THE U.S. DEPARTMENT OF ENERGY

Draft Environmental
Impact Statement for the

Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste (DOE/EIS-0375-D)

Volume 1: Chapters 1 through 8

U.S. DEPARTMENT OF ENERGY

February 2011

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.

COVER SHEET

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

Cooperating Agency: U.S. Environmental Protection Agency (EPA)

Title: Draft *Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste* (DOE/EIS-0375-D)

For additional information on this Draft Environmental Impact Statement (EIS), contact:

Arnold Edelman, EIS Document Manager
Office of Environmental Management
U.S. Department of Energy
Cloverleaf Building, EM-43
1000 Independence Avenue, SW
Washington, DC 20585
Telephone: 301-903-5145
Fax: 301-903-7238
Email: arnold.edelman@em.doe.gov

For general information on the DOE National Environmental Policy Act (NEPA) process, contact:

Carol M. Borgstrom, Director
Office of NEPA Policy and Compliance
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585
Telephone: 202-586-4600, or leave a message at 1-800-472-2756

Abstract: The U.S. Department of Energy (DOE) has prepared this Draft *Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste* (Draft GTCC EIS) to evaluate the potential environmental impacts associated with the proposed development, operation, and long-term management of a disposal facility or facilities for GTCC low-level radioactive waste (LLRW) and DOE GTCC-like waste. GTCC LLRW has radionuclide concentrations exceeding the limits for Class C LLRW established by the U.S. Nuclear Regulatory Commission (NRC). These wastes are generated by activities licensed by the NRC or Agreement States and cannot be disposed of in currently licensed commercial LLRW disposal facilities. DOE has prepared and is issuing this Draft EIS in accordance with Section 631 of the Energy Policy Act of 2005.

The NRC LLRW classification system does not apply to radioactive wastes generated or owned by DOE and disposed of in DOE facilities. However, DOE owns or generates LLRW and non-defense-generated transuranic (TRU) radioactive waste, which have characteristics similar to those of GTCC LLRW and for which there may be no path for disposal. DOE has included these wastes for evaluation in this EIS because similar approaches may be used to dispose of both types of radioactive waste. For the purposes of this EIS, DOE is referring to this waste as GTCC-like waste. The total volume of GTCC LLRW and GTCC-like waste addressed in the EIS is about 12,000 m^3 (420,000 ft^3), and it contains about 160 million curies of radioactivity. About three-fourths of this volume is GTCC LLRW, with GTCC-like waste making up the remaining one-fourth of the volume. Much of the GTCC-like waste is TRU waste. DOE has evaluated the potential environmental impacts associated with the range of reasonable alternatives for disposal of GTCC LLRW and GTCC-like waste in this Draft GTCC EIS. DOE will develop the specific

design for the disposal facility or facilities once it has determined the most appropriate approach and location(s) for disposing of this waste.

Alternatives: The Draft GTCC EIS does not identify a preferred alternative because we do not have a preference at this time. DOE will identify its preferred alternative(s) in the Final GTCC EIS. DOE has evaluated five alternatives in this Draft GTCC EIS, including a No Action Alternative. One of the four action alternatives is for disposal of GTCC LLRW and GTCC-like waste in a geologic repository at the Waste Isolation Pilot Plant (WIPP). The other three action alternatives involve the use of land disposal methods at six federally owned sites and at generic commercial sites. The land disposal alternatives consider the use of intermediate-depth borehole, enhanced near-surface trench, and above-grade vault facilities. The land disposal alternatives cover a spectrum of concepts that could be implemented to dispose of these wastes in order to enable an appropriate site and disposal technology to be selected. Each alternative is evaluated with regard to the transportation and disposal of the entire inventory, but the evaluation of human health and transportation impacts is done on a waste-type basis, so decisions can be made on this basis in the future.

Public Comments: DOE issued an Advance Notice of Intent (ANOI) in the *Federal Register* on May 11, 2005, inviting the public to provide preliminary comments on the potential scope of the EIS. DOE then issued a Notice of Intent (NOI) to prepare this EIS on July 23, 2007; a printing correction was issued on July 31, 2007. The NOI provided responses to the major issues identified by commenters on the ANOI, identified the preliminary scope of the EIS, and announced nine public scoping meetings and a formal scoping comment period lasting from July 23 through September 21, 2007. DOE has used all input received during the scoping process to prepare this Draft GTCC EIS.

A 120-day public comment period on this Draft GTCC EIS begins with the publication of the EPA Notice of Availability in the *Federal Register*. This Draft GTCC EIS is available on the GTCC website at http://www.gtcceis.anl.gov and on the DOE NEPA website at http://nepa.energy.gov. DOE will consider all comments postmarked or received during the comment period in preparing the Final GTCC EIS. DOE will consider any comments postmarked after the comment period to the extent practicable. The locations and times of the public hearings on the Draft GTCC EIS will be identified in the *Federal Register* and through other media, such as local press notices. In addition to the public hearings, multiple mechanisms for submitting comments on the Draft GTCC EIS are available.

Website: http://www.gtcceis.anl.gov/

U.S. mail: Arnold Edelman, EIS Document Manager
Office of Environmental Management
U.S. Department of Energy
Cloverleaf Building, EM-43
1000 Independence Avenue, SW
Washington, DC 20585

Fax: 301-903-7238

A MESSAGE TO READERS

I am pleased to present for your review and comment the U.S. Department of Energy's (DOE's) Draft *Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste* (Draft GTCC EIS) (DOE/EIS-0375-D).

The Department is proposing to construct and operate a new facility or facilities, or use an existing facility, for the disposal of GTCC low-level radioactive waste (LLRW) and DOE GTCC-like waste. The Draft GTCC EIS evaluates the potential impacts on human health and the environment that may result from the construction, operations, and long-term management of a facility for the disposal of this waste. Disposal methods analyzed include a geologic repository, an intermediate-depth borehole, an enhanced near-surface trench, and an above-grade vault. Disposal locations analyzed include the Hanford Site in Washington; Idaho National Laboratory in Idaho; the Los Alamos National Laboratory in New Mexico; the Nevada National Security Site (formerly known as Nevada Test Site) in Nevada; the Savannah River Site in South Carolina; and the Waste Isolation Pilot Plant (WIPP) and other areas within and around WIPP (referred to as WIPP Vicinity in the Draft GTCC EIS) in New Mexico. The Draft GTCC EIS also evaluates disposal at generic commercial sites, as well as a No Action Alternative.

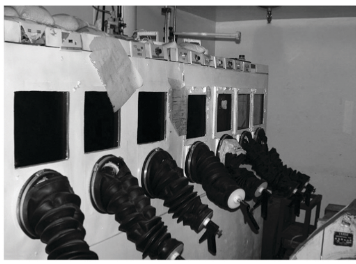
The Draft GTCC EIS does not identify a preferred alternative because we do not have a preference at this time. DOE will identify its preferred alternative(s) in the Final GTCC EIS. We are inviting public comment on this Draft GTCC EIS during a 120-day public comment period. During the comment period, DOE will hold public hearings, to be announced on the Draft GTCC EIS website at http://www.gtcceis.anl.gov, the DOE National Environmental Policy Act (NEPA) website at http://nepa.energy.gov, in the *Federal Register,* and via local print media. DOE will consider public comments in preparing the Final GTCC EIS. As required under the Energy Policy Act of 2005, before we make a decision on the disposal alternative(s) to be implemented, DOE will submit a report to Congress that includes a description of the disposal alternatives under consideration and await action by Congress.

I look forward to receiving your comments on the Draft GTCC EIS and appreciate your continued interest.

Arnold M Edelman

Arnold M. Edelman
EIS Document Manager
U.S. Department of Energy

U.S. DEPARTMENT OF ENERGY



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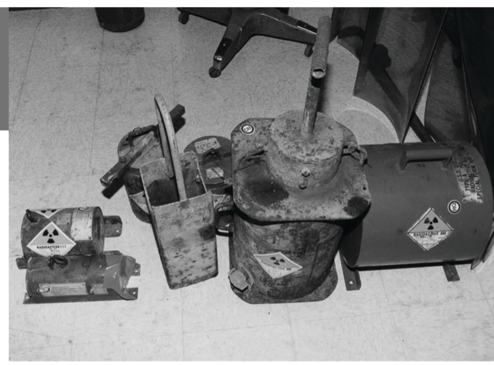

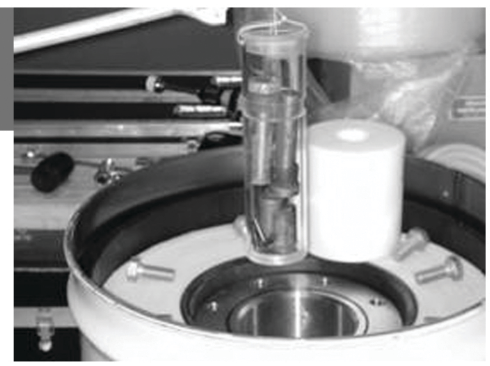

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NOTATION

ACRONYMS AND ABBREVIATIONS

ACHP	Advisory Council on Historic Preservation
AEA	Atomic Energy Act of 1954
AEC	U.S. Atomic Energy Commission
ags	above ground surface
AIP	Agreement in Principle
AIRFA	American Indian Religious Freedom Act of 1978
ALARA	as low as reasonably achievable
AMC	activated metal canister
ATR	Advanced Test Reactor (INL)
ATSDR	Agency for Toxic Substances and Disease Registry
BEIR	Biological Effects of Ionizing Radiation
bgs	below ground surface
BLM	Bureau of Land Management
BLS	Bureau of Labor Statistics
BWR	boiling water reactor
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAP88-PC	Clean Air Act Assessment Package 1988-Personal Computer (code)
CCDF	complementary cumulative distribution function
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area (INL)
CFR	*Code of Federal Regulations*
CGTO	Consolidated Group of Tribes and Organizations
CH	contact-handled
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CWA	Clean Water Act
DCF	dose conversion factor
DCG	derived concentration guide
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE-EM	DOE-Office of Environmental Management
DOE-ID	DOE-Idaho Operations Office
DOE-NV	DOE-Nevada Operations Office
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
DTRA	Defense Threat Reduction Agency

EDE	effective dose equivalent
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act of 1973
ESRP	Eastern Snake River Plain (INL)
FFTF	Fast Flux Test Facility (Hanford)
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FTE	full-time equivalent
FY	fiscal year
GAO	U.S. Government Accountability (formerly General Accounting) Office
GIS	geographic information system
GTCC	greater-than-Class C
GSA	General Separations Area (SRS)
GTRI/OSRP	Global Threat Reduction Initiative/Off-Site Source Recovery Project
HEPA	high-efficiency particulate air
HEU	highly enriched uranium
HF	hydrofluoride
HMS	Hanford Meteorology Station
h-SAMC	half-shielded activated metal canister
ICRP	International Commission on Radiological Protection
IDA	intentional destructive act
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality
INEEL	Idaho National Engineering and Environmental Laboratory
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (INL)
IPCC	Intergovernmental Panel on Climate Change
ISFSI	independent spent fuel storage installation
LANL	Los Alamos National Laboratory
LCF	latent cancer fatality
L_{dn}	day-night sound level
L_{eq}	equivalent-continuous sound level
LLNL	Lawrence Livermore National Laboratory
LLRW	low-level radioactive waste
LLRWPAA	Low-Level Radioactive Waste Policy Amendments Act of 1985
LMP	Land Management Plan (WIPP)
LWA	Land Withdrawal Act (WIPP)
LWB	Land Withdrawal Boundary (WIPP)

MCL	maximum contaminant level
MDA	material disposal area (LANL)
MMI	Modified Mercalli Intensity
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MSL	mean sea level
NAAQS	National Ambient Air Quality Standard(s)
NAGPRA	Native American Graves Protection and Repatriation Act of 1990
NASA	National Aeronautics and Space Administration
NCDC	National Climatic Data Center
NCRP	National Council on Radiation Protection and Measurements
NDA	NRC-licensed disposal area (West Valley Site)
NEPA	National Environmental Policy Act of 1969
NERP	National Environmental Research Park
NESHAP	National Emission Standard for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NMAC	*New Mexico Administrative Code*
NMED	New Mexico Environment Department
NNSA	National Nuclear Security Administration (DOE)
NNSA/NSO	NNSA/Nevada Site Office
NNSS	Nevada National Security Site (formerly Nevada Test Site or NTS)
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NRHP	*National Register of Historic Places*
NTS SA	Nevada Test Site Supplemental Analysis
PCB	polychlorinated biphenyl
PCS	primary constituent standard
P.L.	Public Law
PM	particulate matter
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 μm or less
PM_{10}	particulate matter with an aerodynamic diameter of 10 μm or less
PSD	Prevention of Significant Deterioration
PWR	pressurized water reactor
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RDD	radiological dispersal device
RH	remote-handled
ROD	Record of Decision
ROI	region of influence
ROW	right-of-way

RWMC	Radioactive Waste Management Complex (INL)
RWMS	Radioactive Waste Management Site (NNSS)
SAAQS	State Ambient Air Quality Standards
SDA	state-licensed disposal area (West Valley Site)
SDWA	Safe Drinking Water Act
SHPO	State Historic Preservation Office(r)
SNF	spent nuclear fuel
SRS	Savannah River Site
SWB	standard waste box
SWEIS	Site-Wide Environmental Impact Statement
TA	Technical Area (LANL)
TC&WM EIS	Tank Closure and Waste Management EIS (Hanford)
TDEC	Tennessee Department of Environment and Conservation
TEDE	total effective dose equivalent
TLD	thermoluminescent dosimeter
TRAGIS	Transportation Routing Analysis Information System
TRU	transuranic
TRUPACT-II	Transuranic Package Transporter-II
TSCA	Toxic Substances Control Act
TSP	total suspended particulates
TVA	Tennessee Valley Authority
USACE	U.S. Army Corps of Engineers
USC	*United States Code*
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compound
WAC	waste acceptance criteria or *Washington Administrative Code*
WHB	Waste Handling Building (WIPP)
WIPP	Waste Isolation Pilot Plant
WSRC	Westinghouse Savannah River Company
WTP	Waste Treatment Plant (Hanford)

UNITS OF MEASURE

ac	acre(s)
ac-ft	acre-foot (feet)
°C	degree(s) Celsius
cfs	cubic foot (feet) per second
Ci	curie(s)
cm	centimeter(s)
cms	cubic meter(s) per second
d	day(s)
dB	decibel(s)
dBA	A-weighted decibel(s)
°F	degree(s) Fahrenheit
ft	foot (feet)
ft^2	square foot (feet)
ft^3	cubic foot (feet)
g	gram(s) or acceleration of gravity (9.8 m/s/s)
gal	gallon(s)
gpd	gallon(s) per day
gpm	gallon(s) per minute
h	hour(s)
ha	hectare(s)
hp	horsepower
in.	inch(es)
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
kph	kilometer(s) per hour
kV	kilovolt(s)
L	liter(s)
lb	pound(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
MCi	megacurie(s)
mg	milligram(s)
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
mL	milliliter(s)
mm	millimeter(s)
mph	mile(s) per hour
mR	milliroentgen(s)
mrem	millirem
mSv	millisievert(s)
MW	megawatt(s)
MWh	megawatt-hour(s)
nCi	nanocurie(s)
oz	ounce(s)
pCi	picocurie(s)
ppb	part(s) per billion
ppm	part(s) per million
R	roentgen(s)
rad	radiation absorbed dose
rem	roentgen equivalent man
s	second(s)
t	metric ton(s)
VdB	vibration velocity decibel(s)
yd	yard(s)
yd^2	square yard(s)
yd^3	cubic yard(s)
yr	year(s)
µg	microgram(s)
µm	micrometer(s)

CONVERSION TABLE[a]

Multiply	By	To Obtain
English/Metric Equivalents		
acres (ac)	0.4047	hectares (ha)
cubic feet (ft^3)	0.02832	cubic meters (m^3)
cubic yards (yd^3)	0.7646	cubic meters (m^3)
degrees Fahrenheit (ºF) –32	0.5555	degrees Celsius (ºC)
feet (ft)	0.3048	meters (m)
gallons (gal)	3.785	liters (L)
gallons (gal)	0.003785	cubic meters (m^3)
inches (in.)	2.540	centimeters (cm)
miles (mi)	1.609	kilometers (km)
pounds (lb)	0.4536	kilograms (kg)
short tons (tons)	907.2	kilograms (kg)
short tons (tons)	0.9072	metric tons (t)
square feet (ft^2)	0.09290	square meters (m^2)
square yards (yd^2)	0.8361	square meters (m^2)
square miles (mi^2)	2.590	square kilometers (km^2)
yards (yd)	0.9144	meters (m)
Metric/English Equivalents		
centimeters (cm)	0.3937	inches (in.)
cubic meters (m^3)	35.31	cubic feet (ft^3)
cubic meters (m^3)	1.308	cubic yards (yd^3)
cubic meters (m^3)	264.2	gallons (gal)
degrees Celsius (ºC) +17.78	1.8	degrees Fahrenheit (ºF)
hectares (ha)	2.471	acres (ac)
kilograms (kg)	2.205	pounds (lb)
kilograms (kg)	0.001102	short tons (tons)
kilometers (km)	0.6214	miles (mi)
kilometers per hour (kph)	0.6214	miles per hour (mph)
liters (L)	0.2642	gallons (gal)
meters (m)	3.281	feet (ft)
meters (m)	1.094	yards (yd)
metric tons (t)	1.102	short tons (tons)
square kilometers (km^2)	0.3861	square miles (mi^2)
square meters (m^2)	10.76	square feet (ft^2)
square meters (m^2)	1.196	square yards (yd^2)

[a] Values presented in this Draft GTCC EIS have been converted (as necessary) by using the above conversion table and rounded to two significant figures.

GLOSSARY

Accident	An unplanned event or sequence of events that results in undesirable consequences.
Actinide	Any member of the group of elements with atomic numbers from 89 (actinium) to 103 (lawrencium), including uranium and plutonium. All members of this group are radioactive.
Activated metal	Metal that has been irradiated by neutrons, protons, or other nuclear particles (such as what occurs in a nuclear reactor), producing radionuclides that can emit significant gamma radiation.
Activation product	An element that is formed by absorption of neutrons, protons, or other nuclear particles and thus may be radioactive. (See neutron and proton.)
Acute exposure	A single, short-term exposure to radiation, a toxic substance, or other stressors that may result in biological harm. Pertaining to radiation, the exposure incurred during and shortly after a large radiological release.
Administrative control	Provisions related to organization and management, procedures, record-keeping, assessment, and reporting that are necessary to ensure the safe operation of a facility.
Affected environment	The existing biological, physical, social, and economic conditions of an area that are subject to direct and/or indirect changes as a result of a proposed human action.
Air pollutant	Generally, an airborne substance that could, in high enough concentrations, harm living things or cause damage to materials. From a regulatory perspective, an air pollutant is a substance for which emissions or atmospheric concentrations are regulated or for which maximum guideline levels have been established because of its potential to have harmful effects on human health and welfare.

Air quality The cleanliness of the air as measured by the levels of pollutants relative to standards or guideline levels established to protect human health and welfare. Air quality is often expressed in terms of the pollutant for which concentrations are the highest percentage of a standard (e.g., air quality may be unacceptable if the level of one pollutant is 150% of its standard, even if levels of other pollutants are well below their respective standards).

ALARA Acronym for *as low as reasonably achievable.*

Alkaline Having the properties of a soluble mineral salt capable of neutralizing acids.

Alluvium (alluvial) Unconsolidated, poorly sorted detrital sediments deposited by streams and ranging in size from clay to gravel.

Alpha activity The emission of alpha particles by radioactive materials.

Alpha particle A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus and has a mass number of 4 and a charge of +2. It has low penetrating power and a short range (a few centimeters in air).

Alpha radiation A strongly ionizing, but weakly penetrating, form of radiation consisting of positively charged alpha particles emitted spontaneously from the nuclei of certain elements during radioactive decay. Alpha radiation is the least penetrating of the four common types of ionizing radiation (alpha, beta, gamma, and neutron). Even the most energetic alpha particle generally fails to penetrate the dead layers of cells covering the skin and can be easily stopped by a sheet of paper. Alpha radiation is most hazardous when an alpha-emitting source is inside an organism.

Alternative One of two or more actions, processes, or propositions from which a decision-maker will determine the course to be followed. The National Environmental Policy Act of 1969 (NEPA), as amended, states that in preparing an environmental impact statement (EIS), an agency "shall ... study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources" (Title 42 of the *United States Code,* Section 4322(2)(E)). Council on Environmental Quality NEPA-implementing regulations indicate that the alternatives section in an EIS is "the heart of the environmental impact statement" (40 CFR 1502.14), and the regulations include procedures for presenting the alternatives, including the no action alternative, and their estimated impacts.

Ambient Surrounding.

Ambient air The atmosphere surrounding people, plants, and structures.

Ambient air quality standards As prescribed by regulations, the level of pollutants in the air that may not be exceeded during a specified time in a defined area. Air quality standards are used to provide a measure of the health-related and visual characteristics of the air.

Amphibian Class of cold-blooded, scaleless vertebrates that usually begin life with gills and then develop lungs.

Anadromous Fish (such as salmon) that ascend freshwater streams from saltwater bodies of water to spawn.

Anion A negatively charged ion.

Aquatic Living or growing in, on, or near water.

Aquatic biota The sum total of living organisms within any designated aquatic area.

Aquifer A body of rock or sediment that is capable of transmitting groundwater and yielding usable quantities of water to wells or springs.

Aquitard A semipermeable geologic unit that inhibits the flow of water.

Archaeological sites Any location where humans have discarded artifacts or otherwise altered the terrain during prehistoric or historic times.

Artifact An object produced or shaped by human workmanship that is of archaeological or historical interest.

As low as reasonably achievable (ALARA) An approach to radiation protection designed to manage and control worker and public exposures (both individual and collective) and releases of radioactive material to the environment to as far below applicable limits as social, technical, economic, practical, and public policy considerations permit. ALARA is not a dose limit but a process for minimizing doses to as far below limits as is practicable.

Atmospheric dispersion The distribution of pollutants from their source into the atmosphere by wind, turbulent air motion attributable to solar heating of the earth's surface, or air movement over rough terrain and variable land and water surfaces.

Atomic Energy Commission (AEC) A commission established by the Atomic Energy Act of 1946. Its functions included responsibility for the development and production of nuclear weapons and the regulation of civilian uses of nuclear material. In 1974, the AEC was abolished, and functions were transferred to the U.S. Nuclear Regulatory Commission and the Administrator of the Energy Research and Development Administration (ERDA). ERDA was later terminated, and functions vested by law in the Administrator were transferred to the Secretary of Energy.

Atomic number The number of positively charged protons in the nucleus of an atom or the number of electrons on an electrically neutral atom.

Attainment area An area that the U.S. Environmental Protection Agency has designated as being in compliance with one or more of the National Ambient Air Quality Standards (NAAQS) for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. An area may be in attainment for some pollutants but not for others.

Attenuate	In the context of this environmental impact statement, to reduce, over time, the concentration of a chemical (usually through adsorption, degradation, dilution, and/or transformation) or a radionuclide (through radioactive decay).
Background radiation	Radiation from (1) natural sources of radiation including cosmic rays, (2) naturally occurring radionuclides in the environment such as radon, (3) radionuclides in the body such potassium-40, and (4) man-made sources of radiation including medical procedures and consumer products. The average annual dose from background radiation to an individual in the United States is about 620 mrem/yr.
Backfill	Excavated earth or other material transferred into an open trench, cavity, or other opening in the earth.
Barrier	Any material or structure that prevents or substantially delays movement of constituents toward the accessible environment, especially an engineered structure used to isolate contaminants from the environment in accordance with appropriate regulations.
Basalt	The most common volcanic rock, dark gray to black in color, high in iron and magnesium, low in silica, and typically found in lava flows.
Baseline	The existing environmental conditions against which the impacts of the proposed actions and their alternatives can be compared.
Basin	Geologically, a circular or elliptical downwarp or depression in the earth's surface that collects sediment. Younger sedimentary beds occur in the center of basins. Topographically, a depression into which water from the surrounding area drains.
Becquerel	A unit of radioactivity equal to one disintegration per second. Thirty-seven billion becquerels equal 1 curie.
Bedrock	The solid rock that lies beneath soil and other loose surface materials.

BEIR VII The seventh in a series of committee reports from the National Research Council on the biological effects of ionizing radiation, published in 2006. BEIR VII updates BEIR V, using epidemiologic and experimental research information accumulated since the BEIR V report to develop the best possible risk estimate for exposure experienced by radiation workers and members of the general public.

Beryllium An extremely lightweight element with the atomic number 4. It is metallic and is used in nuclear reactors as a neutron reflector.

Best management practices (BMPs) Structural, nonstructural, and managerial techniques, other than effluent limitations, to prevent or reduce pollution of the environment. They are the most effective and practical means to control pollutants that are compatible with the productive use of the resource to which they are applied. BMPs can include schedules of activities; prohibitions of practices; maintenance procedures; treatment requirements; operating procedures; and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Beta emitter A radioactive substance that decays by releasing a beta particle.

Beta particle A particle emitted in the radioactive decay of many radionuclides. A beta particle can be either positive (positron) or negative (negatron), and a negatron is identical to an electron. It has a short range in air and a limited ability to penetrate other materials; it can be stopped by clothing or a thin sheet of metal.

Beta radiation Ionizing radiation consisting of fast-moving, positively or negatively charged elementary particles emitted from atomic nuclei during radioactive decay. Beta radiation is more penetrating but less ionizing than is alpha radiation. Beta particles can be stopped by clothing or a thin sheet of metal.

Biodiversity The diversity of life forms and their levels of organization.

Biota (biotic) The plant and animal life of a region.

Block U.S. Census Bureau term for small areas bounded on all sides by visible features or political boundaries; used in tabulation of census data.

Borehole As used in this environmental impact statement, a deep and relatively narrow hole drilled into the surface of the earth that can be used for the disposal of radioactive waste.

Borrow Excavated material that has been taken from one area to be used as raw material or fill at another location.

Borrow area (pit, site) An area designated as the excavation site for geologic resources, such as rock/basalt, sand, gravel, or soil, that are to be used elsewhere for fill.

BWR Acronym for *boiling water reactor,* one of two reactor types used in commercial nuclear power plants in the United States. The other reactor type is a pressurized water reactor (PWR).

By-product material (1) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or using special nuclear material; (2) the tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes (underground ore bodies depleted by these solution extraction operations do not constitute “by-product material” within this definition); (3)(i) any discrete source of radium-226 that is produced, extracted, or converted after extraction, before, on, or after August 8, 2005, for use for a commercial, medical, or research activity, or (ii) any material that (A) has been made radioactive by use of a particle accelerator and that (B) is produced, extracted, or converted after extraction, before, on, or after August 8, 2005, for use for a commercial, medical, or research activity; and (4) any discrete source of naturally occurring radioactive material, other than source material, that (i) the NRC, in consultation with the Administrator of EPA, Secretary of DOE, Secretary of Homeland Security, and head of any other appropriate federal agency, determines would pose a threat similar to the threat posed by a discrete source of radium-226 to the public health and safety or the common defense and security, and that (ii) before, on, or after August 8, 2005, is extracted or converted after extraction for use in a commercial, medical, or research activity.

Cancer The name given to a group of diseases characterized by uncontrolled cellular growth in which the cells have invasive characteristics that enable the disease to transfer from one organ to another.

Candidate species Plant or animal native to the United States for which the U.S. Fish and Wildlife Service or the National Marine Fisheries Service has sufficient information on its biological vulnerability and threats to justify proposing to add it to the threatened and endangered species list, but for which the Service cannot do so immediately because other species have a higher priority for listing. The Services determine the relative listing priority of candidate taxa in accordance with general listing priority guidelines published in the *Federal Register.* (See endangered species and threatened species.)

Canister A general term for a metal container, usually cylindrical, used in the handling, storage, transportation, or disposal of waste.

Canyon A large, heavily shielded, concrete building containing a remotely operated plutonium or uranium processing facility.

Cap A cap used to cover a radioactive burial ground with soil, rock, vegetation, or other materials as part of the facility closure process. The cap is designed to reduce the migration of radioactive and hazardous materials in the waste caused by the infiltration of water or the intrusion of humans, plants, or animals from the surface.

Capable fault In general, a geologic fault along which it is mechanically feasible for sudden slip (i.e., earth motion) to occur.

Carbonate A salt or ester of carbonic acid.

Carbon dioxide A colorless, odorless gas that is a normal component of ambient air and a product of fossil fuel combustion, animal expiration, or the decay or combustion of animal or vegetable matter.

Carbon monoxide	A colorless, odorless, poisonous gas produced by incomplete fossil fuel combustion.
Carcinogen	A substance or agent that produces or incites cancerous growth.
Cask	A heavily shielded container used to store or ship radioactive materials.
Cation	A positively charged ion.
Characteristic waste	Solid waste that is classified as hazardous waste because it exhibits any of the following properties or characteristics: ignitability, corrosivity, reactivity, or toxicity, as described in 40 CFR 261.20 through 261.24.
Chronic exposure	The continuous or intermittent exposure of an organism to a stressor (e.g., a toxic substance or ionizing radiation) over an extended period of time or a significant fraction (often 10% or more) of the life span of the organism. Generally, chronic exposure is considered to produce effects that can be observed only some time after the initial exposure. Examples of these effects include impaired reproduction or growth, genetic effects, cancer, precancerous lesions, benign tumors, cataracts, skin changes, and congenital defects.
Class I area	A specifically designated area where the degradation of air quality is stringently restricted; examples include many national parks and wilderness areas.
Class II area	Areas that are generally cleaner than air quality standards require and in which moderate increases in new pollution are allowed after a regulatory-mandated impacts review. Most of the country that is not designated as Class I is designated as Class II.
Clastic	Rock or sediment made up of primarily broken fragments of preexisting rocks or minerals.
Clay	A family of finely crystalline sheet silicate minerals that commonly form as a product of rock weathering; also, any particle that is about 0.002 millimeter (0.00008 inch) or smaller in diameter.

Clean Air Act An act that mandates and provides for the enforcement of regulations to control air pollution from various sources.

Clean Water Act of 1972, 1987 An act that regulates the discharge of pollutants from a point source into navigable waters of the United States in compliance with a National Pollutant Discharge Elimination System permit and that regulates discharges to or the dredging of wetlands.

Closure The deactivation and stabilization of a waste treatment, storage, or disposal unit (such as a waste treatment tank, waste storage building, or landfill) or hazardous materials storage unit (such as an underground storage tank). For storage units, closure typically includes removal of all residues, contaminated system components, and contaminated soil. For disposal units (i.e., where waste is left in place), closure typically includes site stabilization and emplacement of caps or other barriers. Specific requirements for the closure process are found in the regulations applicable to many types of waste management units and hazardous material storage facilities.

***Code of Federal Regulations* (CFR)** Publication in which all federal regulations that are in effect are published in codified form.

Collective dose The sum of the individual doses received in a given period of time by a specified population as a result of exposure to a specified source of radiation. It is expressed in units of person-rem.

Committed effective dose equivalent (CEDE) The dose value obtained by (1) multiplying the committed dose equivalents for the organs or tissues that are irradiated and the weighting factors applicable to those organs or tissues and (2) summing all the resulting products. It is expressed in units of rem.

Community As used for analyzing environmental justice concerns, a group of people or a site within a spatial scope that is exposed to risks that could threaten health, ecology, or land values or that is exposed to an activity or industry that could stimulate unwanted noise, smell, industrial traffic, particulate matter, or other nonaesthetic impacts.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)	A federal law (also known as Superfund), enacted in 1980 and reauthorized in 1986 that provides the legal authority for emergency response and cleanup of hazardous substances released into the environment and for the cleanup of inactive waste sites.
Conformity	Defined in the Clean Air Act as the action's compliance with an implementation plan's purpose of eliminating or reducing the severity and number of violations of the National Ambient Air Quality Standards and achieving expeditious attainment of such standards. Such activities will not cause or contribute to any new violation of any standard in any area; increase the frequency or severity of any existing violation of any standard in any area; or delay timely attainment of any standard, any required interim emission reduction, or other milestones in any area.
Contact-handled waste	Radioactive waste or waste packages whose external dose rate is low enough to permit contact-handling by humans during normal waste management activities (e.g., waste with a surface dose rate not exceeding 200 millirem per hour).
Container	With regard to radioactive waste, the outside envelope in the waste package that provides the primary containment function of the waste package.
Contamination	Deposition of undesirable material in air, soils, water, or ecological resources or on the surfaces of structures, areas, objects, or personnel.
Cooperating agency	According to 40 CFR 1508.5, "Any federal agency (other than a lead agency) that has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major federal action significantly affecting the quality of the human environment."

Criteria pollutant An air pollutant that is regulated by National Ambient Air Quality Standards (NAAQS). The U.S. Environmental Protection Agency must describe the characteristics and potential health and welfare effects that form the basis for setting or revising the standard for each regulated pollutant. Criteria pollutants include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and two size classes of particulate matter: equal to or less than 10 micrometers (0.0004 inch) in diameter, and equal to or less than 2.5 micrometers (0.0001 inch) in diameter. New pollutants may be added to or removed from the list of criteria pollutants as more information becomes available. (See National Ambient Air Quality Standards.) Note: Sometimes pollutants regulated by state laws are also called criteria pollutants.

Critical habitat Habitat essential to the conservation of an endangered or threatened species that has been designated as critical by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service by following the procedures outlined in the Endangered Species Act and its implementing regulations (50 CFR Part 424). (See endangered species and threatened species.) The lists of critical habitats can be found in 50 CFR 17.95 for fish and wildlife, 50 CFR 17.96 for plants, and 50 CFR Part 226 for marine species.

Critical organ The body organ receiving a radionuclide or radiation dose that would result in the greatest overall damage to the body. Specifically, that organ in which the dose equivalent would be most significant due to a combination of the organ's radiological sensitivity and the dose distribution throughout the body.

Criticality The condition in which a system is capable of sustaining a nuclear chain reaction. A chain reaction occurs when a neutron induces a nucleus to fission and the fissioning nucleus releases one or more neutrons that induce other nuclei to fission.

Cultural resources Archaeological sites, historical sites, architectural features, traditional use areas, and American Indian sacred sites. (See archaeological sites and historic resources.)

Cumulative impacts Impacts on the environment that result when the incremental impact of a proposed action is added to the impacts from other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes the other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Curie (Ci) A unit of radioactivity equal to 37 billion disintegrations per second (i.e., 37 billion becquerels); also, a quantity of any radionuclide or mixture of radionuclides having 1 curie of radioactivity.

Deactivation Placing a facility in a stable and known condition (including removing hazardous and radioactive materials) to ensure adequate protection of workers, public health and safety, and the environment, which thereby limits the long-term cost of surveillance and maintenance. Actions include the removing fuel, draining and/or de-energizing nonessential systems, and removing stored radioactive and hazardous materials. Deactivation does not include all the decontamination necessary for the dismantlement and demolition phase of decommissioning (e.g., removing contamination remaining in fixed structures and equipment after deactivation).

Decay, radioactive The decrease in the amount of any radioactive material with the passage of time due to spontaneous nuclear disintegration at a characteristic rate specified by the radionuclide’s half-life.

Decibel A unit for expressing the relative intensity of sounds on a logarithmic scale, from zero for the average least perceptible sound to about 130 for the average level at which sound causes pain to humans. For traffic and industrial noise measurements, the A-weighted decibel (dBA), a frequency-weighted noise unit, is widely used. The A-weighted decibel scale corresponds approximately to the frequency response of the human ear and thus correlates well with loudness.

Decommissioning The process of closing and securing a nuclear facility or nuclear material storage facility to provide adequate protection from radiation exposure and to isolate radioactive contamination from the human environment. It takes place after deactivation and includes surveillance, maintenance, decontamination, and/or dismantlement. These actions are taken at the end of the facility's life to retire it from service with adequate regard for the health and safety of workers and the public and protection of the environment.

Decontamination The removal or reduction of residual chemical, biological, or radiological contaminants and hazardous materials by mechanical, chemical, or other techniques to achieve a stated objective or end condition.

Defense-generated Radioactive waste that is generated by atomic energy defense activities, which are defined by the Nuclear Waste Policy Act of 1982 to mean activities of the U.S. Department of Energy (and predecessor agencies) that are/were performed in whole or in part in carrying out any of the following functions: naval reactor development; weapons activities, including defense inertial confinement fusion; verification and control technology; production of defense nuclear material; management of defense nuclear waste and material by-products; defense nuclear material security and safeguards and security investigations; and defense research and development.

Deposition In geology, the laying down of potential rock-forming materials; sedimentation. In atmospheric transport, the settling out of atmospheric aerosols and particles on ground and building surfaces ("dry deposition") or their removal from the air to the ground by precipitation ("wet deposition" or "rainout").

Derived concentration guide The concentration of a radionuclide in air or water that would, under conditions of continuous exposure for 1 year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), result in an effective dose equivalent of 100 millirem.

Dermal Of or pertaining to the skin or other external body covering.

Design basis	For nuclear facilities, information that identifies the specific functions to be performed by a structure, system, or component and the specific values (or ranges of values) chosen for controlling parameters for reference bounds for design. These values may be (1) restraints derived from generally accepted state-of-the-art practices for achieving functional goals; (2) requirements derived from analysis (based on calculations and/or experiments) of the effects of a postulated accident for which a structure, system, or component must meet its functional goals; or (3) requirements derived from federal safety objectives, principles, goals, or requirements.
Dip	A measure of the angle between the flat horizon and the slope of a sedimentary layer, fault plane, metamorphic foliation, or other geologic structure.
Direct jobs	The number of workers required at a site to implement an alternative.
Discharge	In surface water hydrology, the amount of water issuing from a spring or in a stream that passes a specific point in a given period of time.
Disintegration	Any transformation of a nucleus, whether spontaneous or induced by irradiation, in which the nucleus emits one or more particles or photons.
Disposal	As generally used in this environmental impact statement, the emplacement of waste with no intent to retrieve. Statutory or regulatory definitions of disposal may differ.
DOE Order	Contains requirements internal to the U.S. Department of Energy and its contractors that establish policy and procedures, including those to follow in order to comply with applicable laws.
Dose (radiological)	A generic term meaning absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or committed equivalent dose, as defined elsewhere in this glossary.

Dose commitment The total dose equivalent that a body, organ, or tissue would receive during a specified period of time (e.g., 50 years) as a result of intake (as by ingestion or inhalation) of one or more radionuclides from a defined release.

Dose equivalent A measure of radiological dose that correlates with biological effect on a common scale for all types of ionizing radiation. Defined as a quantity equal to the absorbed dose in tissue multiplied by a quality factor (the biological effectiveness of a given type of radiation) and all other necessary modifying factors at the location of interest.

Dose rate The radiation dose delivered per unit of time (e.g., rem per year). (See dose, ionizing radiation, and roentgen equivalent man [rem].)

Drinking water standards The maximum permissible levels of constituents or characteristics in a drinking water supply as specified by the Safe Drinking Water Act (Title 42 of the *United States Code,* Section 300(f) et seq.).

Ecology A branch of science dealing with the interrelationships of living organisms with one another and with their nonliving environment.

Ecosystem A community of organisms and their physical environment interacting as an ecological unit.

Effective dose equivalent The dose value obtained by multiplying the dose equivalents received by specified tissues or organs of the body by the appropriate weighting factors applicable to the tissues or organs irradiated, and then summing all of the resulting products. It includes the dose from radiation sources internal and external to the body. The effective dose equivalent is expressed in units of rem or mrem.

Effluent A waste stream flowing into the atmosphere, surface water, groundwater, or soil. Most frequently, it applies to wastes discharged to surface waters.

Electron An elementary particle with a mass of 9.107×10^{-28} grams (or 1/1,837 of a proton) and a negative charge. Electrons surround the positively charged nucleus and determine the chemical properties of the atom.

Emission — A material discharged into the atmosphere from a source operation or activity.

Emission standard — A requirement established by the applicable state or the U.S. Environmental Protection Agency that limits the quantity, rate, or concentration of air pollutant emissions on a continuous basis, including any requirement related to (1) the operation or maintenance of a source to ensure a continuous emission reduction and (2) any design, equipment, work practice, or operational standard.

Endangered species — Plant or animal that is in danger of extinction through all or a significant portion of its range and that has been listed as endangered by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service following the procedures outlined in the Endangered Species Act and its implementing regulations (50 CFR Part 424). The lists of endangered species can be found in 50 CFR 17.11 for wildlife, 50 CFR 17.12 for plants, and 50 CFR 222.23(a) for marine organisms. Note: Some states also list species as endangered. Thus, in certain cases, a state definition would also be appropriate.

Enhanced near-surface disposal — As used in this environmental impact statement, near-surface disposal methods that include additional measures beyond those typically used to dispose of low-level radioactive waste. A near-surface land disposal facility is where radioactive waste is disposed of in or within the upper 30 meters of the earth's surface.

Environmental impact statement (EIS) — The detailed written statement that is required by Section 102(2)(C) of the National Environmental Policy Act (NEPA) for a proposed major federal action significantly affecting the quality of the human environment.
A U.S. Department of Energy EIS is prepared in accordance with applicable requirements of the Council on Environmental Quality NEPA regulations in 40 CFR Parts 1500–1508 and the DOE NEPA regulations in 10 CFR Part 1021. The statement includes, among other information, discussions of (1) the environmental impacts of the proposed action and all reasonable alternatives, (2) adverse environmental effects that can not be avoided should the proposal be implemented, (3) the relationship between short-term uses of the human environment and enhancement of long-term productivity, and (4) any irreversible and irretrievable commitments of resources.

Environmental justice The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic groups, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies. Executive Order 12898 directs federal agencies to make achieving environmental justice part of their missions by identifying and addressing disproportionately high and adverse effects from agency programs, policies, and activities on minority and low-income populations.

Epicenter The point on the earth's surface directly above the focus of an earthquake.

Ephemeral stream A stream that flows only after a period of heavy precipitation.

Erosion Removal of material by water, wind, or ice.

