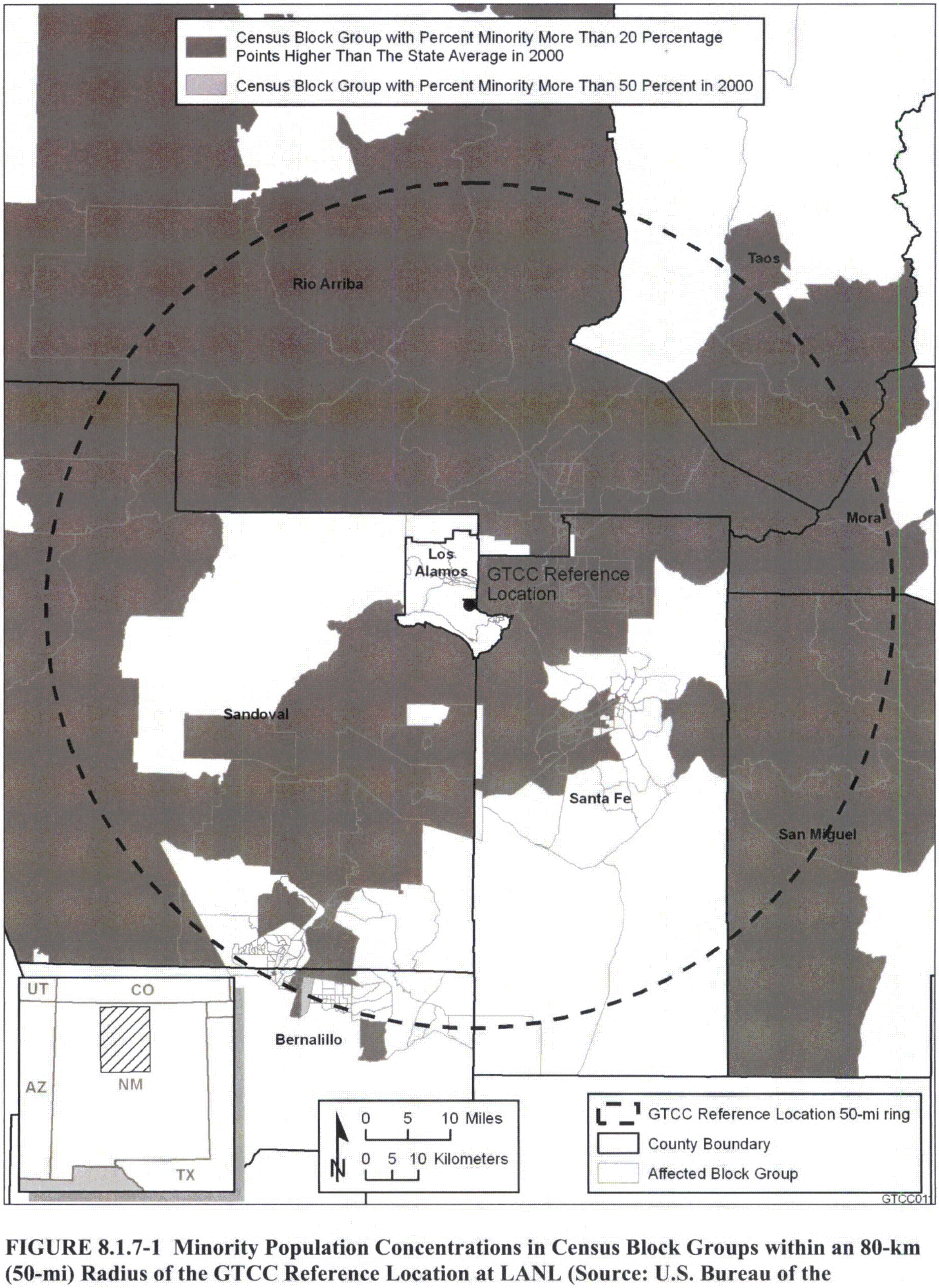

FIGURE 8.1.7-1 Minority Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at LANL (Source: U.S. Bureau of the Census 2008b)

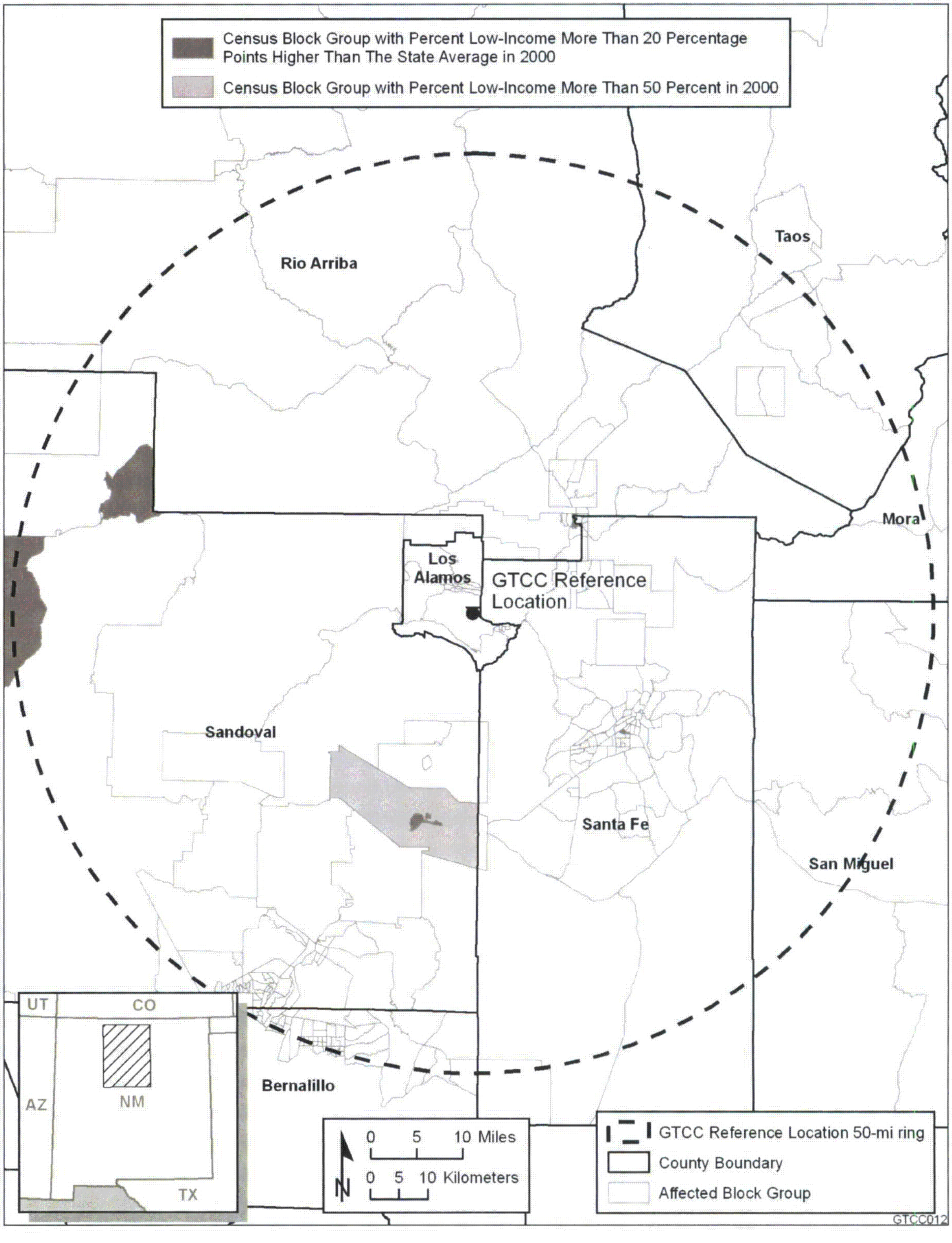

FIGURE 8.1.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at LANL (Source: U.S. Bureau of the Census 2008b)

TABLE 8.1.7-1 Minority and Low-Income Populations within an 80-km (50-mi) Radius of LANL

Population	New Mexico Block Groups
Total population	384,971
White, non-Hispanic	190,224
Hispanic or Latino	158,869
Non-Hispanic or Latino minorities	35,878
One race	30,293
Black or African American	3,627
American Indian or Alaskan Native	21,002
Asian	4,730
Native Hawaiian or other Pacific Islander	244
Some other race	690
Two or more races	5,585
Total minority	194,797
Percent minority in 80-km (50-mi) buffer	50.6
Percent minority in New Mexico	33.2
Low-income	42,616
Percent low-income in 80-km (50-mi) buffer	11.1
Percent low-income in New Mexico	18.4

Source: U.S. Bureau of the Census (2008c)

American Indian Text

There are two major power transmission lines, the Norton and Reeves Power lines, which exist on both mesas that are considered by the proposed GTCC. One line goes through GTCC Zone 6 and the other through GTCC North Side and North Side Expanded. These major district power lines occupy the centers of both mesas and greatly reduce the potential areas of the GTCC. Along both lines are a series of Pueblo archaeology sites, which are currently signed as restricted access areas protected under the National Historic Protection Act.

with the lands of the Pueblo of San Ildefonso sharing LANL's eastern border. The largest nearby city is Santa Fe, the state capital, which has a population of about 70,000 (2009).

Land stewards that determine the land uses within the LANL region include DOE, USFS, NPS, the county of Los Alamos, private land owners, the state of New Mexico, and BLM (DOE 2008c). The Santa Fe National Forest lands adjacent to LANL support multiple activities. Bandelier National Monument has only a small portion that is developed for visitors; about 70% of the main unit, which is located immediately south of LANL, has been designated as a Wilderness Area.

8.1.9 Transportation

SR 502 and SR 4 are the only two major roads that access Los Alamos County, and the traffic volume on these two segments of highway is primarily associated with LANL activities. SR 502 passes along the northern border of the site, connecting to US 84 north of Santa Fe. SR 4 borders the eastern edge of LANL, starting from SR 502 going southward, passing through the community of White Rock and then eventually looping through the southern portion of the site, separating it from Bandelier National Monument. SR 4 passes along the site's western border as it returns to the north, where it again connects with SR 502.

Hazardous and radioactive material shipments leave or enter LANL from East Jemez Road to SR 4 to SR 502. East Jemez Road, as designated by the State of New Mexico and governed by 49 CFR 177.825, is the primary route for the transportation of hazardous and radioactive materials. The average daily traffic flows at LANL's main access points are presented in Table 8.1.9-1.

The primary route designated by the State of New Mexico to be used for radioactive and other hazardous material shipments to and from LANL is the approximately 64-km (40-mi) corridor between LANL and I-25 at Santa Fe (DOE 2006). This route passes through the Pueblos of San Ildefonso, Pojoaque, Nambe, and Tesuque and is adjacent to the northern segment of Bandelier National Monument. This primary transportation route bypasses the city of Santa Fe on SR 599 to I-25.

Motor vehicles are the primary means of transportation to LANL. The nearest commercial rail connection is at Lamy, New Mexico, 83 km (52 mi) southeast of LANL. The New Mexico Rail Runner commuter rail service operates between Santa Fe and Albuquerque. It uses the ROW and new tracks where there was previously a spur into central Santa Fe (the spur is still used by the Santa Fe Southern Railway for some freight and a tourist railroad). LANL does not currently use rail transport for commercial shipments. However, a recently completed supplement analysis to the 2008 SWEIS evaluated rail for shipping wastes off-site to Clive, Utah (DOE 2009).

Most commuter traffic originates from within or east of Los Alamos County (Rio Grande Valley and Santa Fe) because a large number of LANL employees live in these areas (DOE 2006). A small number of LANL employees commute to LANL from the west along SR 4. The average weekday traffic volumes at various points in the vicinity of SR 502 and SR 4 measured in September 2004 are presented in Table 8.1.9-2.

Park-and-ride services are provided by a commercial corporation in conjunction with the New Mexico State Highway and Transportation Department. More than 80 daily departures between Santa Fe and Española, between Santa Fe and Los Alamos, between Española and Los Alamos, between Albuquerque and Santa Fe, and between Albuquerque and Los Alamos are provided for commuters (DOE 2006). Monthly passes are sold for use of most park-and-ride routes. Los Alamos County operates Atomic City Transit with five weekday no-fare routes. The transit center at LANL is located in TA-3.

American Indian Text

Pueblo people note that all waste shipments move by highway. There are no local railroads. Pueblo people believe that GTCC waste shipments will adversely impact natural resources, reservation communities, tribal administration activities, public schools, day schools, and businesses located along Highway 502 and Highway 84/285.

The Pueblo of Nambe is located on Highway 84/285 between the Pueblos of Pojoaque and Tesuque. The Pueblo of Nambe is located on the Rio Nambe, which joins the Rio Grande a few miles downstream. The Rio Nambe is the major water source for the Pueblo. Nambe Falls is on the reservation is an eco-tourism destination. Also on the reservation is Nambe Lake, which is used for irrigation of fields (crops) and recreation. Nambe has established several businesses on Highway 84/285, such as the Nambe Pueblo Development Corporation, Nambe Falls Travel Center, Hi-Tech, and many more businesses are planned for this location. New businesses include a water bottling factory, a housing complex, and solar and wind energy projects.

The Pueblo of Nambe raises the issue of security. The Pueblo government wants to know when radioactive waste is being transported past the reservation lands. We have a "need to know" and this information should be provided to appropriate tribal authorities such as First Responders and Emergency Managers. The tribes with Indian Land on transportation routes should be funded by the DOE to train their own radiation monitor teams, to maintain capability for their own safety and to protect sovereign immunity of Native American Tribes as independent Nations within the United States. This would enable tribes to be effective participants in handling hazards and threats as mandated by US. Department of Homeland Security in the "Metrics for Tribes" to be compliant with NIMS. Tribes should be able to participate in the preparations of waste materials for transportation at DOE sites. This participation/observation would give Tribes confidence that proper packing techniques and guidelines are adhered to. Currently Tribes are expected to "trust" that State and Federal authorities are doing this phase properly. The Indian people will feel more comfortable if we have some role in observing the process/procedures particularly if our observers are properly trained to understand the scientific reasons associated with packaging methodology.