Exposure The condition of being subject to the effects of or acquiring a dose of a potential stressor such as a hazardous chemical agent or ionizing radiation. Exposure can be quantified as the amount of the agent available at various boundaries of the organism (e.g., skin, lungs, gut) and available for absorption. In the radiological context, exposure refers to the state of being irradiated by ionizing radiation or the incidence of radiation on living or inanimate material. More specifically, radiation exposure is a dosimetric quantity for ionizing radiation that is based on the ability of radiation to produce ionizations in air.

Exposure pathway The course a chemical or physical agent takes from the source to the exposed organism. An exposure pathway describes a mechanism by which chemicals or physical agents at or originating from a release site reach an individual or population. Each exposure pathway includes a source or release from a source, an exposure route, and an exposure point. If the exposure point differs from the source, a transport/exposure medium such as air or water is also included.

External dose or exposure The portion of the dose equivalent received from radiation sources external to the body.

Fault A fracture or a zone of fractures within a rock formation along which vertical, horizontal, or transverse slippage has occurred. A normal fault occurs when the hanging wall has been depressed in relation to the footwall. A reverse fault occurs when the hanging wall has been raised in relation to the footwall.

Fill material Soil, rock, gravel, or other matter that is placed at a specified location to bring the ground surface up to a desired elevation.

Fission A nuclear transformation that is typically characterized by the splitting of a heavy nucleus into at least two other nuclei, the emission of one or more neutrons, and the release of a relatively large amount of energy. Fission of heavy nuclei can occur spontaneously or be induced by neutron bombardment.

Fission products Nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the fission fragments' radioactive decay.

Floodplains The lowlands and relatively flat areas adjoining inland and coastal waters and the floodprone areas of offshore islands. Floodplains include, at a minimum, the area that has at least a 1% chance of being inundated by a flood in any given year. The base floodplain is defined as the area that has a 1% or more chance of being flooded in any given year. Such a flood is known as a 100-year flood. The critical action floodplain is defined as the area that has a 0.2% or more chance of being flooded in any given year. Such a flood is known as a 500-year flood. Any activity for which even a slight chance of flooding would be too great (e.g., the storage of highly volatile, toxic, or water-reactive materials) should not occur in the critical action floodplain.

Fluvial Produced by the action of flowing water.

Flux Rate of flow through a unit area; in nuclear reactor operation, the apparent flow of neutrons in a defined energy range. (See nuclear reactor.)

Formation In geology, the primary unit of formal stratigraphic mapping or description. Most formations possess certain distinctive features.

Fugitive emissions Defined as (1) emissions that do not pass through a stack, vent, chimney, or similar opening where they could be captured by a control device and (2) any air pollutant emitted to the atmosphere from something other than a stack. Sources of fugitive emissions include pumps, valves, flanges, seals, area sources (e.g., ponds, lagoons, landfills, piles of stored material such as coal), and road construction areas or other areas where earthwork is occurring.

Gamma radiation High-energy, short-wavelength, electromagnetic radiation emitted from the nucleus of an atom during radioactive decay. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded by dense materials, such as lead or depleted uranium.

GENII A computer code used to predict the radiological impacts on individuals and populations associated with the release of radioactive material into the environment during normal operations and postulated accidents.

Geologic repository As used in this EIS, a system that is intended to be used for or may be used for the disposal of radioactive waste in excavated geologic media.

Geology The science that studies the materials, processes, environments, and history of the earth, including rocks and their formation and structure.

Glove box A large enclosure that separates workers from equipment used to process hazardous material while allowing the workers to be in physical contact with the equipment. Glove boxes are normally constructed of stainless steel, with large acrylic/lead glass windows. Workers access equipment by using heavy-duty, lead-impregnated rubber gloves, the cuffs of which are sealed in portholes in the glove box windows.

Greater-than-Class C (GTCC) low-level radioactive waste Low-level radioactive waste generated by NRC licensees or Agreement State licensees that contains radionuclide concentrations that exceed U.S. Nuclear Regulatory Commission limits for Class C low-level waste as defined in 10 CFR Part 61. It is the most radioactive of the categories of low-level radioactive waste.

Groundwater Water below the ground surface in a zone of saturation. A related definition from 40 CFR 192.01 follows: Subsurface water is all water that exists in the interstices of soil, rocks, and sediment below the land surface, including soil moisture, capillary fringe water, and groundwater. That part of subsurface water in interstices completely saturated with water is called groundwater.

Grout A fluid mixture of cement-like materials and liquid waste that sets up as a solid mass and is used for waste fixation, immobilization, and stabilization.

GTCC-like waste As used in this EIS, GTCC-like waste refers to radioactive waste that is owned or generated by the U.S. Department of Energy and has characteristics similar to those of GTCC low-level radioactive waste (LLRW) such that a common disposal approach may be appropriate. GTCC-like waste consists of LLRW and potential non-defense-generated transuranic waste that has no identified path for disposal. The term is not intended to, and does not, create a new DOE classification of radioactive waste.

Habitat The environment occupied by individuals of a particular species, population, or community.

Half-life (radiological) The time in which one half of the atoms of a particular radionuclide decay to another radionuclide. Half-lives for specific radionuclides vary from millionths of a second to billions of years.

Hazardous air pollutants (HAPs) Air pollutants not covered by ambient air quality standards but that may present a threat of adverse human health effects or adverse environmental effects. Those specifically listed in 40 CFR 61.01 are asbestos, benzene, beryllium, coke oven emissions, inorganic arsenic, mercury, radionuclides, and vinyl chloride. More broadly, HAPs are any of the 189 pollutants listed in or pursuant to Section 112(b) of the Clean Air Act. Very generally, HAPs are any air pollutants that may realistically be expected to pose a threat to human health or welfare.

Hazardous waste A category of waste regulated under the Resource Conservation and Recovery Act (RCRA). To be considered hazardous, a waste must be a solid waste under RCRA and must exhibit at least one of four characteristics described in 40 CFR 261.20 through 261.24 (i.e., ignitability, corrosivity, reactivity, or toxicity) or be specifically listed by the U.S. Environmental Protection Agency in 40 CFR 261.31 through 261.33. Source materials, special nuclear materials, or by-product materials as defined by the Atomic Energy Act are not hazardous waste because they are not solid waste under RCRA.

HEPA (high-efficiency particulate air) filter Air filter capable of removing at least 99.97% of particles that are 0.3 micrometer (about 0.00001 inch) in diameter. These filters include a pleated fibrous medium (typically fiberglass) capable of capturing very small particles.

Highest-exposed individual A hypothetical individual whose location and habits result in the highest total radiological or chemical exposure (and thus dose) from a particular source for all exposure routes (e.g., inhalation, ingestion, direct exposure).

High-level waste or high-level radioactive waste (HLW) Defined by statute (the Nuclear Waste Policy Act of 1982) to mean the highly radioactive waste material resulting from the reprocessing of spent nuclear fuel (including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products nuclides in sufficient concentrations) and other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation.

Historic resources One definition is archaeological sites, architectural structures, and objects produced after the advent of written history or dating to the time of the first European-American contact in an area. (See archaeological sites.) According to the National Historic Preservation Act of 1966, as amended (Title 16 of the *United States Code,* Part 470 et seq.), they are any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion on, the *National Register of Historic Places,* including artifacts, records, and material remains related to such a property or resource.

Hydraulic head A specific measurement of the potential for water to flow, expressed in units of length relative to a vertical datum. For an unconfined aquifer (as modeled in this EIS), the hydraulic head is nearly equivalent to the water table elevation. In this EIS, hydraulic head is expressed in meters relative to the North American Vertical Datum of 1988 (NAVD88).

Hydrology The science dealing with the properties, distribution, and circulation of natural water systems.

Inadvertent intruder As defined in 10 CFR 61.2, a person who might occupy the disposal site after closure and engage in normal activities such as agriculture, the construction of dwellings, or other pursuits in which the person might be unknowingly exposed to radiation from the waste.

Infrastructure The basic facilities, services, and utilities needed for the functioning of an industrial facility. Transportation and electrical systems are part of the infrastructure.

Ingestion The action of taking solids or liquids into the digestive system.

Inhalation The action of taking airborne material into the respiratory system.

Institutional control Measures taken by federal or state organizations to maintain waste management facilities safely for a period of time. The measures, active or passive, may include site access control, site monitoring, facility maintenance, and erosion control.

Intensity (of an earthquake)	Measure of the effects (due to ground shaking) of an earthquake at a particular location that is based on observed damage to structures built by humans, changes in the earth's surface, and reports of how people felt the earthquake. Earthquake intensity is measured in numerical units on the Modified Mercalli scale.
Interbedded (geological)	Occurring between beds (layers) or lying in a bed parallel to other beds of a different material.
Intermediate depth	As used for the disposal of radioactive waste, disposal at depths greater than about 30 m (98 ft) but less than several hundred meters.
Internal dose	That portion of the dose equivalent received from radioactive material taken into the body.
Invertebrate	Of or pertaining to animals that do not have a backbone.
Involved worker	Worker who would participate in a proposed action. (See noninvolved worker.)
Ion	An atom that is electrically charged due to an imbalance between protons and electrons.
Ion exchange resin	An organic polymer that functions as an acid or base. These resins are used to remove ionic material from a solution. Cation exchange resins are used to remove positively charged particles (cations); anion exchange resins are used to remove negatively charged particles (anions).
Ionizing radiation	Alpha particles, beta particles, gamma rays, high-speed electrons, high-speed protons, and other particles or electromagnetic radiation that can displace electrons from atoms or molecules, thereby producing ions. (See alpha radiation, beta particle, electron, gamma radiation, ion, and proton.)
Irradiated	Exposed to ionizing radiation. The condition of reactor fuel elements and other materials in which atoms bombarded with nuclear particles have undergone nuclear changes.

Isotope Any of two or more variations of an element in which the nuclei have the same number of protons (i.e., the same atomic number) but different numbers of neutrons so that their atomic masses differ. Isotopes of a single element possess almost identical chemical properties but often have different physical properties (e.g., carbon-12 and -13 are stable, whereas carbon-14 is radioactive).

Latent cancer fatality (LCF) Death from cancer resulting from, and occurring some time after, exposure to ionizing radiation or other carcinogens.

Leachate As applied to mixed low-level radioactive waste trenches, any liquid, including any suspended components in the liquid, that has percolated through, or drained from, hazardous waste.

Lost workdays The total number of workdays (consecutive or not) during which employees were away from work or limited to restricted work activity because of an occupational injury or illness.

Low-income population Defined in terms of U.S. Bureau of the Census annual statistical poverty levels (Current Population Reports, Series P-60 on Income and Poverty), this term may refer to groups or individuals who live in geographic proximity to one another or who are geographically dispersed or transient (such as migrant workers or Native Americans), where either type of group experiences common conditions or effects of environmental exposure.

Low-level radioactive waste (LLRW) As defined by the Low-Level Radioactive Waste Policy Amendments Act of 1985, radioactive waste that is not high-level waste, spent nuclear fuel, or by-product material (as defined in Section 11e(2) of the Atomic Energy Act of 1954, as amended, and material that the U.S. Nuclear Regulatory Commission, consistent with existing law, classifies as low-level radioactive waste.

Magnitude (of an earthquake) Characteristic of an earthquake that describes the quantity of total energy it releases (as contrasted to intensity, a characteristic that describes an earthquake's effects or damage at a particular place). Magnitude is determined by taking the common logarithm (base 10) of the largest ground motion recorded on a seismograph during the arrival of a seismic wave type and applying a standard correction factor for distance to the epicenter. Three common types of magnitude are Richter or local (ML), P body wave (mb), and surface wave (Ms). Additional magnitude scales, notably the moment magnitude (Mw), have been introduced to increase uniformity in representing earthquake size. Moment magnitude is defined as the rigidity of the rock multiplied by the area of faulting multiplied by the amount of slip. A one-unit increase in magnitude (for example, from magnitude 6 to magnitude 7) represents a 30-fold increase in the amount of energy released.

Mammal Warm-blooded, hairy vertebrates whose offspring are fed by milk secreted by the female.

Maximum contaminant level (MCL) The designation for U.S. Environmental Protection Agency (EPA) standards for drinking water quality under the Safe Drinking Water Act. The maximum contaminant level for a given substance is the maximum permissible concentration of that substance in water delivered by a public water system. The primary MCLs (40 CFR Part 141) are intended to protect public health and are federally enforceable. They are based on health factors but are also required by law to reflect the technological and economic feasibility of removing the contaminant from the water supply. Secondary MCLs (40 CFR Part 143) are set by the EPA to protect the public welfare. The secondary drinking water regulations control substances in drinking water that primarily affect aesthetic qualities (such as taste, odor, and color) related to the public acceptance of water.

Megawatt A unit of power equal to 1 million watts. Megawatt-thermal is commonly used to describe heat produced, while megawatt-electric describes electricity produced.

Meteorology Science dealing with the atmosphere and its phenomena, especially as related to weather.

Migration Natural movement of a material through the air, soil, or groundwater; also, seasonal movement of animals from one area to another.

Millirem (mrem) One-thousandth of a rem (0.001 rem).

Minority population Minority populations exist where either (1) they exceed 50% of the population in the affected area or (2) their percentage in the affected area is meaningfully greater than it is in the general population or other appropriate unit of geographic analysis (such as a governing body's jurisdiction, a neighborhood, census tract, or other similar unit). Minority refers to individuals who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic. Minority populations may include either a single minority group or the total of all minority persons in the affected area. They may consist of groups of individuals living in geographic proximity to one another or a geographically dispersed/transient set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effects.

Mitigation Mitigation includes (1) avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of an action; or (5) compensating for an impact by replacing or providing substitute resources or environments.

Mixed waste Waste that contains both hazardous waste, as defined under the Resource Conservation and Recovery Act, and source, special nuclear, or by-product material subject to the Atomic Energy Act.

Modified Mercalli Intensity scale A standard of relative measurement of earthquake intensity, developed to fit construction conditions in most of the United States. It is a 12-step scale, with values from I (not felt except by a very few people) to XII (damage total). A Modified Mercalli Intensity is a numerical value on the Modified Mercalli scale.

National Ambient Air Quality Standards (NAAQS)
Standards that define the highest allowable levels of certain pollutants in the ambient air (i.e., the outdoor air to which the public has access). Because the U.S. Environmental Protection Agency must establish the criteria for setting these standards, the regulated pollutants are called criteria pollutants. Criteria pollutants include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and two size classes of particulate matter: equal to or less than 10 micrometers (0.0004 inch) in diameter and equal to or less than 2.5 micrometers (0.0001 inch) in diameter. Primary standards are established to protect public health; secondary standards are established to protect public welfare (e.g., visibility, crops, animals, buildings).

National Emissions Standards for Hazardous Air Pollutants (NESHAPs)
Emissions standards set by the U.S. Environmental Protection Agency for air pollutants that are not covered by National Ambient Air Quality Standards (NAAQS) and that may, at sufficiently high levels, cause increased fatalities, irreversible health effects, or incapacitating illness. These standards are given in 40 CFR Parts 61 and 63. NESHAPs are given for many specific categories of sources (e.g., equipment leaks, industrial process cooling towers, dry cleaning facilities, petroleum refineries).

National Environmental Policy Act of 1969 (NEPA)
The basic national charter for protection of the environment. It establishes policy, sets goals (in Section 101), and provides means (in Section 102) for carrying out the policy. Section 102(2) contains action-forcing provisions to ensure that federal agencies follow the letter and spirit of the Act. For major federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of NEPA requires federal agencies to prepare a detailed statement that includes the environmental impacts of the proposed action and other specified information.

National Pollutant Discharge Elimination System (NPDES)
A provision of the Clean Water Act that prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the U.S. Environmental Protection Agency, a state, or, where delegated, a tribal government on an Indian reservation. The NPDES permit lists either the permissible discharges or the level of cleanup technology required for wastewater, or both.

***National Register of Historic Places* (NRHP)** The official list of the nation's cultural resources that are worthy of preservation. The National Park Service maintains the list under direction of the Secretary of the Interior. Buildings, structures, objects, sites, and districts are included in the NRHP because of their importance in American history, architecture, archeology, culture, or engineering. Properties included in the NRHP range from large-scale buildings of monumental proportions to smaller-scale, regionally distinctive buildings. The properties listed are not just those of national importance; in fact, most are significant primarily at the state or local level. Procedures for listing properties on the NRHP are found in 36 CFR Part 60.

Neutron An uncharged elementary particle with a mass slightly greater than that of the proton. Neutrons are found in the nucleus of every atom heavier than hydrogen-1.

Noise Any sound that is undesirable because it interferes with speech and hearing, is intense enough to damage hearing, or is otherwise annoying or undesirable.

Nonattainment area An area that the U.S. Environmental Protection Agency has designated as not meeting (i.e., not being in attainment with) one or more of the National Ambient Air Quality Standards (NAAQS) for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. An area may be in attainment for some pollutants but not for others.

Non-defense-generated TRU Transuranic waste that is not generated by atomic energy defense activities.

Noninvolved worker A worker who would be on the site of an action but would not participate in the action.

Notice of Intent An announcement of the initiation of an environmental impact scoping process. The Notice of Intent is usually published in both the *Federal Register* and a local newspaper. The scoping process includes holding at least one public meeting and requesting written comments on issues and environmental concerns that an environmental impact statement should address.

Nuclear reactor A device that sustains a controlled nuclear-fission chain reaction that releases energy in the form of heat.

Nucleus The positively charged central portion of an atom that composes nearly all of the atomic mass. It consists of protons and neutrons, except in hydrogen-1, where it consists of one proton only.

Nuclide A species of atom characterized by the constitution of its nucleus (the number of protons and neutrons and the energy content).

Other Waste As used in this environmental impact statement, waste that is not activated metals or sealed sources. It includes contaminated equipment, debris, scrap metals, filters, resins, soil, solidified sludges, and other materials.

Ozone The triatomic form of oxygen. In the stratosphere, ozone protects the earth from the sun's ultraviolet rays, but in lower levels of the atmosphere, ozone is considered an air pollutant.

Package For radioactive materials, the packaging and its radioactive contents.

Packaging With regard to hazardous or radioactive materials, the assembly of components needed to ensure compliance with federal regulations for storage and transport. It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, and devices for cooling or absorbing mechanical shocks. The vehicle tie-down system and auxiliary equipment may be designated part of the packaging.

Particulate matter (PM), PM_{10}, $PM_{2.5}$ Any finely divided solid or liquid material, other than uncombined (i.e., pure) water. A subscript denotes the upper limit of the diameter of particles included. Thus, PM_{10} includes only those particles equal to or less than 10 micrometers (0.0004 inch) in diameter, and $PM_{2.5}$ includes only those particles equal to or less than 2.5 micrometers (0.0001 inch) in diameter.

Partitioning or distribution coefficient A quantity that relates the amount or concentration of a substance in a unit of soil or sediment to the amount or concentration in the overlying or pore water that is in contact with the solid medium.

Pathway (exposure) The means by which a substance moves from an environmental source to an organism.

Perched (aquifer/groundwater) A body of groundwater of small lateral dimensions that is separated from an underlying body of groundwater by an unsaturated zone.

Performance assessment An analysis that predicts the behavior of a system or system component under a given set of conditions. In the context of U.S. Department of Energy waste management activities, it refers to the systematic analysis of the potential risks posed by waste management systems to the public and the environment and to the comparison of those risks to established performance objectives.

Permeability In geology, the ability of rock or soil to transmit a fluid.

Person-rem A unit of collective radiation dose applied to populations or groups of individuals (see collective dose); that is, a unit for expressing the dose when summed across all persons in a specified population or group.

pH Measure of the relative acidity or alkalinity of a solution, expressed on scale of 0 to 14, with the neutral point being 7.0. Acid solutions have pH values lower than 7.0, and basic (i.e., alkaline) solutions have pH values higher than 7.0.

Picocurie One trillionth (10^{-12}) of a curie.

Pliocene The latest geologic epoch of the Tertiary period, beginning about 5.3 million years ago and ending 1.6 million years ago.

Plume The elongated volume of contaminated water or air originating at a pollutant source such as an outlet pipe or a smokestack. A plume eventually diffuses into a larger volume of less contaminated material as it is transported away from the source.

Plutonium A heavy, radioactive, metallic element with the atomic number 94. It is produced artificially by neutron bombardment of uranium. Plutonium has 15 isotopes with atomic masses ranging from 232 to 246 and half-lives ranging from 20 minutes to 76 million years.

Population dose See collective dose.

Post-closure As used in this environmental impact statement, the time period that follows the closure of the waste disposal facility.

Preferred alternative
As used in this environmental impact statement, the alternative preferred by the U.S. Department of Energy.

Prevention of Significant Deterioration (of air quality) (PSD) regulations
Regulations established to prevent significant deterioration of air quality in areas that already meet National Ambient Air Quality Standards (NAAQS). Specific details of PSD are found in 40 CFR 51.166. Among other provisions, cumulative increases in sulfur dioxide, nitrogen dioxide, and particulate matter (specifically PM_{10}) levels after specified baseline dates must not exceed specified maximum allowable amounts. These allowable increases, also known as increments, are especially stringent in areas designated as Class I areas (e.g., national parks, wilderness areas) where the preservation of clean air is particularly important. All areas not designated as Class I are currently designated as Class II. Maximum increments in pollutant levels are also given in 40 CFR 51.166 for Class III areas, if any such areas should be so designated by the EPA. Class III increments are less stringent than those for Class I or Class II areas.

Priority habitat
A habitat type with unique or significant value to many species that may be described by (1) a unique type of vegetation or a dominant plant species of primary importance to fish and wildlife (e.g., oak woodlands, eelgrass meadows) or (2) a successional stage (e.g., old growth or mature forest). Alternatively, a priority habitat may consist of a specific habitat element (e.g., consolidated marine/estuarine shorelines, talus slopes, caves, snags) of key value to fish and wildlife.

Proton
An elementary nuclear particle with a positive charge equal in magnitude to the negative charge of the electron; it is a constituent of all atomic nuclei. The atomic number of an element indicates the number of protons in the nucleus of each atom of that element.

PWR
Acronym for pressurized water reactor, one of two reactor types used in commercial nuclear power plants in the United States. The other reactor type is a boiling water reactor (BWR).

Rad
Acronym for radiation absorbed dose, this represents the amount of energy deposited in any material per unit mass of the material. One rad is equal to an absorbed dose of 0.01 joule of energy per kilogram of any material.

Radiation (ionizing) Subatomic particles (alpha, beta, neutrons, and other subatomic particles) or photons (e.g., gamma rays and x-rays) emitted during radioactive decay that are capable of creating ion pairs when they interact with matter.

Radioactive decay The decrease in the amount of any radioactive material with the passage of time due to spontaneous nuclear disintegration at a characteristic rate specified by the radionuclide's half-life.

Radioactive waste In general, as used in this EIS, waste that is managed for its radioactive content. Waste material that contains source material, special nuclear material, or by-product material is subject to regulation under the Atomic Energy Act. Also, waste material that contains accelerator-produced radioactive material or certain naturally occurring radioactive material may be considered radioactive waste.

Radioactivity The spontaneous transformation of unstable atomic nuclei, usually accompanied by the emission of ionizing radiation.

Radioisotope or radionuclide An unstable isotope that undergoes radioactive decay, emitting radiation.

Radiological risk A measure of potential harm to populations or individuals due to the presence or occurrence of an environmental or human-made radiological hazard.

Radon A gaseous, radioactive element with the atomic number 86 that is produced from the radioactive decay of radium. Radon occurs naturally in the environment and can collect in unventilated enclosed areas, such as basements. Large concentrations of radon can cause lung cancer in humans.

RADTRAN Computer code that combines user-determined meteorological, demographic, transportation, packaging, and material factors with health physics data to calculate the expected radiological consequences and accident risk that could result from transporting radioactive material.

Record of Decision (ROD) A concise public document that records a federal agency's decision(s) concerning a proposed action for which the agency has prepared an environmental impact statement (EIS). The ROD is prepared in accordance with the requirements of Council on Environmental Quality NEPA regulations (40 CFR 1505.2). It identifies the alternatives considered in reaching the decision, the environmentally preferable alternative(s), factors balanced by the agency in making the decision, whether all practicable means to avoid or minimize environmental harm have been adopted, and if not, why they were not.

Reference location As used in this environmental impact statement, the location at a U.S. Department of Energy site selected for the analysis of environmental impacts. This location is considered to have characteristics representative of the actual location that could be used for waste disposal purposes.

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

Release Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a material into the environment. Statutory or regulatory definitions of release may differ.

Rem Acronym for Roentgen equivalent man, a unit of dose equivalent. The dose equivalent in rem equals the absorbed dose in rad in tissue multiplied by the appropriate quality factor and possibly other modifying factors.

Remote-handled waste In general, refers to radioactive waste that must be handled at a distance (remotely) to protect workers from unnecessary exposure (e.g., waste with a dose rate of 200 millirem per hour or more at the surface of the waste package).

Resource Conservation and Recovery Act (RCRA) A law that gives the U.S. Environmental Protection Agency the authority to control hazardous waste from cradle to grave (i.e., from the point of generation to the point of ultimate disposal), including its minimization, generation, transportation, treatment, storage, and disposal. RCRA also sets forth a framework for the management of nonhazardous solid wastes.

RESRAD-OFFSITE RESRAD-OFFSITE is an extension of the RESRAD (on-site) computer code that was developed to estimate the radiological consequences to a human receptor located on-site or outside (off-site) the area of primary contamination. It calculates radiological dose and excess lifetime cancer risk with the predicted radionuclide concentrations in the environment. This computer code was used to generate estimates for human health impacts for the post-closure phase of the land disposal methods (borehole, trench, and vault) in the Draft GTCC EIS.

Riparian Of or pertaining to the banks of a river or stream.

Risk The probability of a detrimental effect from exposure to a hazard.

Roentgen Unit of exposure to x-rays or gamma rays that is equal to or produces one electrostatic unit of charge per cubic centimeter of air.

Roentgen equivalent man (rem) Unit of dose equivalent. The dose equivalent in rem equals the absorbed dose in rad in tissue multiplied by the appropriate quality factor and possibly other modifying factors.

Runoff Portion of rainfall, melted snow, or irrigation water that flows across the ground surface and eventually enters streams.

Safe Drinking Water Act Act that protects the quality of public water supplies, water supply and distribution systems, and all sources of drinking water.

Sanitary waste Liquid or solid waste generated by normal housekeeping activities (including sludge) that is not hazardous or radioactive.

Scope Range of actions, alternatives, and impacts to be considered in a document prepared pursuant to the National Environmental Policy Act of 1969.

Scoping An early and open process used to determine the scope of issues to be addressed in an environmental impact statement (EIS) and identify the significant issues related to a proposed action.

Sealed source A source manufactured, obtained, or retained for the purpose of utilizing the emitted radiation from the contained radionuclide(s). It consists of a known or estimated quantity of radioactive material that is either contained within a sealed capsule, sealed between layers of nonradioactive material, or firmly fixed to a nonradioactive surface by electroplating or some other means intended to prevent the radioactive material from leaking or escaping.

Sediment Soil, sand, and minerals washed from land into water and deposited on the bottom of a water body.

Seismic Pertaining to any earth vibration, especially an earthquake.

Seismicity The frequency and distribution of earthquakes.

Shielding With regard to radiation, any material that obstructs (bulkheads, walls, or other construction) and absorbs radiation to protect personnel or equipment.

Shrub steppe Plant community consisting of short-statured, widely spaced, small-leaved shrubs, sometimes aromatic, with brittle stems and an understory dominated by perennial bunch grasses.

Shutdown Facility condition during which operations and/or construction activities have ceased.

Silt Loose particles of rock or mineral sediment ranging in size from about 0.002 to 0.0625 millimeter (0.00008 to 0.0025 inch) in diameter. Silt is finer than sand but coarser than clay.

Site A geographic entity that comprises leased or owned land, buildings, and other structures that are needed in order to perform program activities.

Soils All unconsolidated materials above bedrock; natural earthy materials on Earth's surface, in places modified or even made by human activity, that contain living matter and either support or are capable of supporting plants outdoors.

Solid waste	In general, nonliquid, nonsoluble, discarded materials ranging from municipal garbage to industrial wastes that contain complex and sometimes hazardous substances. They include sewage sludge, agricultural refuse, demolition wastes, and mining residues.
Source material	(1) Uranium or thorium or any combination of uranium and thorium in any physical or chemical form or (2) ores that contain, by weight, one-twentieth of 1 percent (0.05 percent), or more, of uranium, thorium, or any combination of uranium and thorium. Source material does not include special nuclear material.
Source term	The amount of a specific pollutant (e.g., chemical, radionuclide) emitted or discharged to a particular environmental medium (e.g., air, water) from a source or group of sources. It is usually expressed as a rate (i.e., amount per unit of time).
Species of concern (federal)	Species whose conservation standing is of concern to the U.S. Fish and Wildlife Service but for which status information is still needed.
Spent nuclear fuel	Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing.
Storage	The holding of waste for a temporary period, at the end of which the waste is treated, disposed of, or stored elsewhere.
Stratigraphy	Science of the description, correlation, and classification of strata in sedimentary rocks, including the interpretation of the depositional environments of those strata.
Surface water	All bodies of water on the surface of the Earth and open to the atmosphere, such as rivers, lakes, reservoirs, ponds, seas, and estuaries.
Surficial material (deposit)	Any loose, unconsolidated sedimentary deposit lying on or above bedrock.
Tectonic	Of or relating to motion in the Earth's crust and occurring along geologic faults.
Terrestrial	Of or pertaining to life on land.

Threatened species — Any plants or animals that are likely to become endangered species within the foreseeable future throughout all or a significant portion of their ranges and that have been listed as threatened by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service by following the procedures set out in the Endangered Species Act and its implementing regulations (50 CFR Part 424). (See endangered species.) The lists of threatened species can be found at 50 CFR 17.11 for wildlife, 17.12 for plants, and 227.4 for marine organisms.

Total effective dose equivalent (TEDE) — Sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Total recordable cases — Total number of cases recorded of work-related (1) deaths or (2) illnesses or injuries that resulted in loss of consciousness, restriction of work or motion, transfer to another job, or required medical treatment beyond first aid.

Toxic Substances Control Act of 1976 — Law requiring that the health and environmental effects of all new chemicals be reviewed by the U.S. Environmental Protection Agency before they are manufactured for commercial purposes. It also imposes strict limitations on the use and disposal of polychlorinated biphenyls, chlorofluorocarbons, asbestos, dioxins, certain metal-working fluids, and hexavalent chromium.

Traditional cultural property — A property or place that is eligible for inclusion in the *National Register of Historic Places* because of its association with cultural practices and beliefs that are (1) rooted in the history of a community and (2) important to maintaining the continuity of that community's traditional beliefs and practices.

Transuranic — Any element whose atomic number is higher than that of uranium (atomic number 92), including neptunium, plutonium, americium, and curium.

Transuranic (TRU) waste Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than 20 years, per gram of waste, except for (1) high-level radioactive waste; (2) wastes that the Secretary of DOE has determined, with the concurrence of the Administrator of EPA, do not need the degree of isolation required by the disposal regulations; or (3) wastes that the NRC has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61.

Trench As used in this environmental impact statement, near-surface excavation used for the disposal of radioactive waste. A trench has a dominant direction (it is much longer than it is wide) and is capped by an engineered cover after it is filled with waste.

Tritium A radioactive isotope of hydrogen whose nucleus contains one proton and two neutrons.

Type A packaging A regulatory category of packaging used to transport radioactive materials. It must be designed and demonstrate its ability to retain its containment and shielding integrity under normal conditions of transport. Examples of Type A packaging include 55-gallon drums and standard waste boxes. Type A packaging is used to transport materials with low radioactivity levels and usually does not require special handling, packaging, or transportation equipment.

Type B packaging A regulatory category of packaging used to transport radioactive materials. The U.S. Department of Transportation and U.S. Nuclear Regulatory Commission (NRC) require Type B packaging for shipping highly radioactive material. Type B packages must be designed and demonstrate their ability to retain their containment and shielding integrity under severe accident conditions as well as under normal conditions of transport. The current NRC testing criteria for Type B package designs (10 CFR Part 71) are intended to simulate severe accident conditions, including those involving impact, puncture, fire, and immersion in water. The most widely recognized Type B packages are the massive casks used for transporting spent nuclear fuel. Large-capacity cranes and mechanical lifting equipment are usually needed to handle Type B packages.

Uranium	A radioactive, metallic element with atomic number 92; the heaviest naturally occurring element. Uranium has 14 known isotopes, of which uranium-238 is the most abundant in nature. Uranium-235 is commonly used as a fuel for nuclear fission.
Vadose zone	The region of soil and rock between the ground surface and the top of the water table in which pore spaces are only partially filled with water. Over time, contaminants in the vadose zone often migrate downward to the underlying aquifer.
Vault	As used in this environmental impact statement, an above-grade, engineered structure constructed of concrete or a similar material that is used for the disposal of radioactive waste. An engineered cap is expected to be placed over and around vaults after they are filled with radioactive waste.
Volatile organic compound	Any of a broad range of organic compounds, often halogenated, that vaporize at ambient or relatively low temperatures; examples are benzene, chloroform, and methyl alcohol. With regard to air pollution, any organic compound that participates in an atmospheric photochemical reaction, except those determined by the U.S. Environmental Protection Agency Administrator to have negligible photochemical reactivity.
Waste acceptance criteria	Technical and administrative requirements that a waste must meet in order for it to be accepted at a treatment, storage, or disposal facility.
Waste characterization	The identification of a waste's composition and properties by reviewing process knowledge, nondestructive examination, nondestructive assay, or sampling and analysis. Characterization provides the basis for determining appropriate storage, treatment, handling, transportation, and disposal requirements.
Waste Isolation Pilot Plant (WIPP)	A U.S. Department of Energy facility designed and authorized to permanently dispose of defense-generated transuranic radioactive waste in a mined underground facility in deep geologic salt beds. It is located in southeastern New Mexico, 26 mi (42 km) east of the city of Carlsbad.

Waste management The planning, coordination, and direction of those functions related to the generation, handling, treatment, storage, transportation, and disposal of waste, as well as associated surveillance and maintenance activities.

Water table The boundary between the unsaturated zone and the deeper, saturated zone. The upper surface of an unconfined aquifer.

Wetlands Areas that are inundated by surface water or groundwater often enough that, under normal circumstances, they do or could support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas (e.g., sloughs, potholes, wet meadows, river overflow areas, mudflats, natural ponds). Jurisdictional wetlands are wetlands protected by the Clean Water Act. They must have a minimum of one positive wetland indicator from each parameter (i.e., vegetation, soil, and hydrology). The U.S. Army Corps of Engineers requires a permit to fill or dredge jurisdictional wetlands.

Wind rose Circular diagram showing, for a specific location, the percentage of the time the wind is from each compass direction. Wind roses that are used to assess the consequences of airborne releases also show the frequency of different wind speeds for each compass direction.

X-rays Penetrating electromagnetic radiation having a wavelength much shorter than that of visible light. X-rays are identical to gamma rays but originate outside the nucleus.

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1 INTRODUCTION

Greater-than-Class C (GTCC) low-level radioactive waste (LLRW) is defined by the U.S. Nuclear Regulatory Commission (NRC) as LLRW that has radionuclide concentrations exceeding the limits for Class C LLRW established in Title 10, Part 61, of the *Code of Federal Regulations* (10 CFR Part 61), "Licensing Requirements for Land Disposal of Radioactive Waste." In 10 CFR 61.55, the NRC classifies LLRW as A, B, and C according to the concentration of specific short- and long-lived radionuclides, with Class C having the highest radionuclide concentration limits. GTCC LLRW is generated by activities licensed by the NRC or Agreement States and cannot be disposed of in currently licensed commercial LLRW disposal facilities.

Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA) assigned the responsibility for the disposal of GTCC LLRW to the federal government. The LLRWPAA specifies that GTCC LLRW covered under Section 3(b)(1)(D) is to be disposed of in a facility that is licensed by the NRC and that the NRC has determined is adequate for protecting public health and safety. The U.S. Department of Energy (DOE) is the federal agency responsible for disposing of GTCC LLRW.

Section 631 of the Energy Policy Act of 2005 requires the Secretary of Energy to (1) notify Congress of the DOE office responsible for completing the activities needed to provide for safe disposal of GTCC LLRW; (2) submit to Congress a report containing an estimate of the cost and schedule to complete an environmental impact statement (EIS) and Record of Decision (ROD) for a permanent disposal facility for GTCC LLRW; (3) submit to Congress a plan that ensures the continued recovery and storage of GTCC LLRW sealed sources that pose a security threat until a permanent disposal facility is available; and (4) prior to issuing the ROD, submit to Congress a report that includes a description of the alternatives considered in the EIS and await action by Congress. In response to these requirements, DOE designated its Office of Environmental Management (DOE-EM) as the lead organization responsible for developing GTCC LLRW disposal capability. In July 2006 and February 2006, DOE submitted the report and plan described in items 2 and 3, respectively, to Congress. Copies of these documents are available on the GTCC EIS website (http://www.gtcceis.anl.gov/).

GTCC LLRW and GTCC-Like Waste

GTCC LLRW refers to LLRW that has radionuclide concentrations that exceed the limits for Class C LLRW given in 10 CFR 61.55. This waste is generated by activities of NRC and Agreement State licensees, and it cannot be disposed of in currently licensed commercial LLRW disposal facilities. The federal government is responsible for the disposal of GTCC LLRW.

GTCC-like waste refers to radioactive waste that is owned or generated by DOE and has characteristics sufficiently similar to those of GTCC LLRW such that a common disposal approach may be appropriate. GTCC-like waste consists of LLRW and potential non-defense-generated TRU waste that has no identified path for disposal. The use of the term "GTCC-like" is not intended to and does not create a new DOE classification of radioactive waste.

Consistent with NRC's and DOE's authorities under the Atomic Energy Act of 1954 (as amended), the NRC LLRW classification system does not apply to radioactive wastes generated or owned by DOE and disposed of in DOE facilities. However, DOE owns or generates both LLRW and potential non-defense-generated transuranic (TRU) radioactive waste, which have characteristics similar to those of GTCC LLRW and for which there may be no path for disposal. DOE has included these wastes for evaluation in this EIS because their disposal requirements may be similar to those for GTCC LLRW, such that a common approach and/or facility could be used for these wastes. For the purposes of this EIS, DOE is referring to these wastes as GTCC-like waste. The use of the term "GTCC-like" is not intended to and does not create a new DOE classification of radioactive waste.

DOE has considered all public scoping comments received in response to the Notice of Intent (NOI) to prepare the GTCC EIS (Volume 72, page 40135, of the *Federal Register* [72 FR 40135]). A summary of the comments received is presented in Appendix A of this EIS. Comments determined to be within the scope of this EIS are addressed in this EIS.

1.1 PURPOSE AND NEED FOR AGENCY ACTION

There is currently no disposal capability for GTCC LLRW. The LLRWPAA specifies that the GTCC LLRW that is designated a federal responsibility under Section 3(b)(1)(D) is to be disposed of in a facility that is adequate to protect public health and safety and is licensed by the NRC. Although GTCC-like waste is not subject to the requirements in the LLRWPAA, DOE also intends to determine a path to disposal that is similarly protective of public health and safety for the GTCC-like waste that it owns or generates.

The September 11, 2001, terrorist attacks and subsequent threats have heightened concerns that terrorists could gain possession of radioactive sealed sources, including sealed sources requiring management as GTCC LLRW, and use them for malevolent purposes. Such an attack has been of particular concern because of the widespread use of sealed sources and other radioactive materials in the United States for beneficial uses by hospitals and other medical establishments, industries, and academic institutions. Because of a lack of disposal capability, many of these sealed sources remain in temporary storage when no longer needed for their intended uses. The Radiation Source Protection and Security Task Force, established under Section 651(d) of the Energy Policy Act of 2005 (Public Law [P.L.] 109-58), is charged with evaluating and providing recommendations related to securing radiation sources in the United States from potential terrorists threats, including their use in a radiological dispersal device (RDD, such as a dirty bomb). In August 2006 and August 2010, the Task Force submitted reports to the President and U.S. Congress. The 2006 report (NRC 2006) stated that "providing disposal methods for GTCC waste will have the greatest effect on reducing the total risk of long-term storage for risk-significant sources." The 2010 report (NRC 2010) further stated that "by far the most significant challenge identified is

> Disused radioactive sealed sources used in medical treatments and other applications are one of the GTCC waste types for which a disposal capability is needed. Every year, thousands of sealed sources become disused and unwanted in the United States. While secure storage is a temporary measure, unlike permanent disposal, the longer sources remain disused or unwanted, the greater is the chance that they will become unsecured or abandoned. Due to their concentrated activity and portability, radioactive sealed sources could be used in radiological dispersal devices (RDDs), commonly referred to as "dirty bombs." An attack using an RDD could result in extensive economic loss, significant social disruption and potentially serious public health problems. (Source: NNSA News 2010)

access to disposal for disused radioactive sources." Since 2003, the U.S. Government Accountability Office (GAO) has issued several reports on matters related to the security of uncontrolled sealed sources, some of which are concerned with DOE's progress in developing a GTCC LLRW disposal facility (GAO 2003, Executive Summary page). In addition, the Energy Policy Act of 2005 (P.L. 109-58) contains several provisions directed at improving the control of sealed sources, including disposal availability.

Accordingly, DOE has prepared this EIS to evaluate the range of reasonable alternatives for the safe and secure disposal of GTCC LLRW and GTCC-like waste. The range of reasonable alternatives addresses approximately 12,000 m^3 (420,000 ft^3) of in-storage (current) and projected (anticipated) GTCC LLRW and GTCC-like waste.

1.2 PROPOSED ACTION

DOE proposes to construct and operate a new facility or facilities or to use an existing facility or facilities for the disposal of GTCC LLRW and GTCC-like waste. DOE would then close the facility or facilities at the end of each facility's operational life. Institutional controls, including monitoring, would be employed for a period of time determined during the implementation phase. A combination of disposal methods and locations may be appropriate, depending on the characteristics of the waste and other factors.

1.3 DECISIONS TO BE SUPPORTED BY THIS ENVIRONMENTAL IMPACT STATEMENT

DOE intends for this EIS to provide the information that will support the selection of disposal method(s) and site(s) for the GTCC LLRW and GTCC-like waste inventory included in Groups 1 and 2, as described in Section 1.4.1. The specific design for such a facility would be developed once a decision was made on the most appropriate approach for disposing of this waste. The conceptual designs described in Section 1.4.2 of this EIS incorporate a number of engineering enhancements beyond those typically used in designs of LLRW disposal facilities (see also Section 5.1.4 and Appendix D), and the post-closure performance calculations were performed for long time frames (10,000 years or longer to determine peak annual doses) commensurate with the need to protect the general public for up to 10,000 years. DOE would conduct appropriate National Environmental Policy Act (NEPA) reviews to address the impacts from constructing and operating the selected disposal method(s) at alternative locations at the selected site(s).

Before issuing a ROD on the selection of disposal method(s) and site(s), DOE will submit a report to Congress to fulfill the requirement of Section 631(b)(1)(B)(i) of the Energy Policy Act of 2005. Section 631(b)(1)(B)(i) requires that the report include a description of all alternatives under consideration, and all the information required for the comprehensive report on ensuring the safe disposal of GTCC LLRW that was submitted by the Secretary to Congress in February 1987. Section 631(b)(1)(B)(ii) also requires DOE to await Congressional action.

1.4 SCOPE OF THIS ENVIRONMENTAL IMPACT STATEMENT

In this EIS, DOE, in addition to evaluating the impacts from the No Action Alternative, as required by NEPA implementing regulations (40 CFR Parts 1500−1508), evaluates the impacts on human health and the environment that could result from the range of reasonable alternatives for the disposal of GTCC LLRW and GTCC-like waste. DOE's evaluation of the range of action alternatives addresses various methods and sites. The methods include (1) deep geologic disposal, (2) intermediate-depth borehole disposal, (3) enhanced near-surface trench disposal, and (4) above-grade vault disposal. The latter three methods are hereinafter referred to as the borehole, trench, and vault disposal methods, as appropriate. The effectiveness of these disposal methods is evaluated at an existing repository and at various GTCC land disposal locations.

The Waste Isolation Pilot Plant (WIPP) is evaluated for deep geologic disposal. Land disposal methods (i.e., borehole, trench, and vault methods) are evaluated at six federally owned sites: (1) Hanford Site; (2) Idaho National Laboratory (INL); (3) Los Alamos National Laboratory (LANL); (4) Nevada National Security Site (NNSS), which was formerly known as the Nevada Test Site or NTS; (5) Savannah River Site (SRS); and (6) WIPP Vicinity. Two WIPP Vicinity locations are evaluated in this EIS as follows: (1) Section 27, which is located inside the WIPP Land Withdrawal Boundary (LWB) managed by DOE, and (2) Section 35, which is located just outside the WIPP LWB to the southeast and is managed by the Bureau of Land Management (BLM) of the U.S. Department of the Interior (DOI). A map of the United States showing these sites that are being considered for waste disposal is provided in Figure 1.4-1. In addition to these federally owned sites, generic commercial disposal sites for the four regions that make up the United States (coinciding with the NRC's designated regions, as shown in Figure 1.4-2) are also being evaluated for the land disposal methods. DOE is also evaluating each alternative with regard to the transportation and disposal of the entire inventory. The human health and transportation impacts are evaluated on a waste-type basis, so decisions can be made on a waste-type basis in the future, as appropriate.

The combined GTCC LLRW and GTCC-like waste inventory addressed in this EIS has a packaged volume of approximately 12,000 m^3 (420,000 ft^3) and contains a total activity of about 160 million curies (MCi). Section 1.4.1 summarizes the types and estimated quantities of waste, Section 1.4.2 discusses the types of disposal methods evaluated, and Section 1.4.3 describes the sites evaluated as potential disposal locations.

1.4.1 Types and Estimated Quantities of GTCC LLRW and GTCC-Like Waste

GTCC LLRW is radioactive waste that is generated by NRC or Agreement State (i.e., a state that has signed an agreement with NRC to regulate certain uses of radioactive materials within the state) licensees and contains radionuclide concentrations in excess of the limits for Class C LLRW given in two tables in 10 CFR 61.55. These two tables are shown in Table 1.4.1-1. 10 CFR 61.55 identifies four classes of LLRW for disposal purposes: Classes A, B, C, and GTCC. Classes A, B, and C LLRW can be disposed of in near-surface disposal facilities licensed by the NRC or an Agreement State. Examples of Class A, B, and C LLRW

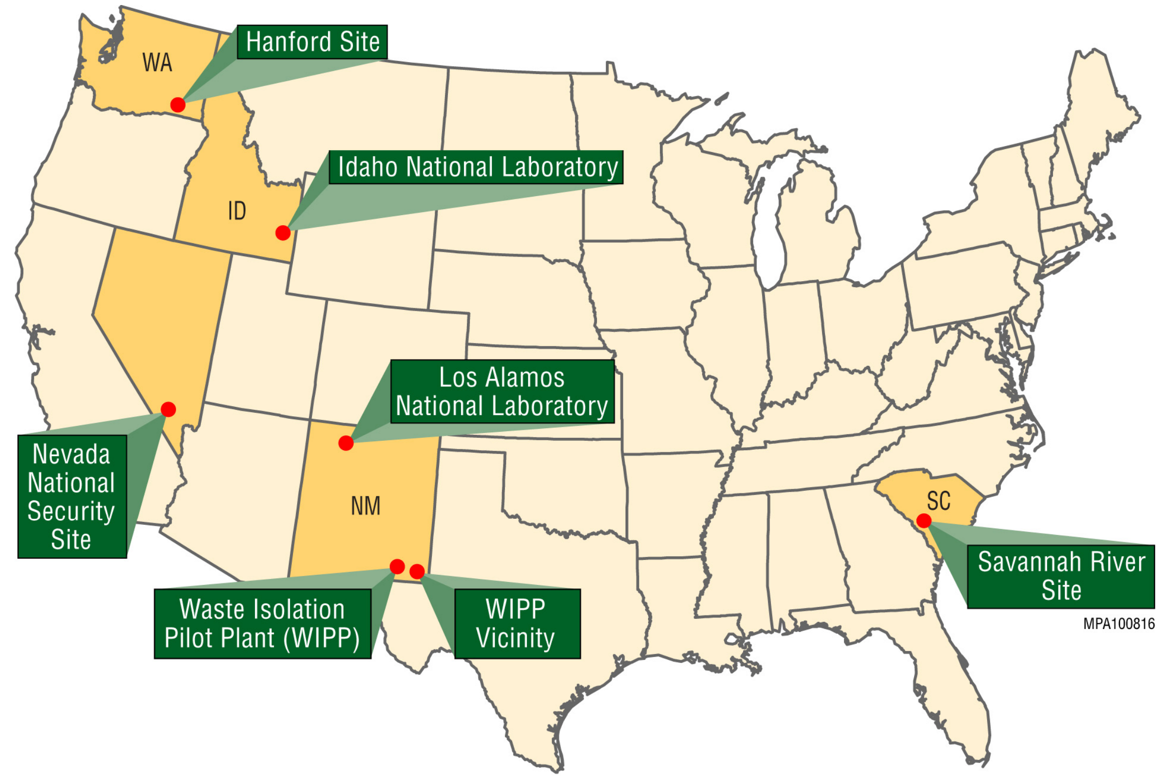

FIGURE 1.4-1 Map of Sites Being Considered for Disposal of GTCC LLRW and GTCC-Like Waste

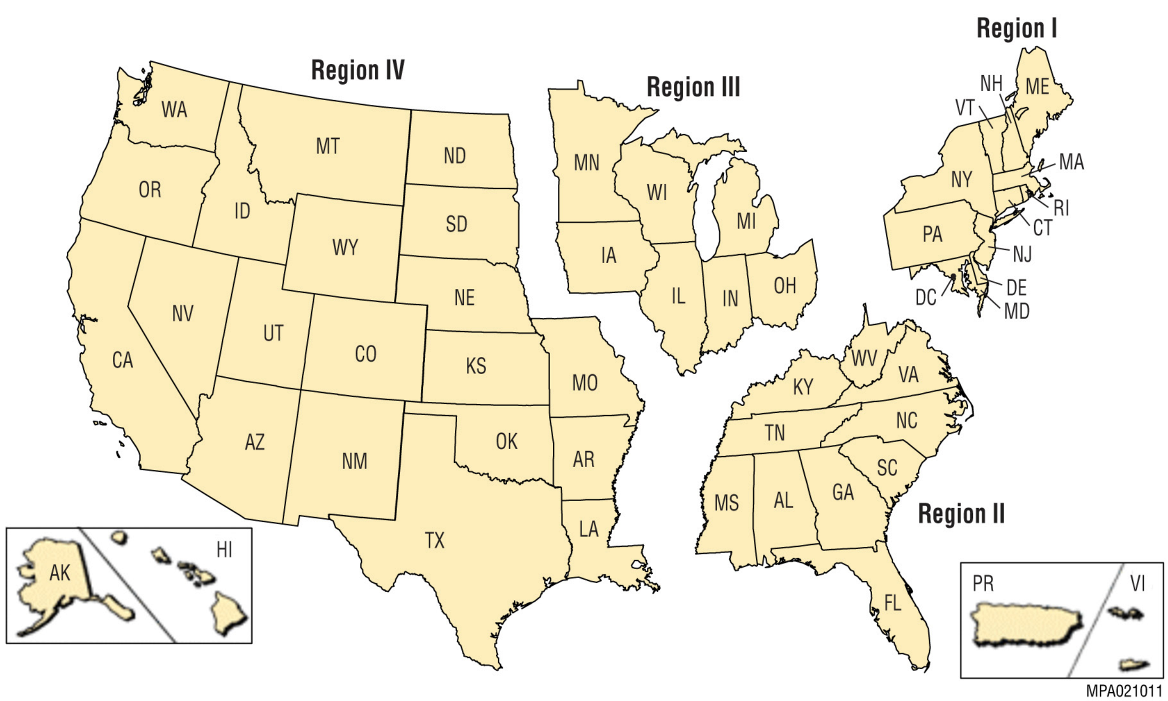

FIGURE 1.4-2 Map Showing the Four NRC Regions

TABLE 1.4.1-1 Tables in 10 CFR 61.55 Used to Determine LLRW Classes[a]

Table 1

Radionuclide	Concentration, curies per cubic meter
C-14	8
C-14 in activated metal	80
Ni-59 in activated metal	220
Nb-94 in activated metal	0.2
Tc-99	3
I-129	0.08
Alpha emitting transuranic nuclides with half-life greater than 5 years	[1] 100
Pu-241	[1] 3,500
Cm-242	[1] 20,000

[1] Units are nanocuries per gram.

Table 2

Radionuclide	Concentration, curies per cubic meter Col. 1	Col. 2	Col. 3
Total of all nuclides with less than 5-year half-life	700	([1])	([1])
H-3	40	([1])	([1])
Co-60	700	([1])	([1])
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

[1] There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in Table 2 determine the waste to be Class C independent of these nuclides.

[a] Table 1 is long-lived radionuclides; Table 2 is short-lived radionuclides. The procedures for how these values are to be used to determine LLRW classes are provided in 10 CFR 61.55. See text for explanation of how columns are applied in Table 2. C-14 = carbon-14, Ni-59 = nickel-59, Nb-94 = niobium-94, Tc-99 = technetium-99, I-129 = iodine-129, Pu-241 = plutonium-241, Cm-242 = curium-242, H-3 = hydrogen-3, Co-60 = cobalt-60, Ni-63 = nickel-63, Sr-90 = strontium-90, Cs-137 = cesium-137.

include radioactively contaminated protective clothing, resins, and filters from nuclear power plants; radiopharmaceutical wastes; and debris and soil from decommissioning of nuclear facilities. Class A LLRW has the lowest radionuclide concentration limits of the four types of waste and is usually segregated from other LLRW at the disposal site. Class B LLRW has higher radionuclide concentration limits than Class A and must meet more rigorous requirements with regard to waste form to ensure its stability after disposal. Class C LLRW is waste that represents a higher long-term risk than does Class A or Class B LLRW. Like Class B waste, Class C waste must meet the more rigorous requirements with regard to waste form to ensure its stability, and it also requires additional measures to be taken at the disposal facility to protect against inadvertent intrusion. GTCC LLRW is waste that is not generally acceptable for near-surface disposal and for which the waste form and disposal methods must be different and, in general, more stringent than those specified for Class C LLRW. In addition to the radionuclides listed in Table 1.4.1-1, other potential radionuclides of concern that are contained in the GTCC LLRW are included in the evaluations in this EIS for completeness (see Appendix B). NRC regulations in 10 CFR 61.55 specify that in the absence of specific requirements, such waste must be disposed of in a geologic repository unless alternative methods for disposal of such waste are proposed to and approved by the NRC.[1]

NRC Classification System for LLRW

The NRC classification system for the four classes of LLRW (A, B, C, and GTCC) is established in 10 CFR 61.55 and is based on the concentrations of specific short- and long-lived radionuclides given in two tables. Classes A, B, and C LLRW are generally acceptable for disposal in near-surface land disposal facilities. GTCC LLRW is LLRW "that is not generally acceptable for near-surface disposal" as specified in 10 CFR 61.55(a)(2)(iv). As stated in 10 CFR 61.7(b)(5), there may be some instances where waste with radionuclide concentrations greater than permitted for Class C would be acceptable for near-surface disposal with special processing or design.

Transuranic Waste

Transuranic (TRU) waste is radioactive waste containing more than 100 nanocuries (nCi) of alpha-emitting transuranic radionuclides with half-lives greater than 20 years per gram of waste, except for (1) high-level radioactive waste; (2) waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the U.S. Environmental Protection Agency, does not need the degree of isolation required by the 40 CFR Part 191 disposal regulations; or (3) waste that the NRC has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61. Examples of TRU radionuclides include plutonium-238 (Pu-238), Pu-239, Pu-240, americium-241 (Am-241), and Am-243. TRU waste is a waste category that applies to wastes owned or generated by DOE.

10 CFR 61.55 provides explicit procedures on how the values in these two tables are to be used to determine waste class. A brief summary of these procedures is as follows. If the LLRW contains only the long-lived radionuclides listed in Table 1, it is Class A if the

[1] In Yankee Atomic Electric Co. v. U.S., 536 F. 3d 1268 (Fed. Cir. 2008) and Pacific Gas & Electric Co. v. U.S., 536 F. 3d 1282 (Fed. Cir. 2008), the Court of Appeals for the Federal Circuit held that because the NRC had determined by rule that, unless NRC approves an alternative method, GTCC waste requires disposal in a geologic repository, such waste is considered high-level radioactive waste under the terms of the Standard Contract. This ruling does not affect DOE's responsibility to evaluate reasonable alternatives for a disposal facility or facilities for GTCC LLRW – including GTCC LLRW covered by a Standard Contract – in accordance with applicable law.

concentration is less than 10% of the value and Class C if the concentration is between 10% and 100% of the value. The LLRW cannot be Class B based solely on the concentration of long-lived radionuclides. If the radionuclide concentration exceeds 100% of the value in Table 1, it is GTCC. A "sum of fractions" approach is used if more than one of these radionuclides is present in the LLRW.

The approach used for the short-lived radionuclides in Table 2 is as follows. The LLRW is Class A if the concentration does not exceed the value in Column 1, Class B if the concentration is between the values in Columns 1 and 2, Class C if the concentration is between the values in Columns 2 and 3, and GTCC if the concentration exceeds Column 3. As done above in the approach used for long-lived radionuclides, a sum of fractions approach is used when multiple radionuclides are present.

If both long-lived and short-lived radionuclides are present, the waste classification is based on the short-lived radionuclides according to the values in Table 2, provided that the concentrations of the long-lived radionuclides do not exceed 10% of their values in Table 1. If the concentrations exceed 10% of the value in Table 1, the LLRW is Class C, provided the concentrations of the radionuclides in Table 2 do not exceed the values given in Column 3. The waste is GTCC if the concentrations exceed the limits for Class C, and a sum of fractions approach is used for multiple long- and short-lived radionuclides. The waste is Class A if the LLRW does not contain any of the radionuclides listed in these two tables.

Although there are commercial facilities available to receive and dispose of Class A, B, and C LLRW (36 states currently lack access to Class B and C disposal facilities), no facilities are currently available to dispose of GTCC LLRW.[2] These wastes are currently being stored and will continue to be generated and stored at a number of sites in the country pending the availability of a suitable disposal facility, which is the purpose of and need for agency action. Most of the GTCC-like waste consists of TRU waste that may not meet the waste acceptance criteria for disposal at WIPP as defense-generated TRU waste and has no other currently identified path to disposal.

For the purpose of analysis in this EIS, DOE has categorized GTCC LLRW and GTCC-like waste as being one of three waste types: activated metals, sealed sources, or "Other Waste." The waste inventory being addressed in the EIS includes both stored inventory (wastes that were already generated and are in storage) and projected inventory (wastes that are expected to be generated in the future). The stored inventory includes waste in storage at sites licensed by the NRC and Agreement States (GTCC LLRW) and at certain DOE sites (GTCC-like waste) and consists of all three waste types (activated metals, sealed sources, and Other Waste).

For analysis in this EIS, the three waste types fall into two groups on the basis of uncertainties associated with their generation. Group 1 consists of wastes that are either already

[2] The LLRWPAA gave the federal government responsibility for disposal of GTCC LLRW and each state responsibility for the disposal of Class A, B, and C LLRW generated within the state (except for certain waste generated by the federal government). The Act authorized the states to enter into compacts for the establishment and operation of regional LLRW disposal facilities.

Three Waste Types

The wastes being addressed in this EIS are divided into three distinct types. These three waste types and their estimated total volumes and radioactivities are as follows:

- Activated metals: 2,000 m^3 (71,000 ft^3) and 160 MCi
- Sealed sources: 2,900 m^3 (100,000 ft^3) and 2.0 MCi
- Other Waste: 6,700 m^3 (240,000 ft^3) and 1.3 MCi

About three-fourths of the waste by volume is GTCC LLRW; GTCC-like waste accounts for the remainder. Much of the GTCC-like waste meets the DOE definition of TRU waste (see Table 1.4.1-2).

Two Waste Groups

For purposes of analysis in this EIS, wastes are considered to be in one of two groups.

- Group 1 consists of wastes from currently operating facilities. Some of the Group 1 wastes have already been generated and are in storage awaiting disposal.
- Group 2 consists of projected wastes from proposed actions or planned facilities not yet in operation.

in storage or are expected to be generated from existing facilities (such as commercial nuclear power plants). All stored GTCC LLRW and GTCC-like wastes are included in Group 1.

Group 2 consists of wastes that may be generated in the future as the result of actions proposed by DOE or commercial entities, such as wastes from proposed commercial reactors that have not been licensed or constructed. Some or all of the Group 2 waste may never be generated, depending on the outcomes of proposed actions that are independent of this EIS. No stored GTCC LLRW and GTCC-like wastes are included in Group 2.

The waste volumes and radionuclide activities of the wastes addressed in this EIS are shown in Table 1.4.1-2 and Figure 1.4.1-1. The volume of GTCC LLRW in Groups 1 and 2 is estimated to be about 8,800 m^3 (310,000 ft^3) and to contain about 160 MCi. Less than 2% of this commercially generated waste volume is currently in storage; most of this waste is expected to be generated in the future. The volume of GTCC-like waste is considerably less than that of GTCC LLRW; it is estimated to be about 2,800 m^3 (99,000 ft^3) and to contain about 1.0 MCi. A higher percentage (about 34%) of the GTCC-like waste than of the GTCC LLRW is already in storage at a number of DOE sites; the remaining 66% is expected to be generated in the future. The GTCC LLRW and GTCC-like waste contain both short-lived and long-lived radionuclides listed in 10 CFR 61.55, Tables 1 and 2 (see Table 1.4.1-1). The major radionuclides in the GTCC LLRW are generally neutron activation and fission products. These include carbon-14 (C-14), iron-55 (Fe-55), cobalt-60 (Co-60), nickel-59 (Ni-59), nickel-63 (Ni-63), strontium-90 (Sr-90), technetium-99 (Tc-99), and cesium-137 (Cs-137). Much of the GTCC-like waste is non-defense-related TRU waste containing relatively high concentrations of actinides, including isotopes of uranium (U), neptunium (Np), plutonium (Pu), americium (Am), and curium (Cm).

The total estimated volume of mixed waste in Group 1 is about 170 m^3 (6,000 ft^3). This volume represents less than 4% of the total volume of Group 1 waste. Current information

TABLE 1.4.1-2 Summary of Group 1 and Group 2 GTCC LLRW and GTCC-Like Waste Packaged Volumes and Radionuclide Activities[a]

Waste Type	In Storage		Projected		Total Stored and Projected	
	Volume (m^3)	Activity (MCi)[b]	Volume (m^3)	Activity (MCi)	Volume (m^3)	Activity (MCi)
Group 1						
GTCC LLRW						
Activated metals (BWRs)[c] - RH	7.1	0.22	200	30	210	31
Activated metals (PWRs) - RH	51	1.1	620	76	670	77
Sealed sources (Small)[d] - CH	–[e,f]	–	1,800	0.28	1,800	0.28
Sealed sources (Cs-137 irradiators) - CH	–	–	1,000	1.7	1,000	1.7
Other Waste[g] - CH	42	0.000011	–	–	42	0.000011
Other Waste - RH	33	0.0042	1.0	0.00013	34	0.0043
Total	130	1.4	3,700	110	3,800	110
GTCC-like waste						
Activated metals - RH	6.2	0.23	6.6	0.0049	13	0.24
Sealed sources (Small) - CH	0.21	0.0000060	0.62	0.000071	0.83	0.000077
Other Waste - CH	430	0.016	310	0.0062	740	0.022
Other Waste - RH	520	0.096	200	0.17	720	0.26
Total	960	0.34	510	0.18	1,500	0.52
Total Group 1	1,100	1.7	4,200	110	5,300	110
Group 2						
GTCC LLRW						
Activated metals (BWRs) - RH	–	–	73	11	73	11
Activated metals (PWRs) - RH	–	–	300	37	300	37
Activated metals (Other) - RH	–	–	740	0.14	740	0.14
Sealed sources - CH	–	–	23	0.000020	23	0.000020
Other Waste - CH	–	–	1,600	0.024	1,600	0.024
Other Waste - RH	–	–	2,300	0.51	2,300	0.51
Total	–	–	5,000	49	5,000	49
GTCC-like waste						
Activated metals - RH	–	–	–	–	–	–
Sealed sources - CH	–	–	–	–	–	–
Other Waste - CH	–	–	490	0.012	490	0.012
Other Waste - RH	–	–	870	0.48	870	0.48
Total	–	–	1,400	0.49	1,400	0.49
Total Group 2	–	–	6,400	49	6,400	49

TABLE 1.4.1-2 (Cont.)

Waste Type	In Storage		Projected		Total Stored and Projected	
	Volume (m^3)	Activity (MCi)[b]	Volume (m^3)	Activity (MCi)	Volume (m^3)	Activity (MCi)
Groups 1 and 2						
GTCC LLRW						
Activated metals - RH	59	1.4	1,900	160	2,000	160
Sealed sources - CH	–	–	2,900	2.0	2,900	2.0
Other Waste - CH	42	0.00091	1,600	0.024	1,600	0.024
Other Waste - RH	33	0.0042	2,300	0.51	2,300	0.51
Total	130	1.4	8,700	160	8,800	160
GTCC-like waste						
Activated metals - RH	6.2	0.23	6.6	0.0049	13	0.24
Sealed sources - CH	0.21	0.0000060	0.62	0.000071	0.83	0.000077
Other Waste - CH	430	0.016	800	0.02	1,200	0.036
Other Waste - RH	520	0.096	1,100	0.65	1,600	0.75
Total	960	0.34	1,900	0.67	2,800	1.0
Total Groups 1 and 2	1,100	1.7	11,000	160	12,000	160

[a] All values have been rounded to two significant figures. Some totals may not equal sum of individual components because of independent rounding. BWR = boiling water reactor, CH = contact-handled (waste), PWR = pressurized water reactor, RH = remote-handled (waste).

[b] MCi means megacurie or 1 million curies.

[c] There are two types of commercial nuclear reactors in operation in the United States, BWRs and PWRs. Different factors were used to estimate the volumes and activities of activated metal wastes for these two types of reactors.

[d] Sealed sources may be physically small but have high concentration of radionuclides.

[e] There are sealed sources currently possessed by NRC licensees that may become GTCC LLRW when no longer needed by the licensee. Due to the lack of information on the current status of the sources (i.e., whether they are in use, waste, etc.), the estimated volume and activity of these sources are included in the projected inventory.

[f] A dash means that there is no value for that entry.

[g] Other Waste consists of those wastes that are not activated metals or sealed sources; it includes contaminated equipment, debris, scrap metals, filters, resins, soil, solidified sludges, and other materials.

is insufficient to allow a reasonable estimate of the amount of Group 2 waste that could be mixed waste. Most of the Group 1 mixed waste is GTCC-like waste; only 4 m^3 (140 ft^3) is GTCC LLRW (Sandia 2007). Available information indicates that much of this waste is characteristic hazardous waste as regulated under the Resource Conservation and Recovery Act (RCRA); therefore, this EIS assumes that for the land disposal methods, the generators will treat the waste to render it nonhazardous under federal and state laws and requirements. WIPP, however, can accept mixed waste as provided in the WIPP Land Withdrawal Act (LWA) of 1992.

Estimates of the volumes and radionuclide activities of GTCC LLRW were first developed and reported in DOE (1994). That report was limited to GTCC LLRW and did not consider GTCC-like waste. Updated estimates (including estimates for GTCC-like waste) were developed by Sandia National Laboratories for DOE in 2007 to support issuance of the NOI for this EIS (Sandia 2007). Additional information on the characteristics of the GTCC LLRW and GTCC-like wastes to support EIS analyses are provided in a more recent report (Sandia 2008b). The approach used to develop estimates of the volumes and activities for Group 1 wastes is described in Sandia (2007, 2008b), and the approach used to develop comparable estimates for Group 2 wastes is described in Argonne (2010).

Additional information on the characteristics of the wastes included in Groups 1 and 2 is provided in the following sections. More detailed information on these wastes is given in Appendix B and the references cited in that appendix.

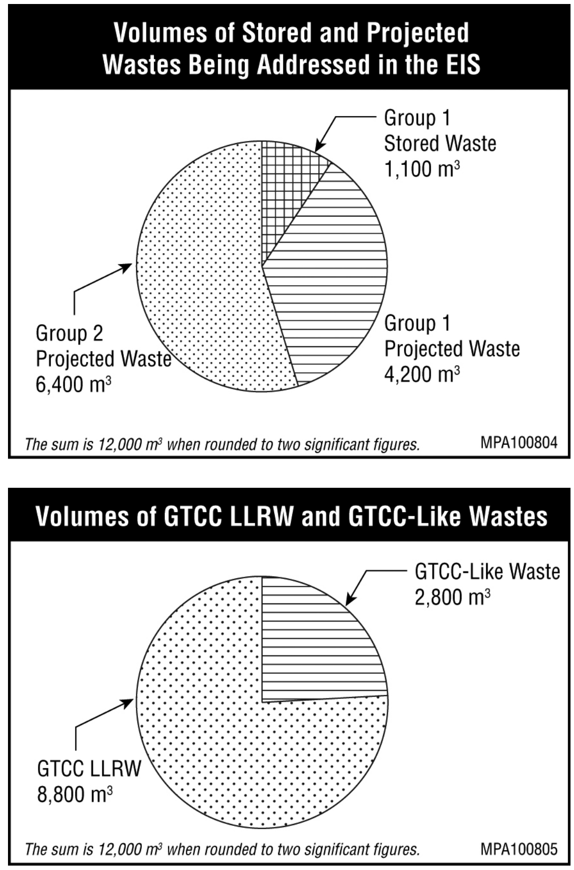

FIGURE 1.4.1-1 Current and Projected Volumes of Waste Needing Disposal

Activated Metals at a Glance

- They are largely generated from the decommissioning of nuclear reactors.
- They include portions of the nuclear reactor vessel, such as the core shroud and core support plate.
- They are not spent nuclear fuel.
- Prevalent radionuclides in activated metals include carbon-14, manganese-54, iron-55, nickel-59 and -63, niobium-94, and cobalt-60.
- In the United States, 104 commercial nuclear reactors are operating in 31 states, and more reactors are planned.
- Most of the reactors are not scheduled to undergo decommissioning for several decades.
- Commercial nuclear reactors provide 19% of the nation's electricity (EIA 2010).

1.4.1.1 Activated Metals

The activated metal wastes consist of steel, stainless-steel, and a number of specialty

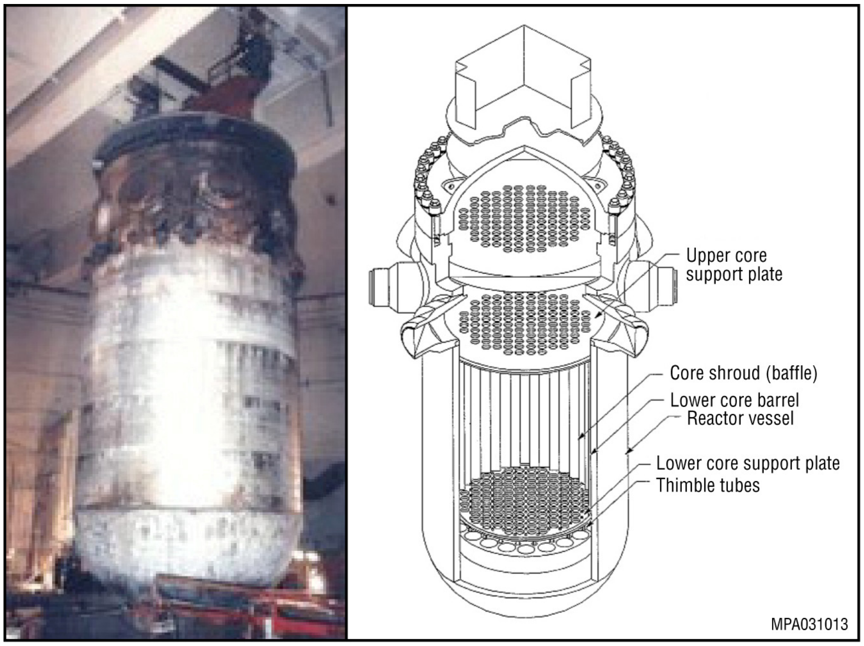

FIGURE 1.4.1-2 Activated Metal Waste, Including Portions of the Reactor Vessel, Such as the Core Shroud and Core Support Plates

alloys used in nuclear reactors (a typical reactor is shown in Figure 1.4.1-2). Portions of the reactor assembly and other components near the nuclear fuel are activated by high fluxes of neutrons during reactor operations for long periods of time, producing high concentrations of some radionuclides. Many of these have very short half-lives (i.e., days to several weeks, such as Co-58, zirconium-95 [Zr-95], and niobium-95 [Nb-95]) and decay quite rapidly, while others have longer half-lives (in some cases, such as C-14 and Ni-59, thousands of years) and remain radioactive for an extended period of time. Most of the activated metal waste will be generated in the future by the decommissioning of commercial nuclear power reactors. The neutron activation products expected to be most prevalent in these wastes at the time the wastes are available for disposal are C-14, manganese-54 (Mn-54), Fe-55, Co-60, Ni-59, Ni-63, molybdenum-93 (Mo-93), and Nb-94. Lower concentrations of some fission products (including Sr-90, Tc-99, and Cs-137) and actinides (such as various isotopes of plutonium) are also expected to be present on these materials as surface contamination.

Reactor Types

There are two types of commercial nuclear reactors used in the United States: pressurized water reactors (PWRs) and boiling water reactors (BWRs). The reactor pressure vessels for these two reactor types are significantly different and will result in different volumes and radionuclide activities of GTCC LLRW activated metal wastes. The reactor pressure vessel for a typical PWR (shown in Figure 1.4.1-2) is about 13 m (43 ft) high with a diameter of about 4.3 m (14 ft). The reactor pressure vessel for a typical BWR is larger, with a height of about 22 m (72 ft) and a diameter of about 6.4 m (21 ft). A greater volume of GTCC LLRW is produced by the decommissioning of a PWR than a BWR (see Argonne 2010).

> **Contact-Handled and Remote-Handled Waste**
>
> As used in this EIS, contact-handled (CH) waste refers to GTCC waste that has a dose rate of less than 200 mrem/h on the surface of the package. Remote-handled (RH) waste refers to GTCC waste that has a surface dose rate of 200 mrem/h or more. These definitions are consistent with the way that these terms are defined for disposal of TRU waste at WIPP.

Only a very small fraction of the metallic waste generated from the decommissioning of commercial nuclear power plants will be GTCC LLRW. Most of the waste is expected to be Class A, B, or C LLRW. For the purpose of analysis in the EIS, all of the GTCC LLRW activated metal waste is assumed to be remote-handled (RH) waste, since high concentrations of gamma-emitting radionuclides are expected in this material. These wastes will need a significant amount of shielding to reduce the levels of radiation to acceptable levels and/or will have to be handled remotely. RH waste refers to radioactive waste that must be handled at a distance (remotely) to protect workers from unnecessary exposure (e.g., waste with a dose rate of 200 millirem per hour [mrem/h] at the surface of the waste package). The physical form of this waste is solid metal.

Group 1 activated metal wastes are largely those associated with currently operating or decommissioned reactors. The GTCC LLRW resulting from the reactors that have already been decommissioned is currently being stored, generally at the reactor site. Most of the Group 1 GTCC LLRW activated metal waste volume results from the future decommissioning of currently operating commercial nuclear power plants, which will not occur for several decades. Group 1 activated metal GTCC-like wastes were identified at two DOE sites (INL and Oak Ridge National Laboratory [ORNL]). The total volume of activated metal waste (stored and projected) at these two DOE sites was determined to be about 13 m^3 (450 ft^3); about half of this volume is currently in storage, and the other half is projected to be generated in the future. The total activity in the GTCC-like activated metal wastes is estimated to be about 0.24 MCi, as shown in Table 1.4.1-2.

The total volume of Group 1 GTCC LLRW activated metal from decommissioning existing commercial nuclear reactors is estimated to be about 880 m^3 (31,000 ft^3). The electric utility industry is currently operating 104 NRC-licensed commercial nuclear reactors; the volume of GTCC LLRW from decommissioning these 104 operating reactors is expected to be about 820 m^3 (29,000 ft^3). Another 18 reactors have been shut down and decommissioned. The waste volume associated with the 18 decommissioned reactors is estimated to be about 59 m^3 (2,100 ft^3). Hence, only a small amount of GTCC LLRW activated metal waste is currently in storage, with more than 90% yet to be generated in the future. The total activity in the GTCC LLRW activated metal wastes is about 110 MCi (Table 1.4.1-2).

The Group 2 activated metal wastes include the GTCC LLRW from the future decommissioning of proposed commercial nuclear reactors that have not yet been licensed or constructed. The NRC has estimated that 33 new commercial nuclear power plants may be constructed in the future, and this number is used in this EIS to estimate the amount of GTCC LLRW activated metal waste that could be generated in the future from these activities (NRC 2009). A further increase in the number of new commercial nuclear power plants in and the volume of GTCC waste associated with the decommissioning of these additional new commercial nuclear power plants is uncertain at this time and therefore not estimated in this EIS.

Similarly, any potential nuclear fuel cycles involving advanced reactors or recycling of used fuel and the GTCC waste associated with these activities are uncertain at this time and therefore not estimated in this EIS. Either of these scenarios could have an impact on the volume of GTCC waste generated and requiring disposal, which would be subject to future NEPA analysis, including an analysis of the types and amount of waste generated and the need for disposal capacity.

In addition, activated metal waste (and sealed sources and Other Waste) may be generated if a decision is made to excavate two disposal areas at the West Valley Site (NRC-licensed disposal area [NDA] and state-licensed disposal area [SDA]) as part of the Phase 2 decommissioning activities for the closure of the site (DOE 2010a,b). Although no decision has been made at this time to exhume the two West Valley disposal areas, inclusion of the GTCC waste volumes in these disposal areas supports a bounding analysis for the GTCC EIS. The GTCC waste from the two disposal areas at West Valley Site is considered to be GTCC LLRW, except for a small quantity (31 m^3 [1,100 ft^3]) of GTCC-like waste in one of the disposal areas. This 31 m^3 (1,100 ft^3) of GTCC-like waste is included with the volume of GTCC LLRW from these two disposal areas for purposes of analysis in the EIS. There is no GTCC-like Group 2 activated metal waste.

The total volume of Group 2 activated metal wastes from decommissioning the proposed 33 new reactors is estimated to be about 380 m^3 (13,000 ft^3), and the total volume of activated metal waste associated with the exhumation of the two West Valley Site disposal areas is estimated to be 740 m^3 (26,000 ft^3). Hence, the total volume of Group 2 activated metal waste is about 1,100 m^3 (39,000 ft^3). This waste has an estimated total activity of about 48 MCi, largely associated with the future decommissioning of new commercial reactors (Table 1.4.1-2). The exhumed metal waste from the West Valley disposal areas would account for less than 1% of the total activity in Group 2 activated metal waste.

In summary, the total volume of activated metal wastes in Groups 1 and 2 is about 2,000 m^3 (71,000 ft^3), and the total activity is about 160 MCi. More than 99% of this waste is GTCC LLRW, with GTCC-like waste accounting for the remainder. Additional information on these waste volumes and activities is given in Table 1.4.1-2, and more detailed information on the radionuclide activities in these wastes is given in Appendix B and Argonne (2010).

Sealed Sources at a Glance

- They are widely used in equipment to diagnose and treat illnesses (particularly cancer), sterilize medical devices, irradiate blood for transplant patients, nondestructively test structures and industrial equipment, and explore geologic formations to find oil and gas.
- They are located in hospitals, universities, and industries throughout the United States.
- Unsecured or abandoned sealed sources are a national security concern because of their potential to be used in a "dirty bomb."
- They commonly consist of small, concentrated radioactive materials encapsulated in metal containers.
- Not all sealed sources are GTCC LLRW when they are disposed of.
- Radionuclides commonly used in sealed sources include cesium-137, americium-241, and plutonium-238.

1.4.1.2 Sealed Sources

The possession and use of sealed sources in the commercial sector are licensed by the NRC and its Agreement States. The term "sealed radioactive source" refers to a radioactive source manufactured, obtained, or retained for the purpose of utilizing the emitted radiation. A sealed radioactive source consists of a known or estimated quantity of radioactive material that is (1) contained within a sealed capsule, (2) sealed between layer(s) of nonradioactive material, or (3) firmly fixed to a nonradioactive surface by electroplating or other means intended to prevent leakage or escape of the radioactive material. These sources are commonly used to sterilize medical products, detect flaws and failures in pipelines and metal welds, determine moisture content in soil and other materials (moisture gauges), and diagnose and treat illnesses such as cancer (teletherapy units) (Figure 1.4.1-3).

Essentially all of the sealed sources being addressed in this EIS are in Group 1. The total packaged volume of Group 1 sealed sources is estimated to be about 2,800 m^3 (99,000 ft^3), with almost all of this volume being GTCC LLRW. The total packaged volume of GTCC-like sealed source waste is estimated to be about 0.83 m^3 (29 ft^3).

Source capsule used in medical teletherapy units

Blood irradiator

Abandoned Am-241 and Cs-137 gauges and shipping shields

Well logging sources being loaded

MPA100810

FIGURE 1.4.1-3 Sealed Sources

The only sealed sources in Group 2 are those associated with the potential exhumation of the SDA at the West Valley Site in western New York. The total in-place volume of sealed sources in the SDA is estimated to be about 22 m^3 (780 ft^3). When exhumed and packaged for disposal, it is estimated that this volume would increase to about 23 m^3 (810 ft^3) (Table 1.4.1-2).

Sealed sources can encompass several physical forms, including ceramic oxides, salts, or metals. Cesium chloride (CsCl) salt was generally used in older Cs-137 sources. While large Cs-137 sources still employ CsCl, newer small sources typically have the radionuclide bonded in a ceramic. Of these two forms, CsCl salt is much more water soluble. For the EIS, all of the Cs-137 sources are conservatively assumed to be present as CsCl salt. In addition to Cs-137, the radionuclides expected to be present in these sealed sources include Pu-238, Pu-239, Pu-240, Am-241, Am-243, and curium-244 (Cm-244). For the purpose of analysis in this EIS, these radionuclides are conservatively assumed to be present in the sealed sources in the form of oxides. These oxide sources are likely to be in the form of pellets (Sandia 2008b).

Sealed sources generally have relatively low exposure rates when packaged for disposal. All of the packaged sealed sources are expected to be contact-handled (CH) waste, with the possible exception of two Am-241/beryllium sources. For purposes of analysis in the EIS, CH waste is considered to be waste that has a dose rate at the surface of the package of less than 200 mrem/h. Should RH sealed source waste be generated, appropriate precautions would be taken during waste handling and disposal operations to protect workers. Sealed sources other than the Cs-137 irradiators are assumed to be packaged in 208-L (55-gal) drums in accordance with packaging factor limits developed by the DOE Global Threat Reduction Initiative/Off-Site Source Recovery Project (GTRI/OSRP) at LANL (Sandia 2007). It is estimated that approximately 8,700 drums would be required for packaging these sealed sources.

Sources recovered by GTRI/OSRP for national security or public health and safety reasons are stored at LANL or off-site contractor facilities pending disposal. Typically, DOE takes ownership of sealed sources recovered under the GTRI/OSRP program. The transfer of ownership from the source owner to DOE is officially documented through an *Authorization to Transfer/Relinquishment of Ownership/Custody* form. Sources owned by DOE may be disposed of at DOE facilities if the sources meet the waste acceptance criteria for those facilities. To date, all of the sources recovered by GTRI/OSRP have an identified path to disposal and are therefore not included in the GTCC EIS inventory. The inventory of GTCC-like sealed sources in storage includes only those sealed sources from other DOE activities that may not have an identified disposal path. The projected inventory for GTCC-like sealed sources does not include sources that may, in the future, be recovered by GTRI/OSRP. Any such sources are the responsibility of the licensees until the point at which they are recovered by GTRI/OSRP; therefore, they are included in the projected inventory for commercial GTCC sealed sources.