The Pueblo of Nambe wants to monitor the transportation of GTCC materials in the same way that transuranic waste is monitored on its route from LANL to WIPP site at Carlsbad.

The Pueblo of Santa Clara is traversed by NM 30. Near this road are tribal residential areas, tribal businesses, schools, and economic developments. This highway is not an alternate route for radioactive waste hauling. A violation of this rule occurred in 2006 when three semi-trailer trucks loaded with radioactive soils from LANL were seen using NM30 as a short-cut route (they should have remained on NM 502) Drivers had disregarded tribal regulations. A tribal representative caught up with them nearby and recorded the violation.

Other Pueblo people have business and tribal resources along potential transportation routes. The Pueblo de San Ildefonso, for example, is concerned about radioactive waste transportation along Highway 502. The Totavi Business Plaza, is an area that was traditionally occupied, and is now a restaurant and gas station and may be a location for new tribal housing. The Pueblo de San Ildefonso youth attend a Day School, a District High School, Middle School, and Elementary Schools along 502. Pojoaque has a business park and two gas stations along 502 and 84/285 as well as their youth attend these schools.

TABLE 8.1.9-1 Main Access Points at LANL[a]

Location	Average No. of Daily Vehicle Trips
Diamond Drive across the Los Alamos Canyon Bridge	24,545
Pajarito Road at SR 4	4,984
East Jemez Road at SR 4	9,502
West Jemez Road at SR 4	2,010
DP Road at Trinity Drive	1,255
Total	42,296

[a] Source: DOE (2006)

TABLE 8.1.9-2 Average Weekday Traffic Volumes in the Vicinity of State Routes 502 and 4

Location	Average No. of Daily Vehicle Trips
Eastbound on SR 502, east of the intersection with SR 4	10,100
Westbound on SR 502, east of the intersection with SR 4	7,765
Eastbound on SR 502, west of the intersection of SR 502 and SR 4	6,540
Westbound on SR 502, west of the intersection of SR 502 and SR 4	4,045
Westbound on SR 4, between East Jemez Road and the SR 502/4 intersection	6,505
Eastbound on SR 4, between East Jemez Road and the SR 502/4 intersection	6,665
Transition road from northbound SR 4 to eastbound SR 502	5,170
Transition road from eastbound SR 502 to southbound SR 4	1,610

Source: DOE (2006)

8.1.10 Cultural Resources

LANL's foundation was associated with the development of the first atomic bomb during World War II. The Laboratory's mission continues to be national security. LANL also has a strong stewardship role over the facilities it has used for the last 60 years and is managing the contamination that resulted from years of experiments. Management of cultural resources at LANL is the ultimate responsibility of DOE's NNSA. Since 2006, operations at LANL have been managed for DOE by Los Alamos National Security LLC or LANS.

The management of cultural resources at LANL is guided by several documents and plans. The first is a programmatic agreement (PA) among DOE, the ACHP, New Mexico SHPO, and Los Alamos County. In addition, a mitigation action plan was developed as part of the

1999 SWEIS to aid in the future operation of LANL. This plan outlines the process and procedures for considering cultural resources during operations. LANL developed an integrated natural and cultural resources management plan in 2002. In 1992, LANL and DOE signed accords with four pueblos (Jemez, Cochiti, San Ildefonso, and Santa Clara) to facilitate communication on cultural issues.

Evidence of prehistoric people goes back to 9500 B.C. in north central New Mexico. Archaeological evidence at LANL shows extensive use of the region beginning in the Archaic period (roughly 5500 B.C.) through the Ancestral Pueblo Classic period (around A.D. 1600). There is no archaeological evidence for agriculturalists on the LANL Plateau during the Archaic period (5500 B.C. to A.D. 600). Between A.D. 900 and A.D. 1150, agriculturalists expanded up the Rio Grande Valley. Pithouses persisted in some places, but sites are typically small adobe and masonry structures that are found at a wide range of elevations. There are only about 10 sites that date to this time period at LANL. These sites consist of artifact scatters, one- to three-room structures (jacal and masonry), and small masonry roomblocks. The sites appear to represent an initial attempt by agriculturalists to colonize the Pajarito Plateau. However, it appears that this strategy was not a success until about A.D. 1150 (Ancestral Pueblo Coalition period) when higher-yielding varieties of 12- to 14-row maize were available for planting in these upland settings. The plateau was presumably being used by both foragers and farmers during this time period.

Between A.D. 1150 and A.D. 1325, there was a substantial increase in the number, size, and distribution of above-ground habitation sites, with year-round settlements expanding into upland areas on the Pajarito Plateau. Early sites contained adobe and masonry rectangular structures with 10 to 20 rooms. These small rubble mound sites are the most common sites at LANL. In contrast, later sites of this period consist of large masonry-enclosed plaza pueblos that contain more than 100 rooms.

Ancestral Pueblo settlements on the Pajarito Plateau between A.D. 1325 and A.D. 1600 (Classic period) are aggregated into three population clusters with outlying one- to two-room fieldhouses. The central site cluster consists of four temporally overlapping sites: Navawi, Otowi, Tsirege, and Tsankawi. Only Tsirege is located on LANL land. The initial occupation of these pueblos occurred during the 14th century. Tsirege, Tsankawi, and Otowi continued to be occupied during the 15th century. Only Tsirege and Tsankawi remained by the 16th century. Oral traditions at San Ildefonso indicate that Tsankawi was the last of the plateau pueblos to be abandoned. As the result of a series of droughts, the Pajarito Plateau was eventually abandoned during the 1580s. New pueblos were occupied in the Rio Grande Valley.

There is evidence for American Indian, Hispanic, and Euro-American use of the area during the Historic period from A.D. 1600 to A.D. 1943. A.D. 1600 corresponds with the first Spanish settlement in New Mexico and the initiation of economic and political influence over the previously established Rio Grande populations. The Pueblo Indians revolted against the Spanish in 1680. Some pueblos were abandoned when the Spanish returned. Some sites on the plateau were reoccupied at the end of this refugee period (e.g., Nake'muu at LANL).

Mexico declared its independence from Spain in 1821. Trade between Mexico and Santa Fe along the Santa Fe Trail began soon after, and this trade dominated events in New Mexico for the next quarter-century. This trade introduced some comparatively inexpensive Euro-American goods to New Mexico; it is reflected in the increase of manufactured items found on sites from this period. New Mexico remained a part of Mexico until war broke out with the United States; New Mexico became part of the United States on August 18, 1846.

During the early 1900s in New Mexico, there was a continuation of traditional farming strategies, cattle grazing, timbering, and a wide variety of cultural practices. However, large-scale sheep herding, timbering, and mining activities during this period displaced some Hispanic communities. Seasonal homesteading continued to be prevalent on the plateau. Wooden cabins, corral structures, and rock or concrete cisterns characterize Hispanic and Anglo Homestead era sites. Many of the wooden structures burned during the May 2000 Cerro Grande fire. Artifact scatters, consisting of historic debris associated with household and farming/grazing activities, are also commonly found at this time period. The period 1890 to 1942 is typically referred to as the Homestead period at LANL. Most of the central Pajarito Plateau homestead patents were filed by Hispanic people who maintained permanent homes in the Rio Grande Valley, using the Pajarito Plateau sites for seasonal farming and resource gathering. Notable exceptions to this pattern included the establishment of a few permanent Anglo commercial concerns, such as the Anchor Ranch and Los Alamos Ranch School, the latter of which operated from 1918 until the late spring of 1943. The end of the Homestead period coincides with the appropriation of lands on the Pajarito Plateau for the Manhattan Project in 1943.

Manhattan Project personnel chose the LANL location in 1943 as the primary facility for research on developing an atomic bomb because it was remote and access could be controlled. The project proved a success when the first atomic bomb was detonated at the Trinity Site in July 1945. With the conclusion of World War II, research continued at LANL; it focused on new weapons. The first hydrogen bomb was successfully tested in 1951. By the late 1950s, research focused on reducing the size of bombs for use with intercontinental missiles. Weapons testing continued until the early 1990s, when the Test Ban Treaty was enacted. Environmental concerns began to be a major issue in the 1970s. Currently LANL focuses on its military and security missions as well as environmental stewardship.

Roughly 90% of the land at LANL has been surveyed for cultural resources. Cultural resource surveys at LANL have identified 1,915 archaeological sites. Of the 1,915 sites, 1,776 date to the prehistoric period. A total of 139 American Indian, Hispanic, and Euro-American historic sites represent populations that lived and/or worked in the region from the 1600s to the 1990s. The majority of these sites are structures or artifact scatters that date between 1600 and 1890. Researchers recommend that 400 of the sites identified be listed on the NRHP. The majority of the remaining sites have yet to be evaluated for their significance (DOE 2006). Archaeological remains include multiroom pueblos, field houses, talus houses, cavates, rock shelters, shrines, animal traps, hunting blinds, water control features, agricultural fields and terraces, quarries, rock art, trails, and limited-activity sites.

Historic buildings at LANL relate to both Manhattan Project and Cold War era research. A total of 510 buildings that date to this period remain. Of these, a total of 98 are considered eligible for listing on the NRHP, and 81 were determined ineligible. A small number of buildings at LANL that are less than 50 years old are considered eligible because of their exceptional importance to American history.

Several pueblos have expressed an interest in traditional cultural properties found on LANL. The Jemez, Cochiti, San Ildefonso, and Santa Clara Pueblos signed accords with DOE to facilitate communication about cultural resources on LANL. Traditional cultural properties identified on LANL include 15 ceremonial archaeological sites, 14 natural features, 10 ethnobotanical sites, 7 artisan material sites, and 8 subsistence features.

Numerous cultural resources have been identified in TA-54, which includes both Zone 6 and the North Site (including North Site Expanded). Cultural resource surveys have been conducted for the proposed GTCC reference location. Eighteen archaeological sites are situated within the assessment area boundaries, including six in Zone 6, five in the North Site, and seven in the North Site Expanded area. These sites include large diffuse chipped and ground stone artifact scatters that, based on diagnostic projectile points, date back to the Archaic period. Ancestral Pueblo sites dating from A.D. 1150 to A.D. 1600 include numerous structural foundations and partial structures representing one- to three-room fieldhouses to multiroom (ranging from 4 to 50 rooms) pueblos; possible kivas (circular subterranean ceremonial structures); and lithic (stone tool) scatters containing thousands of artifacts (2,500 or more). Remains of the Pajarito Plateau Wagon Road from the Homestead era (1890–1942) were also found.

Section 106 of NHPA requires federal agencies to take into account the effect of any federal or federally funded undertaking on any district, site, building, structure, or object that is included in or is eligible for inclusion in the NRHP. Under NHPA, the SHPO is required to identify and inventory historic properties within the state and nominate eligible properties to the NRHP, and it is tasked to ensure that NRHP-eligible properties are taken into account during an undertaking's planning and development. Of the 18 archaeological sites located in the proposed GTCC reference location, four have SHPO concurrence with regard to their eligibility, and LANL has assessed all of the other sites as being NRHP eligible or having undetermined NRHP eligibility. A site with an undetermined eligibility is treated as eligible until a formal determination can be made. The site eligibility and potential effect determinations will involve any American Indian groups determined to be culturally affiliated with respect to the area proposed for development. Affiliated tribes will have to be consulted to determine if traditional cultural properties are present within the GTCC reference location.

American Indian Text

Pueblo oral histories document that they have lived in and used the entire area of LANL including the GTCC proposed site since the beginning of time. Because of this Pueblo people are the descendants of the people who have lived here throughout time and included time periods referred by LANL archaeologists by the terms (1) Paleo-Indian, (2) Archaic, (3) Ancestral Pueblo, (4) American Indian, and (5) Federal Scientific Laboratory. Pueblo people lived in the area before the Ancestral Pueblo period, which is dated at 1600AD. Pueblo people continue to know about and value lands, natural resources, and archaeological materials located on LANL.

Continued on next page

Continued

Pueblo people continue to desire and have a culturally important role and responsibilities in the management of all of these traditional lands.

Recent cultural resource surveys have been conducted on LANL, which have identified some sites that were not identified when LANL was established after 1943. Pueblo people believe that these sites are connected with other much larger sites that were destroyed when the LANL facility was built and operated. The Pueblo people express concern that many early LANL developments destroyed culturally significant sites and that no effort has been made to conduct ceremonies that may alleviate the violations association with site destruction.

A known Sacred Area, primarily identified with Pueblo de San Ildefonso, is located on the next mesa to the north of the proposed GTCC waste site. It is spiritually connected to the surrounding area and is not bounded any federal boundaries. It is recognized as a Sacred Area on old USGS quads. The Sacred Area is continually monitored by Pueblo de San Ildefonso to constantly check on its cultural integrity. It has visual, auditory, and spiritual dimensions. Pueblo de San Ildefonso air quality program consistently monitors for tritium releases, which derive from nearby area G on TA 54 on LANL. Winds blow across this area from the Southwest from LANL on to the Sacred Area. The Cerro Grande fire brought ash debris which contained radionuclides to the Sacred Area. The Sacred Area is thus believed to have been contaminated by the ash from Cerro Grande fire. Dust contaminated from ongoing operations from area G has blown into the Sacred Area.

Although four American Indian pueblos, called by LANL the Accord Tribes: Santa Clara Pueblo, Pueblo de San Ildefonso, Jemez Pueblo, and Pueblo de Cochiti have been singled out during the GTCC consultation process as being both nearby and culturally connected with LANL, there is a widely recognized understanding that other American Indian tribes are also culturally connected with LANL. These include but are not limited to (1) all 8 northern pueblos including San Juan O'Hkayowingee, Nambe O-weenge, Pojoaque, Picuris; (2) Jicarilla Apache; (3) southern Pueblos like Santo Domingo; and (4) western pueblos like Zuni and Hopi. Important LANL actions like the GTCC EIS undergoing a major analysis should include all the culturally connected (affiliated) American Indian tribes.