The sealed source waste inventory also includes 1,435 large Cs-137 irradiators that are in the possession of commercial licensees. These projected GTCC LLRW sources cannot be packaged in standard 208-L (55-gal) drums; it is assumed they would be disposed of individually in their original shielded devices. For purposes of analysis in the EIS, each Cs-137 irradiator is assumed to have a packaged waste volume of about 0.71 m^3 (25 ft^3) with dimensions of about 150 × 65 × 67 cm (59 × 26 × 27 in.) (Sandia 2008b). Hence, the 1,435 commercial Cs-137 irradiators would have a waste volume of about 1,000 m^3 (35,000 ft^3). In these irradiators, the Cs-137 source is contained within a robust shielded device that is expected to retain its integrity for many years following disposal.

In summary, the total packaged volume of all (Group 1 and Group 2) GTCC LLRW sealed sources is estimated to be approximately 2,900 m^3 (100,000 ft^3), and the volume of GTCC-like sealed sources is estimated to be about 0.83 m^3 (29 ft^3). Nearly all of this waste is projected to be generated in the future. For conservatism, it is assumed that none of the sealed sources would be recycled. The total activity of the sealed sources is estimated to be about 2.0 MCi, with Cs-137 accounting for most (86%) of this total. Nearly all of this volume and activity are associated with Group 1 wastes. Additional information on these waste volumes and activities is given in Table 1.4.1-2, and detailed information on the radionuclide activities in these wastes is provided in Appendix B and Argonne (2010).

1.4.1.3 Other Waste

Other Waste consists of a wide variety of materials, such as contaminated equipment, sludges, salts, charcoal, scrap metal, glove boxes, solidified solutions, particulate solids, filters, and organic and inorganic debris, including debris from future decontamination and decommissioning activities, the production of Pu-238 radioisotope power systems, and the production of medical isotopes (Mo-99) (Figure 1.4.1-4). This category of waste includes the GTCC LLRW and GTCC-like wastes that do not fall into one of the other two categories (activated metals or sealed sources). These wastes can come in a number of physical forms, and a wide range of radionuclides may be present.

Other Waste at a Glance

- Other Waste primarily includes contaminated equipment, debris, scrap metal, and decommissioning waste from the:
  - Production of Mo-99, which is used in about 16 million medical procedures (e.g., to detect cancer) each year (Coalition of Professional Organizations 2009). The United States depends on aging foreign reactors to produce Mo-99, and shortages in recent years due to the unexpected shutdowns of the foreign facilities have highlighted the need to produce Mo-99 in the United States.
  - Production of radioisotope power systems in support of space exploration and national security.
  - Environmental cleanup of the West Valley Site in New York.
- A wide range of radionuclides may be present in Other Waste, including Tc-99, Cs-137, and a number of transuranic radionuclides, including isotopes of plutonium, americium, and curium.

While some of this waste is produced in the commercial sector as a result of radionuclide manufacturing, research, and other activities, much of this waste is associated with DOE activities and considered to be GTCC-like waste. Most of the wastes in this category are associated with the cleanup of the West Valley Site and the potential exhumation of wastes from two disposal areas at this site. The total volume of Group 1 and Group 2 GTCC LLRW and GTCC-like Other Waste is about 6,700 m^3 (240,000 ft^3). Of this total, the West Valley Site accounts for about 5,700 m^3 (200,000 ft^3). About 61% of the West Valley Site Other Waste volume is GTCC LLRW (from the possible

FIGURE 1.4.1-4 Other Waste (Glove Boxes)

exhumation of the two disposal areas), and 39% is GTCC-like waste (largely from ongoing and future cleanup activities).

The GTCC-like wastes associated with the cleanup of the West Valley Site are largely composed of building, piping, and process equipment debris, and the volume of the waste is estimated to be about 2,200 m^3 (78,000 ft^3). About 56% of this waste is in Group 1 Other Waste, and 44% is in Group 2 Other Waste. Much of this waste may not meet the waste acceptance criteria for disposal at WIPP as defense-generated TRU waste. Wastes from the NDA and SDA at the West Valley Site that could potentially be exhumed account for about 3,500 m^3 (120,000 ft^3) of GTCC LLRW Other Waste. Most of the wastes in these two disposal areas were produced by commercial activities and are GTCC LLRW. A small quantity (31 m^3 [1,100 ft^3]) of waste in the NDA is considered to be GTCC-like waste. This GTCC-like waste is included with the volume of GTCC LLRW from the NDA and SDA for purposes of analysis in the EIS.

Two commercial generators of GTCC LLRW Other Waste were identified for inclusion in the EIS, and these sites are located in Virginia and Texas. The volume of stored waste is reported to be 75 m^3 (2,600 ft^3), and an additional 1 m^3 (35 ft^3) is projected to be generated in the future. These wastes are included in the Group 1 inventory. The remainder of the Other Waste in Group 1 is largely associated with GTCC-like wastes at two DOE facilities (INL and the Oak Ridge Reservation). A spectrum of radionuclides is present in these wastes, with the isotopes of various actinides (uranium, neptunium, plutonium, americium, and curium) being of most concern for long-term management. The total activity in the Group 1 and Group 2 Other Waste is 1.3 MCi, and many of the radionuclides present in this waste have very long half-lives (see related discussion in Appendix B).

The total volume of Group 1 Other Waste (GTCC LLRW and GTCC-like waste) is estimated to be about 1,500 m^3 (53,000 ft^3). About 67% of the Group 1 waste in this category has already been generated and is in storage; the remainder is projected to be generated in the future. Most of the stored waste is at the West Valley Site. Much of the waste in this category is expected to meet the DOE definition for TRU waste (i.e., waste that contains more than 100 nCi/g of alpha-emitting TRU radionuclides with half-lives longer than 20 years). This TRU waste may not meet the waste acceptance criteria for disposal at WIPP as defense-generated TRU waste and has no other currently identified path to disposal. About half of the Group 1 waste in this category is RH waste and half is CH waste. The total activity in this Group 1 Other Waste is about 0.28 MCi.

The total volume of Group 2 Other Waste (GTCC LLRW and GTCC-like waste) is estimated to be about 5,300 m^3 (190,000 ft^3). All of this waste is in the projected inventory, and it may or may not be generated, depending on future decisions. In addition to wastes associated with the West Valley Site, this category includes GTCC LLRW associated with two Mo-99 production projects and GTCC-like waste associated with a planned DOE Pu-238 production project. The wastes associated with these two activities are described in Argonne (2010) and are summarized in Appendix B. It is estimated that the two Mo-99 projects would generate a total of about 390 m^3 (14,000 ft^3) of GTCC LLRW and that the planned DOE Pu-238 project would generate a total of about 380 m^3 (13,000 ft^3) of GTCC-like waste.

In summary, the total volume of Other Waste in Groups 1 and 2 is about 6,700 m^3 (240,000 ft^3), and it has a total activity of about 1.3 MCi. About 58% of this waste is GTCC LLRW, and 42% is GTCC-like waste. The West Valley Site accounts for 5,700 m^3 (200,000 ft^3) of the waste in this category. Additional information on these waste volumes and activities is provided in Table 1.4.1-2. Detailed information on the radionuclide activities in these wastes is given in Appendix B and Argonne (2010).

1.4.2 Disposal Methods Considered

NRC regulations at 10 CFR 61.55 (a)(2)(iv) require that GTCC LLRW must be disposed of in a geologic repository unless alternative methods of disposal are proposed to the NRC and approved by the Commission. In that regard, 10 CFR 61.7(b)(5) provides for instances in which GTCC LLRW would be acceptable for near-surface disposal with special processing or design. For this EIS, DOE is considering four disposal methods at varying depths of waste isolation (see Figure 1.4.2-1): (1) deep geologic disposal, (2) boreholes, (3) trenches, and (4) vaults.

In the early 1990s, DOE conducted a review of potential technologies for disposing of GTCC LLRW (Henry 1993). This review followed a similar review of near-surface technologies for disposing of LLRW that the NRC had conducted (Bennett et al. 1984). In these reviews, the disposal technologies were categorized as near-surface, intermediate-depth, and deep geologic methods. All of the technologies identified in these reports included the use of high-integrity containers or high-level radioactive waste containers. High-integrity containers are also assumed in this EIS, as described in Appendix B. DOE selected methods that represent the range of technology methods considered in these previous studies for evaluation in this EIS. The WIPP repository alternative represents the deep geologic concept, the borehole method represents the

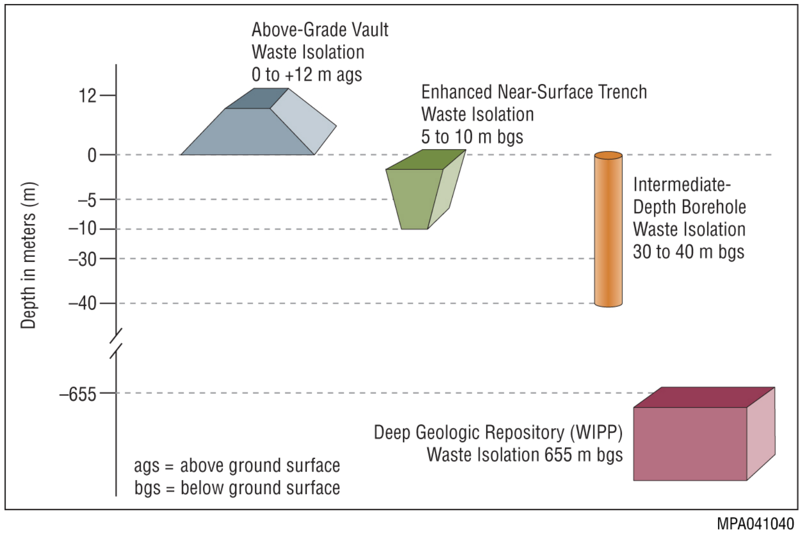

FIGURE 1.4.2-1 Waste Isolation Depths for Proposed GTCC Disposal Methods

intermediate-depth concept, and the trench and vault methods represent the near-surface concept with enhanced engineering features.

The designs for the land disposal facilities that are evaluated in this EIS are conceptual and generic in nature so that the performance of the sites with regard to employing the disposal methods considered in this EIS can be compared. Section 5.1.4 and Appendix D present additional details on the conceptual designs of the land disposal methods. These conceptual designs could be altered or enhanced, as necessary, to provide the optimal application at a given location.

The borehole, trench, and vault disposal methods, which are also referred to as land disposal methods or facilities in this EIS, must provide sufficient distance to the water table so that the intrusion of groundwater (perennial or otherwise) into the waste will not occur.

1.4.2.1 Deep Geologic Disposal

A deep geological repository is a radioactive waste disposal facility excavated generally below 300 m (1,000 ft) within bedrock. It entails a combination of waste form, waste package, and engineered seals that is designed to provide for disposal without future maintenance.

A geologic repository is a system intended to be used for the disposal of radioactive wastes in excavated geologic media and is composed of an operations area and the portion of the geologic setting that isolates the radioactive waste. The operations area typically includes a radioactive waste facility (including both surface and subsurface areas) where waste handling activities are conducted. The geologic setting includes the geologic, hydrologic, and geochemical systems of the region in which a geologic repository operations area is or may be located.

1.4.2.2 Intermediate-Depth Borehole Disposal

Intermediate-depth borehole disposal entails the emplacement of waste in boreholes below 30-m (100-ft) deep but no deeper than 300 m (1,000 ft). The boreholes can vary widely in diameter from 0.3 to 3.7 m (1 to 12 ft), and the proximity of one borehole to another can also vary, depending on the design of the facility. GTCC waste disposal placement is assumed to be about 30 to 40 m (100 to 130 ft) below ground surface (bgs). The technology for drilling larger-diameter boreholes is simple and widely available. The conceptual design used as the basis for the evaluation in this EIS employs boreholes that are about 2.4 m (8 ft) in diameter and are located 40-m (130-ft) deep in unconsolidated to semiconsolidated soils, as shown in Figure 1.4.2-2. The borehole diameter was selected to accommodate various disposal packages that might be used to contain the three waste types evaluated in this EIS. The depth was selected on the basis of a consideration of the subsurface characteristics of the sites being evaluated in this EIS.

A bucket auger or other commercially available drilling device would be used to drill the large-diameter borehole, and a smooth steel casing would be advanced to the depth of the borehole during its drilling and construction. The casing would help stabilize the borehole walls and ensure that waste packages would not snag and plug the borehole as they were lowered; this would also ensure that the packages would sit in an upright position when they reached the bottom. The upper 30 m (100 ft) of smooth steel casing would be removed upon closure of the borehole. An engineered barrier (i.e., reinforced concrete) would be placed on the top of the waste to deter inadvertent human intrusion during the post-closure period. The remainder of the borehole above the barrier would be backfilled with clean fill.

1.4.2.3 Enhanced Near-Surface Disposal

Near-surface disposal involves disposal within the top 30 m (100 ft) of the earth's surface (10 CFR 61.2). Two types of enhanced near-surface disposal methods are considered in this EIS: a trench facility and a vault facility.

1.4.2.3.1 Enhanced Trench Design. In the conceptual design for the trench disposal facility, the trenches are about 3-m (10-ft) wide, 11-m (36-ft) deep, and 100-m (330-ft) long. GTCC waste disposal placement is assumed to be about 5 to 10 m (15 to 30 ft) bgs. The width and depth were selected to optimize the disposal capacity of each trench within the limits of readily available excavation equipment and commercially available shoring equipment. Figure 1.4.2-3 illustrates the trench design features and approximate dimensions. Narrow trenches like this are often referred to as slit trenches, and they are often used for high-activity LLRW because the soil provides greater shielding when this configuration is used.

The side walls of the trench would be vertical. A well-compacted material would be placed on top of the native material in the floor of the trench. A 0.3-m (1-ft) layer of sand or gravel would then be placed on top of the compacted material to improve stability. The nature of the compacted material would be selected to be compatible with surrounding geologic material.

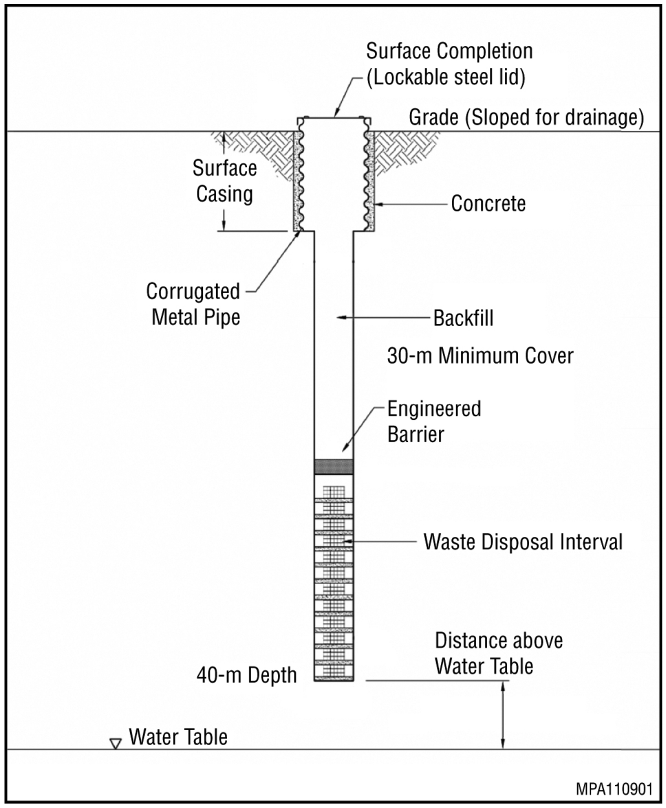

FIGURE 1.4.2-2 Cross Section of the Conceptual Design for an Intermediate-Depth Borehole

The trench sidewalls would be constructed by using temporary metal shoring, which would be removed when the trench was closed.

Wastes would be contained in packages designed to retain their integrity for an extended time period, and these wastes would be carefully emplaced into the trenches. A fine-grained, cohesionless fill (sand) would be used to backfill around the waste containers and fill voids. After the trench was filled with the waste containers and backfill, an engineered barrier (i.e., reinforced concrete) would be placed over the waste packages. It is anticipated that clean fill from the construction-site would be used to backfill the trench above the engineered barrier.

1.4.2.3.2 Above-Grade Vault Design. The conceptual design for the above-grade disposal of GTCC LLRW would employ a reinforced concrete vault constructed near grade level, with the footings and floors of the vault situated in a slight excavation just below the frost line that might occur at the sites being evaluated for the vault method in this EIS. The design is a modification of a disposal concept proposed by Henry (1993) for GTCC LLRW, and it is similar to a belowground vault option for LLRW disposal (Denson et al. 1987) that was previously investigated by the U.S. Army Corps of Engineers (USACE). A similar concrete vault structure is currently in use for the below-grade disposal of higher-activity LLRW at SRS (MMES et al. 1994).

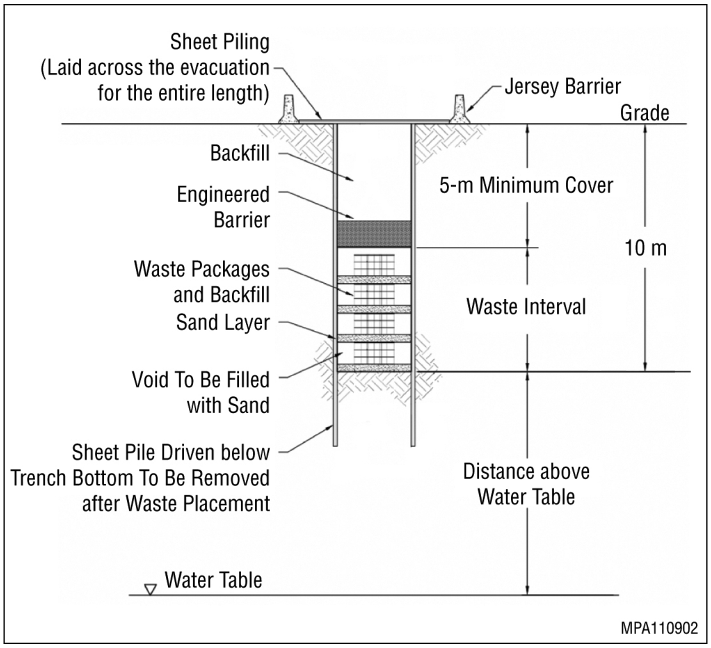

FIGURE 1.4.2-3 Cross Section of the Conceptual Design for a Trench

Each vault would be about 11-m (36-ft) wide, 94-m (310-ft) long, and 7.9-m (26-ft) tall, with 11 disposal cells situated in a linear array. Interior cell dimensions would be 8.2-m (27-ft) wide, 7.5-m (25-ft) long, and 5.5-m (18-ft) high, with an internal volume of 340 m^3 (12,000 ft^3) per cell. Double interior walls with an expansion joint would be included after every second cell. GTCC waste disposal placement is assumed to be about 4.3 to 5.5 m (14 to 18 ft) above ground surface. Figure 1.4.2-4 shows a schematic cross section of a vault cell.

The exterior walls and roof would be composed of reinforced concrete that is 1.1-m (3.8-ft) thick. In addition to adding strength and durability to the vault, the thick concrete would attenuate the gamma radiation associated with some of the RH waste. An engineered cover (i.e., about 5-m [17-ft] thick) would be placed over the vault after disposal activities were completed to isolate the waste from the environment over the long term.

1.4.3 Sites Considered for Disposal Locations

For deep geologic disposal, WIPP in New Mexico was included for evaluation in this EIS because of its characteristics as a geologic repository. DOE also evaluated three land disposal methods (borehole, trench, and vault) at six federally owned sites: Hanford Site, INL, LANL, NNSS, SRS, and the WIPP Vicinity. Two different locations were evaluated for the WIPP Vicinity site: Section 27 (which is located within the WIPP LWB) and Section 35 (which is on BLM-managed land that is just outside the WIPP LWB). In addition to the six federally owned sites, the land disposal methods were evaluated for generic commercial sites in the four regions that make up the United States, as shown in Figure 1.4-2.

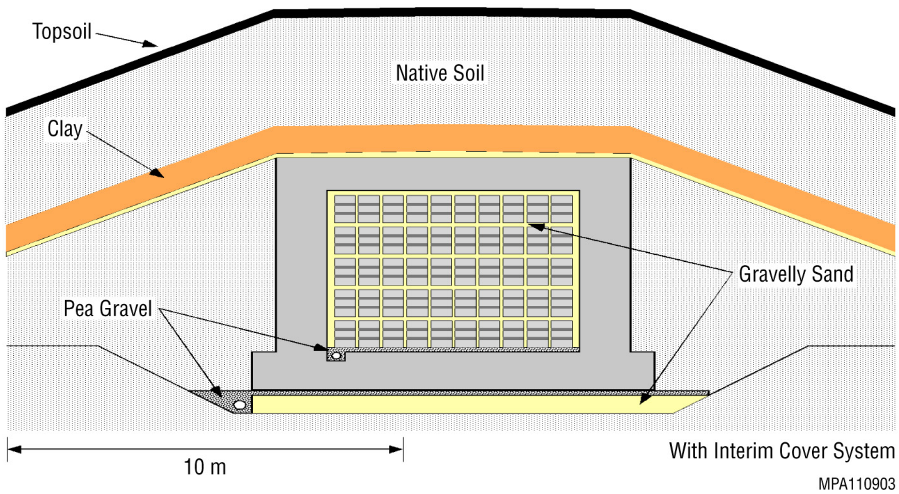

FIGURE 1.4.2-4 Schematic Cross Section of the Conceptual Design for a Vault Cell

As shown in Table 1.4.3-1, because of shallow water considerations, the borehole method is evaluated for all sites except SRS and the generic commercial sites in Regions I, II, and III; the trench method is evaluated for all sites except the generic commercial sites in Regions I and III; and the vault method is evaluated for all sites, both the federally owned sites and the generic commercial sites in all four regions. (See Table 1.4.3-1 for a summary of which land disposal method was evaluated.)

TABLE 1.4.3-1 Land Disposal Methods Evaluated at the Six Federal Sites and Generic Regional Commercial Sites

Site	Borehole	Trench	Vault
Hanford Site	√	√	√
INL	√	√	√
LANL	√	√	√
NNSS	√	√	√
SRS	No	√	√
WIPP Vicinity	√	√	√
Region I[a]	No	No	√
Region II[a]	No	√	√
Region III[a]	No	No	√
Region IV[a]	√	√	√

[a] Based on the NRC Regions.

The DOE sites evaluated for the land disposal methods were identified on the basis of mission compatibility (i.e., only DOE sites that currently have radioactive waste disposal as part of their ongoing mission were considered). These DOE sites would also have supporting infrastructure already in place that might be useful for future potential GTCC waste disposal activities. The WIPP Vicinity was identified for evaluation because of its proximity to ongoing waste disposal operations at WIPP and the potential for using supporting infrastructure.

Aside from mission compatibility, site factors that were considered in identifying an acceptable area for developing a GTCC waste disposal facility were that it should (1) have sufficient depth to groundwater; (2) not be located within the 100-year floodplain or in wetlands; (3) be consistent with current land use plans; and (4) have a low probability for erosion, mass wasting, faulting, folding, and seismic activity that would occur often enough and to a large enough extent that the facility's performance would be affected. All of these are mentioned in

10 CFR Part 61 as requirements for siting a commercial LLRW disposal facility and are consistent with the siting requirements in the *Radioactive Waste Management Manual*, DOE M 435.1-1 (DOE 1999).

> The selection of site(s) for GTCC waste disposal will consider existing laws, regulations, and agreements. The site-specific chapters (4 and 6–11) and Chapter 13 identify relevant laws, regulations, and agreements that will be considered in the decision-making process.

For each of the DOE sites identified above for inclusion, a reference location was identified in order to serve as the basis for the evaluations presented in this EIS. These evaluations are intended to serve as a starting point for each of the sites being considered. In other words, if a site or sites were selected for possible implementation of a land disposal method or methods, a follow-on site-specific NEPA evaluation and documentation, as appropriate, along with further optimization by a selection study, would be conducted to identify the location or locations within a given site that would be considered the best ones to accommodate the land disposal method(s). The use of the reference locations for the EIS is considered to be an acceptable approach to meet the objective of identifying the site and technology combination that could provide the most suitable option for GTCC waste disposal.

It is expected that the potential environmental impacts identified in this EIS for the various sites and disposal methods would be representative of those that would occur if the disposal facility was located at a given site. In other words, these results are expected to represent how each site would perform under each of the three land disposal methods being considered in this EIS and provide a basis for comparison among sites. Once a site and a disposal method were selected, additional studies would be necessary to identify the most appropriate location for this facility. While institutional knowledge was used to select the reference locations evaluated in this EIS, more in-depth, site-specific, follow-on studies and appropriate NEPA reviews would be needed to ensure proper land use planning, assure protection of local ecological and cultural resources, and account for local variations in hydrology and geology to minimize potential waste migration.

Sections 1.4.3.1 through 1.4.3.9 provide brief descriptions of the site locations considered in this EIS for the disposal of GTCC LLRW and GTCC-like waste.

1.4.3.1 Waste Isolation Pilot Plant

WIPP is a DOE facility that is the first underground deep geologic repository permitted by the U.S. Environmental Protection Agency (EPA) and the State of New Mexico to safely and permanently dispose of defense-generated TRU radioactive waste (WIPP LWA) (P.L. 102-579). WIPP is located 42 km (26 mi) east of Carlsbad, New Mexico, in the Chihuahuan Desert in the southeast corner of the state (Figure 1.4.3-1). Project facilities include disposal rooms that are mined 655 m (2,150 ft) under the ground in a salt formation (the Salado Formation) that is 610-m (2,000-ft) thick and has been stable for more than 200 million years.

The WIPP facility sits in the approximate center of a 41-km^2 (16-mi^2) area that was withdrawn from public domain and transferred to DOE (Figure 1.4.3-2). The facility footprint

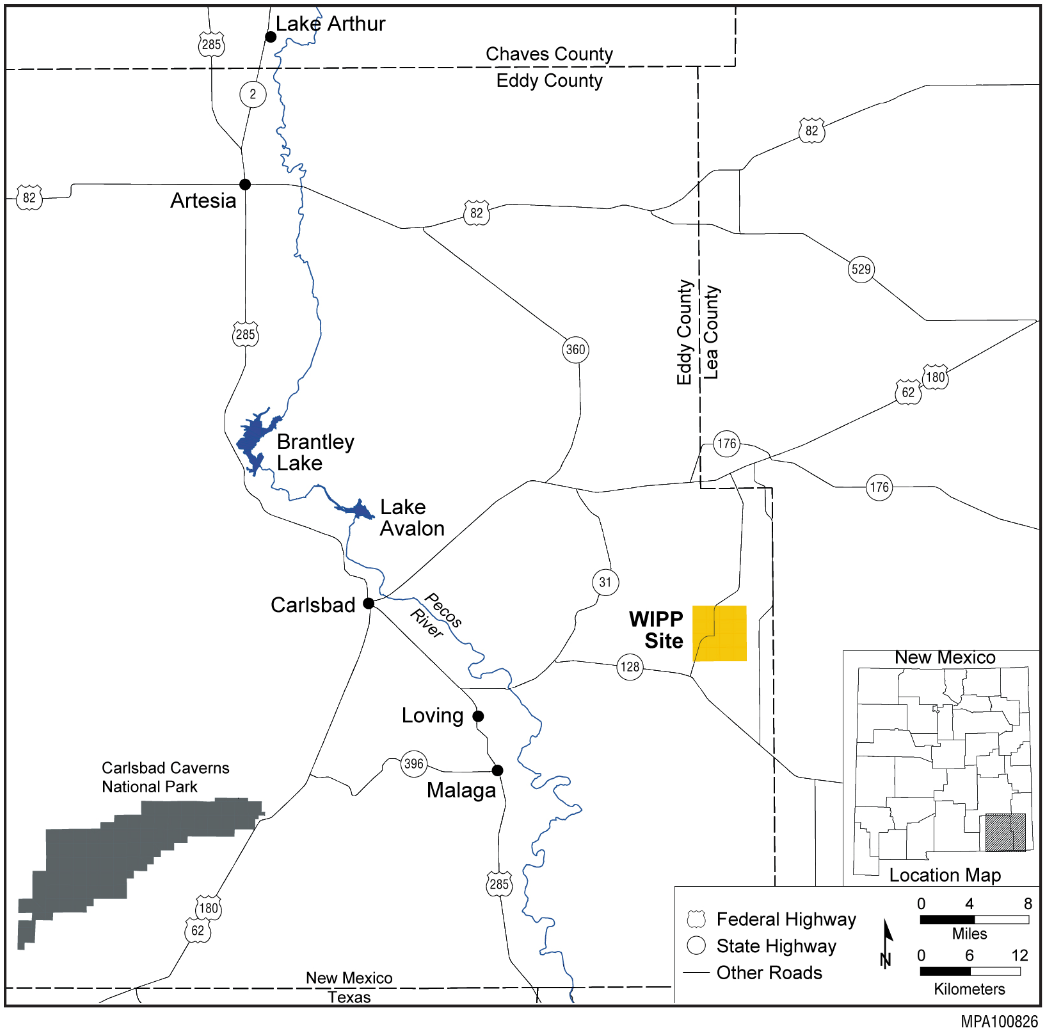

FIGURE 1.4.3-1 General Location of WIPP in Eddy County, New Mexico (Source: Sandia 2008a)

itself encompasses 14 fenced ha (35 fenced ac) of surface space and about 12 km (7.5 mi) of underground excavations in the Salado Formation. There are four shafts to the underground: the waste shaft, salt handling shaft, air intake shaft, and exhaust shaft (Figure 1.4.3-3). There are several miles of paved and unpaved roads in and around the WIPP site, and an 18-km-long (11-mi-long) access road runs north from the site to U.S. Highway (US) 62-180. The access road that is used to bring TRU waste shipments to WIPP is a wide, two-lane road with paved shoulders. Railroad access to the site is in place but is not currently in use.

The initial construction of WIPP began in the 1980s. The first shipments of CH TRU and RH TRU waste were received at WIPP on March 26, 1999, and January 23, 2007, respectively. The total capacity for the disposal of TRU waste established under the WIPP LWA is 175,675 m^3 (6.2 million ft^3). The Consultation and Cooperative Agreement with the State of New Mexico (1981) established a total RH capacity of 7,080 m^3 (250,000 ft^3), with the remaining capacity for CH TRU at 168,500 m^3 (5.95 million ft^3). In addition, the WIPP LWA

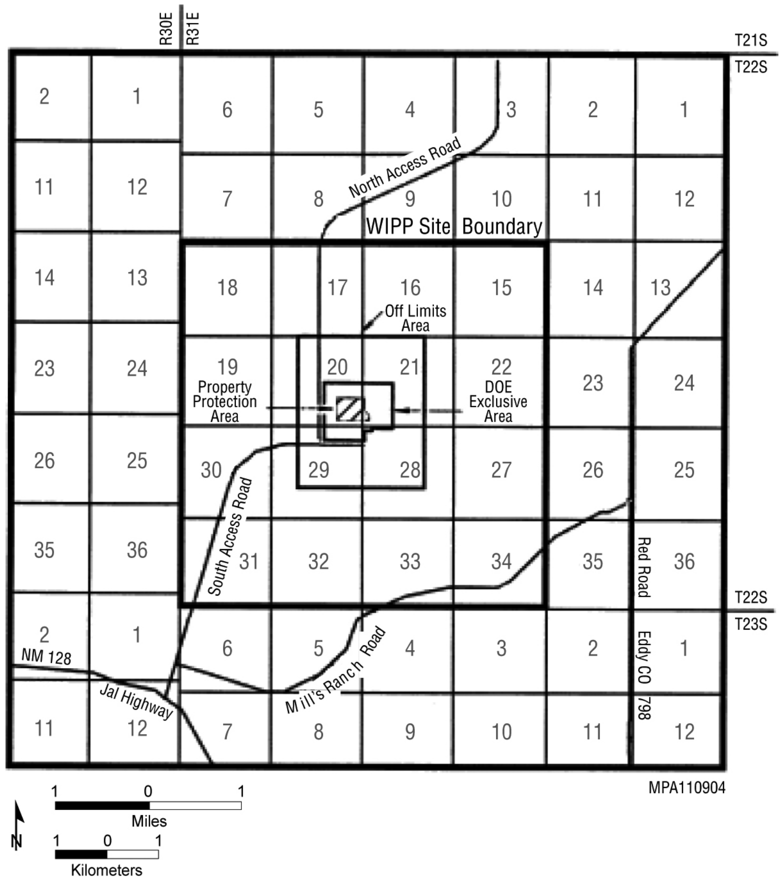

FIGURE 1.4.3-2 Land Withdrawal Area Boundary at WIPP (Source: Sandia 2008a)

limits the total radioactivity of RH waste to 5.1 million curies. Current plans include receipt and emplacement of TRU waste in 10 waste disposal panels (there are seven rooms in each panel) through fiscal year (FY) 2030. As of FY 2010, waste emplacement in four panels was completed, and emplacement in the fifth panel and mining of the sixth panel had begun.

1.4.3.2 Hanford Site

The Hanford Site is located in south-central Washington State on 151,775 ha (375,040 ac) of land between the Cascade Range and the Rocky Mountains (Figure 1.4.3-4). The Columbia River flows through the northern portion of the site and forms part of its eastern boundary. Hanford has been operated by DOE and its predecessors (the Manhattan Engineer District, U.S. Atomic Energy Commission [AEC], and U.S. Energy Research and Development Administration) since it was created in 1943. Its primary mission was to produce nuclear materials in support of national defense and research. Operations associated with those programs used facilities for the fabrication of nuclear reactor fuel, reactors for nuclear materials production, chemical separation plants, nuclear material processing facilities, research

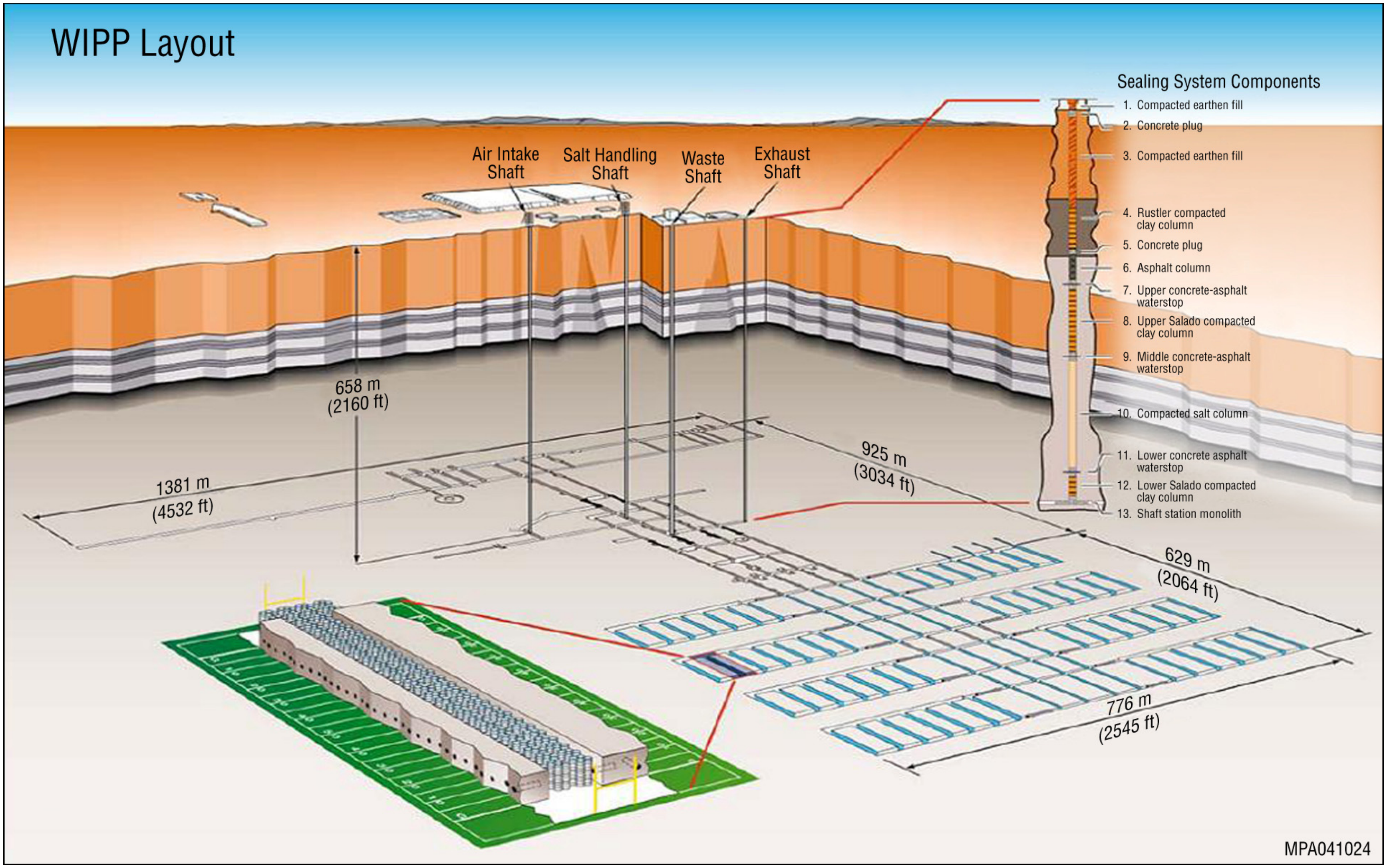

FIGURE 1.4.3-3 Spatial View Showing Underground Shafts at WIPP (Source: Sandia 2008a)

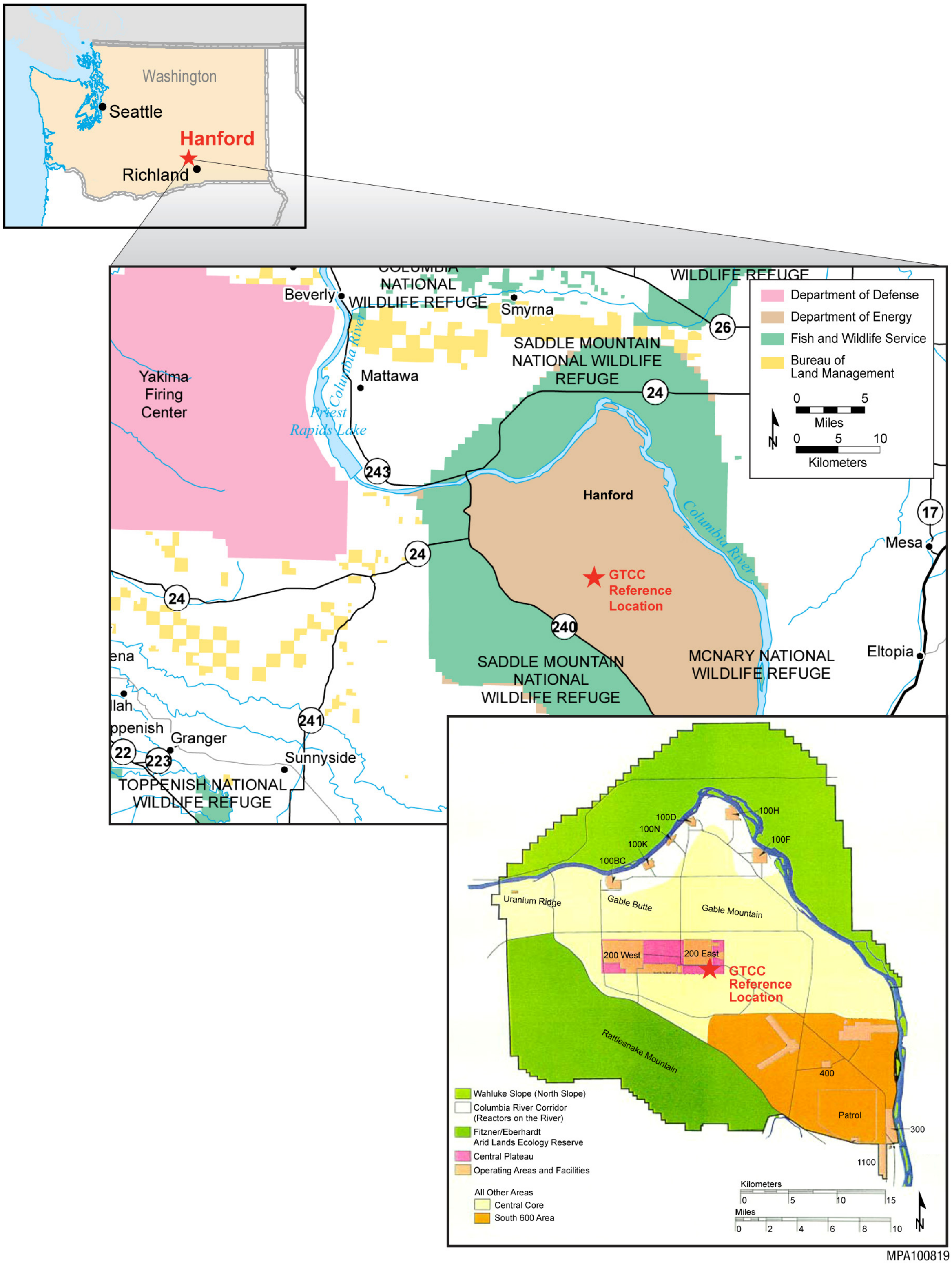

FIGURE 1.4.3-4 GTCC Reference Location at the Hanford Site

laboratories, and waste management facilities. Current activities include research, environmental restoration, and waste management (Bunn et al. 2005). The Hanford Reach National Monument (Monument) covers an area of 78,900 ha (195,000 ac) on DOE's Hanford Reservation. Of this, the U.S. Fish and Wildlife Service (USFWS) manages approximately 66,773 ha (165,000 ac) through a DOE permit and other agreements with DOE. DOE directly manages approximately 11,736 ha (29,000 ac), and the Washington Department of Fish and Wildlife currently manages the remainder (approximately 324 ha [800 ac]) under a DOE permit. Because DOE is currently the underlying land holder, it retains approval authority over certain management aspects of the Monument (USFWS 2009).