The LANL NAGPRA consultation report includes the following statement "It is noted that since around 1994, LANL has consistently consulted with five tribes on issues relating to cultural resources management, or at least have informed them of proposed construction projects and other issues surrounding cultural resources management at LANL." These include the "Accord Pueblos" of San Ildefonso, Santa Clara, Cochiti, and Jemez, each of which has signed agreements with LANL, along with the Mescalero Apache Tribe. In addition, the Pueblo of Acoma and the Jicarilla Apache Nation have been recognized as having an active interest in cultural resources management at LANL. A draft version of that NAGPRA report was subsequently also sent in January 2002 to all New Mexico Pueblos and to the Pueblos of Hopi in Arizona and Ysleta del Sur in Texas, as well as to the Jicarilla Apache Nation, the Mescalero Apache Tribe, the Navajo Nation, and the Ute Mountain and Southern Ute Tribes. The pueblo writers find the patterns of consultation by LANL to be confusing and not clearly grounded in a formal policy based on an agreed to Cultural Affiliation study.

Meaning of Artifacts, Places, and Resources – There is a general pueblo concern for pre-agricultural period Indian artifacts and the places where they were left. These include the role of ceremony itself as an act of sanctifying places, such as has been conducted and occurred near Sacred Area over the past thousands of years. Pueblo people believe they have been in the area since the beginning of time. This connection back in time thus connects them to all places, artifacts, and resources in the area.

American Indian Text

The Pueblo people would like to point out a direct conflict in current LANL policy and the GTCC proposal. Today LANL is officially remediating contaminated areas. These actions result in the waste being moved to new sites such as WIPP. Some of this may be transported past Pueblo communities and economic business along transportation routes. LANL has already agreed to remove radioactive waste from Area G to WIPP. Currently LANL is shipping most kinds of radioactive and TRU waste off-site. This current LANL policy is in conflict with the GTCC proposal, which would place radioactive waste and TRU waste on LANL and near Area G. In addition, the Pueblos along the transportation routes will now be exposed twice – once to current LANL waste leaving for elsewhere like the WIPP site, and secondly to new GTCC waste shipments that are arriving from elsewhere.

The Pueblo people note that one of the potential GTCC sites, indicated as Zone 4, that is being considered in the EIS appears to have been withdrawn (June 2009) from consideration for GTCC waste because LANL is continuing to dispose of LLRW waste there. This is LLRW that has been or will be produced by LANL. These additional LANL wastes add to perceived contamination risks by the Pueblo people.

The Pueblo people note that the potential site for the GTCC waste disposal is already leaking radioactive contaminants around the perimeter of Area G and DARHT. GTCC waste could only increase the contamination of this area and add to the off-site flow of contaminants.

There is a known Sacred Area on the next ridge next to the existing LANL Area G radioactive waste isolation facility and also across from the proposed GTCC site. This Sacred Area is spiritually connected to the surrounding area and is not bounded any federal boundaries (it is even recognized as a sacred area on old USGS quads). Area is constantly monitored by Pueblo de San Ildefonso to check on its integrity. The Sacred Area has visual, auditory dimension, which are consistently monitoring for tritium from nearby areas. Winds blow across this area. The Cerro Grande fire brought ash debris, which contained radionuclides to the Sacred Area, thus the area is believed to have been contaminated by the ash from Cerro Grande fire. Radioactive Dust has blown away from Area G and has been recorded near Sacred Area. The Pueblo de San Ildefonso and other pueblo people believe that locating a GTCC facility in this area will further diminish the spiritual integrity of the Sacred Area.

Radioactivity studies using the TIMS (Thermo Ionization Mass Spectrometry) method have been fingerprinted and thus identified the source (1996) of radioactivity found in the sediments of Cochiti Reservoir as coming from LANL. This is a major concern for the Cochiti people. Storm and snow run off bring LANL radioactivity downstream to places where clay is deposited. There has even been a 100-year runoff event since the Cerro Grande fire. Automated recorders have documented radioactivity being recently brought down as far as the Pueblo de San Ildefonso. Jemez Pueblo potters also express concerns they these radioactive movement will impact them when they dig through these deposits while collecting clay for pottery and minerals for other uses.

8.1.11 Waste Management

Site management of the waste types generated by the land disposal methods for Alternatives 3 to 5 is discussed in Section 5.3.11.

8.2 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

The following sections address the potential environmental and human health consequences for each resource area in Section 8.1.

8.2.1 Climate and Air Quality

This section presents potential climate and air quality impacts from the construction and operations of each of the disposal facilities (borehole, trench, and vault) at LANL. Noise impacts are discussed in Section 5.3.1.

8.2.1.1 Construction

During the construction period, emissions of criteria pollutants (e.g., SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$), VOCs, and the primary greenhouse gas CO_2 would be caused by fugitive dust emissions from earth-moving activities and engine exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Typically, the potential impacts from exhaust emissions on ambient air quality would be smaller than those from fugitive dust emissions.

Air emissions of criteria pollutants, VOCs, and CO_2 from construction activities are estimated for the peak year when site preparation and the construction of support facility and some disposal cells would take place. The estimates for PM_{10} and $PM_{2.5}$ include the diesel particulate emissions from engine exhaust. These estimates are provided in Table 8.2.1-1 for each disposal method. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in the table, total peak-year emission rates are estimated to be rather small when compared with emission totals for the two counties encompassing LANL (Los Alamos and Santa Fe Counties). Peak-year emissions for all criteria pollutants (except PM_{10} and $PM_{2.5}$) and VOCs would be the highest for the vault method because it would consume more materials and resources for construction than would the other two methods. Construction for the borehole method would disturb a larger area, so it is estimated that fugitive dust emissions would be the highest. Peak-year emissions of all pollutants would be the lowest for the trench method, which would also involve the smallest disturbed area among the disposal methods. In terms of contribution to the emissions total, peak-year emissions of SO_2 for the vault method would be the highest, about 0.75% of the two-county emissions total, while it is estimated that emissions of other criteria pollutants and VOCs would each be 0.43% or less of the two-county emissions total.

TABLE 8.2.1-1 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction of the Three Land Disposal Facilities at LANL

Pollutant	Total Emissions (tons/yr)[a]	Construction Emissions (tons/yr)					
		Trench (%)		Borehole (%)		Vault (%)	
SO_2	429	0.90	(0.21)[b]	3.0	(0.70)	3.2	(0.75)
NO_x	7,210	8.1	(0.11)	26	(0.36)	31	(0.43)
CO	65,596	3.3	(0.01)	11	(0.02)	11	(0.03)
VOCs	8,423	0.90	(0.01)	2.7	(0.03)	3.6	(0.05)
PM_{10}[c]	55,674	5.0	(0.01)	13	(0.02)	8.6	(0.02)
$PM_{2.5}$[c]	6,303	1.5	(0.02)	4.1	(0.07)	3.6	(0.06)
CO_2		670		2,200		2,300	
County[d]	5.28×10^6		(0.01)		(0.04)		(0.04)
New Mexico[e]	6.50×10^7		(0.001)		(0.003)		(0.004)
U.S.[e]	6.54×10^9		(0.00001)		(0.00003)		(0.00004)
World[e]	3.10×10^{10}		(0.000002)		(0.000007)		(0.000007)

[a] Total emissions in 2002 for the two counties encompassing LANL (Los Alamos and Santa Fe Counties).

[b] Numbers in parentheses are percent of total emissions.

[c] Estimates for GTCC construction include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

[e] Annual CO_2 emissions in New Mexico, the United States, and worldwide in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

Background concentration levels for PM_{10} and $PM_{2.5}$ at LANL are below the standards (less than 80%) (see Table 8.1.1-3). Construction at LANL could occur within about 200 m (660 ft) of the site boundary. Under unfavorable dispersion conditions, it is expected that high concentrations of PM_{10} or $PM_{2.5}$ could occur and could exceed the standards at the site boundary, although such exceedances would be rare. Construction activities would not contribute much to concentrations at the nearest residence in White Rock, about 3.5 km (2.2 mi) from the GTCC reference location. Construction activities would be conducted so as to minimize potential impacts of construction-related emissions on ambient air quality. In so doing, where appropriate, fugitive dust would be controlled by following established standard dust control practices (primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles), as stipulated in the construction permits.

Levels of O_3 in Santa Fe, about 29 km (18 mi) southwest of the GTCC reference location, are below the standard (about 84%) (see Table 8.1.1-3). Los Alamos and Santa Fe Counties are currently in attainment for O_3 (40 CFR 81.332). O_3 precursor emissions from the possible GTCC waste disposal facility for all methods would be relatively small, less than 0.43%

and 0.05% of two-county total NO_x and VOC emissions, respectively, and would be much lower than those for the regional air shed in which emitted precursors are transported and formed into O_3. Accordingly, potential impacts of O_3 precursor releases from construction on regional O_3 would not be of concern.

The major air quality concern with respect to emissions of CO_2 is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. The combustion of fossil fuels makes CO_2 the most widely emitted greenhouse gas worldwide. CO_2 concentrations in the atmosphere increased continuously from about 280 ppm in preindustrial times to 379 ppm in 2005 (a 35% increase), and most of this increase occurred in the last 100 years (IPCC 2007).

The climatic impact of CO_2 does not depend on the geographic location of the sources because CO_2 is stable in the atmosphere and is essentially uniformly mixed; that is, it is the global total that is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the construction of a disposal facility is useful in understanding whether CO_2 emissions from the site are significant with respect to global warming. As shown in Table 8.2.1-1, the highest peak-year amounts of CO_2 emissions from construction would be 0.04%, 0.004%, and 0.00004% of 2005 county, state, and U.S. CO_2 emissions, respectively. In 2005, CO_2 emissions in the United States were about 21% of worldwide emissions (EIA 2008). Emissions from construction would be less than 0.00001% of global emissions. Potential impacts on climate change from construction emissions would be small.

Appendix D assumes an initial construction period of 3.4 years. The disposal units would be constructed as the waste became available for disposal. The construction phase would be extended over more years, and thus emissions for nonpeak years would be lower than peak-year emissions, as shown in the table. In addition, construction activities would likely occur only during daytime hours, when air dispersion is most favorable. Accordingly, potential impacts from construction activities on ambient air quality would be minor and intermittent in nature.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and is not applicable to the proposed action at the LANL site because the area is classified as being in attainment for all criteria pollutants (40 CFR 81.332).

8.2.1.2 Operations

Criteria pollutants, VOCs, and CO_2 would be released into the atmosphere during operations. These emissions would include fugitive dust emissions from emplacement activities and exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Annual emissions of criteria pollutants, VOCs, and CO_2 at the facility are estimated in Table 8.2.1-2. Detailed information on emission factors, assumptions, and emission inventories is provided in Appendix D. As shown in the table, for the borehole and vault methods, annual emissions from operations are estimated to be lower than those from construction. Annual

TABLE 8.2.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations of the Three Land Disposal Facilities at LANL

Pollutant	Total Emissions (tons/yr)[a]	Operation Emissions (tons/yr)		
		Trench (%)	Borehole (%)	Vault (%)
SO_2	429	3.3 (0.7)[b]	1.2 (0.28)	33 (0.77)
NO_x	7,210	27 (0.37)	10 (0.14)	27 (0.37)
CO	65,596	15 (0.02)	6.7 (0.01)	15 (0.02)
VOCs	8,423	3.1 (0.04)	1.2 (0.01)	3.1 (0.04)
PM_{10}[c]	55, 674	2.5 (<0.01)	0.91 (<0.01)	2.5 (<0.01)
$PM_{2.5}$[c]	6,303	2.2 (0.03)	0.81 (0.01)	2.2 (0.03)
CO_2		3,200	1,700	3,300
County[d]	5.28×10^6	(0.06)	(0.03)	(0.06)
New Mexico[e]	6.50×10^7	(0.005)	(0.003)	(0.005)
U.S.[e]	6.54×10^9	(0.00005)	(0.00003)	(0.00005)
World[e]	3.10×10^{10}	(0.00001)	(0.00001)	(0.00001)

[a] Total emissions in 2002 for the two counties encompassing LANL (Los Alamos and Santa Fe Counties). See Table 8.1.1-1 for criteria pollutants and VOCs.

[b] Numbers in parentheses are percent of total emissions.

[c] Estimates for GTCC operations include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

[e] Annual CO_2 emissions in New Mexico, the United States, and the world in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

emissions for the trench and vault methods would be higher than those for the borehole. Compared with annual emissions for counties encompassing LANL, annual emissions of SO_2 for the trench and vault methods would be about 0.77% of the county total, respectively, while annual emissions of other criteria pollutants and VOCs would be about 0.37% or less.

It is expected that except for particulates, concentration levels from operations would remain well below the standards. Estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. However, the impacts of emissions from fugitive dust during emplacement would be lower than the impacts during construction activities, although fugitive dust emissions could exceed the standards under unfavorable meteorological conditions because of the proximity of the GTCC reference location to the site boundary. As discussed in the construction section, established fugitive dust control measures (primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles) could be implemented to minimize potential impacts on ambient air quality.

With regard to regional O_3, precursor emissions of NO_x and VOCs would be comparable to those resulting from construction activities (about 0.37% and 0.04% of the two-county total, respectively), and it is not anticipated that they would contribute much to regional O_3 levels. The highest emissions of CO_2 among the disposal methods would be comparable to the highest construction-related emissions; thus, the potential impacts of CO_2 emissions on climate change would also be negligible.

PSD regulations are not applicable to the proposed action because the proposed action is not a major stationary source.

8.2.2 Geology and Soils

Direct impacts from land disturbance would be proportional to the total area of land disturbed during site preparation activities (e.g., grading and backfilling) and construction of the waste disposal facility and related infrastructure (e.g., roads). Land disturbance would include the surface area covered by each disposal method and the vertical displacement of geologic materials for the borehole and trench disposal methods. The increased potential for soil erosion would be an indirect impact of land disturbance at the construction site. Indirect impacts would also result from the consumption of geologic materials (e.g., aggregate) for facility and other associated infrastructure construction. The impact analysis also considers whether the proposed action would preclude the future extraction and use of mineral materials or energy resources.

8.2.2.1 Construction

Land surface area disturbance impacts would be a function of the disposal method implemented at LANL (Table 5.1-1). Of the three disposal methods, the borehole facility layout would result in the greatest impact in terms of land area disturbed (44 ha or 110 ac). It also would result in the greatest disturbance with depth, 40 m (130 ft), with boreholes completed in unconsolidated mesa top alluvium and tuff.

Geologic and soil material requirements are provided in Table 5.3.2-1. Of the three disposal methods, the vault facility would require the most material since it involves the installation of interim and final cover systems. This material would be considered permanently lost. However, none of the three disposal methods are expected to result in adverse impacts on geologic and soil resources at LANL, since these resources are in abundant supply at the site and in the surrounding area.

No significant changes in surface topography or natural drainages are anticipated in the construction area. However, the disturbance of soil during the construction phase would increase the potential for erosion in the immediate vicinity. This potential would be somewhat reduced by the low precipitation rates at LANL (although catastrophic rainfall events do occur). Mitigation measures (e.g., siting the facility away from the cliff edge of the mesa) also would be implemented to avoid or minimize the risk of erosion.

The GTCC waste disposal facility would be sited and designed with safeguards to avoid or minimize the risks associated with seismic and volcanic hazards. LANL is in a seismically active region, and earthquakes with magnitudes of more than 5 have been recorded in recent history. The annual probability of a volcanic event at LANL has not been determined; however, it is believed that volcanism would be detected years in advance by regional uplift and doming (in the event of a large eruption) or weeks in advance by the existing LANL seismographic network (in the event of smaller eruptions). Airborne ash could be deposited on-site, depending on the location of the eruption and the prevailing wind direction. The potential for other hazards (e.g., subsidence and liquefaction) is considered to be low.

8.2.2.2 Operations

The disturbance of soil and the increased potential for soil erosion would continue throughout the operational phase while waste was being delivered to the site for disposal over time. The potential for soil erosion would be somewhat reduced by the low precipitation rates at LANL (although catastrophic rainfall events do occur). Mitigation measures also would be implemented to avoid or minimize the risk of erosion.

Impacts related to the extraction and use of valuable geologic materials would be low, since only the area within the facility itself would be unavailable for mining and geothermal energy development.

8.2.3 Water Resources

Direct and indirect impacts on water resources could occur as a result of water use at the proposed GTCC waste disposal facility during construction and operations. Table 5.3.3-1 provides an estimate of the water consumption and discharge volumes for the three land disposal methods; Tables 5.3.3-2 and 5.3.3-3 summarize the water use impacts (in terms of change in annual water use) to water resources from construction and normal operations, respectively. A discussion of potential impacts during each project phase is presented in the following sections. In addition, contamination due to potential leaching of radionuclides into groundwater from the waste inventory could occur, depending on the post-closure performance of the land disposal facilities discussed in Section 8.2.4.2.

8.2.3.1 Construction

Of the three land disposal methods considered for LANL, construction of a vault facility would have the highest water requirement (Table 5.3.3-1). Water demands for construction at LANL would be met by using groundwater from on-site wells completed in the regional aquifer in three well fields: Otowi, Pajarito, and Guaje. No surface water would be used at the site during construction. As a result, no direct impacts on surface water resources would be expected. The potential for indirect surface water impacts (in nearby canyons) related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures.

LANL uses about 1.4 billion L/yr (359 million gal/yr) of groundwater, about 21% of its water right of 6.8 billion L/yr (1.8 billion gal/yr). Construction of the proposed GTCC waste disposal facility would increase the annual water use at LANL by a maximum of about 0.24% (vault method) over the 20-year period that construction would occur. This increase would be well within LANL's water right. Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at LANL. As a result, impacts due to groundwater withdrawals are expected to be small.

Construction activities could potentially change the infiltration rate at the site of the proposed GTCC waste disposal facility, first by increasing the rate as ground would be disturbed in the initial stages of construction, and later by decreasing the rate as impermeable materials (e.g., the clay material and geotextile membrane assumed for the cover or cap for the land disposal facility designs) would cover the surface. These changes are expected to be negligible since the area of land associated with the proposed GTCC waste disposal facility (up to 44 ha [110 ac], depending on the disposal method) is small relative to the LANL site.

Disposal of waste (including sanitary waste) generated during construction of the land disposal facilities would have a negligible impact on the quality of water resources at LANL (see Sections 5.3.11 and 8.2.11). The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

8.2.3.2 Operations

Of the three types of land disposal facilities considered for LANL, a vault or trench facility would have the highest water requirement during operations (Table 5.3.3-1). Water demands for operations at LANL would be met by using groundwater from on-site wells completed in the regional aquifer. No surface water would be used at the site during operations. As a result, no direct impacts on surface water resources are expected. The potential for indirect surface water impacts related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures.

Operations of the proposed GTCC waste disposal facility would increase annual water use at LANL by a maximum of about 0.39% (vault or trench method). This increase would be well within LANL's water right. Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at LANL. As a result, impacts due to groundwater withdrawals are expected to be small.

Disposal of waste (including sanitary waste) generated during operations of the land disposal facilities would have a negligible impact on the quality of water resources at LANL. The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

8.2.4 Human Health

Potential impacts on members of the general public and the involved workers from the construction and operations associated with the land disposal facilities are expected to be comparable for all of the sites evaluated in this EIS for the land disposal method, and these are presented in Section 5.3.4. The following sections discuss the impacts from hypothetical facility accidents associated with waste handling activities and the impacts during the post-closure phase. They address impacts on members of the general public who might be affected by these waste disposal activities at the LANL GTCC reference location, since these impacts would be site dependent.

8.2.4.1 Facility Accidents

Data on the estimated human health impacts from hypothetical accidents at a land GTCC waste disposal facility at LANL are provided in Table 8.2.4-1. The accident scenarios are discussed in Section 5.3.4.2.1 and Appendix C. A reasonable range of accidents that included operational events and natural causes was analyzed. The impacts presented for each accident scenario are for the sector with the highest impacts, and no protective measures are assumed; therefore, the impacts represent the maximum expected for such an accident.

The collective population dose includes exposure from inhalation of airborne radioactive material, external exposure from radioactive material deposited on the ground, and ingestion of contaminated crops. The exposure period is considered to last for 1 year immediately following the accidental release. It is recognized that interdiction of food crops would likely occur if a significant release did occur, but many stakeholders are interested in what could happen without interdiction. For the accidents involving CH waste (Accidents 1–9, 11, 12), the ingestion dose accounts for approximately 20% of the dose to the collective population shown in Table 8.2.4-1. External exposure was found to be negligible in all cases. All exposures are dominated by the inhalation dose from the passing plume of airborne radioactive material downwind of the hypothetical accident immediately following release.

The highest estimated impact on the general public, 160 person-rem, would be from a hypothetical release from an SWB caused by a fire in the Waste Handling Building (Accident 9). Such a dose is not expected to lead to any additional LCFs in the population. This dose would be to the 83,100 people living to the southeast of the facility, resulting in an average dose of approximately 0.002 rem per person. Because this dose would result from internal intake (primarily inhalation, with some ingestion) and because the DCFs used in this analysis are for a 50-year CEDE, this dose would be accumulated over the course of 50 years.

The dose to an individual (expected to be a noninvolved worker because there would be no public access within 100 m [330 ft] of the GTCC reference location) includes exposure from inhalation of airborne radioactive material and 2 hours of exposure to radioactive material deposited on the ground. As shown in Table 8.2.4-1, the maximum estimated dose to an individual, 12 rem, is for Accident 9 from inhalation exposure immediately after the postulated

TABLE 8.2.4-1 Estimated Radiological Human Health Impacts from Hypothetical Facility Accidents at LANL

		Off-Site Public		Individual[b]	
Accident Number	Accident Scenario	Collective Dose (person-rem)	Latent Cancer Fatalities[c]	Dose (rem)	Likelihood of LCF[c]
1	Single drum drops, lid failure in Waste Handing Building	0.0035	<0.0001	0.00025	<0.0001
2	Single SWB drops, lid failure in Waste Handing Building	0.008	<0.0001	0.00058	<0.0001
3	Three drums drop, puncture, lid failure in Waste Handling Building	0.0063	<0.0001	0.00045	<0.0001
4	Two SWBs drop, puncture, lid failure in Waste Handling Building	0.011	<0.0001	0.00081	<0.0001
5	Single drum drops, lid failure outside	3.5	0.002	0.25	0.0001
6	Single SWB drops, lid failure outside	8	0.005	0.58	0.0003
7	Three drums drop, puncture, lid failure outside	6.3	0.004	0.45	0.0003
8	Two SWBs drop, puncture, lid failure outside	11	0.007	0.81	0.0005
9	Fire inside the Waste Handling Building, one SWB assumed to be affected	160	0.1	12	0.007
10	Single RH waste canister breach	<0.0001	<0.0001	<0.0001	<0.0001
11	Earthquake affects 18 pallets, each with 4 CH drums	100	0.06	7.2	0.004
12	Tornado, missile hits one SWB, contents released	32	0.02	2.3	0.001

[a] CH = contact-handled, RH = remote-handled, LCF = latent cancer fatality, SWB = standard waste box.

[b] The individual receptor is assumed to be 100 m (330 ft) downwind from the release point. This individual is expected to be a noninvolved worker because there would be no public access within 100 m (330 ft) of the GTCC reference location.

[c] LCFs are calculated by multiplying the dose by the health risk conversion factor of 0.0006 fatal cancer per person-rem (see Section 5.2.4.3). Values are rounded to one significant figure.

release. This estimated dose is for a hypothetical individual located 100 m (330 ft) to the south-southeast of the accident location. As discussed above, the estimated dose of 12 rem would be accumulated over a 50-year period after intake; thus, it is not expected to result in symptoms of acute radiation syndrome. A maximum annual dose of about 5% of the total dose would occur in the first year. The increased lifetime probability of a fatal cancer for this individual would be approximately 0.07% on the basis of a total dose of 12 rem.

8.2.4.2 Post-Closure

The potential radiation dose from airborne releases of radionuclides to the off-site members of the public after the closure of the disposal facility would be small. The RESRAD-OFFSITE calculation results (see Table 5.3.4-3) indicate that there would be no measurable radiation exposure for this pathway if a borehole facility was used, but small radiation exposures would result from either a trench or vault facility. The potential inhalation dose at a distance of 100 m (330 ft) from the disposal facility would be less than 1.8 mrem/yr for trench disposal and 0.52 mrem/yr for vault disposal. The potential radiation exposures would be caused mainly by inhalation of radon gas and its short-lived progeny.

The use of boreholes would provide better protection against potential exposures from airborne releases of radionuclides because of the greater depth of cover material involved. The top of the waste placement zone of the boreholes would be 30 m (100 ft) bgs, and this depth of overlying soil would inhibit the diffusion of radon gas, CO_2 gas (containing C-14), and tritium (H-3) water vapor to the atmosphere above the disposal area. However, because the distance to the groundwater table would be closer under the borehole method than under the trench and vault methods, radionuclides that leached out from wastes in the boreholes would reach the groundwater table in a shorter time than would radionuclides that leached out from a trench or vault facility.

Within 10,000 years, C-14, Tc-99, and I-129 could reach the groundwater table and a well installed by a hypothetical farmer at a distance of 100 m (330 ft) from the downgradient edge of the disposal facility. All three of these radionuclides are highly soluble in water, a quality that could lead to potentially significant groundwater concentrations and subsequently a measurable radiation does to the resident farmer. The peak annual dose associated with the use of contaminated groundwater from disposal of the entire GTCC inventory at LANL was calculated to be 160 mrem/yr for the borehole method, 430 mrem/yr for the vault method, and 380 mrem/yr for the trench method. Exposure pathways related to the use of contaminated groundwater include ingestion of water, soil, plants, meat, and milk; external radiation; and inhalation of radon gas and its short-lived progeny. Except for the water ingestion pathway, all the pathways that contribute significantly to the dose to this hypothetical resident farmer are associated with the accumulation of radionuclides in agricultural fields due to the use of contaminated groundwater for irrigation.

In Tables 8.2.4-2 and 8.2.4-3, the peak annual doses and LCF risks to the hypothetical resident farmer (from use of potentially contaminated groundwater within the first 10,000 years after closure of the disposal facility) are those associated with the disposal of the entire GTCC

TABLE 8.2.4-2 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Water within 10,000 Years of Disposal at the GTCC Reference Location at LANL[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual Dose from Entire Inventory
Borehole									160^b
Group 1 stored	3.0	-	0.0	0.065	0.33	0.0	0.74	67	
Group 1 projected	46	0.0	-	0.0	0.81	0.0	0.21	0.18	
Group 2 projected	22	0.0	0.35	13	-	-	0.42	0.96	
Vault									430^b
Group 1 stored	60	-	0.0	0.22	0.45	0.0	1.8	230	
Group 1 projected	64	0.0	-	0.0	1.1	0.0	0.52	0.62	
Group 2 projected	30	0.0	0.87	40	-	-	1.0	3.1	
Trench									380^b
Group 1 stored	5.2	-	0.0	0.21	0.55	0.0	2.2	210	
Group 1 projected	78	0.0	-	0.0	1.4	0.0	0.63	0.58	
Group 2 projected	37	0.0	1.1	38	-	-	1.2	2.9	

[a] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual doses to the hypothetical resident farmer at the time of peak annual dose for the entire GTCC waste inventory. These contributions do not represent the maximum doses that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses that could result from each of the waste types are presented in Tables E-22 through E-25 in Appendix E.

[b] The times for the peak annual doses of 160 mrem/yr for boreholes, 430 mrem/yr for vaults, and 380 mrem/yr for trenches were calculated to be about 500 years, 1,100 years, and 1,000 years, respectively, for disposal of the entire GTCC waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual doses from the specific waste types at the time of these peak doses. The primary contributors to the dose in all cases are GTCC LLRW activated metals and GTCC-like Other Waste - RH. The primary radionuclides causing this dose would be C-14, Tc-99, and I-129.