Current waste management activities at the Hanford Site include the treatment and disposal of LLRW on-site, the processing and certification of TRU waste pending its disposal at WIPP, and the storage of high-level radioactive waste on-site pending its disposal. DOE announced in the December 18, 2009, *Federal Register* (74 FR 67189) that its preferred alternative in the Draft Tank Closure and Waste Management EIS includes not shipping GTCC LLRW to Hanford at least until the Waste Treatment Plant is operational. The Waste Treatment Plant is expected to be operational in 2022. The main areas where waste management activities occur are the 200 West Area and the 200 East Area, which are south of the Columbia River. These 200 Areas cover about 16 km^2 (6 mi^2). Activities at the 200 Areas include the operation of lined trenches for the disposal of LLRW and mixed LLRW and the operation of the Environmental Restoration Disposal Facility for the disposal of LLRW generated by environmental restoration activities that are being conducted at the Hanford Site to comply with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). US Ecology, Inc., operates a commercial LLRW disposal facility on a 40-ha (100-ac) site leased by the State of Washington near the 200 East Area. The facility is licensed by the NRC and the State of Washington.

The GTCC reference location (see Section 1.4.3) is south of the 200 East Area (Figure 1.4.3-4). The 200 East and West Areas are located on a plateau about 11 and 8 km (7 and 5 mi), respectively, south of the Columbia River. Historically, these areas have been dedicated to fuel reprocessing and to waste management and disposal activities (Bunn et al. 2005).

1.4.3.3 Idaho National Laboratory

INL is located on 230,000 ha (580,000 ac) of relatively undisturbed DOE land in the upper Snake River Plain in southeastern Idaho (Figure 1.4.3-5). Basalt flows cover most of the plain, producing a rolling topography. The average elevation at the site is 1,500 m (4,900 ft). INL is bordered by mountain ranges on the north and by volcanic buttes and open plain on the south. Lands immediately adjacent to the INL site consist of open rangeland, foothills, and agricultural fields. About 60% of the site is open to livestock grazing (DOE 2006).

The laboratory was created by the AEC in 1949 to build and test nuclear power reactors. During the 1970s, its mission broadened to include areas such as biotechnology, energy and materials research, conservation, and renewable energy. In 2003, DOE announced that Idaho National Engineering and Environmental Laboratory and Argonne National Laboratory-West

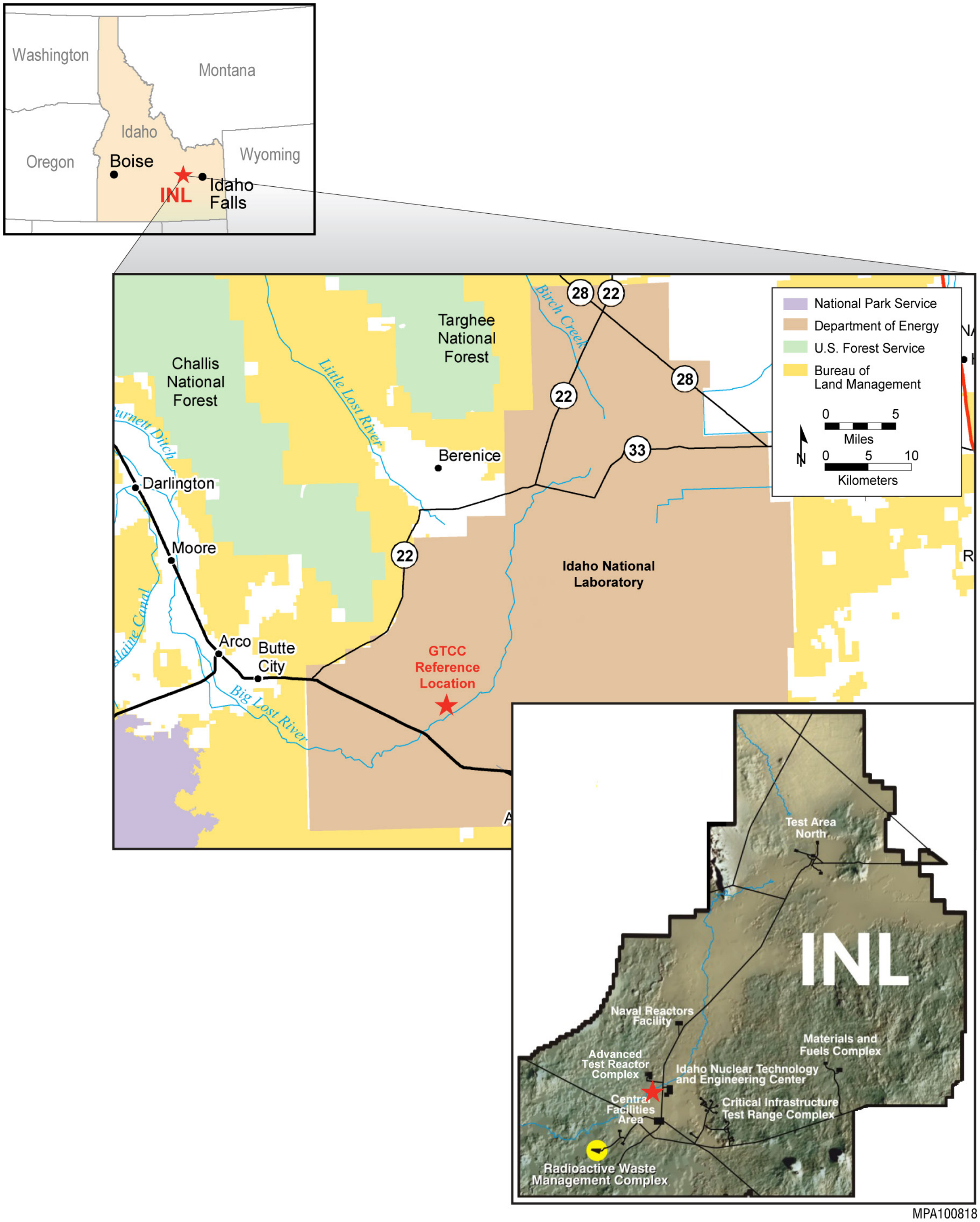

FIGURE 1.4.3-5 GTCC Reference Location at INL

would be the lead laboratories for the development of the next generation of power reactors. In 2005, the two laboratories became INL (DOE 2006).

Key facilities consist of clusters of buildings and structures that are typically less than a few square miles each, separated from each other by miles of gently rolling, sagebrush-covered, semi-arid desert. In addition to the INL site, DOE owns or leases laboratories and administrative offices in the city of Idaho Falls, about 40 km (25 mi) east of the INL site boundary.

Current waste management activities at INL include the treatment and storage of mixed LLRW (waste containing hazardous constituents in addition to radionuclides) on-site, the treatment of LLRW on-site and its disposal on-site or off-site in DOE or commercial facilities, the storage of TRU waste on-site and its treatment and shipment to SWPP, and the storage of high-level radioactive waste and spent nuclear fuel (SNF) on-site pending the disposal of these last two materials. These wastes originate from DOE activities and from the on-site Naval Reactors Program. LLRW (RH waste) from INL site operations is disposed of at the Subsurface Disposal Area at the Radioactive Waste Management Complex (RWMC). CH waste is sent off-site. TRU waste is also stored and treated at the RWMC and Idaho Nuclear Technology and Engineering Center (INTEC) to prepare it for disposal at WIPP.

The GTCC reference location is southwest of the Advanced Test Reactor (ATR) Complex in the south central portion of INL (Figure 1.4.3-5). The ATR is dedicated to research supporting DOE missions, including nuclear technology research.

1.4.3.4 Los Alamos National Laboratory

LANL is located in northern New Mexico, within Los Alamos County, on 10,360 ha (25,600 ac) of land owned by the U.S. Government and administered by DOE and the National Nuclear Security Administration (NNSA) (Figure 1.4.3-6). The site is situated on the eastern flank of the Jemez Mountains along an area known as the Pajarito Plateau. The terrain in the LANL area consists of mesa tops and canyon bottoms that trend in a west-to-east direction, with the canyons intersecting the Rio Grande River to the east of LANL. Elevations range from about 2,380 m (7,800 ft) at the highest elevation on the western side of the site to about 1,890 m (6,200 ft) at the lowest point along the eastern boundary at the Rio Grande. Laboratory operations are conducted in numerous facilities located in 48 designated Technical Areas (TAs) and at other leased properties located nearby. The laboratory’s core mission since its creation in 1943 has been to maintain the effectiveness of the nation’s nuclear deterrent. As one of the world’s leading research institutions, it performs scientific, technological, and engineering work that supports nuclear materials handling, processing, and fabrication; stockpile managing; materials and manufacturing technologies; nonproliferation programs; and waste management activities (LANL 2008).

There are more than 2,000 structures on the site, providing about 800,000 m^2 (8.6 million ft^2) of covered space. About half of the square footage at LANL is considered laboratory or production space; the remaining area is considered administrative, storage, service, or other space. Most of the site is undeveloped, which provides a buffer for security and safety

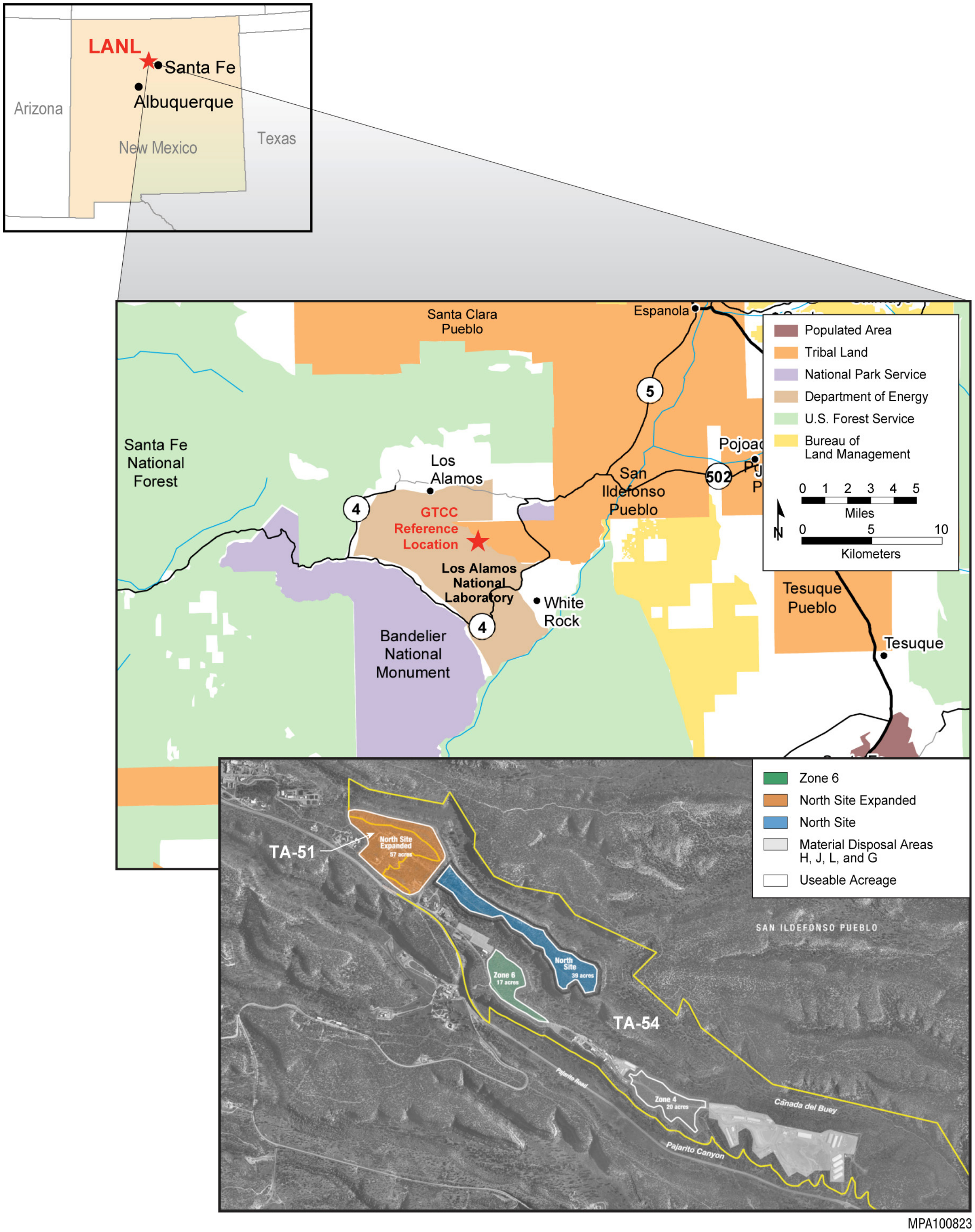

FIGURE 1.4.3-6 GTCC Reference Location at LANL

and offers the possibility of expansion for future use. LANL is the largest institution in northern New Mexico and has more than 9,000 employees (LANL 2008).

Current waste management activities at LANL include the storage of mixed LLRW, the disposal of LLRW on-site, the storage of TRU waste on-site, and storage of sealed sources recovered by the GTRI/OSRP for national security or public health and safety reasons pending disposal. Area G at Technical Area-54 (TA-54) currently accepts on-site LLRW for disposal; also, in special cases, off-site waste has been accepted from other DOE sites for disposal. Engineered shafts are actively used to dispose of RH LLRW.

The GTCC reference location is situated in three undeveloped and relatively undisturbed areas within TA-54 on Mesita del Buey: Zone 6, North Site, and North Site Expanded (Figure 1.4.3-6). Zone 6 is slightly less than 7 ha (17 ac) in area. It is not fenced, but access is controlled by staffed vehicle access portals on Pajarito Road. The total area of the North Site is about 16 ha (39 ac). The North Site Expanded section adds another 23 ha (57 ac). The primary function of TA-54 is the management of radioactive and hazardous chemical wastes. Its northern border coincides with the boundary between LANL and the San Ildefonso Pueblo; its southeastern boundary borders the community of White Rock (LANL 2008).

1.4.3.5 Nevada National Security Site

NNSS is located about 96 km (60 mi) northwest of Las Vegas in southern Nevada on 352,512 ha (870,400 ac) of land managed by DOE (Figure 1.4.3-7). NNSS is surrounded by federal installations with strictly controlled access and by federal lands that are open to the public. Its terrain is characterized by high relief, with elevations ranging from about 823 m (2,700 ft) at Frenchman Flat in the southeastern portion of the site to about 2,340 m (7,680 ft) on Rainier Mesa. Historically, the primary mission of NNSS was to conduct nuclear weapons tests. The tests have altered the natural topography of NNSS, creating craters in the Yucca Flat and Frenchman Flat basins and on the Pahute and Rainier Mesas. Since the moratorium on nuclear testing in the United States began in October 1992, the mission of NNSS has been to maintain the readiness to conduct nuclear tests in the future. The site also supports DOE’s waste management program, as well as other national-security-related research and development (R&D) and testing programs (DOE 1996).

NNSS presently serves as a regional disposal site for LLRW and mixed LLRW generated by DOE facilities. It is also an interim storage site for a limited amount of newly-generated TRU mixed wastes pending transfer to WIPP for disposal. Radioactive waste management activities are conducted in Areas 3 and 6. From 1984 through 1989, boreholes (at depths of 21 to 37 m [70 to 120 ft]) were used at the Area 5 Radioactive Waste Management Site (RWMS) to dispose of LLRW and TRU waste.

The GTCC reference location at NNSS is within Area 5 and serves as a basis for evaluation for this EIS (Figure 1.4.3-7).

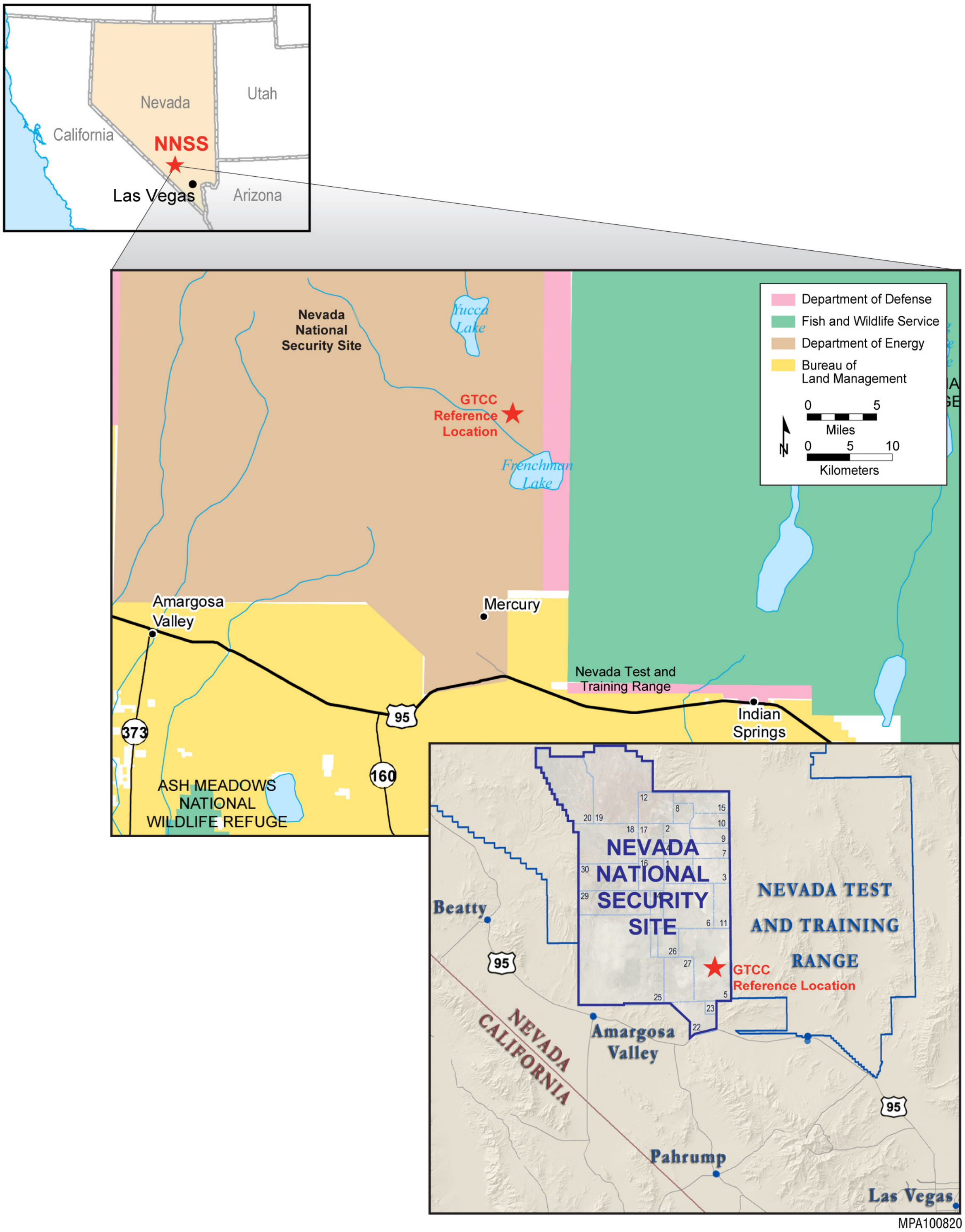

FIGURE 1.4.3-7 GTCC Reference Location at NNSS

1.4.3.6 Savannah River Site

SRS occupies 80,130 ha (198,000 ac) in Aiken, Allendale, and Barnwell Counties in South Carolina. SRS is approximately 19 km (12 mi) south of Aiken, South Carolina, and 24 km (15 mi) southeast of Augusta, Georgia. It is bounded on the southwest by the Savannah River (Figure 1.4.3-8).

The AEC established SRS in the early 1950s, and until the early 1990s, its primary mission was the production of nuclear materials to support national programs. The Savannah River National Laboratory was so designated in 2004. Currently the site's missions are environmental management, which includes the treatment, storage, and disposal of radioactive waste; defense programs, which include tritium services to meet stockpile stewardship requirements; and nuclear nonproliferation, which includes the construction of the Mixed Oxide Fuel Fabrication Facility. The SRS management and operations contractor is currently Savannah River Nuclear Solutions, LLC, while Savannah River Remediation operates the liquid radioactive waste program.

SRS currently manages high-level waste, TRU waste, LLRW, and mixed LLRW. High-level waste is vitrified at the Defense Waste Processing Facility and stored on-site pending disposal. TRU waste is stored, prepared for shipment, and shipped to WIPP for disposal. LLRW is treated and disposed of on-site, or it is prepared for shipment to be disposed of at other DOE sites (e.g., NNSS) or commercial facilities. On-site facilities for LLRW disposal include engineered trenches and vaults.

The GTCC reference location at SRS is situated on an upland ridge within the Tinker Creek drainage, about 3.2 km (2 mi) to the northeast of Z-Area in the north-central portion of SRS (Figure 1.4.3-8). The area is not currently being used for waste management.

1.4.3.7 WIPP Vicinity

WIPP Vicinity refers to Township 22 South, Range 31 East, Sections 27 and 35, with each section containing a total of 260 ha (640 ac) or 2.6 km^2 (1 m^2). Section 27 is within the WIPP LWB, while Section 35 is just outside the WIPP LWB to the southeast and is managed by BLM (Figure 1.4.3-9). Only a portion of Section 27 and 35, if selected, would be needed to accommodate a new GTCC waste disposal facility. WIPP is located in Eddy County in southeastern New Mexico, about 50 km (30 mi) east of the city of Carlsbad. The land is a relatively flat, sparsely inhabited area (101,000 people in a 80-km [50-mi] radius, according to the 2000 census), known as Los Medaños (Spanish for "the dunes"). There are no potash or oil and gas leases on Section 27 since it is part of the land that has been withdrawn. Section 35 contains oil and gas leases. Currently, no waste management activities are being conducted at Section 27 or Section 35.

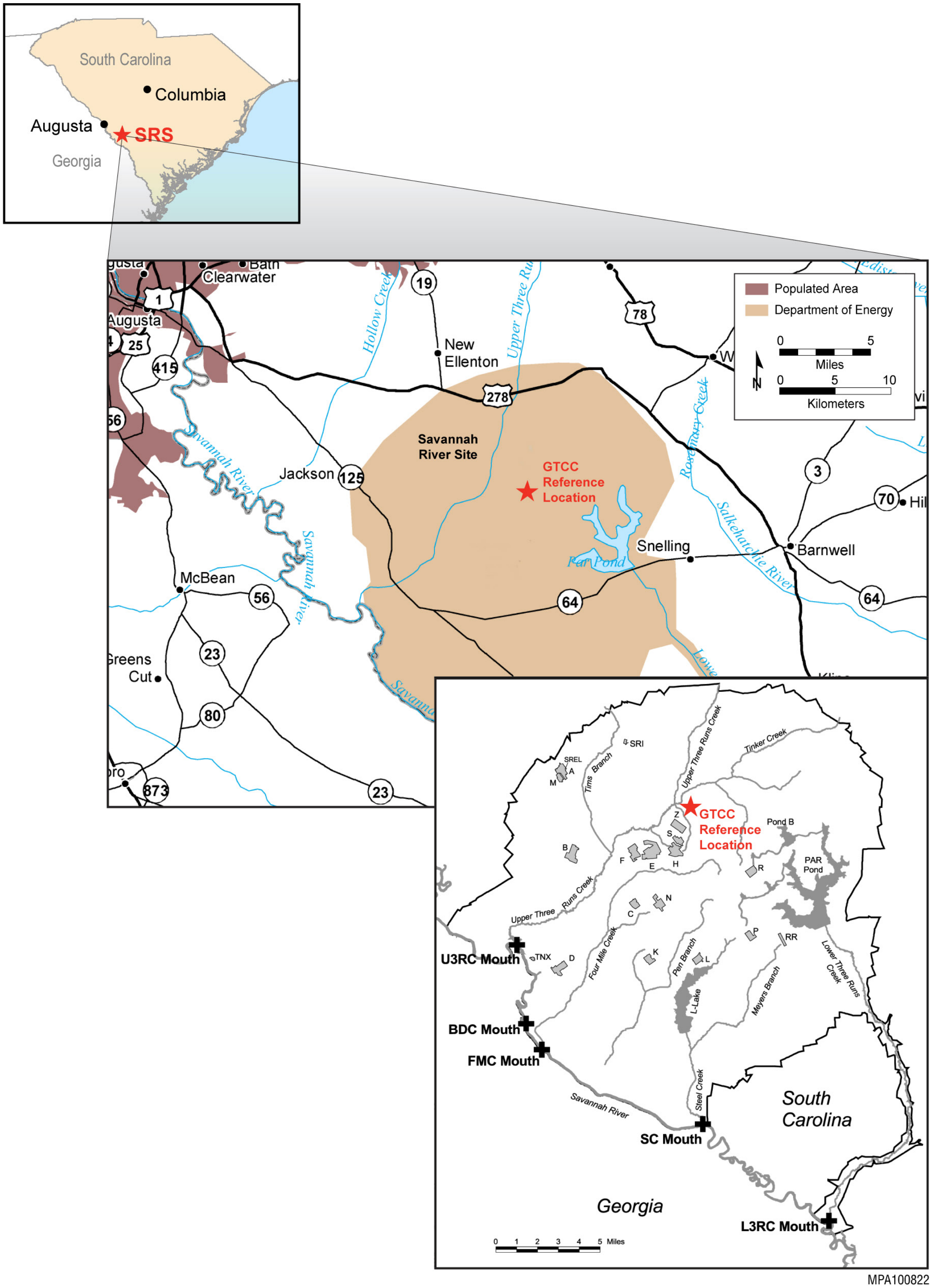

FIGURE 1.4.3-8 GTCC Reference Location at SRS

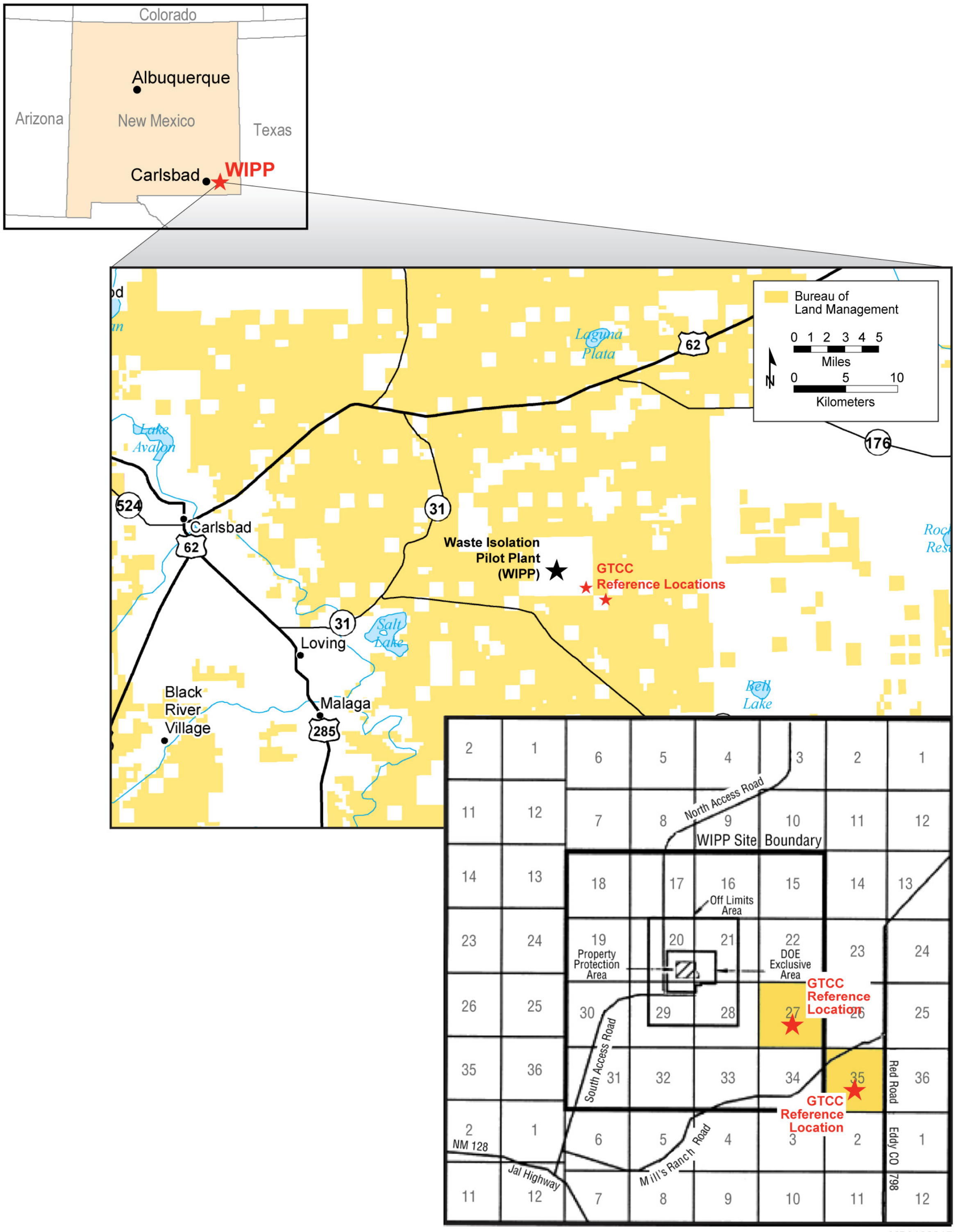

FIGURE 1.4.3-9 GTCC Reference Locations (Sections 27 and 35) at the WIPP Vicinity

1.4.3.8 Generic Regional Commercial Disposal Sites

The generic commercial sites are evaluated in this EIS on the basis of a regional approach that divides the United States into four regions consistent with the designations of Regions I through IV of the NRC. The states that make up each of these four regions are shown in Figure 1.4-2. Region I comprises the 11 states in the northeast; Region II comprises the 10 states in the southeast; Region III comprises the 7 states in the Midwest; and Region IV comprises the remaining 22 states in the western part of the United States.

Current commercially operated LLRW disposal facilities for non-GTCC LLRW are located in Region II (Barnwell in South Carolina, which receives Class A, B, and C waste) and Region IV (facilities in Richland, Washington, and in Clive, Utah, which receive Class A, B, and C waste, and Class A waste, respectively). One new disposal facility located in Andrews County, Texas, has been licensed and is expected to begin operating in 2011. The federal sites evaluated in this EIS are also located within these same two regions.

1.5 PUBLIC PARTICIPATION PROCESS

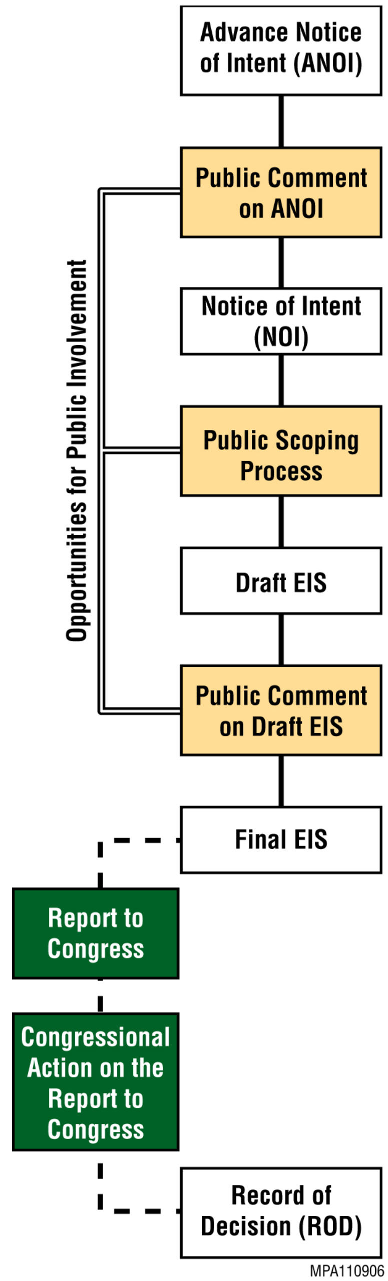

FIGURE 1.5-1 GTCC EIS NEPA Process

Several opportunities for public participation are being provided during the preparation of this EIS. Consistent with requirements of the Council on Environmental Quality (CEQ) (40 CFR 1501.7) and DOE NEPA implementation procedures, an early and open scoping process was carried out to determine the scope of the EIS and identify the significant issues related to the proposed action; that is, an Advance Notice of Intent (ANOI) (70 FR 24775) and an NOI (72 FR 40135) were issued for public review. Public participation is also being solicited during the review of the Draft EIS during the public comment period. NEPA requires that comments on the Draft EIS be evaluated and considered during the preparation of the Final EIS and that a response to comments be provided. Figure 1.5-1 shows the NEPA process for this EIS.

The ANOI was issued on May 11, 2005 (70 FR 24775). The NOI was issued on July 23, 2007 (72 FR 40135), with a printing correction issued on July 31, 2007 (72 FR 41819). Nine public scoping meetings were held during the 60-day comment period from July 23 through September 21, 2007. A meeting was held at each of the following cities: (1) Carlsbad, New Mexico; (2) Los Alamos, New Mexico; (3) Oak Ridge, Tennessee; (4) North Augusta, South Carolina; (5) Troutdale, Oregon; (6) Pasco, Washington; (7) Idaho Falls, Idaho;

(8) Las Vegas, Nevada; and (9) Washington, D.C. Approximately 330 members of the public attended these meetings.

Oral comments were made and written comments were received at the meetings. Transcripts of each meeting were generated, and the oral comments included in these transcripts were reviewed for consideration in preparing this EIS. Written comments submitted at the meetings and other comments received via the project website, by electronic mail, and in letters were also considered and incorporated as appropriate in preparing this EIS. Approximately 250 comments (oral and written) were received. A summary of the public scoping process conducted in 2007 and a summary of the comments received are presented in Appendix A of this EIS. The summaries and transcripts of the public scoping meetings can be viewed on the project website at www.gtcceis.anl.gov.

Comments received during the public scoping period focused on the amount of inventory being included for evaluation in the EIS, the sites that would be considered, the disposal methods or technologies that would be considered, the resource areas to be evaluated, and the impact assessment methodologies. Representative comments and DOE responses are provided as follows. The first set of comments presents those determined to be within the EIS scope, and the second set presents those determined to be outside the scope of the EIS.

1.5.1 Comments Determined To Be within EIS Scope

- *Disposal of GTCC LLRW and GTCC-like waste at the sites proposed in the NOI should not be considered because these sites are still undergoing cleanup. In addition, these sites either have regulatory conditions or site characteristics (e.g., geology) that make them unsuitable for consideration in the EIS.*

  The basis for proposing the sites to be considered in the NOI and evaluated in the EIS was their mission compatibility, in the sense that all of these sites have radioactive waste disposal operations as part of their current missions. These sites are thus considered viable for analysis for disposal of this waste in the EIS. The scope of the EIS includes the identification of potential disposal sites and the evaluation of the feasibility and effectiveness of these sites for hosting a safe disposal facility for GTCC LLRW and GTCC-like waste.

- *The preferred alternative for disposal of GTCC LLRW and GTCC-like waste should be a geologic repository.*

  Disposal at WIPP, a geologic repository, is one of the alternatives evaluated in this EIS. In addition, DOE is evaluating alternative methods of disposal (i.e., borehole, trench, and vault disposal). NRC regulations governing disposal of GTCC LLRW contemplate that nongeologic disposal alternatives may be approved (see 10 CFR 61.55(a)(2)(iv)).

- *More detailed characterization information should be provided on the waste inventory, including the source of the waste, its location (by state), and its specific characteristics. It is not clear how the volumes and activities for stored and projected waste were developed, and the distinction between what is considered stored versus what is considered projected is not clear either. The sources of information and important assumptions used to develop this information should be provided in the EIS, along with an indication of the accuracy of the estimates.*

  The GTCC EIS and the supporting technical documents provide sufficient characterization information on the wastes to allow for a comparative analysis of the environmental impacts associated with disposal of these wastes. Details on the approach used to develop the inventory information are provided in this EIS and in supporting documents, including the identification of relevant references. The Draft EIS provides information on the current location of GTCC waste generators (e.g., Table B-2).

- *The EIS should identify the quantity of mixed waste requiring disposal and identify the process for working with the EPA and respective state agencies to manage these wastes.*

  The GTCC LLRW and GTCC-like waste inventory includes a very small volume of mixed waste that may require disposal. It is assumed that the generator of the waste will treat it to remove the hazardous waste characteristic or obtain a waiver from the appropriate regulatory authority so that the waste is no longer regulated as mixed waste. No mixed GTCC LLRW or GTCC-like waste is assumed to be disposed of in the sites being evaluated in the EIS. The volume of potential mixed waste is about 170 m^3 (6,000 ft^3).

- *What is the scope of the EIS and evaluation endpoints (e.g., period of time with respect to risk of release)? The EIS should identify long-term monitoring requirements for the disposal sites.*

  The scope of the EIS addresses all aspects associated with disposal of GTCC LLRW and GTCC-like waste. Impacts are evaluated at the various time periods associated with the actions needed to safely dispose of these wastes. The long-term impacts on groundwater are evaluated for 10,000 years or to the point of maximum dose and LCF risk, whichever is longer. The EIS identifies the need for long-term monitoring of disposal sites, as appropriate.

- *The EIS should incorporate available site-specific data for the generic commercial facility evaluations. In addition, the evaluation of the disposal of GTCC LLRW and GTCC-like waste in boreholes for all sites being evaluated should be based on actual site data.*

Site-specific data were used to identify the important parameters necessary to site and operate a disposal facility for GTCC wastes at arid and humid generic sites. The analyses of the various disposal technologies (including the use of boreholes) in the EIS were based on actual site data to the extent necessary to provide defensible evaluations. A site-specific evaluation would be done in a subsequent NEPA review as appropriate.

- *Consultation with tribal nations should be initiated early in the process.*

  Consultations with the various tribal nations have been initiated and are ongoing, as reflected in this EIS.

- *The EIS should identify all federal and state agencies and any jurisdictional authority by law and/or special expertise. Also, the EIS should address all pertinent regulatory issues and standards, including NRC regulation of a facility at a DOE site.*

  The EPA is a cooperating agency on the EIS because of its expertise in radiation protection. The NRC is a commenting agency. Pertinent regulatory issues and standards associated with disposal of GTCC LLRW and GTCC-like waste are addressed in the EIS.

1.5.2 Comments Determined To Be outside EIS Scope

- *In addition to considering disposal at WIPP in the EIS, efforts should be initiated to site and construct a new geologic repository for GTCC LLRW and GTCC-like waste in case this repository is not acceptable.*

  As discussed in the NOI (72 FR 40135), DOE does not plan to evaluate an additional deep geologic repository facility because siting another deep geologic repository facility for GTCC LLRW and GTCC-like waste would be impractical due to the cost and time involved and the relatively small volume of GTCC LLRW and GTCC-like waste.

- *Hardened on-site storage (HOSS) should be added to the alternatives evaluated in the EIS. In addition, HOSS should be the preferred alternative.*

  HOSS and other waste storage approaches beyond the No Action Alternative are considered to be outside the scope of this EIS because they do not meet the purpose and need for agency action. Consistent with Congressional direction in Section 631 of the Energy Policy Act of 2005, DOE plans to complete an EIS and a ROD for a permanent disposal facility for this waste, not for long-term storage options. In addition, the No Action Alternative evaluates storage of this waste consistent with ongoing practices.

- *The EIS should include disposal options for Class B and Class C LLRW in its scope.*

  Inclusion of Class B and Class C LLRW is beyond the scope of this EIS. DOE is responsible under the LLRWPAA for the disposal of GTCC LLRW and DOE wastes. States and Compacts are responsible for the disposal of Class A, B, and C LLRW.

- *The GTCC LLRW inventory needs to be expanded to address the disposal and possible consolidation and concentration of Class B and Class C LLRW by commercial nuclear utilities, resulting in additional GTCC LLRW.*

  The waste inventory is based on the best available information on GTCC LLRW, and it considers utility waste resulting from decommissioning activities. Data on the GTCC LLRW that might be generated by the concentration and consolidation of Class B and Class C LLRW are difficult to ascertain at this time because of the speculative nature of these events. The uncertainty that would be introduced in the EIS process by including this potential volume is not warranted.

- *Additional radioactive wastes should not continue to be produced until there is a waste disposal solution for these materials.*

  This issue is beyond the scope of the EIS, which is limited to the evaluation of the potential environmental impacts from using various disposal options for GTCC LLRW and GTCC-like waste.

- *The EIS should address the increased sensitivity of children, the elderly, pregnant women, and women in general to radiation exposure. The analysis should not be based on a reference man but on the reference family concept. In addition to radiation doses, estimates of the cancer risks should be provided in the EIS to allow for a comparison to EPA carcinogenic risk standards.*

  The concerns with regard to the increased sensitivity of various elements of the population are noted. The EIS presents a comparative analysis of the potential radiation doses and LCF risks to members of the general public (as represented by an adult receptor) from use of the various disposal alternatives presented in the NOI. As such, the level of detail requested here is not necessary for the purposes of this EIS, and the hazards associated with management of these wastes are presented in terms of the annual dose and LCF risk to a potentially exposed adult receptor.

  The estimates for dose and LCF risk were based on a resident farmer receptor, which is considered a conservative scenario that accounts for the largest number of pathways of potential exposure. The primary pathway of concern, however, is the ingestion of groundwater potentially contaminated with radionuclides released from wastes at the proposed disposal facility. The estimated dose and LCF risk to an adult receptor presented in the EIS are considered conservative (relative to any other potential receptor) because the ingestion rate assumed for water intake is the 90th percentile value for the general public recommended by the EPA (i.e., two liters per day for 365 days per year) (EPA 2000).

Follow-on NEPA evaluations will be conducted, as needed, to assess potential human health impacts on a site-specific basis (accounting for sensitive populations as applicable) when a disposal site or location is identified.

- *Further research on and/or investigation of other treatment and disposal technologies currently being developed should be considered to ensure that these wastes are managed safely. The hazards posed by GTCC LLRW and GTCC-like waste are comparable to those from high-level radioactive wastes and should be managed in a similar manner.*

  DOE does not believe further research on treatment and disposal technologies is needed to ensure these wastes are safely managed and that disposal complies with the LLRWPAA, which makes the federal government responsible for the disposal of GTCC LLRW.

1.6 RELATIONSHIP OF PROPOSED ACTION TO OTHER DOE ACTIVITIES AND PROGRAMS

Other DOE NEPA documents were reviewed to identify other concurrent or proposed NEPA actions that relate to the proposed action described in this EIS. The NEPA proposed actions summarized below contribute to or are sources of the waste inventory evaluated in this EIS.

1.6.1 Final Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico (DOE/EIS-0380, May 2008)

DOE's GTRI/OSRP recovers unwanted or disused sealed sources that pose a national security or public health and safety threat from NRC and Agreement State licensees. These recovered sources are stored at LANL and off-site commercial storage facilities under contract to LANL pending disposal.

The GTRI/OSRP grew out of early efforts at LANL to recover and disposition excess Pu-239 sealed sources that were distributed in the 1960s and 1970s under the Atoms for Peace Program. After being transferred to the NNSA to be part of GTRI, OSRP's mission was expanded to include recovery of materials based on national security considerations.

The ROD issued for the LANL Site-Wide EIS (SWEIS) (DOE 2008) adopted an expanded alternative providing NEPA coverage for LANL recovery, storage, and disposition of types and activities of sources in addition to those originally managed by GTRI/OSRP. In addition to the actinide sources that will continue to be managed at LANL pending disposal at WIPP, the SWEIS addressed issues associated with the recovery and non-LANL storage of other radionuclides not eligible for disposal at WIPP. These radionuclides, which are brought to LANL only when off-site storage and management are not possible, will either be maintained in storage at the off-site facilities or be disposed of at commercial or DOE disposal facilities if waste acceptance criteria can be met.

1.6.2 Final Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center (DOE/EIS-0226, January 2010)

As announced in the April 20, 2010, ROD (DOE 2010b) for the *Final Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center*, DOE decided to implement the Preferred Alternative, Phased Decision-making. Under this alternative, decommissioning will be completed in two phases. Phase 1 involves near-term decommissioning and removal actions for certain facilities and areas and undertakes characterization work and studies that could facilitate future decision-making for the remaining facilities or areas on the property. DOE intends to complete any remaining West Valley Demonstration Project (WVDP) decommissioning decision-making with its Phase 2 decision (to be made within 10 years of the ROD) and expects to select either removal or in-place closure, or a combination of the two, for those portions of the site for which it has decommissioning responsibility. The Phase 2 decision will include whether to remove or close in-place buried waste at the NDA and SDA. If a decision is made to remove the buried waste, the volume of GTCC LLRW and GTCC-like waste that could be generated is projected to be about 4,300 m^3 (150,000 ft^3) and is included in the Group 2 inventory evaluated in this GTCC EIS. The 4,300 m^3 (150,000 ft^3) includes 3,500 m^3 (120,000 ft^3) of Other Waste, 740 m^3 (26,000 ft^3) of activated metals, and 22 m^3 (780 ft^3) of sealed sources.

Currently stored GTCC-like waste (potential non-defense-generated TRU waste) at the West Valley Site has also been included in the Group 1 inventory for this EIS. The volume of stored GTCC-like waste at the West Valley Site is 880 m^3 (31,000 ft^3). In addition to this stored waste, a total of 1,400 m^3 (49,000 ft^3) of GTCC-like waste would be generated from decontamination and decommissioning (exclusive of the NDA and SDA) at the West Valley Site in the future. About 370 m^3 (13,000 ft^3) of this projected waste is included in the Group 1 inventory, and 980 m^3 (35,000 ft^3) is included in the Group 2 inventory for this GTCC EIS (Argonne 2010).

1.6.3 Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (DOE/EIS-0391, October 2009)

The *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (TC&WM EIS) analyzes alternatives for three types of actions: (1) retrieving and managing waste from 177 underground storage tanks at Hanford and closing the single-shell tanks; (2) decommissioning the Fast Flux Test Facility and its auxiliary facilities; and (3) continuing and expanding solid waste management operations on-site, including disposing of Hanford's LLRW and mixed LLRW and limited volumes of LLRW and mixed LLRW from other DOE sites in the IDF at Hanford. Further, 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 agreement settles NEPA claims made in the case State of Washington v. Bodman (Civil No. 2:03-cv-05018-AAM), which addressed the January 2004 *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington*.

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. Off-site waste would be addressed after the WTP was operational, subject to appropriate NEPA reviews. Similar to its preference regarding the importation of LLRW and mixed LLRW, DOE announced in the December 18, 2009, *Federal Register* (74 FR 67189) that, consistent with its preference regarding receipt at Hanford of off-site LLRW and mixed LLRW, DOE would not ship GTCC LLRW to Hanford until, at the earliest, the WTP was operational. As stated in the Hanford TC&WM EIS, 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.

1.7 OTHER GOVERNMENT AGENCIES

Because of its technical expertise in radiation protection, the EPA is participating as a cooperating agency in the preparation of this EIS. The EPA's role as a cooperating agency does not imply its endorsement of DOE's selection of specific approaches, alternatives, or methods. The EPA will conduct independent reviews of the Draft and Final EIS and associated documents in accordance with Section 309 of the Clean Air Act (*United States Code,* Volume 42, page 7609 [42 USC 7609]). The NRC will be a commenting agency on the EIS.

Once (a) specific site (sites) is (are) selected for further consideration, DOE plans to consult with other agencies including the Advisory Council on Historic Preservation, the appropriate State Historic Preservation Officer(s), and pertinent Regional Fish and Wildlife Service Office(s).

1.8 TRIBAL CONSULTATION FOR THE GTCC EIS

DOE and Tribal Representatives have been working cooperatively over the last decade to improve consultation and communication related to decision making. This is an ongoing dialog, and DOE is committed to formal and meaningful consultation and interaction, at the earliest practical stages in the decision-making process, consistent with DOE's American Indian and Alaska Natives Tribal Government Policy (DOE Order 144.1). This Order communicates the Departmental, programmatic, and field responsibilities for interacting with American Indian governments and establishes the Department's Indian policy, including its guiding principles and framework for implementing the policy. Tribal governments affected by DOE-EM activities have been and are invited to participate and assist in the implementation of the policy. The GTCC EIS, directed by Congress under the LLRWPA and the Energy Policy Act of 2005, has created a unique opportunity for the tribes to participate in this EIS process.

Tribal Nations Participating in GTCC EIS Consultation Activities

Hanford Site

- Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Pendleton, OR
- Nez Perce, Lapwai, ID
- Wanapum People, Ephrata, WA
- Yakama Nation, Union Gap, WA

INL

- Shoshone-Bannock Tribes, Fort Hall, ID

LANL

- Acoma Pueblo, Acoma, NM
- Cochiti Pueblo, Cochiti, NM
- Jemez Pueblo, Jemez, NM
- Laguna Pueblo, Laguna, NM
- Nambe Pueblo, Santa Fe, NM
- Pojoaque Pueblo, Santa Fe, NM
- Santa Clara Pueblo, Española, NM
- San Ildefonso Pueblo, Santa Fe, NM

NNSS

- Consolidated Group of Tribes and Organizations (CGTO) (representing 16 Paiute and Shoshone Tribes). Consultation with these tribal nations is being conducted through the CGTO.

DOE initiated consultation and communication activities on the GTCC EIS with 14 participating American Indian tribal governments that have cultural or historical ties to the DOE sites being analyzed in this EIS, as identified in the text box. The consultation activities are being conducted in accordance with President Obama's Memorandum on Tribal Consultation (dated November 5, 2009); Executive Order 13175 (dated November 6, 2000) entitled "Consultation and Coordination with American Indian Tribal Governments"; Executive Memorandum (dated September 23, 2004) entitled "Government-to-Government Relationship with Tribal Governments" (White House 2004); and DOE Order 144.1, "American Indian Tribal Government Interaction and Policy" (dated January 2009). The consultation activities include technical briefings, the development of the written tribal narrative included in this EIS related to the specific site affiliated with the tribe, and/or discussions with elected tribal officials, based on individual tribal preferences and mutually agreed-upon protocols.

In response to tribal requests for consultation at the October 2007 State and Tribal Government Working Group meeting in Snowbird, Utah, DOE, in a January 2008 letter to tribal government officials, communicated its interest in consulting with tribal nations on the GTCC

EIS. DOE proposed several consultation activities and invited tribal nations to identify their preferences on the consultation approach to be used for the EIS. Proposed consultation activities included, but are not limited to, formal government-to-government consultations between senior DOE officials and elected tribal officials, staff-to-staff technical briefings, and participation in the development of written narratives on tribal views and beliefs related to the specific site affiliated with the tribe for inclusion in the EIS, such as the cultural resources, socioeconomics, and environmental justice sections.

On February 10 and 11, 2009, DOE met with representatives from the participating tribes and organizations. DOE shared background information on the GTCC EIS; obtained input on technical issues from tribal representatives; identified possible topics for government-to-government consultations; presented information on the opportunity for tribes to submit written narratives describing their unique perspectives on the DOE sites and environmental resource areas being analyzed in this EIS; and obtained preliminary feedback from tribal representatives as to their interest in submitting written narratives. Representatives from the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Consolidated Group of Tribes and Organizations (CGTO), Duckwater Shoshone, Jemez Pueblo, Moapa Paiute, Nambe Pueblo, Nez Perce, Pueblo of Pojoaque, Pueblo of San Ildefonso, Santa Clara Pueblo, Shoshone-Bannock Tribes, Wanapum People, and Yakama Nation participated in the meeting. DOE provided meeting materials to the tribes that were unable to attend the meeting.

The tribes held follow-up discussions to determine if they were interested in developing tribal narratives. Based on the discussions, the following tribes, by site, agreed to participate in developing written narratives: Hanford (CTUIR, Nez Perce, Wanapum), LANL (Nambe Pueblo, Pueblo of San Ildefonso, Pueblo of Santa Clara, Pueblo of Cochiti), and NNSS (CGTO–Pahrump Paiute Tribe, Colorado River Indian Tribes, Duckwater Shoshone Tribe, Moapa Paiute Tribe, Bishop Paiute Tribe, Big Pine Paiute Tribe, Ely Shoshone Tribe). In addition to the development of written narratives, other agreed-upon consultation activities began. For example, as requested by the CTUIR, the senior DOE official for tribal consultations met with elected officials of the CTUIR on June 4, 2009, to discuss the GTCC EIS.

Although tribes from the Yakama Nation and the Shoshone-Bannock declined at that time to participate in the development of written narratives for the Draft GTCC EIS, these tribes will have an opportunity to review the tribal narrative contained in the Draft EIS and submit an update to the existing narrative or provide written narrative for inclusion in the Final GTCC EIS. DOE will continue to work with these and the other tribes in the development of the GTCC EIS and provide opportunities for communication and consultation, as needed.

In the development of the tribal narrative, DOE held three facilitated week-long workshops with participating tribes to develop the written tribal narratives. Workshops were held in Las Vegas, Nevada (May 10–15, 2009); Los Alamos, New Mexico (June 8–12, 2009), and Richland, Washington (June 15–19, 2009). During the workshops, the tribes reviewed each of the environmental resource areas being evaluated as part of the GTCC EIS for their specific site (Hanford Site, LANL, or NNSS) and prepared their respective tribal narrative. The CGTO and Pueblos developed a consolidated tribal narrative. The CTUIR and the Nez Perce developed their own stand-alone narratives (Appendix G), with the Wanapum integrating their views into the tribal narrative found in the Hanford Chapter (Chapter 6) along with the narrative related to the Wanapum People found in Appendix G. As presented in the Hanford chapter (Chapter 6), tribal views reflect the views of the CTUIR, Nez Perce, and Wanapum People unless otherwise noted. The written tribal narratives related to specific resource areas are included in the Draft EIS chapters on Hanford, LANL, and NNSS. Some common issues identified by the tribes include the following:

- *Climate change*. The climate has changed in the past 10,000 years. Tribes perceived that the lives of American Indian people have changed during these climatic shifts, that plant and animal communities have shifted, and that such shifts would occur again in the future (perhaps in the near future, given the potential impacts of global climate change).

- *Soils and minerals*. At each of the potential GTCC locations, regional soils and minerals found at or around the site play an important role in cultural and ceremonial activities.

- *Ecological impacts on the traditional use of plant and animal species by American Indians*. Ecological concerns relate to the fact that the analyses tend to focus on threatened and endangered species and plants. The full ranges of species need to be evaluated, especially in terms of American Indian use of plants and animals. Plants are used for medicine, food, basketry, tools, homes, clothing, fire, and social and healing ceremonies. Animals and insects are culturally important, and the relationship between them, the earth, and American Indian people are represented by the roles they play in the stories of American Indian people.

- *Human health impacts and American Indian pathways analysis*. Tribes raised concerns that pathways specific to American Indian peoples be analyzed. They believe that standard calculations of human health exposure as used in the GTCC EIS for the general public are not applicable to American Indian populations.

- *Cultural resources*. Tribal cultural resources include all physical, artifactual, and spiritual aspects for each of the potential areas being evaluated at Hanford, LANL, and NNSS. All things of the natural environment contribute to the cultural resources for the tribal lifestyle.

- *Visual resources*. Views are important cultural resources that contribute to the location and performance of American Indian ceremonies. Viewscapes are typically experienced from high places or tend to provide panoramic views.

Tribal perspectives, comments, and concerns identified during the consultation process, those received during the public scoping process (see Appendix A), and those received from the Draft GTCC EIS public comment period will be considered by DOE in the decision-making process for selecting and implementing (a) disposal alternative(s) for GTCC waste.

1.9 ORGANIZATION OF THIS ENVIRONMENTAL IMPACT STATEMENT

In this EIS, each chapter has its own reference list. The chapters that present the assessments for each of the action alternatives (i.e., Chapters 4 through 12) provide descriptions of the affected environment, an impacts analysis, a summary of the impacts, and a cumulative impacts analysis. The appendices provide additional supporting information for the analyses discussed in Chapters 1 through 13. Figure 1.9-1 further provides a guide on where key sections are presented in this EIS.

- Chapter 1 provides an introduction that explains the purpose and need for DOE action and describes the proposed action by DOE. It also briefly describes the waste inventory, the disposal methods being considered, and the potential sites for disposal that were evaluated.

- Chapter 2 describes the alternatives evaluated in this EIS and compares them with regard to the environmental and human health impacts they would have.

- Chapter 3 presents an evaluation of the No Action Alternative (Alternative 1).

- Chapter 4 presents the evaluation of geologic disposal at WIPP (Alternative 2).

- Chapter 5 describes disposal in a new intermediate-depth borehole facility (Alternative 3) and disposal in new enhanced near-surface facilities using the trench method (Alternative 4) or vault method (Alternative 5). Chapter 5 also describes the EIS assessment approaches, assumptions, and impacts that are common to these methods at the sites evaluated.

- Chapters 6 through 11 present results of the assessments of the borehole, trench, and vault disposal methods, as applicable, by site for the federally owned sites (Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity). Tribal narratives as provided by the tribes are also incorporated in the Hanford, LANL, and NNSS chapters (Chapters 6, 8, and 9, respectively).

- Chapter 12 presents the results of the assessments of the borehole, trench, and vault disposal methods at the generic commercial sites for Regions I to IV (based on NRC regions).

- Chapter 13 summarizes applicable laws, regulations, and other requirements that are relevant to the activities and sites considered in this EIS.

- Chapter 14 is an index.

- Appendix A provides summaries of the public scoping process and of the comments received.

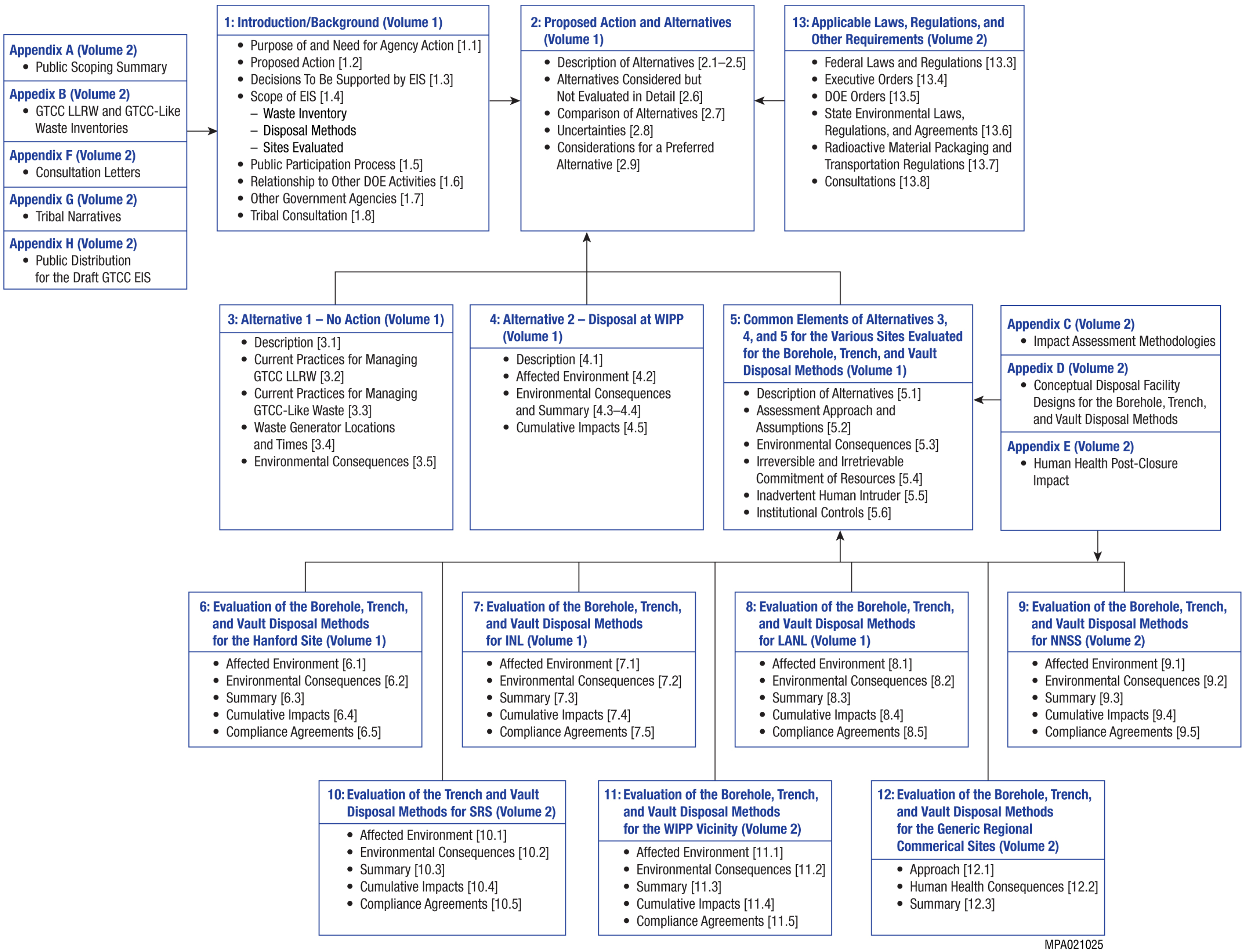

FIGURE 1.9-1 Organization of the Draft GTCC EIS and Relationships of Its Components (Note that the Draft GTCC EIS is made up of two volumes; the specific volume in which each component is contained is indicated in the figure above.)

- Appendix B discusses the waste inventory in more detail.
- Appendix C provides information on the potential impacts, assessment methodology, and other considerations.
- Appendix D presents details on the borehole, trench, and vault conceptual facility designs and information on the construction and operations associated with the design concepts.
- Appendix E provides supporting information for the calculations performed to estimate groundwater concentrations and doses from the disposal facilities extended to 10,000 years after closure of the facility and beyond.
- Appendix F provides consultation letters.
- Appendix G provides the tribal narratives for Hanford, INL, and LANL.
- Appendix H provides a distribution list for the Draft EIS.
- Appendix I provides a list of the preparers of this EIS.
- Appendix J is a disclosure statement.

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2 PROPOSED ACTION AND ALTERNATIVES

Consistent with the purpose and need described in Chapter 1, DOE is evaluating the range of reasonable alternatives for the disposal of GTCC LLRW and GTCC-like waste, which consists of four action alternatives in addition to the No Action Alternative. The action alternatives address a range of disposal depths, from deep disposal (geologic repository), to intermediate-depth disposal (borehole facility), to enhanced near-surface disposal (trench and vault facilities). DOE is evaluating the use of an existing geologic repository (WIPP) and/or the construction of a new borehole, trench, or vault facility or facilities to safely dispose of the GTCC LLRW and GTCC-like waste. The new facility or facilities could be located at the Hanford Site, INL, LANL, NNSS, SRS, or the WIPP Vicinity, or at generic nonfederal (commercial or private) lands. Combinations of disposal alternatives may be appropriate based on the characteristics of the waste types and other considerations (e.g., waste volumes, physical and radiological characteristics, and generation rates), as discussed in Section 2.9.

DOE developed these action alternatives after careful consideration of the waste inventory, disposal technologies, and comments received during the public scoping period for this EIS. The WIPP repository, although not subject to NRC licensing as a geologic repository under 10 CFR Parts 60 and 63, is evaluated to determine the feasibility of the disposal of GTCC waste at a geologic repository. The proposed land disposal methods (i.e., borehole, trench, and vault) are being evaluated because NRC regulations allow other disposal methods to be proposed for NRC approval and state that there might be some instances when GTCC LLRW would be acceptable for near-surface disposal with special processing or design.

In summary, DOE is evaluating the following five alternatives in this EIS:

- Alternative 1: No Action,

- Alternative 2: Disposal in the WIPP geologic repository,

- Alternative 3: Disposal in a new borehole disposal facility,

- Alternative 4: Disposal in a new trench disposal facility, and

- Alternative 5: Disposal in a new vault disposal facility.

DOE has identified reference locations for evaluating Alternatives 3 to 5 since these alternatives involve the construction of new disposal facilities. These reference locations are generally in areas within the various sites that have been used for other waste disposal activities or in which other disposal facilities or activities are also planned. Figures showing the reference locations of the land disposal facilities can be found in Section 1.4.3 and Chapters 6 through 11 of this EIS, which correspond to the six federal sites being evaluated for the borehole, trench, and vault methods. Reference locations have not been identified for the generic commercial disposal facilities (Chapter 12), and these facilities are evaluated for potential human health impacts in this EIS on a regional basis (coinciding with the four NRC regions) by using generalized input parameters assumed to be representative of each of the regions as a whole.

DOE has evaluated each alternative for its potential consequences on the following 11 environmental resource areas (see also Figure 2-1).

1. Climate, air quality, and noise,
2. Geology and soils,
3. Water resources,
4. Human health,
5. Ecology,
6. Socioeconomics,
7. Environmental justice,
8. Land use,
9. Transportation,
10. Cultural resources, and
11. Waste management.

In addition to the above resource areas, DOE has evaluated cumulative impacts to address the impacts that could result from implementation of the proposed GTCC action at each site in combination with past, present, and planned activities (including federal and nonfederal activities) at or in the vicinity of that site.

DOE has evaluated each of the alternatives in this EIS for disposal of the entire waste inventory in Groups 1 and 2 (i.e., 12,000 m^3 [420,000 ft^3]). The analyses of impacts on two environmental resource areas — human health and transportation — are presented on a waste-type basis and consider whether the waste is stored or projected. This approach provides more details on the alternatives' potential impacts on these two resource areas so that decisions can be made on a waste-type basis, as appropriate. In other words, an alternative might be considered for only a particular waste type; or a combination of alternatives that account for various waste types, waste generation times, disposal site features, and other factors (including regulatory requirements and limitations) might be considered to optimize disposal decisions. With regard to the other remaining environmental resource areas (climate, air quality, and noise; geology and soils; water resources; ecology; socioeconomics; environmental justice; land use; cultural resources; and waste management), the results of an analysis that accounts for the entire inventory was considered adequate to support future decisions on a preferred alternative, because the estimated potential impacts would probably be small overall or could be mitigated.

The resource areas above are evaluated for the construction, operations, and post-closure phases of the proposed action. However, the proposed disposal facility would not be closed until some time in the far future and would be properly decommissioned at that time. The impact analysis for the decommissioning phase has not been included in this EIS but would be conducted at a later time, as appropriate.

Sections 2.1 through 2.5 of this chapter describe the No Action Alternative and the four action alternatives. Alternatives considered but not analyzed in detail are discussed in

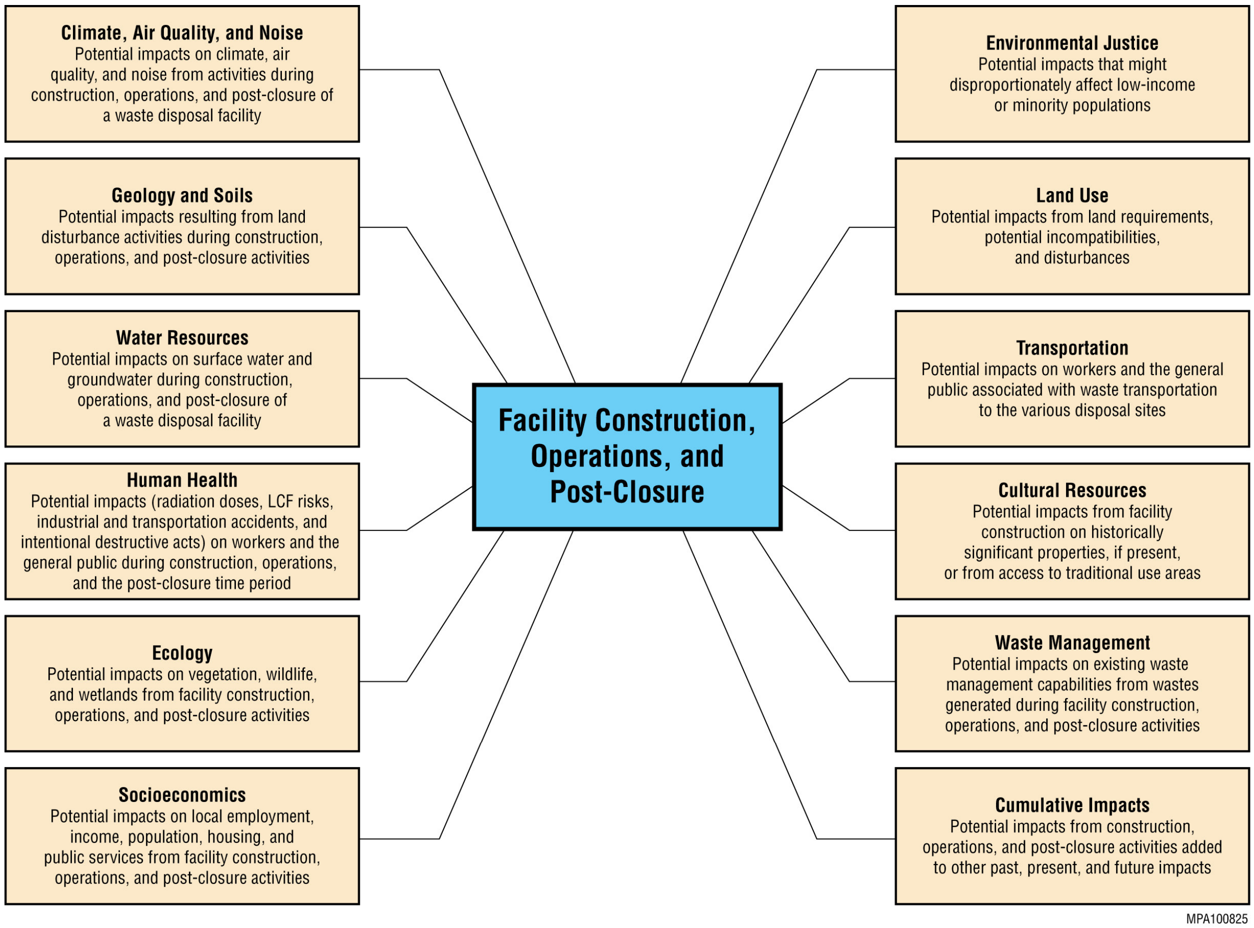

FIGURE 2-1 Environmental Resource Areas on Which the Impacts of the Alternatives Are Evaluated

Section 2.6. The environmental consequences of the alternatives that are evaluated are summarized and compared in Section 2.7. The uncertainties associated with key areas of this EIS (i.e., human health evaluations) are discussed in Section 2.8. Finally, since a preferred alternative has not been included in this Draft GTCC EIS, key information gleaned from this Draft GTCC EIS has been summarized in Section 2.9 for consideration in developing a preferred alternative.

2.1 ALTERNATIVE 1: NO ACTION

Under the No Action Alternative, current practices for storing GTCC LLRW and GTCC-like waste would continue. The GTCC LLRW generated by the operation of commercial nuclear reactors (mainly activated metal waste) would continue to be stored at the various nuclear reactor sites that generated this waste or at other reactors owned by the same utility. Sealed sources would also remain at generator or other licensee sites. GTRI/OSRP would continue to recover disused or unwanted sealed sources that present a national security or public health and safety threat. The third category of waste, “Other Waste,” would also remain stored and managed at the generator or other interim storage sites. In a similar manner, all stored and projected GTCC-like waste would remain at current DOE storage and generator locations (these wastes are being stored at several DOE sites). Many of the GTCC-like wastes meet the definition of TRU waste but may not have been generated from atomic energy defense activities and therefore may not meet the current waste acceptance criteria for disposal at WIPP.

Under this alternative, DOE would take no further action to develop disposal capability for these wastes, and current practices for managing these wastes would continue into the future, as described in Chapter 3. No impacts from construction of a disposal facility or from operations to emplace the waste in a disposal facility at the federal sites or generic commercial locations would be incurred, since these activities would not be conducted there. However, potential impacts could occur at the generator or current storage sites as a result of constructing storage structures or additional storage capacities (as in the case where wastes are already being stored). In the evaluation of the No Action Alternative in Chapter 3 of this EIS, it is further assumed that for the short term, management of the stored wastes would continue for 100 years (a time period typically assumed for active institutional controls), and long-term impacts are analyzed for the period beyond 100 years up to 10,000 years to be consistent with the time frame analyzed for the action alternatives.

2.2 ALTERNATIVE 2: DISPOSAL IN THE WIPP GEOLOGIC REPOSITORY

This alternative involves the evaluation of the incremental environmental consequences that would occur at WIPP from the disposal of the 12,000 m^3 (420,000 ft^3) of GTCC LLRW and GTCC-like waste included in Groups 1 and 2. This evaluation is performed on a waste-type basis for the human health and transportation analyses, as discussed previously.

The current operation at WIPP involves disposal of TRU waste by emplacement in underground disposal rooms that are mined as part of a panel and an access drift. Each mined panel consists of seven rooms. CH TRU waste containers are emplaced on disposal room floors, and RH TRU waste containers are currently emplaced in horizontal boreholes in disposal room wall spaces. However, DOE has submitted a planned change request to use shielded containers for safe emplacement of selected RH TRU waste streams on the floor of the repository (EPA 2010). The use of the shielded containers will enable DOE to significantly increase the efficiency of transportation and disposal operations for RH TRU waste at WIPP. Consistent with this planned change request, this EIS assumes that all activated metal waste and Other Waste - RH would be packaged in shielded containers that would be emplaced on the floor of the mined panel rooms in a manner similar to that used for the emplacement of CH waste.

The analysis discussed in this EIS assumes that current disposal procedures and practices at WIPP would continue, except for the emplacement of activated metals and Other Waste - RH on room floors (not in wall spaces, as is the current procedure). It is also assumed that all aboveground support facilities would be available for the disposal of GTCC LLRW and GTCC-like waste and that construction of additional aboveground facilities would not be required. However, the construction of approximately 26 additional underground rooms would be required.

Underground rooms are constructed by conventional mining techniques that use an electric-powered continuous miner rather than blasting. The mined salt is transported underground by diesel-powered haul trucks; once there, the salt is placed on the salt hoist and lifted to the surface. It is estimated that about 560,000,000 kg (or 560,000 t) of salt would be generated in the process of mining the underground rooms needed to emplace the GTCC LLRW and GTCC-like waste. The salt generated would be stored at the Salt Storage Area (Sandia 2008a).

The total capacity for disposal of TRU waste established under the WIPP LWA (P.L. 102-579) is 175,675 m^3 (6.2 million ft^3). The Consultation and Cooperative Agreement with the State of New Mexico (1981) established a total RH capacity of 7,080 m^3 (250,000 ft^3), with the remaining capacity for CH TRU at 168,500 m^3 (5.95 million ft^3). In addition, the WIPP LWA limits the total radioactivity of RH waste to 5.1 million curies. For comparison, the GTCC LLRW and GTCC-like CH volume, RH volume, and RH total radioactivity are approximately 6,650 m^3 (235,000 ft^3), 5,050 m^3 (178,000 ft^3), and 157 million curies, respectively. On the basis of emplaced and anticipated waste volumes, the disposal of all GTCC LLRW and GTCC-like waste at WIPP would exceed the limits for RH volume and RH total activity. The majority of the GTCC LLRW and GTCC-like RH volume is from the Other Waste category (e.g., DOE non-defense TRU), and activated metal waste contributes to most of the RH activity. The WIPP LWA also limits disposal in WIPP to defense-generated TRU waste. Under the current schedule for WIPP, DOE would complete its operations in 2035. However, this EIS assumes that WIPP operations would continue beyond 2035, allowing for disposal of GTCC LLRW and GTCC-like waste that is projected to be generated after 2035.

Most of the GTCC-like waste consists of TRU waste that may not have been generated from atomic energy defense activities. Disposing of these wastes and GTCC LLRW in WIPP may require a modification of the WIPP LWA to allow receipt of non-defense wastes and non-transuranic (non-TRU) waste. The total estimated inventory of GTCC LLRW and GTCC-like waste, added to the DOE defense TRU waste disposed of or scheduled to be disposed of at WIPP, could exceed the WIPP LWA and the Consultation and Cooperative Agreement RH volume and curie limits for WIPP, as discussed above. The LWA and the regulations at 40 CFR Parts 191 and 194 may also require modification, depending on the specific characteristics of the GTCC LLRW and GTCC-like wastes (see Chapter 13).

The affected environment and the potential environmental and human health consequences at the WIPP facility are discussed in Sections 4.2 and 4.3, respectively. The number of additional rooms needed to emplace the GTCC LLRW and GTCC-like waste is estimated to be about 26 (Sandia 2008a,b).

The GTCC waste inventory would be packaged in approximately 63,000 waste disposal packages. The types of containers or packages used would depend on the type of waste in the inventory. It is assumed that waste disposal containers would include 208-L (55-gal) drums, standard waste boxes (SWBs), and shielded containers, and that Cs-137 irradiators would be disposed of individually in their original shielded devices. The size of these irradiators is assumed to be approximately 150 × 65 × 67 cm (59 × 26 × 27 in.) (Sandia 2008c).

Should WIPP be identified as the preferred option for disposal of these wastes, further evaluation and analysis of alternative technologies and methods to optimize the transport, handling, and emplacement of the wastes would be conducted to identify those technologies and methods that would minimize to the extent possible any potential impacts on human health or the environment. Follow-on WIPP-specific NEPA evaluation and documentation, as appropriate, would be conducted to examine in greater detail the potential impacts associated with the disposal of GTCC LLRW and GTCC-like wastes at WIPP.

2.3 ALTERNATIVE 3: DISPOSAL IN A NEW INTERMEDIATE-DEPTH BOREHOLE DISPOSAL FACILITY

Alternative 3 involves the evaluation of the environmental consequences from the construction, operations, and post-closure of a new borehole facility for the Groups 1 and 2 GTCC LLRW and GTCC-like waste inventory. Reference locations at the following five sites are evaluated for this alternative: the Hanford Site, INL, LANL, NNSS, and the WIPP Vicinity. Because of the shallow depth to groundwater at SRS, this alternative is not evaluated for this site. Of the four NRC regions considered for the hypothetical commercial facility analysis, human health impacts are analyzed for the NRC Region IV generic commercial location only because the depth to groundwater at the other three regions is considered too shallow for application of this method for the purposes of this EIS.

The conceptual design (see Section 5.1.1) indicates that about 44 ha (110 ac) of land would be required for the 930 boreholes needed to accommodate the waste packages containing the 12,000 m^3 (420,000 ft^3) of GTCC LLRW and GTCC-like waste. This acreage would include land required for supporting infrastructure, such as facilities or buildings for receiving and handling waste packages or containers, and space for a stormwater retention pond to collect stormwater runoff and truck washdown. The borehole method entails emplacement of waste in boreholes at depths below 30 m (100 ft) but above 300 m (1,000 ft) bgs. Boreholes can vary widely in diameter (from 0.3 to 3.7 m [1 to 12 ft]), and the proximity of one borehole to another can vary depending on the design of the facility. The technology for drilling larger-diameter boreholes is simple and widely available. The conceptual design evaluated in this EIS employs boreholes that are 2.4 m (8 ft) in diameter and 40-m (130-ft) deep in unconsolidated to semiconsolidated soils, as shown in Figure 1.4.2-2, with a spacing of 30 m (100 ft) between boreholes. Deeper or shallower boreholes than those evaluated in this EIS could be used, depending on-site-specific considerations (e.g., depth to groundwater).

A bucket auger would be used to drill the large-diameter boreholes (see Figure 5.1.1-2), and a smooth steel casing would be advanced to the depth of the borehole during the drilling and construction of the borehole. The casing would provide stability to the borehole walls and ensure that waste packages would not snag and plug the borehole as they were lowered and that they would sit in an upright position when they reached the bottom. The upper 30 m (100 ft) of smooth steel casing would be removed upon closure of the borehole. In some cases where consolidated materials might be encountered, a more robust drilling technology would be required. A casing would also be used in this case as an aid in placing the waste package. After placement of the waste in the borehole, a reinforced concrete barrier would be added above the disposal containers to deter inadvertent drilling into the isolated waste during the post-closure period, and backfill would be added to the surface level. Details describing facility construction, operations, and integrity are provided in Section 5.1.4.

Adequate acreage (44 ha or 110 ac) is available at the GTCC reference locations for the sites being considered for the borehole method (Hanford Site, INL, LANL, NNSS, and the WIPP Vicinity). At LANL, the reference location is composed of three separate parcels of land located in Technical Area-54 (TA-54).

2.4 ALTERNATIVE 4: DISPOSAL IN A NEW TRENCH DISPOSAL FACILITY

Under Alternative 4, the construction, operations, and post-closure performance of a new trench disposal facility at the Hanford Site, INL, LANL, NNSS, SRS, and the WIPP Vicinity are evaluated for disposal of GTCC LLRW and GTCC-like waste. The conceptual design of the trench is described further in Section 5.1.2. Alternative 4 is also evaluated for the generic commercial location in NRC Regions II and IV in order to allow for a comparison of these methods with the federal sites in these two regions.

For disposal of the entire 12,000 m^3 (420,000 ft^3) of GTCC LLRW and GTCC-like waste, the conceptual design for the trench method includes 29 trenches occupying a footprint of about 20 ha (50 ac) (see Table 5.1-1 and Figure 5.1.4-2). This acreage includes land required for supporting infrastructure, such as facilities or buildings for receiving and handling waste packages or containers, and space for a stormwater retention pond to collect stormwater runoff and truck washdown. Each trench would be approximately 3-m (10-ft) wide, 11-m (36-ft) deep, and 100-m (330-ft) long. After wastes were placed in the trench, a concrete barrier would be placed on top, and backfill would be added to the surface level. The cover would be a minimum of 5 m (16 ft). The additional concrete barrier would provide additional shielding during the operational period, and at some sites where the material through which drilling would be done is typically soft (e.g., sand or clay), the layer could deter inadvertent drilling into the buried waste during the post-closure period. Additional intruder barriers could be adopted for those sites in a hard rock environment on the basis of final engineering designs.

Additional features would be necessary in the trenches where RH waste would be emplaced in order to provide shielding for the workers once the waste was in place. The RH waste packages would be disposed of in vertical cylinders with concrete shield plugs on the top of each cylinder. A mating flange would enable coupling of the bottom-loading transfer cask to a given cylinder for transfer of the waste package into the disposal unit. The transfer cask would be moved off an on-site transport truck and moved into position by an overhead crane. The facility construction, operations, and post-closure activities assumed in the evaluation of the trench disposal method are discussed in Section 5.1.4.

2.5 ALTERNATIVE 5: DISPOSAL IN A NEW VAULT DISPOSAL FACILITY

Under Alternative 5, the construction, operations, and post-closure performance of a new vault disposal facility at the Hanford Site, INL, LANL, NNSS, SRS, and the WIPP Vicinity are evaluated for disposal of GTCC LLRW and GTCC-like waste. The conceptual design of the vault is described further in Section 5.1.3. Alternative 5 is evaluated for the generic commercial location at all four NRC regions.

The conceptual design for the vault disposal of GTCC LLRW and GTCC-like waste that is evaluated in this EIS employs a reinforced concrete vault constructed near grade level, with the footings and floors of the vault situated in a slight excavation just below grade (see Figure 1.4.2-4). The design is a modification of a disposal concept proposed by Henry (1993) for GTCC LLRW, and it is similar to a belowground vault LLRW disposal option (Denson et al. 1987) previously investigated by USACE. A similar concrete vault structure is currently in use (mostly below grade) for the disposal of higher-activity LLRW at SRS (MMES et al. 1994).

The vault disposal facility to emplace 12,000 m^3 (420,000 ft^3) of waste would consist of 12 vault units (each with 11 vault cells) and occupy a footprint of about 24 ha (60 ac). This acreage includes land required for supporting infrastructure, such as facilities or buildings for receiving and handling waste packages or containers, and space for a stormwater retention pond. Each vault would be about 11-m (36-ft) wide, 94-m (310-ft) long, and 7.9-m (26-ft) tall, with 12 vault units situated in a linear array (see Table 5.1-1 and Figure 5.1.4-3). The vault cell would be 8.2-m (27-ft) wide, 7.5-m (25-ft) long, and 5.5-m (18-ft) high, with an internal volume of 340 m^3 (12,000 ft^3) per vault cell. Double interior concrete walls with an expansion joint would be included after every second cell.