TABLE 8.2.4-3 Estimated Peak Annual LCF Risks from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at LANL[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual LCF Risk from Entire Inventory
Borehole									9E-05[b]
Group 1 stored	2E-06	-	0E+00	4E-08	2E-07	0E+00	4E-07	4E-05	
Group 1 projected	3E-05	0E+00	-	0E+00	-	-	1E-07	1E-07	
Group 2 projected	1E-05	0E+00	2E-07	8E-06	0E+00	0E+00	3E-07	6E-07	
Vault									3E-04[b]
Group 1 stored	4E-05	-	0E+00	1E-07	3E-07	0E+00	1E-06	1E-04	
Group 1 projected	4E-05	0E+00	-	0E+00	7E-07	0E+00	3E-07	4E-07	
Group 2 projected	2E-05	0E+00	5E-07	2E-05	-	-	6E-07	2E-06	
Trench									2E-04[b]
Group 1 stored	3E-06	-	0E+00	1E-07	3E-07	0E+00	1E-06	1E-04	
Group 1 projected	5E-05	0E+00	-	0E+00	8E-07	0E+00	4E-07	3E-07	
Group 2 projected	2E-05	0E+00	6E-07	2E-05	-	-	7E-07	2E-06	

[a] These annual LCF risks are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to one significant figure, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual LCF risks to the hypothetical resident farmer at the time of peak annual LCF risk for the entire GTCC waste inventory. These contributions do not represent the maximum LCF risks that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum LCF risks that could result from each waste type individually generally occur at different times than the peak annual LCF risk from the entire inventory.

[b] The times for the peak annual LCF risks of 9E-05 for boreholes, 3E-04 for vaults, and 2E-04 for trenches were calculated to be about 500 years, 1,100 years, and 1,000 years, respectively, for disposal of the entire GTCC waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual LCF risks from the specific waste types at the time of peak LCF risks. The primary contributors to the LCF risk in all cases are GTCC LLRW activated metals and GTCC-like Other Waste - RH. The primary radionuclides causing this risk would be C-14, Tc-99, and I-129.

waste inventory by using the land disposal methods evaluated. In these tables, the annual doses and LCF risks contributed by each waste type (i.e., dose and risk for each waste type at the time or year when the peak dose or risk for the entire inventory is observed) to the peak dose and risk are also tabulated. The doses and LCF risks presented for the various waste types do not necessarily represent the peak dose and LCF risk of the waste type itself when it is considered on its own.

For borehole disposal, it is estimated that the peak annual dose and LCF risks would occur at about 500 years, and calculations indicate that the peak annual doses and LCF risks would occur at about 1,100 years after disposal for vaults and at about 1,000 years for trenches. These times represent the time after failure of the engineered barriers (including the cover), which is assumed to begin 500 years after closure of the disposal facility. The GTCC LLRW activated metals and GTCC-like Other Waste - RH would be the primary contributors to the doses in all cases. The doses from C-14 and Tc-99 would be largely attributable to the GTCC LLRW activated metal wastes and the doses from I-129 and Tc-99 would be largely attributable to GTCC-like Other Waste - RH.

Tables E-22 through E-25 in Appendix E present peak doses for each waste type when considered on its own. Because these peak doses generally occur at different times, the results should not be summed to obtain total doses for comparison with those presented in Table 8.24-2 (although for some cases, those sums might be close to those presented in the site-specific chapters).

Figure 8.2.4-1 is a temporal plot of the radiation doses associated with the use of contaminated groundwater for a time period extending to 10,000 years, and Figure 8.2.4-2 shows these results to 100,000 years for the three land disposal methods. Note that the time scale is logarithmic in Figure 8.2.4-1 and linear in Figure 8.2.4-2. A logarithmic time scale was used in the first figure to better illustrate the projected radiation doses to a hypothetical resident farmer in the first 2,000 years after closure of the disposal facility.

Although C-14, Tc-99, and I-129 would result in measureable radiation doses for the first 10,000 years, the inventory in the disposal areas would be depleted rather quickly, and the doses would gradually decrease with time after about 2,000 years. After the depletion of these three radionuclides, there would be no other radionuclides reaching the groundwater table within 100,000 years. The lack of groundwater contamination from other radionuclides at the LANL site between 10,000 and 100,000 years would be attributable to a low water infiltration rate of 0.5 cm/yr (0.2 in./yr) and the relatively long distance to the groundwater table (about 270 m [890 ft]).

The results given here are assumed to be conservative because the location selected for the residential exposure is 100 m (330 ft) from the edge of the disposal facility. Use of a longer distance, which might be more realistic for the sites being evaluated, would significantly lower the estimated doses (i.e., by as much as 70%). A sensitivity analysis performed to determine the effect of a distance longer than 100 m (330 ft) is presented in Appendix E.

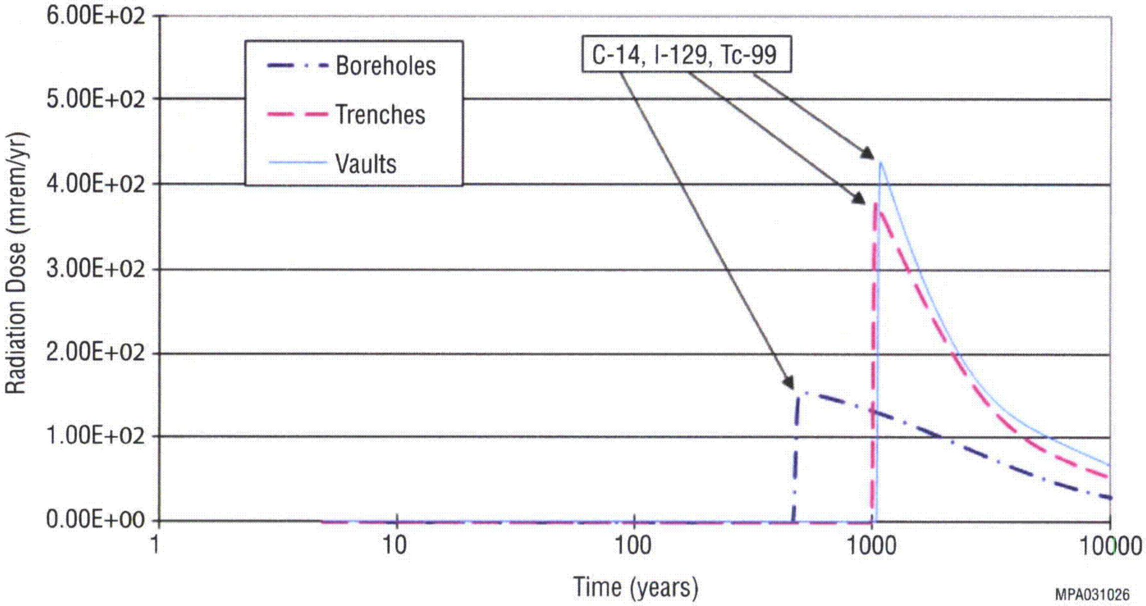

FIGURE 8.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal for the Three Land Disposal Methods at LANL

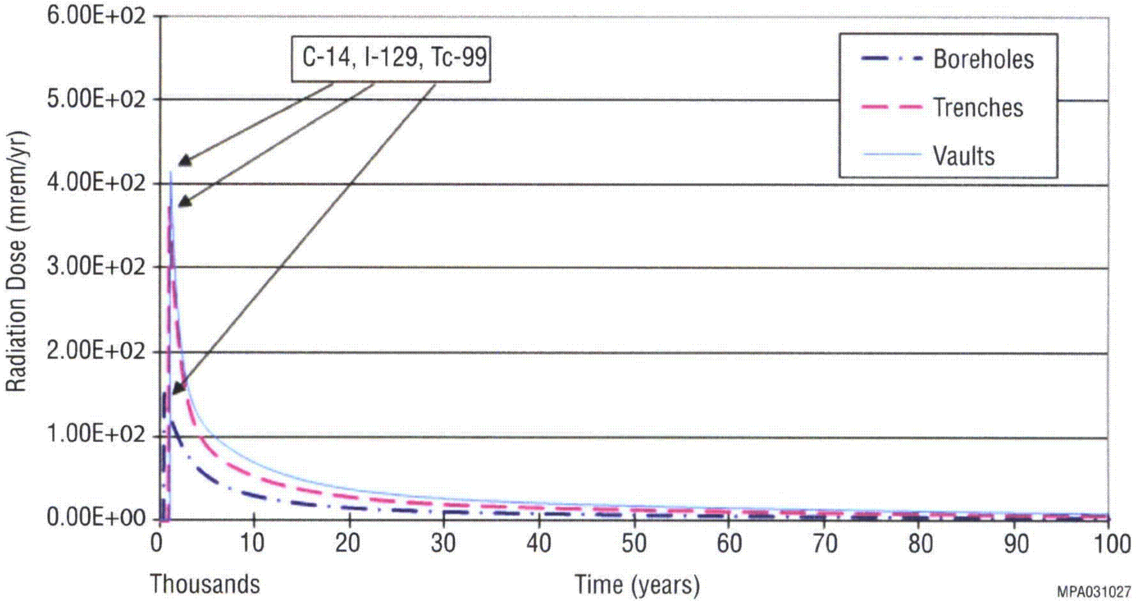

FIGURE 8.2.4-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Three Land Disposal Methods at LANL

These analyses assume that engineering controls would be effective for 500 years following closure of the disposal facility. This means that essentially no infiltrating water would reach the wastes from the top of the disposal units during the first 500 years. It is assumed that after 500 years, the engineered barriers would begin to degrade, allowing infiltrating water to come in contact with the disposed-of wastes. For purposes of analysis in this EIS, it is assumed that the amount of infiltrating water that would contact the wastes would be 20% of the site-specific natural infiltration rate for the area, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate for the area. This approach is conservative because the engineered systems (including the disposal facility cover) are expected to last significantly longer than 500 years, even in the absence of active maintenance measures.

It is assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. Consistent with the assumptions used for engineering controls, no credit was taken for the effectiveness of this stabilizing agent after 500 years in this analysis. That is, it is assumed that any water that would contact the wastes after 500 years would be able to leach radioactive constituents from the disposed-of materials. These radionuclides could then move with the percolating groundwater to the underlying groundwater system. This assumption is conservative because grout or other stabilizing materials could retain their integrity for longer than 500 years.

Sensitivity analyses performed relative to these assumptions indicate that if a higher infiltration rate to the top of the disposal facilities was assumed, the doses would increase in a linear manner from those presented. Conversely, they would decrease in a linear manner with lower infiltration rates. This finding indicates the need to ensure a good cover over the closed disposal units. Also, the doses (particularly for the GTCC-like Other Waste - RH) would be lower if the grout was assumed to last for a longer time. Because of the long-lived nature of the radionuclides associated with the GTCC LLRW and GTCC-like waste, any stabilization effort (such as grouting) would have to be effective for longer than 5,000 years in order to substantially reduce doses that could result from potential future leaching of the disposed-of waste.

The radiation doses presented in the post-closure assessment in this EIS are intended to be used for comparing the performance of each land disposal method at each site evaluated. The results indicate that the use of robust engineering designs and redundant measures (e.g., types and thicknesses of covers and long-lasting grout) in the disposal facility could delay the potential release of radionuclides and could reduce the release to very low levels, thereby minimizing the potential groundwater contamination and associated human health impacts in the future. DOE will consider the potential doses to the hypothetical farmer and other factors in developing the preferred alternative, as discussed in Section 2.9.

8.2.5 Ecology

Section 5.3.5 presents an overview of the potential impacts on ecological resources that could result from the construction and operations of the potential GTCC waste disposal facility, regardless of the location selected for the facility. This section evaluates the potential impacts of the GTCC waste disposal facility on the ecological resources at LANL.

Habitat lost during construction would be mostly pinyon-juniper woodland. It is not expected that the initial loss of mostly pinyon-juniper woodland habitat, followed by eventual establishment of low-growth vegetation on the disposal site, would create a long-term reduction in the local or regional ecological diversity. After closure of the GTCC waste disposal site, the cover would become vegetated with annual and perennial grasses and forbs. As appropriate, regionally native plants would be used to landscape the disposal site (EPA 1995). The vegetation that would be planted as the disposal facility was closed would include native grasses, such as blue grama grass (*Bouteloua gracilis*), buffalo grass (*Buchloe dactyloides*), western wheatgrass (*Pascopyrum smithii*), and dropseed (*Sporobolus* spp.), as well as alfalfa (*Medicago sativa*) (Shuman et al. 2002). An aggressive revegetation program would be necessary so that nonnative species, such as cheatgrass and Russian thistle, would not become established. These species are quick to colonize disturbed sites and are difficult to eradicate because each year, they produce large amounts of seeds that remain viable for long periods of time (Blew et al. 2006).

Construction of the GTCC waste disposal facility would affect wildlife species that inhabit the TA-54 area (see Section 8.1.5). Small mammals, ground-nesting birds, and reptiles would recolonize the site once a vegetative cover was reestablished. Larger mammals, such as elk, American black bears, mountain lions, and bobcats, would probably avoid the area. Species such as mule deer, coyote, and gray fox, which forage or hunt in early successional habitats, would be excluded from the GTCC waste disposal facility because of the fencing. Nesting habitat would also be lost for raptors and other tree-nesting species.

Because no aquatic habitats or wetlands occur within the immediate vicinity of the GTCC reference location, direct impacts on aquatic or wetland biota are not expected. DOE would use appropriate erosion control measures to minimize off-site movement of soils. The GTCC waste disposal facility retention pond would probably not become a highly productive aquatic habitat. However, depending on the amount of water and the length of time that the water was retained within the pond, aquatic invertebrates could become established within it. Waterfowl, shorebirds, and other birds might also make use of the retention pond, as would mammal and amphibian species that might enter the site.

Several federally and state-listed bird and mammal species occur within the area of the GTCC reference location. Localized impacts on these species might result from the construction and operations of the disposal facility. However, the area of pinyon-juniper woodland habitat that might be disturbed by construction would be small relative to the overall area of such habitat on the LANL site. Therefore, removal of pinyon-juniper woodland habitat would have a small impact on the populations of special-status species at LANL.

Among the goals of the waste management mission at DOE sites is to design, construct, operate, and maintain disposal facilities in a manner that protects the environment and complies with regulations. Therefore, impacts associated with the GTCC waste disposal facility that could affect ecological resources (Section 5.3.3.6) would be minimized and mitigated.