Vault cells for disposal of RH waste would be similar in design to the trenches. Waste containers would be emplaced from a bottom-loading transfer cask into vertical concrete cylinders with thick concrete shield plugs within each cell. The cylinder loading would be the same as that for the trench method. Two engineered cover systems would be used for the vaults. If needed, rock armor could also be incorporated into the final cover to further protect against erosion. Construction, operations, and post-closure activities for the vault method are discussed in Section 5.1.4, with additional details provided in Appendix D.

2.6 ALTERNATIVES CONSIDERED BUT NOT EVALUATED IN DETAIL

DOE identified the alternatives for detailed analysis in this EIS on the basis of the rationale provided in the NOI for the GTCC EIS (72 FR 40135). Several comments received during the scoping process indicated that DOE should include alternatives in addition to those identified in the NOI. However, none of the suggested alternatives was determined to be a reasonable alternative (see Appendix A).

In the NOI for the GTCC EIS, DOE identified co-disposal of the GTCC waste at the then-proposed Yucca Mountain repository as one alternative to be considered; however, DOE did not include this as an alternative in this Draft EIS because since publication of the NOI, the Administration has determined that developing a permanent repository for high-level waste and spent nuclear fuel at Yucca Mountain, Nevada, is not a workable option and that the project should be terminated. No funding has been requested in the fiscal year 2011 budget for the Yucca Mountain project. Therefore, because a repository for high-level waste and spent nuclear fuel at Yucca Mountain has been determined not to be a workable option and will not be developed, co-disposal at a Yucca Mountain repository is not a reasonable alternative.

In addition to Yucca Mountain, the NOI for the GTCC EIS also identified the Oak Ridge Reservation as a site to be evaluated for potential disposal of GTCC waste by using a land disposal method because of its ongoing waste disposal mission. However, disposal of radioactive waste at the Oak Ridge Reservation is currently limited to only CERCLA wastes. Through further reviews conducted by the Low-Level Waste Disposal Facility Federal Review Group, DOE determined that the site is not appropriate for disposal of LLRW containing high concentrations of long-lived radionuclides (such as those found in GTCC waste), especially those with high mobility in the subsurface environment. For this reason, DOE concluded that the Oak Ridge Reservation is not a reasonable disposal site alternative and has eliminated it from detailed evaluation in this EIS.

In developing Alternatives 3 to 5 for this EIS, all DOE sites were carefully considered for inclusion. The DOE sites with an ongoing waste disposal mission are included in the scope of this EIS. Of these DOE sites, the evaluation for SRS is limited to the trench and vault methods because of the relatively shallow depth to groundwater at SRS.

The reference locations being evaluated in this EIS are limited to federal sites. DOE solicited technical capability statements from commercial vendors that might be interested in constructing and operating a GTCC waste disposal facility in a request for information in the *FedBizOpps* on July 1, 2005. Although several commercial vendors expressed an interest, no vendors at that time and at the time this EIS was issued provided specific information on disposal locations and methods for analysis in this EIS. Commercial disposal locations are therefore evaluated in this EIS by using a generic approach in which the United States is divided into four regions, as the NRC has done. The estimates for the four regions could be used in the future as a basis for considering the feasibility of siting a borehole, trench, or vault disposal facility on private or commercial land in the United States.

2.7 COMPARISON OF THE POTENTIAL CONSEQUENCES FROM THE FIVE ALTERNATIVES

- Alternative 1: No Action
- Alternative 2: Disposal in the WIPP geologic repository
- Alternative 3: Disposal in a new borehole disposal facility
- Alternative 4: Disposal in a new trench disposal facility
- Alternative 5: Disposal in a new vault disposal facility

The following sections describe the consequences from the five alternatives (including No Action) evaluated for each of the environmental resource areas (see Tables 2.7-1 through 2.7-6, which are presented consecutively following the discussion for Section 2.7).

2.7.1 Climate, Air Quality, and Noise

Potential air quality and noise impacts for the alternatives evaluated are discussed in Sections 3.5, 4.3.1, 5.3.1.1, 6.2.1, 7.2.1, 8.2.1, 9.2.1, 10.2.1, and 11.2.1. There would be no changes to the current air quality and noise under Alternative 1, since no additional construction activities would occur. The incremental air quality and noise impacts under Alternative 2 would be very low, because no new surface facilities would be constructed at the WIPP repository. There would be very minor increases in the impacts from the surface storage of mined materials at WIPP to allow for the increased disposal capacity. However, the impacts would be in terms of time more than magnitude; the time frame over which the impacts would occur would be extended more than would their magnitude. The ambient air concentrations of criteria pollutants, volatile organic compounds (VOCs), and carbon dioxide (CO_2) would not likely change as a result of disposing of GTCC LLRW and GTCC-like wastes at WIPP.

Under Alternatives 3 to 5, the air quality and noise impacts are expected to be low, but higher than they would be under Alternative 2. It is estimated that during construction, total peak-year emission rates for criteria pollutants, VOCs, and CO_2 associated with all three Alternatives (3 to 5) would be low. Construction activities would take place well within the site boundaries at all sites evaluated (except at LANL, where construction activities could take place within about 200 m [660 ft] of the boundary), so emissions would contribute little to concentrations at or beyond the site boundaries. For most sites, during the construction phase, emission levels associated with the borehole method would be between those associated with the trench method and the vault method, with the vault method having the most relative emissions and the trench method having the least. Construction-related emissions from all three disposal methods would add 1% or less to emissions in the nearby areas surrounding the various sites.

During operations, total peak-year emission rates for criteria pollutants, VOCs, and CO_2 for the three disposal methods would be low (even lower than during construction). Operational activities would be well within the site boundaries at all candidate sites (except for LANL, as discussed above), so emissions from operational activities would contribute little to the concentrations at or beyond the site boundaries. At all sites, the borehole method would emit the least emissions of all three disposal methods during the operations phase.

The impacts of construction-related and operations-related emissions (e.g., fugitive dust) on ambient air quality would be reduced by implementing best management practices, such as watering unpaved roads and other sources of dust. Ozone (O_3) levels in the counties encompassing the evaluated sites are currently in attainment, and O_3 precursor emission levels from construction and operational activities would be relatively small and much lower than those for the regional air shed in which emitted precursors are transported and formed into O_3. As a result, the potential impacts of O_3 precursor releases from construction and operational activities for the three land disposal methods would not be of concern. The highest peak-year amount of CO_2 emissions would occur during construction, but those emissions would be considered small at all the sites evaluated (less than 0.00005% of U.S. emissions).

The highest composite noise during construction at any of the sites under Alternatives 3 to 5 would be about 92 dBA at a distance of 15 m (50 ft) from the source (noise generated from operations would be less than the noise in the construction phase). Sound levels would actually be lower because of air absorption and ground effects due to terrain and vegetation. Noise levels at a distance of 690 m (2,300 ft) from the source would be below the EPA guideline of 55 dBA or decibels for all the sites evaluated. This distance is smaller than the distance between the GTCC reference locations and the respective nearest known off-site residences. 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.

2.7.2 Geology and Soils

Potential impacts on geology and soils are discussed in Sections 3.5, 4.3.2, 6.2.2, 7.2.2, 8.2.2, 9.2.2, 10.2.2, and 11.2.2. Under Alternative 1, the land currently used for storage would continue to be used. Under Alternative 2, no surface support structures in addition to those already in place at the WIPP facility would be needed; the construction of additional underground rooms would not increase the current footprint of the WIPP site.

Under Alternatives 3 to 5, impacts from land disturbance would be proportional to the total area of land disturbed during site preparation and construction. The borehole method would disturb more land than would the trench and vault methods. Of the three land disposal methods, the borehole method also would result in the greatest disturbance with depth. The vault disposal method would disturb more land than the trench method. No adverse impacts from the extraction and use of geologic and soil resources are expected at any of the six sites, and no significant changes in surface topography would occur. No changes in natural drainages are expected. Potential impacts at soil resource areas (borrow areas) that might be needed to implement the vault disposal facility in particular (because of the larger amount of soil required for the cover system) would have to be considered in follow-on evaluations to support implementation of this method.

The potential for erosion would be lower at the five western sites evaluated (Hanford Site, INL, LANL, NNSS, and WIPP Vicinity) than at the eastern site (SRS) because of the low precipitation rates at the western sites. Erosion rates at all six evaluated sites would be reduced by employing best management practices. For most of the sites, the borehole and the trench methods would be completed in unconsolidated sediments. However, these two disposal methods could penetrate the upper surface of the basalt interlayered with sediment at INL and the Bandelier Tuff at LANL.

2.7.3 Water Resources

Potential impacts on water resources are discussed in Sections 3.5, 4.3.3, 5.3.3, 6.2.3, 7.2.3, 8.2.3, 9.2.3, 10.2.3, and 11.2.3. Under Alternative 1 (No Action Alternative), no potential impacts on water resources in terms of water consumption are expected other than those that already exist as a result of waste storage. The impacts associated with any surficial spills are expected to be the same as those from storage activities practiced currently. The incremental water resource impacts under Alternative 2 are expected to be very low, since the facilities for unloading, managing, transporting, and decontaminating waste packages and equipment would already be in place. The increased water needs for potable purposes would not result in any additional significant impacts in the region of the WIPP repository. As is the case for the air quality impacts, the most significant incremental effects associated with adding the GTCC LLRW and GTCC-like waste to the wastes being disposed of at the WIPP repository is that the impacts would occur over a longer time period. There would be very little, if any, change in the magnitude of the impacts.

Under Alternatives 3 to 5 (borehole, trench, or vault), water consumption associated with the borehole method during construction would be about 530,000 L/yr (140,000 gal/yr), which is the smallest amount associated with the three land disposal methods. The corresponding values for the trench and vault methods are 1,000,000 L/yr (270,000 gal/yr) and 3,300,000 L/yr (860,000 gal/yr), respectively. The initial construction period was assumed to be about 3.4 years for all three land disposal methods. The amount of potable and raw water consumed during the operational phase of the borehole method would also be the smallest of the three disposal methods; it would be about 2,500,000 L/yr (650,000 gal/yr). A total of 5,300,000 L/yr (1,400,000 gal/yr) would be required for operating either the trench or the vault method.

The increase in annual water use under Alternatives 3 to 5 would be low for all of the sites evaluated. However, at the WIPP Vicinity, the increase in demand would have to be considered in conjunction with the water demands of the nearby WIPP repository operation. Construction of a GTCC disposal facility at the WIPP Vicinity reference locations (at either Section 27 or 35) could increase the water usage in that area by as much as 0.24% of the pumpage for the Carlsbad Double Eagle South Well Field (i.e., 3,300,000 L/yr or 860,000 gal/yr versus a capacity of 1,400 million L or 360 million gal). Operations would increase water use by as much as 0.39% of the pumpage for the Carlsbad Double Eagle South Well Field. Off-site wells (i.e., Double Eagle South Well Field system) are the source of water at the WIPP Vicinity reference locations.

Potential impacts on underlying aquifers and any surface waters at the Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity from sanitary and other nonhazardous waste (including surficial spills) from construction and operations of the three land disposal methods would be small. Groundwater quality at Hanford, INL, LANL, and SRS could be impacted by leaching of waste constituents resulting in concentrations of radionuclides at some time in the future (within 10,000 years after closure of the proposed land disposal facilities). Groundwater quality at NNSS and the WIPP Vicinity would not be impacted because disposal facility post-closure estimates presented in this EIS indicate that radionuclides would not reach groundwater during the 10,000-year period of analysis.

2.7.4 Human Health

Potential human health impacts are discussed in Sections 3.5, 4.3.4, 5.3.4, 6.2.4, 7.2.4, 8.2.4, 9.2.4, 10.2.4, 11.2.4, and 12.2. Human health impacts are evaluated separately for workers and members of the general public in the EIS. The two major worker impacts that are addressed quantitatively are the radiation doses and latent cancer fatality (LCF) risks to the workforce who would implement the various alternatives and the estimated numbers of injuries and fatalities that could occur as a result of a construction project of this size. The worker impacts are generally comparable for all of the action alternatives. Data on worker impacts for the No Action Alternative in this EIS were obtained from documents prepared by some of the sites expected to generate GTCC LLRW.

2.7.4.1 Worker Impacts

Worker doses are estimated on the basis of projected worker requirements during the operations phase under the various action alternatives. Under the No Action Alternative, the annual incremental collective radiation dose to the workforce associated with the storage of GTCC LLRW and GTCC-like waste is estimated to be 4 person-rem on the basis of the storage of activated metal waste (see Table 2.7-3). The annual collective worker dose estimate associated with Alternative 2 is 0.29 person-rem/yr, while those for Alternatives 3, 4, and 5 are 2.6, 4.6, and 5.2 person-rem/yr, respectively. The estimates for Alternatives 3 to 5 are applicable to all sites considered, because the same procedures would generally be used at each site.

These differences in worker doses are attributable to the different assumptions used to develop the estimates for the various alternatives and do not reflect actual benefits of one alternative over the other in terms of worker doses. Actual worker dose information was used for Alternative 2, while conservative assumptions were used to develop worker dose estimates for Alternatives 3, 4, and 5. Comparable doses would likely occur under any of the four action alternatives. The maximum annual dose to any individual worker would be kept below the DOE limit of 5 rem/yr and would be no more than the DOE administrative control level of 2 rem/yr and a project-specific administrative control level that could be lower still. In addition, worker exposures would follow the ALARA (as low as reasonably achievable) principle to further reduce doses. It is expected that none of these worker doses would result in an estimated LCF. The estimates of LCFs were obtained by using a risk factor of 0.0006 LCF per rem (see Section 5.2.4.3).

It is projected that no worker fatalities would occur during operational activities under any of the alternatives, and the annual number of lost workdays due to occupational injuries and illnesses for the land disposal methods are estimated to range from 1 day for the borehole method to 2 days for the trench and vault methods (see Table 2.7-3). Under Alternative 2, the annual number of lost workdays due to occupational injuries and illnesses is estimated to be 3 days, and this is an incremental value over the number estimated to occur as a result of the geologic repository's implementing its current missions to dispose of defense TRU waste. The value for Alternative 2 is larger than that for the other three action alternatives as a result of assuming that the GTCC wastes would be managed as CH wastes at WIPP, which requires more workers to dispose of the larger number of waste packages. The accident rates are comparable for all four action alternatives. As is the case for the estimates of worker doses, these differences are not considered significant and would likely be attributable to the different assumptions used to develop these estimates.

2.7.4.2 Impacts on Members of the General Public

The human health impacts on members of the general public and on-site noninvolved workers are evaluated for waste handling accidents that could occur prior to completion of disposal activities and also for the long-term impacts from disposal of the GTCC LLRW and GTCC-like wastes. The highest impacts would be from an accidental fire affecting an SWB. The doses to the highest-exposed individual (i.e., the individual who could receive the highest dose estimated) located 100 m (330 ft) from the fire range from 2.4 to 16 rem and result in no LCFs for the various sites (see Table 2.7-3). The collective dose to the population in the sector downwind of the fire ranges from 0.47 to 160 person-rem and no LCFs. These results indicate that accidents involving waste packages could have significant impacts, so care needs to be taken to minimize the likelihood of such accidents. Information on accidents at the WIPP repository is included in safety documentation for the site, and the wastes being addressed in this EIS generally fall within the safety envelope of that evaluation. Such impacts are thus not quantified for the WIPP repository in this EIS.

The potential long-term human health impacts of the No Action Alternative could amount to as much as 470,000 mrem/yr or an annual LCF risk of about 0.3 (see Table 2.7-3) from the continued storage of GTCC wastes in NRC Region I. With regard to the wastes assumed to remain in storage in NRC Regions II to IV, estimates indicate much lower potential doses and no LCFs. To assess the impacts of Alternative 1, it is assumed that GTCC wastes would generally remain in the NRC region where the facilities that generate them are located. Most of the expected inventory is in NRC Region I, which is one of the reasons that the doses in this region are so much higher than those in the other three NRC regions. These health impacts would be on a hypothetical resident farmer residing 100 m (330 ft) from the edge of the disposal facility. This scenario is described further below.

For Alternative 2, there would be no releases to the accessible environment and therefore no radiation doses and latent cancer fatality (LCF) risks during the first 10,000 years following closure of the WIPP repository.

Under Alternatives 3 to 5, the long-term human health impacts are addressed by considering the future radiation dose and LCF risk to a hypothetical individual who resides 100 m (330 ft) from the edge of the disposal facility and develops a farm. This resident farmer scenario is assumed to be conservative (i.e., one that overestimates the expected dose and LCF risk) because it assumes a total loss of institutional control and institutional memory with regard to the disposal facility and because the radiation doses and LCF risks estimated to occur to this individual would likely never occur.

There are three release mechanisms considered in the RESRAD-OFFSITE computer model that can lead to contamination at off-site locations: wind erosion, surface runoff, and leaching (see Section E.1). However, only two of these mechanisms are considered applicable to disposal of GTCC wastes in land disposal facilities in the long term: (1) airborne emissions and (2) leaching of radioactive contaminants from the waste packages with transport to groundwater and migration to an accessible location such as a groundwater well. These two mechanisms are addressed in this EIS to determine the impacts on off-site members of the general public following closure of the disposal facility.

Release of particulates by wind erosion is not considered to be a viable pathway, given the depth of the disposal facility cover and use of good engineering practices during closure of the disposal facility, which would include measures to minimize erosion of the cover material. That is, it is assumed in this EIS that the disposed-of wastes would always be overlain by some clean soil cover. The only airborne emissions would be radioactive gases (such as radon) that could migrate through the facility cover and be released to the atmosphere.

The second release mechanism listed above (surface runoff) is also considered not relevant to the analysis conducted for this EIS. This mechanism addresses the loss of surficial contamination by precipitation that flows along the slope of the ground surface to the surrounding area. Since it is assumed in this EIS that there would always be some clean soil over the disposed-of wastes, this pathway is also not relevant to this assessment.

The most significant exposure pathway would be from groundwater contamination, and it is assumed that the resident farmer would install a drinking water well for use at his or her farm. The annual radiation doses within the first 10,000 years would range from zero to 2,300 mrem/yr for the three land disposal methods. The use of the resident farmer scenario is intended to provide estimates for comparing the various sites evaluated; however, this scenario may not be consistent with the reasonably foreseeable future scenario at some of the sites evaluated (e.g., Hanford Site).

Because the radionuclide mix for each waste type (i.e., activated metals, sealed sources, and Other Waste) is different, the peak doses and LCF risks for each waste type do not necessarily occur at the same time. In addition, the peak doses and LCF risks for the entire GTCC waste inventory considered as a whole could be different from those for the individual waste types. The results presented in the main body of the EIS are for the entire GTCC waste inventory, and the contributions of the individual waste types given in these tables are those that occur at the time of the peak doses and LCF risks for the entire inventory.

The estimated doses and LCF risks for the hypothetical resident farmer scenario evaluated to assess the long-term impacts for GTCC waste disposal using a borehole, trench, or vault disposal facility are presented in two ways in this EIS. The first presents the peak doses and LCF risks when disposal of the entire GTCC waste inventory is considered. These are provided in tables in the site-specific chapters and are summarized in Table 2.7-3. The second way presents the peak doses and LCF risks for each waste type considered on its own. These results are presented in Appendix E to provide additional information on a waste-type basis.

In evaluating the performance of the three land disposal methods at the various sites in this EIS, it is assumed that the waste inventory contained in the land disposal facilities would be available for leaching into groundwater 500 years after closure. The calculations assume that the GTCC LLRW Other Waste and GTCC-like Other Waste would be stabilized (such as with grout or another similar material) prior to being placed in the disposal facility. It is assumed that stabilization with grout material would be effective for 500 years after closure of the disposal facility. Use of such a stabilizing agent is not assumed for the activated metal waste and sealed sources. Most of the radiation dose and LCF risk associated with the groundwater pathway is attributable to leaching from the Other Waste type, and use of a stabilizing agent such as grout would tend to reduce leaching of radionuclides from these wastes.

The long-term calculations conservatively assume that the receptor (a hypothetical resident farmer) is located 100 m (330 ft) downgradient from the edge of the disposal facility. This distance was selected because it is the minimum distance identified in the DOE *Radioactive Waste Management Manual*, DOE M 435.1-1 (DOE 1999), as the point of compliance for LLRW performance assessments. The distance to the nearest existing population from the edge of all reference locations evaluated in this EIS is much greater than 100 m (330 ft). Use of the actual (greater) distance would significantly lower the estimated doses (see Appendix E).

A number of engineering measures were included in the conceptual facility designs to minimize the likelihood of contaminants migrating from the disposal units. To account for these measures, the water infiltration rate into the waste disposal area was reduced to 20% of the natural rate for the surrounding area after 500 years following facility closure. This reduced rate is assumed to be effective for the entire remaining period of analysis. This reduced rate is limited to the waste disposal area; outside the area of the waste disposal units, the natural background infiltration rate was used. This method is assumed to be a reasonable way to model the use of an improved cover over the waste disposal units.

In this analysis, the same land disposal facility concepts and designs were used at each of the various sites. That is, the designs were not adjusted to account for site-specific environmental factors. The results given here indicate that the geologic repository (WIPP) and land disposal facilities located in arid regions of the country perform better than land disposal facilities located in more humid regions. This 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 may be necessary for such a site to meet the necessary performance objectives. Factors such as the infiltration rate, soil adsorption coefficients, engineered barriers, and stabilization techniques appear to make a difference and should be considered when making a decision on how to dispose of GTCC wastes. Using robust engineering designs and redundant measures to contain the radionuclides in the disposal facility could delay the potential releases of radionuclides and could reduce them to very low levels, thereby minimizing future potential groundwater contamination and its associated human health impacts.

The primary exposure pathway of concern for the borehole, trench, and vault disposal methods is leaching of radionuclides from the GTCC wastes to the groundwater. The radionuclides are assumed to move downgradient with the water and subsequently be withdrawn in a well located 100 m (330 ft) from the disposal facility and used by a hypothetical resident farmer. The key input parameters that influenced the long-term human health results are the precipitation rates and the soil distribution coefficients (K_ds) assumed in the calculations.

On the basis of site-specific precipitation rates that were assumed, it is estimated that the federal sites located in the arid regions of the country (Hanford Site, LANL, NNSS, and WIPP Vicinity) would generally have lower long-term human health impacts from the groundwater pathway than would the sites located in more humid regions (such as SRS). The exception is INL, which is shown in Table 2.7-3 to have the highest dose and LCF risk estimates. The INL results are primarily due to the distribution coefficient (K_d) of zero assumed in the calculations for the radionuclides identified in the waste inventory; this assumption was made as a conservative approach to account for the basalt layer that is present in some parts of INL (including the GTCC reference location). Essentially, this assumption allows radionuclides to be released to the full extent once the basalt layer has been penetrated. Estimates of long-term human health impacts from the groundwater pathway for the No Action Alternative also indicate that the arid regions would result in lower doses and LCF risks.

Site- and radionuclide-specific K_ds were assumed in the long-term human health calculations and can vary significantly between sites. K_ds provide an indication of the degree to which the radionuclide would adhere to soil and not move with the percolating water. The higher the K_d for a specific radionuclide, the more that radionuclide would adhere to soil particles. Sites that have high K_ds would generally result in lower groundwater radionuclide concentrations than those with lower K_ds.

SRS was estimated to have the second-highest dose and LCF risks after INL. The peak annual dose to the hypothetical farmer receptor at SRS was estimated to be about 1,700 mrem/yr, with C-14, Tc-99, and I-129 as the major radionuclide contributors to the dose. The K_ds assumed for these three radionuclides are very low and generally the same as those used for all the federal sites evaluated in the EIS. As a result, these three radionuclides are also the major dose and risk contributors to the hypothetical resident farmer for the groundwater pathway for the federal sites in the western part of the country. However, the low precipitation rates for these sites resulted in generally lower peak annual doses and LCF risks than those for SRS, which is located in a more humid region.

Finally, of the three waste types, the activated metals and sealed sources would result in lower peak annual doses and LCF risks than the Other Waste. This would occur because the Other Waste type is physically the most leachable of the three waste types. In this EIS, it is assumed that the Other Waste would be stabilized with grout to minimize degradation over time.

This would also reduce leaching of radionuclides. The activated metal and sealed source wastes are much more durable than the stabilized Other Waste, and leaching from these two waste types would be much lower over the long term.

The estimated doses to the hypothetical resident farmer provided in Table 2.7-3 are intended to serve as indicators of the performance or effectiveness of each of the land disposal methods at each of the sites evaluated and are expected to provide a metric for comparing the relative performance of the land disposal methods at these sites. 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.

2.7.4.3 Analysis of Intentional Destructive Acts

The EIS addressed the impacts of intentional destructive acts (IDAs) to provide perspective on the risks that the GTCC wastes could pose should such an act occur. An IDA could occur during waste handling, transportation, and disposal activities for the various alternatives. Since DOE has already considered the potential impacts of IDAs at WIPP (see Section 4.3.4.4), this EIS focuses on the three land disposal alternatives.

There would be no unpackaged GTCC wastes or bulk hazardous chemicals at the GTCC reference locations since it is assumed that no waste processing activities would be conducted there. All GTCC wastes would be shipped to the GTCC disposal facilities at the reference locations in approved waste packages, and the activated metal wastes would be transported in heavily shielded casks. The only time that the wastes would be a target for an IDA would be before they were placed in the disposal facility and before the facility closed. After facility closure, the GTCC waste would be well-isolated from any potential IDA.

Since the GTCC reference locations addressed at this EIS are at secured federal sites, it would be very difficult for terrorists to gain access to the wastes, and even if they did, the generally remote locations would make these sites generally unattractive targets. The sealed source and activated metal wastes are very robust, and it would be difficult to disperse the radionuclides in them. In addition, the Other Waste is assumed to be stabilized with grout or some other similar material, which reduces the likelihood for dispersion. The impacts from any attempts to disperse these materials (such as those from an explosive blast) would likely be greater than those from the released radionuclides.

However, should a terrorist successfully obtain access to these wastes and disperse them, the potential impacts could be significant. Potential acute fatalities could be on the order of 10 to 50 people, with potential LCFs being in the hundreds. The economic impacts could reach billions of dollars (see Section 5.3.4.4). The extent of the impacts would depend on the exact location of the release, density of the surrounding population, local meteorology, and emergency response capabilities of individuals in the affected area. Appropriate security measures would be taken during all phases of waste handling and disposal activities to ensure that such events would not occur.

2.7.5 Ecology

Potential impacts on ecological resources are discussed in Sections 3.5, 4.3.5, 5.3.5, 6.2.5, 7.2.5, 8.2.5, 9.2.5, 10.2.5, and 11.2.5. There would be minimal ecological impacts associated with Alternatives 1 and 2. Under Alternative 1, no additional activities other than continued storage would occur. Under Alternative 2, no surface support structures in addition to those already in place at the WIPP facility would be needed. Hence, no additional land surface would be affected from the construction of the additional underground rooms at WIPP to emplace the GTCC LLRW and GTCC-like wastes, except for the small increased amount of land within the existing footprint of the WIPP site needed to store excavated material (salt) from the repository. Since construction activities under this alternative would be minimal, and since the ecological impacts associated with operations would be low, the ecological impacts associated with implementing this alternative would be minimal.

Under Alternatives 3 to 5, loss of habitat (specific to each site), followed by the eventual establishment of low-growth vegetation, would affect species that depend on these habitats at the candidate sites. However, population-level impacts on species are not expected. Reestablishing habitat after closure of the disposal facility could take up to 20 years or more. Although there are no natural aquatic habitats on any of the candidate sites under these alternatives, certain aquatic species (e.g., invertebrates, waterfowl, shorebirds, amphibians, and mammals) could become established in stormwater retention ponds, depending on the amount of water and the length of the retention time.

There are no federally listed or state-listed threatened or endangered species reported to be in the GTCC project areas at INL or the WIPP Vicinity. Construction activities could affect federal or state candidate species or species under review for federal listing at INL or the WIPP Vicinity. Impacts on these species would likely be small, since the area of habitat disturbance would be small relative to the overall size of such habitat in the area. Several federally listed or state-listed bird and mammal species occur within the GTCC project areas at the Hanford Site, SRS, LANL, and NNSS. Impacts on these species would likely be small, since the area of habitat disturbance would be small relative to the overall size of such habitat in the area. Adverse impacts would be minimized by conducting biological surveys in the project area and using good engineering practices to minimize impacts on the environment.

2.7.6 Socioeconomics

Potential impacts on socioeconomics are discussed in Sections 3.5, 4.3.6, 6.2.6, 7.2.6, 8.2.6, 9.2.6, 10.2.6, and 11.2.6. There would be minimal socioeconomic impacts associated with Alternatives 1 and 2. Under Alternative 1, the approach currently used for storing the wastes would continue and require the same workforce. Under Alternative 2, the construction activities necessary to expand the disposal capacity at WIPP to accommodate the incremental waste volume could be done with the same workforce employed at the site. The same holds true for operational activities. Since there would be no significant influx of new workers to implement this alternative, the socioeconomic impacts are expected to be very low.

Although it is expected that the potential socioeconomic impacts under Alternatives 3 to 5 would be larger than those under Alternatives 1 and 2, they would still be small. For Alternatives 3 to 5, construction and operations of a GTCC waste disposal facility at the various sites considered in this EIS would increase the annual average employment growth rate by less than 0.1% in the region of interest (ROI). The amount of income that would be produced in the peak construction year would range from about $4 to $8 million (borehole and trench methods) to $11 to $13 million (vault method) (see Table 2.7-4 for the values for each method at each site).

The estimated in-migration to the ROI during peak construction ranges from a low of 10 individuals (borehole method at NNSS) to a high of 127 (vault method at the WIPP Vicinity) as a result of employment at the GTCC waste disposal site. This in-migration would have only a marginal effect on population growth and require less than about 1% of vacant rental housing in the peak year at all of the candidate sites. Operations would create about 40 to 50 direct jobs and approximately the same number of indirect jobs in the ROI. The annual income during operations is estimated to be about $4 to $5 million per year.

2.7.7 Environmental Justice

Potential environmental justice issues are discussed in Sections 3.5, 4.3.7, 6.2.7, 7.2.7, 8.2.7, 9.2.7, 10.2.7, and 11.2.7. Under Alternative 1, the approach currently used for storing these wastes would continue, and environmental justice issues, if any, should remain similar to current conditions. Under Alternative 2, there would be no incremental impacts beyond those that have already occurred.

Under Alternatives 3 to 5, construction, operations, and post-closure of the land disposal facilities would not result in the potential for disproportionate and adverse impacts on minority and low-income populations in the vicinity of the federal sites evaluated in this EIS. However, subsequent NEPA analysis to support any GTCC implementation would have to consider any unique exposure pathways (such as subsistence fish, vegetation or wildlife consumption, and well water use) to determine any additional potential health and environmental impacts. DOE recognizes that concerns have been expressed by the American Indian tribes at the various federal sites involved, as discussed in Section 1.8 and in the tribal narratives in Chapters 6, 8, and 9 and Appendix G. DOE will continue to consult and coordinate with tribal governments to ensure that their concerns are considered in the decision-making process for selecting and implementing (a) disposal alternative(s) for GTCC waste.

2.7.8 Land Use

Potential land use impacts are discussed in Sections 3.5, 4.3.8, 6.2.8, 7.2.8, 8.2.8, 9.2.8, 10.2.8, and 11.2.8. There would be no incremental land use impacts associated with Alternatives 1 and 2. No additional land would be affected by Alternative 1, since this alternative involves the continuation of the current storage of these wastes for the indefinite future. Under Alternative 2, no additional land surface within the existing footprint of the WIPP site would be affected by the construction of the additional underground rooms at WIPP to emplace the GTCC LLRW and GTCC-like wastes, except for the small increased amount of land within the existing facility boundary needed to store excavated material (salt) from the repository. The land use impacts associated with use of the WIPP facility for disposal of GTCC wastes were already incurred when the current WIPP facility was constructed.

Under Alternatives 3 to 5, it is estimated that the amount of land required for the various disposal methods would be 20 ha (50 ac) for the trench method, 24 ha (60 ac) for the vault method, and 44 ha (110 ac) for the borehole method. Reference locations were identified for the various federal sites for purposes of analysis in this EIS on the basis of site characteristics (e.g., depth to groundwater, consistency with current land use plans). The use of reference locations for the EIS is considered to be an acceptable approach to meet the objective of identifying the site and technology combination that could provide the most suitable option for GTCC waste disposal. While institutional knowledge was used to select the reference locations evaluated in this EIS, more in-depth, site-specific, follow-on studies and appropriate NEPA reviews would be needed to ensure proper land use planning, assure protection of local ecological and cultural resources, and account for local variations in hydrology and geology to minimize potential waste migration.

At three of the six federal sites considered for the land disposal methods (Hanford Site, INL, and NNSS), no conflicts with the current land use designation are expected. Locating the GTCC facility within LANL's TA-54, which is currently designated as a reserve or experimental science area, would require that the reference locations be reclassified as waste management areas. Locating the GTCC facility at the WIPP Vicinity Section 35, which is designated for multiple uses, would require up to 44 ha (110 ac) to be reclassified as a waste management area and could result in the loss of about 0.2% of a 22,000-ha (56,000-ac) grazing allotment. The SRS GTCC reference location would also likely require reclassification; marketable timber on the site would have to be removed.

2.7.9 Transportation

Potential impacts on transportation are discussed in Sections 3.5, 4.3.9, 5.3.9, 6.2.9, 7.2.9, 8.2.9, 9.2.9, 10.2.9, and 11.2.9. The impacts associated with transporting the GTCC LLRW and GTCC-like wastes to the various disposal sites are evaluated for the truck and rail transport modes as separate options in this EIS. The higher number of estimated shipments to the WIPP repository as compared to the other three action alternatives is primarily due to the assumption that activated metals and RH wastes with higher external dose rates would be packaged in shielded canisters prior to being loaded onto the transport vehicles for disposal at WIPP. The impacts cover radiological impacts on the transport crew and general public and nonradiological impacts associated with both routine conditions and accidents. There would be no transportation impacts under Alternative 1, because this alternative does not involve the shipment of wastes to potential disposal sites. The wastes are assumed to be stored indefinitely at their current locations under the No Action Alternative.

Radiological impacts on transportation crew members and the general public would be small under Alternatives 2 to 5. No LCFs in the general public or the transportation crew are estimated for truck or rail transport under these alternatives. Because the estimated doses in these cases would be spread over thousands of individuals, the risk to any single member of the public would be small.

Care would be taken to limit the doses to crew members by controlling the number of shipments that individual workers would be involved with, so that the doses to these individuals would not exceed regulatory health-based dose limits and would be ALARA. The transport crew would consist of radiation workers, and doses to individual workers would not exceed the annual limit of 5 rem/yr, as specified in Subpart C of 10 CFR Part 20. Since transportation of GTCC wastes is expected to be done in vehicles consigned for exclusive use, the dose limits specified in 49 CFR 173.441 would be followed for all shipments. There are two dose limit requirements in these transportation regulations: a dose limit of 2 mrem/h in any normally occupied position in the vehicle (to limit worker doses), and a limit of 10 mrem/h at 2 m (6.6 ft) from the sides of the transport vehicle (to limit doses to members of the general public). By adhering to these requirements, it is expected that the radiation doses and LCF risks to workers and members of the general public would be small.

Under Alternatives 2 to 5, the estimated nonradiological impacts (accident fatalities) are expected to be small. Up to one fatality from accidents is estimated from all rail transport, with Alternative 2 having a bit higher number of estimated fatalities than Alternatives 3 to 5. Similarly for truck transport, up to two fatalities resulting from accidents are estimated, with Alternative 2 having a higher number of estimated fatalities than Alternative 3, 4, or 5. Alternative 2 has a slightly higher number of estimated fatalities for truck and rail transport because of the larger number of shipments associated with the different waste packages evaluated for disposal at WIPP. The results of these analyses are summarized in Tables 2.7-5 and 2.7-6 for truck and rail transport, respectively.

2.7.10 Cultural Resources

Potential impacts on cultural resources are discussed in Sections 3.5, 4.3.10, 5.3.10, 6.2.10, 7.2.10, 8.2.10, 9.2.10, 10.2.10, and 11.2.10. For the No Action Alternative (Alternative 1), there would be no incremental impacts on cultural resources at the potential disposal sites evaluated in this GTCC EIS because no construction activities related to GTCC waste disposal would occur at these sites. Under Alternative 2, no additional impacts would occur from the construction of the additional underground rooms to emplace the GTCC wastes at WIPP beyond those that were already incurred when the current WIPP facility was constructed.

Cultural resources are known or likely to occur at five of the sites considered for the land disposal methods: (1) the Hanford Site (traditional cultural properties, including Rattlesnake Mountain, portions of which have been determined eligible for listing on the *National Register of Historic Places* [NRHP], and isolated artifacts were found in the area), (2) INL (prehistoric sites and historic homestead sites are possible), (3) LANL (18 cultural sites were found, some of which are eligible for listing on the NRHP), (4) SRS (seven archeological sites were identified), and (5) the WIPP Vicinity site (prehistoric artifact was found). A handful of very small lithic scatters are located within the GTCC reference location at NNSS, but none of them are eligible for listing on the NRHP. Local tribes would be consulted to identify appropriate mitigations to address potential adverse effects on historic properties and sensitive cultural resources that might occur as a result of a GTCC waste disposal facility.

Because the borehole method requires the most land, it has the greatest potential to affect cultural resources, especially during the construction phase. Impacts that would occur at the locations that would provide the soil needed for backfill and cover material (the most of which is required for the vault method) would also be considered.

2.7.11 Waste Management

Potential impacts on waste management programs evaluated are discussed in Sections 3.5, 4.3.11, 5.3.11, 6.2.11, 7.2.11, 8.2.11, 9.2.11, 10.2.11, and 11.2.11. The potential waste management impacts discussed in the various chapters are intended to address potential waste generated from the construction and operational activities associated with the disposal facilities being proposed rather than impacts from the GTCC waste inventory itself. Under the No Action Alternative, no waste from construction or operations of a waste disposal facility would be generated because these activities would not be conducted. Under Alternative 2, current waste management practices at WIPP would continue to manage any waste generated from the construction of additional underground rooms and the emplacement of GTCC LLRW and GTCC-like waste at the repository. It is expected that the waste volumes generated would not affect current waste management capacities.

Under Alternatives 3 to 5, the types of waste generated during the construction and operations of the land disposal facilities would be typical of those generated by large industrial projects (e.g., sanitary wastes, hazardous wastes, concrete, and steel spoilage). These waste types are routinely handled at the sites evaluated in this EIS. In addition, it is expected that the volumes generated would be small increments when added to the much larger quantities already produced at those sites, so these additional wastes would not affect waste management resources at these sites. Wastes generated from the proposed GTCC waste disposal facility at the WIPP Vicinity reference locations would likely be disposed of off-site at permitted facilities, as necessary.

2.7.12 Cumulative Impacts

Potential impacts of the GTCC proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. Cumulative impacts are discussed in Section 4.5 for Alternative 2 and in Sections 6.4, 7.4, etc., to 11.4 for Alternatives 3 to 5. DOE did not evaluate the cumulative impacts of the No Action Alternative, since such an evaluation would involve making speculative assumptions about environmental conditions and future activities at the many locations where the GTCC LLRW and GTCC-like waste could be stored.

For Alternative 2, the low potential impacts (discussed in Sections 2.7.1 to 2.7.11 and Section 4.3) of that alternative indicate that the cumulative impacts from the construction, operations, and post-closure phases of the proposed action at the WIPP site would be small and would not exceed regulatory requirements established for the WIPP facility. The post-closure performance analysis performed for emplacement of all GTCC LLRW and GTCC-like waste at WIPP demonstrates that disposal of these wastes would result in WIPP still being in compliance with existing regulatory requirements (see Section 4.3.4.3).

For Alternatives 3 to 5 at the federal sites, the estimated impacts from the GTCC proposed action are not expected to contribute substantially to cumulative impacts for the various resource areas evaluated (see Sections 2.7.1 to 2.7.11 and Sections 6.2, 7.2, etc., to 11.2), with the likely exception of potential human health impacts in the long term. That is, during the post-closure phase of the proposed action, potential leaching of radionuclides from the GTCC waste inventory into groundwater could contribute to doses and LCF risks to a hypothetical resident farmer located about 100 m (330 ft) from the edge of the borehole, trench, or vault disposal facility at the federal reference locations (i.e., at the Hanford Site, INL, LANL, and SRS). For the Hanford Site, 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. The post-closure doses and LCF risks are summarized in Table 2.7-3. The resident farmer scenario is assumed to be conservative (i.e., one that overestimates the expected dose and LCF risk) because it assumes a total loss of institutional control and institutional memory with regard to the disposal facility. (The sites evaluated for Chapters 6 to 11 are on federal land and would most likely continue to be managed by the federal government for a long time.) In addition, land use designations for these sites might be incompatible with or would not allow a resident farmer scenario. Follow-on NEPA evaluations to support further considerations of siting a new borehole, trench, or vault disposal facility at the sites evaluated in this EIS would provide more detailed analyses of site-specific issues relative to cumulative impacts.

2.8 UNCERTAINTIES ASSOCIATED WITH THE EVALUATIONS IN THIS EIS

The impact analyses conducted for this EIS used methodologies and approaches consistent with CEQ recommendations and DOE guidelines for preparing an EIS. As such, any uncertainties associated with the various environmental resource areas evaluated in this EIS are not unique to this EIS and should not differ from those in other EISs in general. Also, the results of the impact analyses for the action alternatives (as summarized and compared in Section 2.7) indicate that the impacts on the various resource areas from the proposed action would probably be small and also that they would not vary much among the sites evaluated, with the possible exception of potential post-closure impacts on human health.