8.2.6 Socioeconomics

8.2.6.1 Construction

The potential socioeconomic impacts from constructing a GTCC waste disposal facility and support buildings at LANL would be small for all disposal methods. Construction activities would create direct employment of 47 people (borehole method) and 145 people (vault method) in the peak construction year and an additional 64 indirect jobs (trench method) to 169 indirect jobs (vault method) in the ROI (Table 8.2.6-1). Construction activities would constitute less than 1% of total ROI employment in the peak year. A GTCC waste disposal facility would produce between $4.6 million in income (trench method) and $12.2 million in income (vault method) in the peak year of construction.

In the peak year of construction, between 21 people (borehole method) and 64 people (vault method) would in-migrate to the ROI (Table 8.2.6-1) as a result of employment on the site. In-migration would have only a marginal effect on population growth and would require up to 1% of vacant rental housing in the peak year. No significant impact on public finances would occur as a result of in-migration, and no more than one new public service employee would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small to moderate impact on levels of service in the local transportation network surrounding the site.

8.2.6.2 Operations

The potential socioeconomic impacts from operating a GTCC waste disposal facility would be relatively small for all disposal methods. Operational activities would create 38 direct jobs (borehole method) to 51 direct jobs (vault method) annually, and an additional 41 indirect jobs (borehole method) to 48 indirect jobs (vault method) in the ROI (Table 8.2.6-1). A GTCC waste disposal facility would also produce between $4.0 million in income (borehole method) and $5.0 million in income (vault method) annually during operations.

Two people would move to the ROI area at the beginning of operations (Table 8.2.6-1). However, in-migration would have only a marginal effect on population growth and would require less than 1% of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur as a result of in-migration, and no local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have only a small impact on levels of service in the local transportation network surrounding the site.

TABLE 8.2.6-1 Effects of GTCC Waste Disposal Facility Construction and Operations on Socioeconomics at the ROI for LANL[a]

	Trench		Borehole		Vault	
Impact Category	Construction	Operation	Construction	Operation	Construction	Operation
Employment (number of jobs)						
Direct	62	48	47	38	145	51
Indirect	64	46	93	41	169	48
Total	126	94	140	79	314	99
Income ($ in millions)						
Direct	2.3	3.2	2.0	2.6	6.2	3.4
Indirect	2.3	1.6	3.4	1.4	6.0	1.6
Total	4.6	4.8	5.4	4.0	12.2	5.0
Population (number of new residents)	27	2	21	2	64	2
Housing (number of units required)	14	1	10	1	32	1
Public finances (% impact on expenditures)						
Cities and counties[b]	<1	<1	<1	<1	<1	<1
Schools in ROI[c]	<1	<1	<1	<1	<1	<1
Public service employment (number of new employees)						
Local government employees[d]	1	0	0	0	1	0
Teachers	0	0	0	0	1	0
Traffic (impact on current levels of service)	Small	Small	Small	Small	Moderate	Small

[a] Impacts shown are for waste facility and support buildings in the peak year of construction and the first year of operations.

[b] Includes impacts that would occur in the cities of Los Alamos, Espanola, and Santa Fe and in Los Alamos, Rio Arriba, and Santa Fe Counties.

[c] Includes impacts that would occur in the Los Alamos, Chama, Dulce, Espanola, Jemez, Santa Fe, and Pojoaque school districts.

[d] Includes police officers, paid firefighters, and general government employees.

8.2.7 Environmental Justice

8.2.7.1 Construction

No radiological risks and only a very low level of chemical exposure and risk are expected during construction of the trench, borehole, or vault facility. Chemical exposure during construction would be limited to airborne toxic air pollutants at less than standard levels and would not result in any adverse health impacts. Because the health impacts of each facility on the general population within the 80-km (50-mi) assessment area during construction would be negligible, the impacts from the construction of each facility on the minority and low-income population would not be significant. The most potentially affected population in the 80-km (50-mi) assessment area is the adjacent Pueblos.

8.2.7.2 Operations

Because incoming GTCC waste containers would only be consolidated for placement in trench, borehole, and vault facilities, with no repackaging necessary, there would be no radiological impacts on the general public during operations, and no adverse health effects on the general population. In addition, no surface releases that might enter local streams or interfere with subsistence activities by low-income or minority populations would occur. Because the health impacts of routine operations on the general public would be negligible, it is expected that there would be no disproportionately high and adverse impact on minority and low-income population groups within the 80-km (50-mi) assessment area. As was the case for the construction phase, the most potentially affected population in the 80-km (50-mi) assessment area is the adjacent Pueblos. Subsequent NEPA analysis to support any GTCC implementation would consider any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well water use) to determine any additional potential health and environmental impacts.

8.2.7.3 Accidents

A GTCC waste release at any of the disposal facilities would have the potential to cause LCFs in the surrounding area. However, it is highly unlikely that such an accident would occur. Therefore, the risk to any population, including low-income and minority communities, is considered to be low. In the unlikely event of a GTCC release at a facility, the communities most likely to be affected could be minority or low-income, given the demographics within 80 km (50 mi) of the GTCC reference location.

If an accident that produced significant contamination did occur, appropriate measures would be taken to ensure that the impacts on low-income and minority populations would be minimized. The extent to which low-income and minority population groups would be affected would depend on the amount of material released and the direction and speed at which airborne material was dispersed from any of the facilities by the wind. Although the overall risk would be very small, the greatest short-term risk of exposure following an airborne release and the greatest one-year risk would be to the population groups residing to the south-southwest of the site. Airborne releases following an accident would likely have a larger impact on the area than would an accident that released contaminants directly into the soil surface. A surface release entering local steams could temporarily interfere with subsistence activities carried out by low-income and minority populations within a few miles downstream of the site.

Monitoring of contaminant levels in soil and surface water following an accident would provide the public with information on the extent of any contaminated areas. Analysis of contaminated areas to decide how to control the use of high-health-risk areas would reduce the potential impact on local residents.

8.2.8 Land Use

Section 5.3.8 presents an overview of the potential land use impacts that could result from a GTCC waste disposal facility regardless of the location selected for the facility. This section evaluates the potential impacts from a GTCC waste disposal facility on land use at LANL.

Siting the GTCC waste disposal facility at LANL would alter portions of TA-54 that are currently reserve or experimental science areas to waste management areas. Addition of the GTCC waste disposal facility within TA-54 would expand the amount of this technical area that is currently used for disposal of radioactive wastes. Land use on areas surrounding LANL would not be affected. Future land use activities that would be permitted within or immediately adjacent to the GTCC waste disposal facility would be limited to those that would not jeopardize the integrity of the facility, create a security risk, or create a worker or public safety risk.

8.2.9 Transportation

The transportation of GTCC LLRW and GTCC-like waste necessary for the disposal of all such waste at LANL was evaluated. As discussed in Section 5.3.9, transportation of all cargo is considered for both truck and rail modes of transport as separate methods for the purposes of this EIS. Currently, there is no rail at LANL, and construction of a rail spur would have additional potential impacts. Upgrades on-site roads needed for truck transportation on the TA-54 area would also have additional impacts. Transportation impacts are expected to be the same for disposal in boreholes, trenches, or vaults because the same type of transportation packaging would be used regardless of the disposal method chosen.

As discussed in Appendix C, Section C.9, the impacts of transportation were calculated in three areas: (1) collective population risks during routine conditions and accidents (Section 8.2.9.1), (2) radiological risks to individuals receiving the highest impacts during routine conditions (Section 8.2.9.2), and (3) consequences to individuals and populations after the most severe accidents involving the release of a radioactive or hazardous chemical material (Section 8.2.9.3).

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rates for CH shipments to LANL are assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rates are assumed to be 2.5 and 5.0 mrem/h for truck and rail shipments, respectively. These assignments are based on shipments of similar types of waste. Dose rates from rail shipments are approximately double those for truck shipments because rail shipments are assumed to have twice the number of waste packages as a truck shipment. Impacts from accidents are dependent on the amount of radioactive material in a shipment and on the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

8.2.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group, without specifying individual receptors. Exposures to four different groups are considered: (1) persons living and working along the transportation routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for cargo-related causes for routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and are calculated only for traffic accidents (fatalities caused by physical trauma).

Estimated impacts from the truck and rail options are summarized in Tables 8.2.9-1 and 8.2.9-2, respectively. For the truck option, it is estimated that about 12,600 shipments would result in about 36 million km (22 million mi) of travel and no LCFs among truck crew members or the public. One fatality directly related to accidents could result. For the rail option, it is estimated that no LCFs and potentially one physical fatality from accidents would occur, with about 5,010 railcar shipments resulting in about 14 million km (9 million mi) of travel. In addition, for the purpose of the analysis, no intermodal shipments were assumed.

8.2.9.2 Highest-Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals in the vicinity of a shipment may be exposed to radiation. Risks to these individuals for a number of hypothetical exposure-causing events were estimated. The receptors include transportation workers, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living and or working near a destination site. The assumptions about exposure are given in Section C.9.2.2 of Appendix C, and transportation impacts are provided in Section 5.3.9. The scenarios for exposure are not meant to be exhaustive; they were selected to

TABLE 8.2.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at LANL[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[c]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	20	63,900	0.66	0.025	0.1	0.12	0.24	0.00019	0.0004	0.0001	0.0015
Past PWRs	143	399,000	4.2	0.15	0.63	0.73	1.5	0.001	0.002	0.0009	0.0088
Operating BWRs	569	1,580,000	16	0.55	2.4	2.9	5.9	0.0031	0.01	0.004	0.036
Operating PWRs	1,720	4,350,000	45	1.5	6.7	8	16	0.0085	0.03	0.01	0.098
Sealed sources - CH	209	344,000	0.14	0.036	0.2	0.25	0.48	0.018	<0.0001	0.0003	0.0087
Cesium irradiators - CH	240	396,000	0.17	0.041	0.23	0.28	0.56	0.0029	<0.0001	0.0003	0.01
Other Waste - CH	5	5,750	0.0024	0.00052	0.0034	0.0041	0.008	<0.0001	<0.0001	<0.0001	0.00014
Other Waste - RH	54	157,000	1.6	0.057	0.24	0.29	0.59	<0.0001	0.001	0.0004	0.0036
GTCC-like waste											
Activated metals - RH	38	76,100	0.79	0.02	0.11	0.14	0.27	<0.0001	0.0005	0.0002	0.0034
Sealed sources - CH	1	1,650	0.00069	0.00017	0.00096	0.0012	0.0023	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	69	205,000	0.086	0.03	0.12	0.15	0.3	0.00099	<0.0001	0.0002	0.0042
Other Waste - RH	1,160	3,330,000	34	1.2	5.1	6.1	12	0.0021	0.02	0.007	0.069

TABLE 8.2.9-1 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	202	432,000	4.5	0.12	0.65	0.79	1.6	0.00089	0.003	0.0009	0.01
New PWRs	833	2,040,000	21	0.7	3.2	3.8	7.6	0.0038	0.01	0.005	0.045
Additional commercial waste	1,990	6,050,000	63	2.3	9.3	11	23	<0.0001	0.04	0.01	0.12
Other Waste - CH	139	423,000	0.18	0.063	0.26	0.3	0.62	0.003	0.0001	0.0004	0.0087
Other Waste - RH	3,790	11,400,000	120	4.3	18	21	43	0.00065	0.07	0.03	0.24
GTCC-like waste											
Other Waste - CH	44	118,000	0.05	0.016	0.071	0.085	0.17	0.00041	<0.0001	0.0001	0.0025
Other Waste - RH	1,400	4,150,000	43	1.5	6.4	7.6	16	0.0021	0.03	0.009	0.086
Total Groups 1 and 2	12,600	35,500,000	350	13	53	64	130	0.048	0.2	0.08	0.76

[a] BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

[b] Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

[c] Vehicle-related impacts are impacts independent of the cargo in the shipment.

[d] LCFs were calculated by multiplying the dose by the health risk conversion factor of 6 × 10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

[e] Dose risk is a societal risk and is the product of accident probability and accident consequence.

TABLE 8.2.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at LANL[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	7	20,400	0.17	0.054	0.0032	0.077	0.13	0.00035	0.0001	<0.0001	0.0016
Past PWRs	37	101,000	0.84	0.28	0.017	0.39	0.69	0.0014	0.0005	0.0004	0.0054
Operating BWRs	154	422,000	3.5	1.1	0.062	1.7	2.9	0.0025	0.002	0.002	0.016
Operating PWRs	460	1,200,000	10	3.4	0.18	4.9	8.4	0.0091	0.006	0.005	0.052
Sealed sources - CH	105	190,000	0.53	0.16	0.0085	0.38	0.56	0.00095	0.0003	0.0003	0.0062
Cesium irradiators - CH	120	217,000	0.61	0.19	0.0097	0.44	0.64	0.00013	0.0004	0.0004	0.0071
Other Waste - CH	3	2,740	0.011	0.0025	0.00017	0.0083	0.011	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - RH	27	85,600	0.68	0.27	0.012	0.33	0.61	<0.0001	0.0004	0.0004	0.0025
GTCC-like waste											
Activated metals - RH	11	23,400	0.21	0.051	0.0028	0.1	0.16	<0.0001	0.0001	<0.0001	0.0023
Sealed sources - CH	1	1,810	0.0051	0.0016	<0.0001	0.0037	0.0053	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	35	99,700	0.24	0.11	0.0066	0.18	0.29	0.00011	0.0001	0.0002	0.0036
Other Waste - RH	579	1,670,000	14	4.5	0.25	6.7	11	0.00024	0.008	0.007	0.061

TABLE 8.2.9-2 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		Physical Accident Fatalities
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	54	119,000	1.1	0.3	0.018	0.52	0.84	0.0012	0.0006	0.0005	0.0051
New PWRs	227	587,000	5	1.7	0.082	2.4	4.2	0.0033	0.003	0.003	0.025
Additional commercial waste	498	1,450,000	12	3.8	0.23	6	10	<0.0001	0.007	0.006	0.054
Other Waste - CH	70	203,000	0.49	0.23	0.014	0.36	0.6	0.00035	0.0003	0.0004	0.0076
Other Waste - RH	1,900	5,550,000	45	15	0.85	23	38	<0.0001	0.03	0.02	0.2
GTCC-like waste											
Other Waste - CH	22	64,300	0.15	0.078	0.0039	0.11	0.19	<0.0001	<0.0001	0.0001	0.0023
Other Waste - RH	702	2,040,000	17	5.4	0.31	8.3	14	0.00022	0.01	0.008	0.076
Total Groups 1 and 2	5,010	14,000,000	110	36	2.1	56	94	0.02	0.07	0.06	0.53

[a] BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

[b] Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

[c] Vehicle-related impacts are impacts independent of the cargo in the shipment.

[d] LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

[c] Dose risk is a societal risk and is the product of accident probability and accident consequence.

provide a range of representative potential exposures. On a site-specific basis, if someone was living or working near the LANL entrance and present for all 12,600 truck or 5,010 rail shipments projected, that individual's estimated dose would be approximately 0.5 or 1.0 mrem, respectively, over the course of more than 50 years. The individual's associated lifetime LCF risk would then be 3×10^{-7} or 6×10^{-7} for truck or rail shipments, respectively.

8.2.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Because the exact location of such a transportation accident is impossible to predict and thus not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

8.2.10 Cultural Resources

The GTCC reference location is situated in the easternmost portion of the LANL site in TA-54. Most of TA-54 has been surveyed for cultural resources. Eighteen cultural resources are reported to be in or near the project area, and some of the sites in the GTCC reference location are considered eligible for listing on the NHRP. Several sites need evaluation. In addition, several traditional cultural properties are located in the area. If the location is chosen for development, the NHPA Section 106 process would be followed for considering the impact of the project on significant cultural resources. The Section 106 process requires that the project location and any ancillary locations that would be affected by the project be investigated for the presence of cultural resources prior to disturbance. All resources present would be evaluated for historical significance. Impacts on significant resources would be assessed and mitigated during the project. DOE would consult with the New Mexico SHPO and the Jemez, Cochiti, San Ildefonso, and Santa Clara Pueblos, and any other appropriate American Indian tribes. The tribes would be consulted to ensure that no traditional cultural properties were located in the project area.

It is expected that the majority of the impacts on cultural resources would occur during the construction phase. The intermediate-depth borehole method has the greatest potential to affect cultural resources because of its 44-ha (110-ac) land requirement. The amount of land needed to employ this method is twice the amount needed to construct a vault or trench.

Unlike the other two methods being considered, the vault method requires large amounts of soil to cover the waste. Potential impacts on cultural resources could occur during the removal and hauling of the soil required for this method. Impacts on cultural resources would need to be considered for the soil extraction locations. The NHPA Section 106 process would be followed for all locations. Potential impacts on cultural resources from the operation of a vault facility could be comparable to those expected from the borehole method. While the actual footprint would be smaller for the vault method, the amount of land disturbed to obtain the soil for the cover could exceed the land requirements for the boreholes. Impacts on culturally significant resources could result from the project. The appropriate tribes would be consulted to ensure that no traditional cultural properties were affected by the project. Most impacts on significant cultural resources could be mitigated through data recovery, but avoidance is preferred.

Activities associated with operations and post-closure are expected to have a minimal impact on cultural resources. No new ground-disturbing activities are expected to occur in association with operational and post-closure activities.

8.2.11 Waste Management

The construction of the land disposal facilities would generate small quantities of hazardous and nonhazardous solids and hazardous and nonhazardous liquids. Waste generated from operations would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable wastes). These waste types would either be disposed of on-site or sent off-site for disposal. It is expected that no impacts on waste management programs at LANL would result from the waste that could be generated from the construction and operations of the land disposal methods. Section 5.3.11 provides a summary of the waste handling programs at LANL for the waste types generated.

8.3 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences from the disposal of GTCC LLRW and GTCC-like waste under Alternatives 3 to 5 are summarized by resource area as follows:

Air quality. It is estimated that during construction and operations, total peak-year emissions of criteria pollutants, VOCs, and CO_2 would be small. The highest construction emissions would be from the vault method and would be about 0.75% of the two-county emissions total for SO_2. The highest operational emissions would be from the trench and vault methods and would be about 0.76% and 0.77%, respectively, of the two-county emissions total for SO_2. O_3 levels in the two counties encompassing LANL are currently in attainment; O_3 precursor emissions from construction and operational activities would be relatively small, less than 0.43% and 0.05% of NO_x and VOC emissions, respectively, and much lower than those for the regional air shed. During construction and operations, maximum CO_2 emissions would be negligible.

Some construction and operational activities might occur within about 200 m (660 ft) of the site boundary. Under unfavorable dispersion conditions, high concentrations of PM_{10} or $PM_{2.5}$ would likely occur and could at times exceed the standards at the site boundary. However, these activities would not contribute significantly to concentrations at the nearest residence in White Rock, about 3.5 km (2.2 mi) from the GTCC reference location. Fugitive dust emissions during construction would be controlled by following established standard dust control practices.

Noise. The highest composite noise during construction would be about 92 dBA at 15 m (50 ft) from the source. Noise levels at 690 m (2,300 ft) from sources would be below the EPA guideline of 55 dBA as the L_{dn} for residential zones. There are no residences within this distance; the nearest residence is in White Rock, about 3.5 km (2.2 mi) away. Noise generated from operations would be less than noise during the construction phase. No groundborne vibration impacts are anticipated, since low-vibration generating equipment would be used and since there are no residences or vibration-sensitive buildings in the area.

Geology. No adverse impacts from the extraction or use of geologic and soil resources are expected, nor would there be significant changes in surface topography or natural drainages. Boreholes (at depths of 40 m or 130 ft) would be completed in unconsolidated mesa top alluvium and tuff. The potential for erosion would be reduced by the low precipitation rates (although catastrophic rainfall events do occur) and would be further reduced by best management practices.

Water resources. Construction of a vault facility would have the highest water requirement. Water demands for construction at LANL would be met using groundwater from on-site wells completed in the regional aquifer. No surface water would be used at the site during construction; therefore, no direct impacts on surface water are expected. Indirect impacts on surface water would be reduced by implementing good industry practices and mitigation measures. Construction and operations of the proposed GTCC waste disposal facility would increase the annual water use at LANL by a maximum of about 0.24% (vault method) and 0.39% (vault or trench method), respectively. Since these increases are well within LANL's water right and would not significantly lower the water table or change the direction of groundwater flow, impacts due to groundwater withdrawals are expected to be negligible. Groundwater could become contaminated with some highly soluble radionuclides during the post-closure period; indirect impacts on surface water could occur as a result of aquifer discharges to seeps, springs, and rivers.

Human health. The worker impacts during operations would mainly be those from the radiation doses associated with handling of the wastes. It is expected that the annual radiation dose would be 2.6 person-rem/yr for boreholes, 4.6 person-rem/yr for trenches, and 5.2 person-rem/yr for vaults. These worker doses are not expected to result in any LCFs (see Section 5.3.4.1.1). The maximum dose to any individual worker would not exceed the DOE administrative control level (2 rem/yr) for site operations. It is expected that the maximum dose to any individual worker over the entire project would not exceed a few rem. The worker impacts from accidents would be associated with the physical injuries and possible fatalities that could result from construction and waste handling activities. It is estimated that the annual number of lost workdays due to injuries and illnesses during disposal operations would range from 1 (for boreholes) to 2 (for trenches and vaults) and that no fatalities would result from construction and waste handling accidents (see Section 5.3.4.2.2). These injuries would not be associated with the radioactive nature of the wastes but would simply be those expected to occur during any construction project of this size.

With regard to the general public, no measurable doses are expected to occur during waste disposal operations at the site, given the solid nature of the wastes and the distance of waste handling activities from potentially affected individuals. It is estimated that the highest dose to an individual from an accident involving the waste packages prior to disposal (from a fire impacting an SWB) would be 12 rem and would not result in any LCFs. The collective dose to the affected population from such an event is estimated to be 160 person-rem. The peak annual dose in the first 10,000 years after closure of the disposal facility to a hypothetical nearby receptor (resident farmer) who resides 100 m (330 ft) from the disposal site is estimated to be 430 mrem/yr for the vault method. This dose would result mainly from the GTCC LLRW activated metal waste and GTCC-like Other Waste - RH and is projected to occur about 1,100 years in the future. The peak annual doses for the borehole and trench methods would be lower: 160 mrem/yr and 380 mrem/yr, respectively. These doses would occur at 500 years for the borehole method and 1,000 years for the trench method. These times represent the length of time after failure of the engineered barrier (including the cover), which is assumed to begin 500 years after closure of the disposal facility.

Ecology. The initial loss of mostly pinyon-juniper woodland habitat, followed by the eventual establishment of low-growth vegetation, would not create a long-term reduction in the local or regional ecological diversity. After closure, the cover would become vegetated with annual and perennial grasses and forbs. Construction of the GTCC waste disposal facility would affect wildlife species inhabiting TA-54; however, small mammals, ground-nesting birds, and reptiles would recolonize the site once vegetative cover was reestablished. Larger mammals, such as elk, American black bears, mountain lions, and bobcats, would likely avoid the area. Foragers and hunters (e.g., mule deer, coyotes, and gray foxes) would be excluded by fences around the facility. There are no natural aquatic habitats or wetlands within the immediate vicinity of the GTCC reference location; however, depending on the amount of water in the retention pond and length of retention, certain species (e.g., aquatic invertebrates, waterfowl, shorebirds, amphibians, and mammals) could become established. Several federally and state-listed bird and mammal species occur within the project area. Impacts on these species would likely be small, since the area of habitat disturbance would be small relative to the overall area of such habitat at LANL.

Socioeconomics. Impacts associated with construction and operations of the land disposal facilities would be small. Construction would create direct employment for a maximum of 145 people in the peak construction year and 169 indirect jobs in the ROI (vault method); the annual average employment growth rate would increase by less than 0.1 of a percentage point. The waste facility would produce a maximum of $12.2 million in income in the peak construction year. An estimated 64 people would in-migrate to the ROI as a result of employment on-site; in-migration would have only a marginal effect on population growth and require less than 1% of vacant housing in the peak year. Impacts from operating the facility would also be small, creating a maximum of 51 direct jobs annually and an additional 48 indirect jobs in the ROI (vault method). The disposal facility would produce up to $5.0 million in income annually during operations.

Environmental justice. Because the health impacts on the general population within the 80-km (50-mi) assessment area during construction and operations would be negligible, no impacts on minority and low-income populations as a result of the construction and operations of a GTCC waste disposal facility are expected.

Land use. Portions of TA-54 that are currently designated as reserve or experimental science areas would need to be reclassified as waste management areas. The addition of the facility within TA-54 would expand the area that is currently used for disposal of radioactive waste. Land use in areas surrounding LANL would not be affected.

Transportation. Shipment of all waste to LANL by truck would result in approximately 12,600 shipments involving a total distance of 36 million km (22 million mi). For shipment of all waste by rail, 5,010 railcar shipments involving 14 million km (9 million mi) would be required. It is estimated that no LCFs would occur to the public or crew members for either mode of transportation, but one fatality from an accident could occur.

Cultural resources. There are 18 cultural resources within TA-54. Some of these resources are considered significant and would require consideration under the NHPA. The borehole method has the greatest potential to affect cultural resources because of its 44-ha (110-ac) land requirement. The amount of land needed to employ this method is twice the amount needed to construct a vault or trench. It is expected that the majority of the impacts on cultural resources would occur during the construction phase. Activities associated with operations and post-closure are expected to have a minimal impact on cultural resources since no new ground-disturbing activities would occur during these phases. Section 106 of the NHPA would be followed to determine the impact of the project on significant cultural resources. Local tribes would be consulted to ensure no traditional cultural properties were impacted by the project.

Waste management. The wastes that could be generated from the construction and operations of the land disposal methods are not expected to affect the current waste management programs at LANL.

8.4 CUMULATIVE IMPACTS

Section 5.4 presents the methodology for the cumulative impacts analysis. In the analysis that follows, impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. This section begins with a description of reasonably foreseeable future actions at LANL, including those that are ongoing, under construction, or planned for future implementation. Past and present actions are generally accounted for in the affected environment section (Section 8.1).

8.4.1 Reasonably Foreseeable Future Actions at LANL

Reasonably foreseeable future actions at LANL are summarized in the following sections. These actions were included in the cumulative impacts discussion presented in the 2008 SWEIS (DOE 2008c) and consist of the actions described under "expanded operations alternative" in the SWEIS, other DOE or NNSA actions, and actions planned by other agencies for the region surrounding LANL. The cumulative impacts analysis presented in the 2008 SWEIS is used as the baseline for the discussion of potential cumulative impacts at LANL from the proposed action discussed in this EIS. The actions listed are planned, under construction, or ongoing and may not be inclusive of all actions at the site. However, they should provide an adequate basis for determining potential cumulative impacts at LANL.

8.4.1.1 Radioisotope Power Systems Project

In the RPS Project, radioactive power systems are developed for space exploration and national security missions. DOE is currently supporting RPS production, testing, and delivery operations for a national security mission and for the NASA Mars Science Laboratory mission planned for launch in 2011.

8.4.1.2 Plutonium Facility Complex

The production of pits (detonation device for a nuclear bomb) would be achieved by consolidating a number of plutonium processing and support activities (such as analytical chemistry and materials characterization at the Chemistry and Metallurgy Research Replacement Facility). Pit production is expected to have negligible cumulative impacts at LANL (DOE 2008c).

8.4.1.3 Biosafety Level-3 Facility

Construction on the Biosafety Level-3 (BSL-3) Facility was substantially completed in the fall of 2003, but the facility has not yet been put into operation. The facility is a windowless, single-story, 3,200-ft^2 building, housing one BSL-2 laboratory and two BSL-3 laboratories. DOE is preparing an EIS to evaluate the environmental consequences of operating the BSL-3 Facility, which was built upon fill material, including the ability of the facility to withstand seismic loads (LANL 2010).

8.4.1.4 NNSA Complex Transformation

Under the NNSA Complex Transformation, the U.S. nuclear weapons complex would be modified to one that is smaller, more efficient, more secure, and better able to respond to changes in national security requirements. This action would be covered by the national stockpile, stewardship, and management program (DOE 2008b). The current NNSA Complex consists of sites located in seven states (California, Missouri, Nevada, New Mexico, South Carolina, Tennessee, and Texas). Possible alternatives are to restructure special nuclear materials manufacturing and R&D facilities; consolidate special nuclear materials throughout the NNSA Complex; consolidate, relocate, or eliminate duplicate facilities and programs and improve operating efficiencies; and identify one or more sites for conducting NNSA flight test operations (DOE 2008b). In the December 19, 2008, ROD for the Complex Transformation Supplemental Programmatic EIS (73 FR 245, page 77644), the NNSA stated its decision to continue conducting manufacturing and R&D activities involving plutonium at LANL. To support these activities, it will construct and operate the Chemistry and Metallurgy Research Replacement Nuclear Facility at LANL as a replacement for portions of the Chemistry and Metallurgy Research Facility.

8.4.1.5 BLM Electrical Power Transmission Project

Under the BLM Electrical Power Transmission Project, DOE would construct and operate a 31-km (19-mi) electric transmission power line reaching from the Norton Substation, west across the Rio Grande, to locations within LANL TA-3 and TA-5. The construction of one electric substation at LANL would be included in the project, as would the construction of two line segments less than 366-m (1,200-ft) long that would allow for uncrossing a crossed portion of two existing power lines. In addition, a fiber-optic communications line would be included and installed concurrently as part of the required overhead ground conductor for the power line. The new power line would improve the reliability of electric service in LANL and Los Alamos County areas, as would the uncrossing of the crossed segments of the existing lines. In addition, installation of the new power line would enable the LANL and Los Alamos County electric grid, which is a shared resource, to be adapted to accommodate future increased power imports when additional power service becomes available in northern New Mexico (DOE 2000, 2008a).

8.4.1.6 New Mexico Products Pipeline Project

The New Mexico Products Pipeline Project would involve the construction and operation of two additional segments for an existing petroleum products pipeline between distribution terminals in Odessa, Texas, and Bloomfield, New Mexico. Neither of the new segments would be within 80 km (50 mi) of LANL (DOE 2008a).

8.4.1.7 Mid-America Pipeline Western Expansion Project

The Mid-America Pipeline Western Expansion Project would add 12 separate loop sections to the existing liquefied natural gas pipeline to increase system capacity. A 37-km (23-mi) segment would be placed in Sandoval County, 48 km (30 mi) from the LANL boundary. This segment would be constructed parallel to and 7.6 m (25 ft) away from the existing pipeline ROWs (DOE 2008a).

8.4.1.8 Santo Domingo Pueblo-Bureau of Land Management Land Exchange

The Santo Domingo Pueblo-BLM land exchange involves an equal-value exchange of approximately 2,985 ha (7,376 ac) of BLM lands for 261 ha (645 ac) of Santo Domingo Pueblo land in Santa Fe and Taos Counties. A ROD has not yet been issued for this land exchange (DOE 2008a).

8.4.1.9 Treatment of Saltcedar and Other Noxious Weeds

The treatment of saltcedar and other noxious weeds is an ongoing adaptive management program for the control of exotic weeds at LANL. An environmental assessment prepared for this project resulted in a finding of no significant impact (FONSI). The project area is approximately 64 km (40 mi) from the LANL boundary (DOE 2008a).

8.4.1.10 Buckman Water Diversion Project

The Buckman Water Diversion Project would divert water from the Rio Grande River for use by the City of Santa Fe and Santa Fe County. The diversion project would withdraw water from the Rio Grande approximately 5 km (3 mi) downstream from where SR 4 crosses the river. The pipelines for this project would largely follow existing roads and utility corridors. Decreased water withdrawals from the Buckman Well Field would benefit groundwater levels. Potential impacts on fish and aquatic habitats below the proposed project due to effects on water flow would be minimal (DOE 2008a).

8.4.1.11 46-kV Transmission Loop System

Another project at LANL would upgrade the existing 46-kV transmission loop system that serves central Santa Fe County with a 115-kV system (DOE 2008a).

8.4.2 Cumulative Impacts from the GTCC Proposed Action at LANL

Potential impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. The impacts from Alternatives 3 to 5 at LANL are described in Section 8.2 and summarized in Section 8.3. These sections indicate that the potential impacts from the proposed action (construction and operations of a borehole, trench, or vault facility) for all the resource areas and the transportation of waste would be small. On the basis of the total impacts (including the reasonably foreseeable future actions summarized in Section 8.4.1) reported in the 2008 SWEIS (DOE 2008c), it is unlikely that the additional potential impacts from the GTCC proposed action would contribute substantially to cumulative impacts for the resource areas evaluated for LANL.

To provide perspective, the potential impacts from this EIS were compared to values provided in the *Final Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico* (DOE 2008c). For example, the maximum acreage of land affected by the disposal of GTCC LLRW and GTCC-like waste would be about 44 ha (110 ac). This is a small percentage of the total amount of land (10,360 ha or 40 mi^2 or 25,600 ac) that makes up the 48 contiguous TAs at LANL. The GTCC EIS socioeconomics evaluation indicates that about 51 additional (direct) jobs would be created by the operation of any of the facilities considered. This number is small relative to the 13,500 people who currently work at LANL and the 1,890 new direct jobs projected to be created for the expanded operations alternative at LANL by 2011. With regard to potential worker doses, the GTCC EIS estimate of about 5.2 person-rem/yr is low when compared to the 540 person-rem/yr estimated as the total for LANL from various other activities under the expanded operations alternative.

However, the estimated human health impacts from the GTCC proposed action could add an annual dose of up to 430 mrem/yr or result in an annual LCF risk of 3E-04 (based on the vault disposal method) 1,100 years after closure of the GTCC waste disposal facility at LANL. The performance assessment and composite analysis for LANL TA-54 indicate that the peak mean dose incurred by members of the closest residential communities would be 4 mrem/yr over the compliance period of 1,000 years (LANL 2008). Final considerations regarding any cumulative impacts on human health should incorporate the actual design of the GTCC waste disposal facility at LANL and use similar assumptions and a similar compliance period. Finally, follow-on NEPA evaluations and documents prepared to support any further considerations of siting a new borehole, trench, or vault disposal facility at LANL would provide more detailed analyses of site-specific issues, including cumulative impacts.

8.5 SETTLEMENT AGREEMENTS AND CONSENT ORDERS FOR LANL

A review of existing settlement agreements and consent orders for LANL did not identify any that would contain requirements that would be affected by Alternatives 3 to 5 for this EIS.

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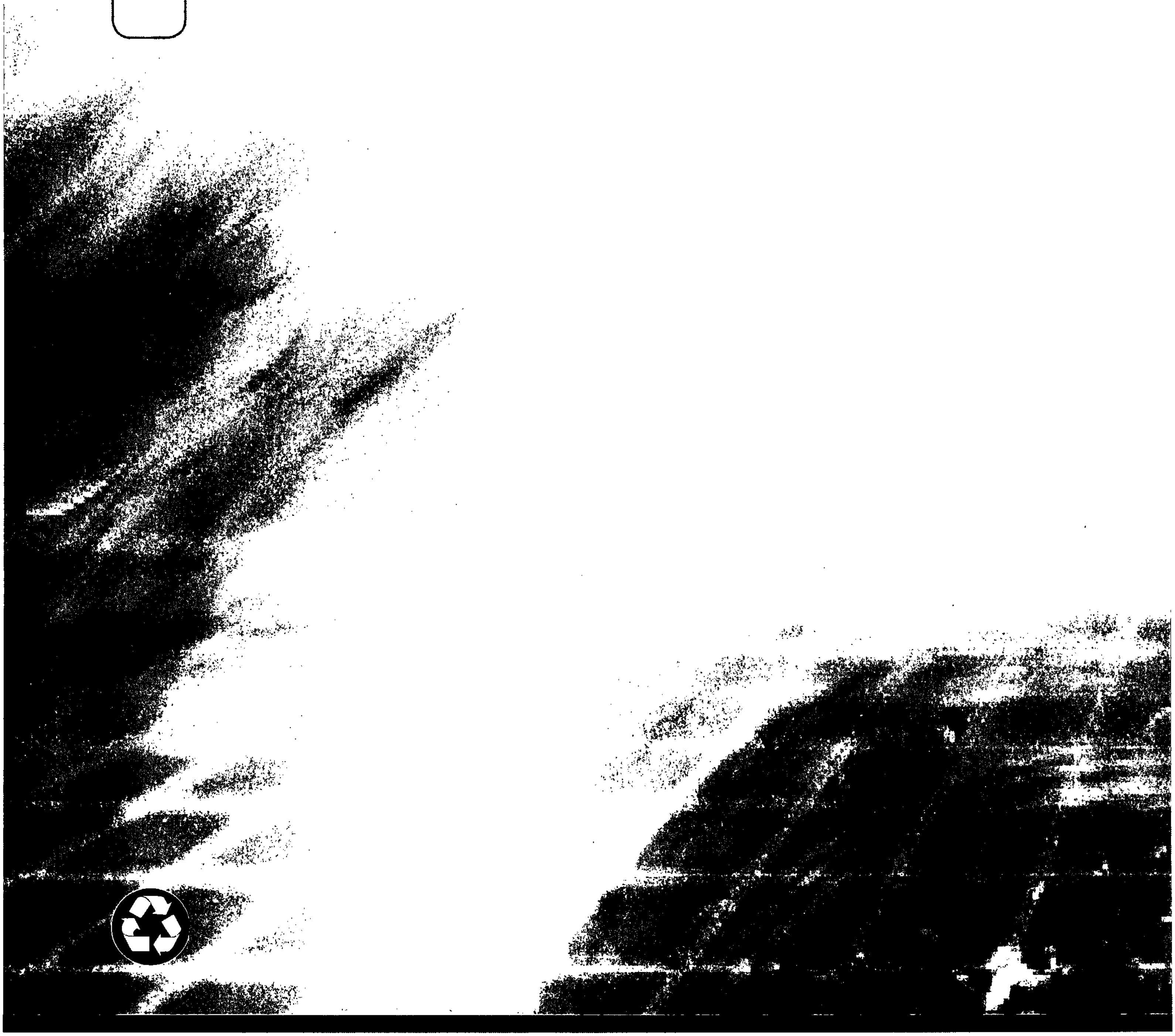
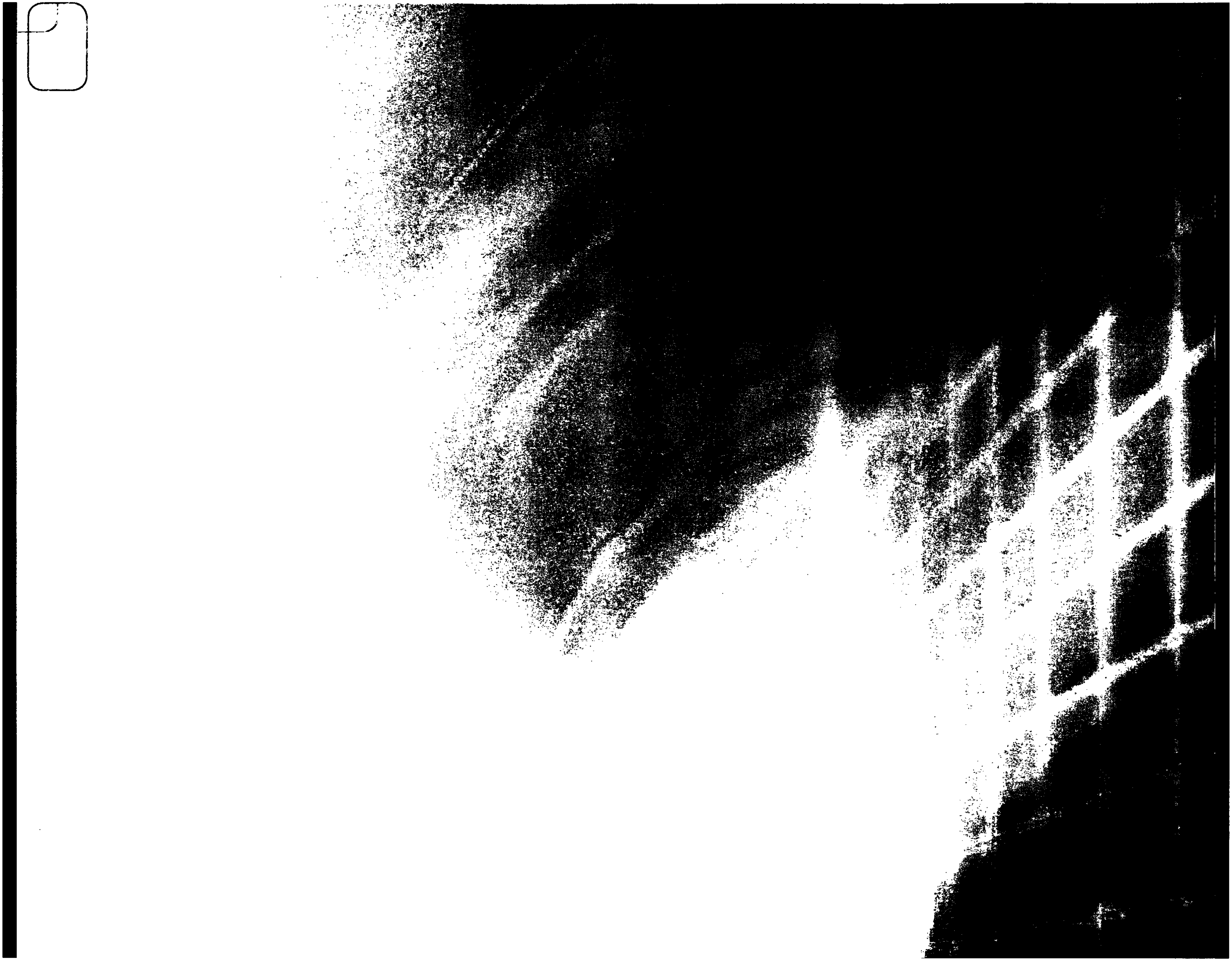
On the cover:

The photographs on the front cover are, from left to right: glove boxes contaminated with GTCC Other Waste, abandoned Am-241 and Cs-137 gauges and shipping shields, and disused well logging sources being loaded into a 55-gallon drum.





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