The results from the analysis of human health impacts in the post-closure phase indicate that potential future doses and LCF risks to a hypothetical resident farmer could vary significantly by site. Hence, the discussion on uncertainties presented in the remainder of this

TABLE 2.7-1 Comparison of Potential Impacts from Alternatives 1 through 5 on Air Quality and Noise

Alternative	Air Quality	Noise
1: No Action	No incremental air quality impacts due to construction activities for a disposal facility would occur because none would be undertaken. Procedures currently being used to store wastes would continue. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.
2: WIPP	Emissions from construction and operational activities would not contribute significantly to concentrations at the site boundary or nearest residence. Concentration levels during operation are expected to remain below National Ambient Air Quality Standards/State Ambient Air Quality Standards (NAAQS/SAAQS). The average-year emissions would be about one-third of peak-year emissions.	No significant vibration impacts are anticipated because most activities would occur underground and because no major equipment that could cause ground vibration would be used. The noise from operational activities would be barely discernable or completely inaudible at the site boundaries and the nearest residences. Incremental impacts would extend the time frame of the impacts and not the magnitude of annual or single events.
3: Borehole method		
Hanford	Potential impacts of construction and operations would be low but higher than for Alternatives 1 and 2. Construction and operational activities would be well within the site boundaries, and emissions would contribute little to concentrations at or beyond the site boundaries. The total peak-year emissions of criteria pollutants, VOCs, and CO_2 would be very small. O_3 levels are currently in attainment, and O_3 precursor emissions levels are much lower than are those for the regional air shed. Activities would not contribute significantly to particulate matter (PM) concentrations at the boundary or nearest residence.	During construction, the highest composite noise would be about 92 dBA at 15 m (50 ft) from the source, and levels at 690 m (2,300 ft) would be below the EPA guideline of 55 dBA. The nearest off-site residences are 6 km (4 mi) from the Hanford GTCC reference location. No groundborne vibration impacts are anticipated. The impacts during operations would be less than those during the construction phase.
INL	Same as for the Hanford Site.	Same as for the Hanford Site. The nearest off-site residences are >11 km (7 mi) from the INL GTCC reference location.

TABLE 2.7-1 (Cont.)

Alternative	Air Quality	Noise
LANL	Same as for the Hanford Site.	Same as for the Hanford Site. The nearest off-site residences are approximately 3.5 km (2.2 mi) from the LANL GTCC reference location.
NNSS	Same as for the Hanford Site.	Same as for the Hanford Site. The nearest off-site residences are >6 km (4 mi) from the NNSS GTCC reference location.
WIPP Vicinity	Same as for the Hanford Site.	Same as for the Hanford Site. The nearest off-site residences are >5 km (3 mi) from the WIPP Vicinity reference locations.
4: Trench method		
Hanford	Potential impacts from construction and operations would be low but higher than for Alternatives 1 to 3. Construction and operational activities would be well within the site boundaries, and emissions would contribute little to concentrations at or beyond the site boundaries. The total peak-year emissions of criteria pollutants, VOCs, and CO_2 would be small. O_3 levels are currently in attainment, and O_3 precursor emission levels are much lower than those for the regional air shed. Activities would not contribute significantly to PM concentrations at the boundary or nearest residence. The emission levels for the trench method are slightly lower than those for the vault method.	Same as for Alternative 3.
INL	Same as for the Hanford Site.	Same as for Alternative 3.
LANL	Same as for the Hanford Site.	Same as for Alternative 3.
NNSS	Same as for the Hanford Site.	Same as for Alternative 3.

TABLE 2.7-1 (Cont.)

Alternative	Air Quality	Noise
SRS	Same as for the Hanford Site.	Same as for Alternative 3, except the highest composite noise would be about 90 dBA at 15 m (50 ft) from the source, and levels at 610 m (2,000 ft) would be below the EPA guideline of 55 dBA. The nearest off-site residences are >14 km (9 mi) from the SRS reference location.
WIPP Vicinity	Same as for the Hanford Site.	During construction, the highest composite noise would be about 92 dBA at 15 m (50 ft) from the source, and levels at 690 m (2,300 ft) would be below the EPA guideline of 55 dBA. No groundborne vibration impacts are anticipated. The impacts during operations would be less than those during the construction phase. The nearest off-site residences are >5 km (3 mi) at the WIPP Vicinity GTCC reference locations.
5: Vault method		
Hanford	Potential impacts from construction and operations would be low but higher than for Alternatives 1 to 4. Construction and operational activities would be well within the site boundaries, and emissions would contribute little to concentrations at or beyond the site boundaries. The total peak-year emissions of criteria pollutants, VOCs, and CO_2 would be very small. O_3 levels are currently in attainment, and O_3 precursor emission levels are much lower than those for the regional air shed. Activities would not contribute significantly to PM concentrations at the boundary or nearest residence. The emission level for the vault method is almost the same as that for the trench method, and it is the highest of those for the three land disposal methods.	Same as Alternative 3.
INL	Same as for the Hanford Site.	Same as Alternative 3.

TABLE 2.7-1 (Cont.)

Alternative	Air Quality	Noise
LANL	Same as for the Hanford Site.	Same as Alternative 3.
NNSS	Same as for the Hanford Site.	Same as Alternative 3.
SRS	Same as for the Hanford Site.	Same as Alternative 3.
WIPP Vicinity	Same as for the Hanford Site.	Same as Alternative 3.

TABLE 2.7-2 Comparison of Potential Impacts from Alternatives 1 through 5 on Geology, Water Resources, Ecological Resources, and Cultural Resources

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
1: No Action	No incremental impacts are expected because construction activities for a disposal facility would not be undertaken. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.	No incremental impacts are expected to occur. Continued monitoring procedures would ensure that discharges to surface waters would not exceed regulatory limits.	No incremental impacts are expected because construction activities for a disposal facility would not be undertaken. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.	No incremental impacts are expected because continued waste storage activities would not require disruption of additional areas not already affected.
2: WIPP	No incremental impacts are expected because construction, operational, and post-closure activities would not involve additional land disturbance beyond that already occupied by the existing footprint of the WIPP site.	The incremental impacts would be minor when added to those already associated with operations at the WIPP facility. Surface water and groundwater resources would not be affected because no land surfaces would be disturbed.	The incremental impacts on habitat and wildlife would be localized and are not expected to result in adverse population-level impacts.	No incremental impacts are expected because construction, operational, and post-closure activities would not involve additional land disturbance beyond that already occupied by the existing footprint of the WIPP site.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
3: Borehole method				
Hanford	Impacts due to land disturbance would be proportional to the total land area affected. The borehole method would disturb the most land of the three land disposal methods. The boreholes would be completed in unconsolidated material, and there would be no adverse impacts from extraction and use of geologic and soil resources. No significant changes in surface topography or natural drainages are expected. The soil erosion potential is low and would be further reduced by use of best management practices.	The borehole method requires the least water of the three land disposal methods. The maximum increase in annual water use (from the Columbia River) would be as high as 0.31% during normal operations. Surface water and groundwater resources could be impacted by surficial spills. Wastewater discharges to drainage fields and evaporation ponds would have a small impact on groundwater resources. The GTCC reference location is not within a 100-yr floodplain. In addition, groundwater could become contaminated with radionuclides from GTCC waste disposal, as indicated by estimates from the post-closure performance of a borehole disposal facility.	Impacts are expected to be small because of the small amount of land that would be affected. The loss of sagebrush habitat, followed by eventual establishment of low-growth vegetation, would affect sagebrush-dependent species. Loss of sagebrush would be compensated for by restoration elsewhere. Ground disturbance during the nesting season could destroy eggs and affect birds that use these areas for nests. There are no natural aquatic habitats within the immediate vicinity of the GTCC reference location. No federally listed species have been reported in the GTCC reference location. However, construction could affect federal and state candidate species that depend on sagebrush habitat.	There are no known cultural resources within the GTCC reference location, although isolated prehistoric artifacts have been found in the area. Section 106 of the National Historic Preservation Act (NHPA) would be followed to determine the impact on cultural resources and to develop appropriate mitigation measures. Local tribes would be consulted to ensure no traditional cultural properties were impacted. Of the three land disposal methods, the borehole method has the greatest potential to affect cultural resources because it requires the most land.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
INL	Same as for the Hanford Site, except that the boreholes would be completed in unconsolidated material interlayered with basalt. There is a potential for fractures in basalt, either as a result of drilling or due to other influences; these could possibly lead to fissure pathways to the aquifer, which could accelerate the release of potential contaminants through the groundwater pathway.	Same as for the Hanford Site, except the maximum increase in annual water use (from on-site wells) would be as high as 0.05% during normal operations.	Same as for the Hanford Site.	There are no known cultural resources within the GTCC reference location, although prehistoric archaeological sites and a substantial number of historic homestead sites are possible. Section 106 of NHPA would be followed to determine the impact on cultural resources and to develop appropriate mitigation measures. Local tribes would be consulted to ensure that no traditional cultural properties were impacted. Of the three land disposal methods, the borehole method has the greatest potential to affect cultural resources because it requires the most land.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
LANL	Same as for the Hanford Site, except that the boreholes would be in unconsolidated mesa top alluvium and tuff. The facility would have to be sited away from a mesa cliff edge.	Same as for the Hanford Site, except the maximum increase in annual water use (from on-site wells) would be as high as 0.18% during operations. The GTCC reference location is not within the 100-year floodplain.	Impacts are expected to be minor because of the small amount of land that would be affected. The loss of pinyon-juniper woodland habitat, followed by eventual establishment of low-growth vegetation, would affect some species. Ground disturbance during the nesting season could destroy eggs and affect birds that use these areas for nests. There are no natural aquatic habitats within the immediate vicinity of the GTCC reference location. Construction activities could affect wildlife species, but small mammals, ground-nesting birds, and reptiles would eventually recolonize. Larger mammals would likely avoid the area. Foragers and hunters would be excluded by fencing. Several federally or state-listed species occur within the GTCC reference location. Construction could affect federal and state candidate species that depend on pinyon-juniper woodland habitat.	Eighteen cultural resources are reported to be in and near the project area, and some of the sites in the GTCC reference location are considered eligible for listing under the NHPA. Section 106 of NHPA would be followed to determine the impact on cultural resources and to develop appropriate mitigation measures. Local tribes would be consulted to ensure no traditional cultural properties were affected. Of the three land disposal methods, the borehole method has the greatest potential to affect cultural resources because it requires the most land.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
NNSS	Same as for the Hanford Site.	Same as for the Hanford Site, except the maximum increase in annual water use (from on-site wells) would be as high as 0.23% during normal operations. Nearby streams are ephemeral, and the GTCC reference location is not within any known floodplains.	Same as for LANL, except the existing habitat is creosote bush/white bursage. The desert tortoise is the only federally listed animal species resident on NNSS. It inhabits the southern third of the site at low estimated densities. However, since the Radioactive Waste Management Site (RWMS) is not considered a suitable habitat for the tortoise, the area is not subject to the requirements of the U.S. Fish and Wildlife Service's (USFWS's) 1996 Biological Opinion. Construction activities might destroy western burrowing owl burrows or directly kill owls. Adverse impacts would be minimized by conducting biological surveys in the GTCC reference location and using appropriate mitigation measures.	A handful of very small lithic scatters are located within the GTCC reference location at NNSS, but none of them are eligible for inclusion in the NRHP. Section 106 of NHPA would be followed to determine the impact on cultural resources and to develop appropriate mitigation measures. Local tribes would be consulted to ensure no traditional cultural properties were affected. Of the three land disposal methods, the borehole method has the greatest potential to affect cultural resources because it requires the most land.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
WIPP Vicinity	Same as for the Hanford Site. In addition, oil production and gas production currently occur at Section 35, and potash mining occurs at other sections. Disposal activities in Section 35 would not have adverse impacts on the extraction of economic minerals in the surrounding region (an area known to be rich in potash ore), but they would preclude mining within the section. Section 27, which is within the WIPP Land Withdrawal Boundary (LWB), is closed to commercial mineral development.	Same as for the Hanford Site, except the maximum increase in annual water use would be as high as 26% of what is currently used at the nearby WIPP repository during normal operations. The increased demand on Carlsbad's Double Eagle South Well Field water supply system would be about 0.39% of its capacity. The GTCC reference location is not within a 100-year floodplain, and there are no surface water bodies in the immediate vicinity.	Impacts are expected to be minor because only a small amount of land would be affected. Loss of shrub-dominated sand dune habitat, followed by eventual establishment of low-growth vegetation, would not create a long-term reduction in the local or regional ecological diversity. DOE's wildlife management goals for WIPP include protection and maintenance of crucial habitats for certain species; wildlife management goals at the WIPP Vicinity would likely be similar. There are no natural aquatic habitats within the immediate vicinity of the GTCC reference location. No endangered, threatened, or other special-status species have been reported in the GTCC reference location; however, the site provides favorable habitat for the lesser prairie-chicken, a federal candidate species. Impacts on this species would likely be small, since the area of disturbance would be relatively small.	Some isolated prehistoric artifacts and possibly some larger prehistoric cultural resources would be found in the project area. One known prehistoric site is within the WIPP Vicinity reference location (Section 35) and has yet to be evaluated for listing on the NRHP. If additional archaeological sites were identified, they would require evaluation for listing on the NRHP. Section 106 of the NHPA would be followed to determine the impacts of disposal facility activities on significant cultural resources, as needed. Local tribes would be consulted to ensure that no traditional cultural properties were impacted.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
4: Trench method				
Hanford	Same impacts as those under Alternative 3, except there would be less land disturbed.	Water needs would be greater for the trench method than for the borehole method. The maximum increase in annual water use would be as high as 0.65% during normal operations for the trench method. Surface water and groundwater resources could be affected by surficial spills. Wastewater discharges to drainage fields and evaporation ponds would have a negligible impact on groundwater resources. The GTCC reference location is not within a floodplain for a probable maximum flood. Same as for the borehole method with regard to the potential for radionuclide contamination in groundwater from the proposed trench facility during the post-closure phase.	Same as for Alternative 3.	Same as for Alternative 3.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
INL	Same as Alternative 3, except there would be less land disturbed and the bottom of the trench could penetrate the top basalt layer and have potential impacts similar to those discussed for the borehole method.	Same as for the Hanford Site (the potential impact would be greater than Alternative 3 relative to the increase in annual water use). The maximum increase in annual water use would be as high as 0.13% during normal operations for the trench method.	Same as for Alternative 3.	The potential for impacts is less than that for Alternative 3 because less land would be affected.
LANL	Same as Alternative 3, except there would be less land disturbed and the bottom of the trench could penetrate the tuff.	Same as for the Hanford Site (the potential impact would be greater than Alternative 3 relative to the increase in annual water use). The maximum increase in annual water use would be as high as 0.39% during normal operations for the trench method. The GTCC reference location is not within the 100-year floodplain.	Same as for Alternative 3.	Same as for Alternative 3.
NNSS	Same as Alternative 3, except there would be less land disturbed.	Same as for the Hanford Site (the potential impact would be greater than Alternative 3 relative to the increase in annual water use). The maximum increase in annual water use would be as high as 0.48% during normal operations for the trench method. Nearby streams are ephemeral, and the GTCC reference location is not within any known floodplains.	Same as for Alternative 3.	Same as for Alternative 3.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
SRS	Same as Alternative 3, except there would be less land disturbed. There would be no changes in the natural drainages.	Same as for the Hanford Site (the potential impact would be greater than Alternative 3 relative to the increase in annual water use). The maximum increase in annual water use would be as high as 0.1% during normal operations for the trench method. The GTCC reference location is not within the 100-year floodplain.	Similar to Alternative 3 for other sites, except mostly upland pine and some hardwood forest habitats would be lost. Several state-listed or special-status species occur within the GTCC reference location. Impacts on these species would likely be small, since the area of disturbance would be relatively small. Forest removal during construction would eliminate a small portion of about 0.1% of the Supplemental Red-Cockaded Woodpecker Management Area; population-level impacts are not expected.	There are seven archaeological sites within the GTCC reference location. These sites would require evaluation for listing on the NRHP. Mitigation for eligible sites would be determined through consultation with the South Carolina State Historic Preservation Office (SHPO) and appropriate tribes. The potential for impacts is greater for the vault method because it would affect more land than would the trench method.
WIPP Vicinity	Same as Alternative 3, except there would be less land disturbed.	Same as for the Hanford Site, except the maximum increase in annual water use would be as high as 26% of what is currently used at the nearby WIPP repository during normal operations. The increased demand on Carlsbad's Double Eagle South Well Field water supply system would be about 0.39 of its capacity. The GTCC reference location is not within a 100-year floodplain, and there are no surface water bodies in the immediate vicinity.	Same as for Alternative 3.	Same as for Alternative 3.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
5: Vault method				
Hanford	Same impacts as those under Alternative 3, except there would be less land disturbed. Associated land disturbance would be greater than for Alternative 4.	Water needs would be greater than those for Alternative 3 but about the same as those for Alternative 4. Surface water and groundwater resources could be affected by surficial spills. Wastewater discharges to drainage fields and evaporation ponds would have a small impact on groundwater resources. The GTCC reference location is not within a floodplain for a probable maximum flood.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4, except that the vault method could have a greater potential for impacts because it would affect more land than would the trench method.
INL	Same impacts as those under Alternative 3, except there would be less land disturbed. Associated land disturbance would be greater than for Alternative 4.	Water needs would be greater than those for Alternative 3 but about the same as those for Alternative 4.	Same as for Alternatives 3 and 4.	Same as for Alternative 3, except that the vault method could have a greater potential for impacts because it would affect more land than would the trench method.
LANL	Same impacts as those under Alternative 3, except there would be less land disturbed. Associated land disturbance would be greater than for Alternative 4.	Water needs would be greater than those for Alternative 3 but about the same as those for Alternative 4.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4
NNSS	Same impacts as those under Alternative 3, except there would be less land disturbed. Associated land disturbance would be greater than for Alternative 4.	Water needs would be greater than those for Alternative 3 but about the same as those for Alternative 4.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
SRS	Same impacts as those under Alternative 3, except there would be less land disturbed. Associated land disturbance would be greater than for Alternative 4. There would be no changes in the natural drainages.	Same as for Alternative 4.	Same as for Alternative 4.	Same as for Alternative 4.
WIPP Vicinity	Same as for the Hanford Site.	Water needs would be greater than those for Alternative 3 but about the same as those for Alternative 4.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4.

TABLE 2.7-3 Comparison of Potential Impacts from Alternatives 1 through 5 on Human Health[a]

Alternative	Annual Collective Worker Dose (person-rem)[b]	Annual Collective Worker LCF Risk	Annual No. of Physical Injuries to Workers[c]	Highest Annual Dose to a Hypothetical Resident Farmer (mrem/yr)[d]	Highest Annual LCF Risk to Resident Farmer[d]	Highest Individual Dose from Waste Handling Accident (rem)[e]	Highest Individual LCF Risk from Waste Handling Accident[e]	Highest Population Dose from Waste Handling Accident (person-rem)[e]	Highest Population LCF Risk from Waste Handling Accident[e]
1: No Action	4[f]	0.002	NA			NA	NA	NA	NA
Region I				470,000	0.3				
Region II				860	0.0005				
Region III				120	0.00007				
Region IV				0[g]	0				
2: WIPP	0.29	0.0002	3	0[h]	0[h]	7.5[i]	0.005[i]	1.7[j]	0.001[j]
3: Borehole method									
Hanford Site	2.6	0.002	1	4.8	0.000003	16	0.009	95	0.06
INL	2.6	0.002	1	820	0.0005	11	0.007	13	0.008
LANL	2.6	0.002	1	160	0.00009	12	0.007	160	0.1
NNSS	2.6	0.002	1	0	0	2.4	0.001	0.47	0.0003
WIPP Vicinity	2.6	0.002	1	0	0	7.5	0.005	7.0	0.004
Generic Commercial Region IV	2.6	0.002	1	0	0	NA[k]	NA[k]	NA[k]	NA[k]
4: Trench method									
Hanford Site	4.6	0.003	2	48	0.00003	16	0.009	95	0.06
INL	4.6	0.003	2	2,100	0.001	11	0.007	13	0.008
LANL	4.6	0.003	2	380	0.0002	12	0.007	160	0.1
NNSS	4.6	0.003	2	0	0	2.4	0.001	0.47	0.0003
SRS	4.6	0.003	2	1,700	0.001	4.3	0.003	45	0.03
WIPP Vicinity	4.6	0.003	2	0	0	7.5	0.005	7.0	0.004
Generic Commercial Region II	4.6	0.003	2	1,200	0.0007	NA[k]	NA[k]	NA[k]	NA[k]
Generic Commercial Region IV	4.6	0.003	2	0	0	NA[k]	NA[k]	NA[k]	NA[k]
5: Vault method									
Hanford Site	5.2	0.003	2	49	0.00003	16	0.009	95	0.06
INL	5.2	0.003	2	2,300	0.001	11	0.007	13	0.008
LANL	5.2	0.003	2	430	0.0003	12	0.007	160	0.1

TABLE 2.7-3 (Cont.)

Alternative	Annual Collective Worker Dose (person-rem)[b]	Annual Collective Worker LCF Risk	Annual No. of Physical Injuries to Workers[c]	Highest Annual Dose to a Hypothetical Resident Farmer (mrem/yr)[d]	Highest Annual LCF Risk to Resident Farmer[d]	Highest Individual Dose from Waste Handling Accident (rem)[e]	Highest Individual LCF Risk from Waste Handling Accident[e]	Highest Population Dose from Waste Handling Accident (person-rem)[e]	Highest Population LCF Risk from Waste Handling Accident[e]
5: Vault method (Cont.)									
NNSS	5.2	0.003	2	0	0	2.4	0.001	0.47	0.0003
SRS	5.2	0.003	2	1,300	0.0008	4.3	0.003	45	0.03
WIPP Vicinity	5.2	0.003	2	0	0	7.5	0.005	7.0	0.004
Generic Commercial Region I	5.2	0.003	2	12,000	0.007	NA[k]	NA[k]	NA[k]	NA[k]
Generic Commercial Region II	5.2	0.003	2	1,200	0.0007	NA[k]	NA[k]	NA[k]	NA[k]
Generic Commercial Region III	5.2	0.003	2	530	0.0003	NA[k]	NA[k]	NA[k]	NA[k]
Generic Commercial Region IV	5.2	0.003	2	0	0	NA[k]	NA[k]	NA[k]	NA[k]

[a] Radiation doses are given to two significant figures, and LCF risks and physical injuries are given to one significant figure. NA means not analyzed, and a value of 0 for long-term human health impacts means that the radioactive contamination does not reach the well of the hypothetical receptor (for Alternatives 1, 3, 4, and 5) or the Culebra Dolomite at WIPP for Alternative 2.

[b] The annual occupational doses for Alternatives 3, 4, and 5 were based on an average annual dose rate of 0.2 rem per full-time equivalent (FTE) worker and the number of FTE workers estimated for waste disposal. An “FTE worker” for waste disposal purposes would not actually be one worker but would likely consist of several individually badged workers, since the workers would perform other tasks in addition to waste disposal. The worker dose estimates for Alternative 2 were based on actual doses that have occurred during defense-generated TRU waste disposal operations.

[c] Physical injuries to workers are given as number of lost workdays. The estimate for Alternative 2 was based on actual data from operations at WIPP and generic accident rates were used for Alternatives 3, 4, and 5.

[d] For Alternatives 1, 3, 4, and 5, these impacts are the peak long-term annual radiation doses and LCF risks estimated to occur within the first 10,000 years after closure of the waste disposal facility to a hypothetical resident farmer 100 m (330 ft) downgradient from the edge of the disposal facility. For Alternative 2, there would be no releases to the accessible environment and therefore no radiation doses and LCF risks during the first 10,000 years following closure of the WIPP repository, as noted in Section 5.1.12.1 of DOE (1997).

[e] The highest individual dose and LCF risk is for an individual assumed to be located 100 m (330 ft) from an accident involving a fire to a standard waste box (SWB). This individual is expected to be a noninvolved worker. The highest exposed population is that group of people in the sector downwind from the site resulting in the highest population dose.

Footnotes continue on next page.

TABLE 2.7-3 (Cont.)

[f] Estimate is based on outdoor storage of spent nuclear fuel at several locations and is assumed to be conservative. For the No Action Alternative, GTCC wastes would continue to be stored at facilities licensed by the NRC and Agreement States (GTCC LLRW) and at DOE facilities (GTCC-like waste) in accordance with all applicable requirements.

[g] Radionuclides are not expected to reach groundwater within 10,000 years for a number of sites and disposal methods. The radiation doses and LCF risks are reported as zero in these cases.

[h] The disposal of defense-generated TRU waste at WIPP is conducted in accordance with the standards and criteria in 40 CFR Part 191 and 40 CFR Part 194. As noted in footnote d, there would be no radionuclide releases to the accessible environment in the first 10,000 years following closure of WIPP, and the corresponding annual dose and LCF risk are both reported as 0.

[i] While the impacts from a waste handling accident involving a fire to an SWB were not calculated for disposal of GTCC waste at the WIPP repository, the highest individual dose and LCF risk from this accident would be expected to be very similar to those reported for disposal at the WIPP Vicinity site. These values are given here for these impacts.

[j] While the impacts from a waste handling accident involving a fire to an SWB were not calculated for disposal of GTCC waste at the WIPP repository, the nearby population dose and LCF risk from this accident would be expected to be very similar to those reported for disposal at the WIPP Vicinity site. These values are given here for these impacts.

[k] The impacts from a waste handling accident associated with the use of a commercial GTCC waste disposal facility are dependent on the local meteorology and location of nearby individuals. While these cannot be calculated lacking a specific site, these impacts would be expected to be comparable to those given for the federal sites in this table.

TABLE 2.7-4 Comparison of Potential Impacts from Alternatives 1 through 5 on Socioeconomics, Environmental Justice, Land Use, and Waste Management

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
1: No Action	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.
2: WIPP	Overall impacts would be small. Construction for expanding the disposal capacity to accommodate the increased waste volume could be done by the current workforce at the site. The duration of facility operations would be extended to accommodate the schedule for disposal of the wastes.	There would be no incremental impacts beyond those that have already occurred on the minority and low-income population near the facility.	No changes in land use at the WIPP site or surrounding area would occur. Other uses within the site (e.g., oil and gas leases and livestock grazing) would not be affected. No additional land surface within the existing footprint of the WIPP site would be affected by the construction of the additional underground rooms at WIPP to emplace the GTCC LLRW and GTCC-like wastes, except for the small increased amount of land within the existing facility boundary needed to store excavated material (salt) from the repository.	Small quantities of nonradioactive hazardous and nonhazardous and radioactive solid and liquid wastes would be produced during construction and waste disposal operations. These would be managed in the same manner as other such wastes produced by current operations at the site.

1

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
3: Borehole method				
Hanford	The overall impacts would be small. The annual average employment growth rate would increase by less than 0.1%, and about $4.2 million in income would be produced in the peak construction year. An estimated 21 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 rental housing in the peak year. Operating a borehole facility would create 38 direct jobs annually and an additional 36 indirect jobs in the ROI. A borehole facility would produce $3.9 million in annual income during operations.	Potential impacts on the minority and low-income population are not expected from Alternative 3. Subsequent NEPA analysis to support any GTCC waste disposal facility implementation would consider any unique exposure pathways (such as subsistence fish, vegetation or wildlife consumption, and well water use) to determine any additional potential human health and environmental impacts.	Land use impacts are expected to be relatively small. About 44 ha (110 ac) of land would be altered to accommodate the necessary facilities. The GTCC reference location would be near the 200 Area complex, and there would be no conflicts with current land use designations or patterns.	Small quantities of nonradioactive hazardous and nonhazardous and radioactive solid and liquid wastes would be produced during construction and GTCC waste disposal operations. These would be managed in the same manner as other such wastes produced by current operations at the site. Alternative 3 would generate the least (between Alternatives 3 and 5) hazardous and nonhazardous waste during construction and operations, with the exception of nonhazardous solids that could be generated during construction.

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
INL	Same as for the Hanford Site, except about $8.8 million in income would be produced in the peak construction year. An estimated 32 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 38 direct jobs annually and an additional 42 indirect jobs in the ROI and produce $3.9 million in annual income.	Same as for the Hanford Site.	Same as for the Hanford Site, except the GTCC reference location is not within existing major complex areas.	Same as for the Hanford Site.
LANL	Same as for the Hanford Site, except about $5.4 million in income would be produced in the peak construction year. An estimated 21 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 38 direct jobs annually and an additional 41 indirect jobs in the ROI and produce $4.0 million in annual income.	Same as for the Hanford Site.	Same as for the Hanford Site, except the GTCC reference location is within TA-54. Land use at the reference location might have to be reclassified as waste management areas. The addition of a GTCC waste disposal facility would expand the area of T-54 currently used for waste disposal.	Same as for the Hanford Site.
NNSS	Same as for the Hanford Site, except about $4.3 million in income would be produced in the peak construction year. An estimated 10 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 38 direct jobs annually and an additional 31 indirect jobs in the ROI and produce $4.1 million in annual income.	Same as for the Hanford Site.	Same as for the Hanford Site, except the GTCC reference location would be integrated into the radioactive waste management zone of the Area 5 RWMC, an area where defense-related activities are conducted.	Same as for the Hanford Site.

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
WIPP Vicinity	Same as for the Hanford Site, except about $5.2 million in income would be produced in the peak construction year. An estimated 41 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 38 direct jobs annually and an additional 32 indirect jobs in the ROI and produce $3.8 million in annual income.	Same as for the Hanford Site.	Same as for the Hanford Site, except the current land use at the GTCC reference location would have to be altered from a multiple-use area to a waste management area. A loss of about 0.2% of a 22,000-ha (56,000-ac) grazing allotment would result. Management of withdrawn land would be transferred to DOE.	Same as for the Hanford Site, except specific waste management plans would have to be prepared as necessary to address these wastes because there are currently no waste operations ongoing at the WIPP Vicinity.
4: Trench method				
Hanford	Same as for Alternative 3 except about $4.5 million in income would be produced in the peak construction year. An estimated 27 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 48 direct jobs annually and an additional 42 indirect jobs in the ROI and produce up to $4.7 million in annual income.	Same as for Alternative 3.	Same as for Alternative 3, except about 20 ha (50 ac) of land would be required for the trench method.	Small quantities of nonradioactive hazardous and nonhazardous and radioactive solid and liquid wastes would be produced during construction and GTCC waste disposal operations. These would be managed in the same manner as other such wastes produced by current operations at the site. In general, Alternative 4 would generate more waste than Alternative 3 but less than Alternative 5.

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
INL	Same as for Alternative 3, except about $4.6 million in income would be produced in the peak construction year. An estimated 27 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 48 direct jobs annually and an additional 48 indirect jobs in the ROI and produce up to $4.7 million in annual income.	Same as for Alternative 3.	Same as for Alternative 3, except about 20 ha (50 ac) of land would be required for the trench method.	Same as for the Hanford Site.
LANL	Same as for Alternative 3 except about $4.6 million in income would be produced in the peak construction year. An estimated 27 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 48 direct jobs annually and an additional 46 indirect jobs in the ROI and produce up to $4.8 million in annual income.	Same as for Alternative 3.	Same as for Alternative 3, except about 20 ha (50 ac) of land would be required for the trench method.	Same as for the Hanford Site.
NNSS	Same as for Alternative 3 except about $4.6 million in income would be produced in the peak construction year. An estimated 14 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 48 direct jobs annually and an additional 35 indirect jobs in the ROI and produce up to $4.8 million in annual income.	Same as for Alternative 3.	Same as for Alternative 3, except about 20 ha (50 ac) of land would be required for the trench method.	Same as for the Hanford Site.

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
SRS	About $4.8 million in income would be produced in the peak construction year. An estimated 27 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 48 direct jobs annually and an additional 43 indirect jobs in the ROI and produce up to $4.8 million in annual income.	No potential impacts on the minority and low-income population are expected from Alternative 4.	Land use impacts are expected to be relatively small. The GTCC reference location is within an area designated as a forest timber unit. Marketable timber would be removed and sold, and the area would likely be reclassified to accommodate the proposed GTCC waste disposal facility.	Same as for the Hanford Site.
WIPP Vicinity	Same as for Alternative 3, except about $4.4 million in income would be produced in the peak construction year. An estimated 55 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 48 direct jobs annually and an additional 37 indirect jobs in the ROI and produce up to $4.5 million in annual income.	Same as for Alternative 3.	Same as for Alternative 3, except about 20 ha (50 ac) of land would be required for the trench method.	Same as for the Hanford Site, except specific waste management plans would have to be prepared as necessary to address these wastes because there are currently no waste operations ongoing at the WIPP Vicinity.

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
5: Vault method				
Hanford	Same as for Alternatives 3 and 4, except about $12.3 million in income would be produced in the peak construction year. An estimated 64 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 51 direct jobs annually and an additional 43 indirect jobs in the ROI and produce up to $5.0 million in annual income.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4, except about 24 ha (60 ac) would be required for the vault method.	Alternative 5 would generally generate more waste than Alternatives 3 and 4.
INL	Same as for Alternatives 3 and 4, except about $12.1 million in income would be produced in the peak construction year. An estimated 64 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 51 direct jobs annually and an additional 50 indirect jobs in the ROI and produce up to $4.9 million in annual income.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4, except about 24 ha (60 ac) would be required for the vault method.	Same as for the Hanford Site.

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
LANL	Same as for Alternatives 3 and 4, except about $12.2 million in income would be produced in the peak construction year. An estimated 64 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 51 direct jobs annually and an additional 48 indirect jobs in the ROI and produce up to $5.0 million in annual income.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4, except about 24 ha (60 ac) would be required for the vault method.	Same as for the Hanford Site.
NNSS	Same as for Alternatives 3 and 4, except about $12.8 million in income would be produced in the peak construction year. An estimated 32 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 51 direct jobs annually and an additional 36 indirect jobs in the ROI and produce up to $5.1 million in annual income.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4, except about 24 ha (60 ac) would be required for the vault method.	Same as for the Hanford Site.

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
SRS	Same as for Alternative 4, except about $12.7 million in income would be produced in the peak construction year. An estimated 64 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 51 direct jobs annually and an additional 45 indirect jobs in the ROI and produce up to $5.0 million in annual income.	Same as for Alternative 4.	Land use impacts are expected to be relatively small. About 24 ha (60 ac) would be altered to accommodate the necessary facilities for the vault method. The GTCC reference location is within an area designated as a forest timber unit. Marketable timber would be removed and sold, and the area would likely be reclassified to accommodate the proposed GTCC waste disposal facility.	Same as for the Hanford Site.
WIPP Vicinity	Same as for Alternatives 3 and 4, except about $11.7 million in income would be produced in the peak construction year. An estimated 127 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 51 direct jobs annually and an additional 38 indirect jobs in the ROI and produce up to $4.8 million in annual income.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4, except about 24 ha (60 ac) would be required for the vault method.	Same as for the Hanford Site, except specific waste management plans would have to be prepared as necessary to address these wastes because there are currently no waste operations ongoing at the WIPP Vicinity.

TABLE 2.7-5 Comparison of Potential Impacts from Alternatives 1 through 5 on Truck Transportation

	Truck Transportation						
Alternative	Number of Shipments	Total Distance Travelled (km)	Collective Population Dose (person-rem)	Collective Population LCFs	Collective Transportation Crew Dose (person-rem)	Collective Transportation Crew LCFs	Accident Fatalities
1: No Action	–[a]	–	–	–	–	–	–
2: WIPP	33,700	89,700,000	68	0.04	180	0.1	2
3: Borehole method							
Hanford Site	12,600	50,300,000	160	0.09	500	0.3	1
INL	12,600	42,000,000	130	0.08	410	0.2	0.8
LANL	12,600	35,500,000	120	0.07	350	0.2	0.8
NNSS	12,600	47,800,000	150	0.09	470	0.3	0.9
WIPP Vicinity	12,600	35,600,000	120	0.07	350	0.2	0.8
4: Trench method							
Hanford Site	12,600	50,300,000	160	0.09	500	0.3	1
INL	12,600	42,000,000	130	0.08	410	0.2	0.8
LANL	12,600	35,500,000	120	0.07	350	0.2	0.8
NNSS	12,600	47,800,000	150	0.09	470	0.3	0.9
SRS	12,600	17,800,000	63	0.04	170	0.1	0.6
WIPP Vicinity	12,600	35,600,000	120	0.07	350	0.2	0.8
5: Vault method							
Hanford Site	12,600	50,300,000	160	0.09	500	0.3	1
INL	12,600	42,000,000	130	0.08	410	0.2	0.8
LANL	12,600	35,500,000	120	0.07	350	0.2	0.8
NNSS	12,600	47,800,000	150	0.09	470	0.3	0.9
SRS	12,600	17,800,000	63	0.04	170	0.1	0.6
WIPP Vicinity	12,600	35,600,000	120	0.07	350	0.2	0.8

[a] A dash means not applicable.

TABLE 2.7-6 Comparison of Potential Impacts from Alternatives 1 through 5 on Rail Transportation

	Rail Transportation						
Alternative	Number of Shipments	Total Distance Travelled (km)	Collective Population Dose (person-rem)	Collective Population LCFs	Collective Transportation Crew Dose (person-rem)	Collective Transportation Crew LCFs	Accident Fatalities
1: No Action	–[a]	–	–	–	–	–	–
2: WIPP	11,800	32,100,000	42	0.03	54	0.03	1
3: Borehole method							
Hanford Site	5,010	20,600,000	97	0.06	150	0.09	0.7
INL	4,980	17,000,000	88	0.05	130	0.08	0.5
LANL	5,010	14,000,000	81	0.05	110	0.07	0.5
NNSS	5,010	21,200,000	93	0.06	150	0.09	0.6
WIPP Vicinity	5,010	14,000,000	81	0.05	110	0.07	0.5
4: Trench method							
Hanford Site	5,010	20,600,000	97	0.06	150	0.09	0.7
INL	4,980	17,000,000	88	0.05	130	0.08	0.5
LANL	5,010	14,000,000	81	0.05	110	0.07	0.5
NNSS	5,010	21,200,000	93	0.06	150	0.09	0.6
SRS	5,010	8,320,000	61	0.04	78	0.05	0.6
WIPP Vicinity	5,010	14,000,000	81	0.05	110	0.07	0.5
5: Vault method							
Hanford Site	5,010	20,600,000	97	0.06	150	0.09	0.7
INL	4,980	17,000,000	88	0.05	130	0.08	0.5
LANL	5,010	14,000,000	81	0.05	110	0.07	0.5
NNSS	5,010	21,200,000	93	0.06	150	0.09	0.6
SRS	5,010	8,320,000	61	0.04	78	0.05	0.6
WIPP Vicinity	5,010	14,000,000	81	0.05	110	0.07	0.5

[a] A dash means not applicable.

section focuses on this aspect of the analysis because it could provide information that would be useful for identifying a preferred alternative.

A number of uncertainties are associated with the human health evaluations, and those that are considered most significant are discussed below. The major assumptions used to assess these impacts are described in Section 5.2.4. Several factors could alter the estimated human health impacts associated with disposal of these wastes, including changes in (1) the waste volume and radionuclide inventory, (2) the assumptions about the design and layout of the facilities, (3) the assumptions used to simulate how long the integrity of the engineered barriers and waste stabilizing agents would stay intact, and (4) the assumptions about site characteristics used as input for the calculations.

As noted previously, the results given here in terms of the long-term doses and LCF risks to a hypothetical resident farmer are to be used in a comparative manner to aid in identifying those parameters that influence the selection of a disposal method for these wastes. These results are not based on an actual facility design for use at a specific location. With proper engineering design and construction, an acceptable disposal facility could likely be built at any of the sites addressed in this EIS. The sites having the higher doses and LCF risks are those that would require the most effort in terms of design and licensing features to ensure the long-term effectiveness of the disposal facility.

2.8.1 Waste Volume and Radionuclide Inventory Uncertainties

Values for the waste volumes and radionuclide activities used for the analysis of impacts on human health in this EIS were developed by using the most recent information available, including information from published reports and databases and information that resulted from a call to DOE field offices for data. To support this analysis, wastes were placed in one of two groups, as discussed in Section 1.4.1. The uncertainty associated with the Group 1 inventory is low, because these wastes either were already generated and are in storage or are projected to be generated from facilities already in operation. The uncertainty associated with the Group 2 wastes is higher than that associated with Group 1 wastes, because the generation of such wastes is contingent upon facilities not yet constructed or in operation.

The radiological impacts on human health would depend mostly on the total radioactivity and the mix of radionuclides that would make up the waste. That is, if the waste volumes doubled but total activity remained the same, there would be no major change in the radiological impacts. Increasing the total radionuclide activity by a factor of two with the same mix of radionuclides, however, would essentially double the radiological impacts. Because the uncertainty with regard to the waste inventory is generally low to moderate, the inventory does not represent a major source of uncertainty in the human health impact analysis.

2.8.2 Assumptions about the Facility Design and Layout (for input to RESRAD-OFFSITE)

In addition to the direct effect that the uncertainties about the waste inventory could have on the estimated results in this EIS, several indirect effects could also affect the results. The waste volumes presented in this EIS were used in developing the conceptual designs of the disposal facilities addressed in this EIS (i.e., the volumes were used to determine the number of disposal boreholes, trenches, and vaults needed and the resultant size of the disposal area). The determined total disposal area was then used to estimate the dimensions of the source term, which is a primary input (along with the radionuclide activity in the wastes) for determining the source concentrations used in the RESRAD-OFFSITE computer code. Changes in the waste volumes and radionuclide activities could change both the geometry and the magnitude of the source term. In this EIS, the estimated human health impacts were calculated by assuming that all of the Group 1 and 2 wastes would be disposed of in a single location. If any of the waste streams were to be excluded (by not being generated or by being disposed of elsewhere), the potential human health impacts would be correspondingly lower at the specific site addressed.

Changes in the design and layout of the disposal facility could also change the potential human health impacts. For purposes of analysis in the EIS, the depth intervals available for waste disposal placement are assumed to be at about 4.3 to 5.5 m (14 to 18 ft) above ground surface for vaults, at 5 to 10 m (15 to 30 ft) below ground for trenches, and from 30 to 40 m (100 to 130 ft) below ground for boreholes. Changes in the design and layout of the disposal facility could result in changes in the total area and the subsequent depths of the waste disposal horizon in the EIS analyses. The footprint of the disposal facility, along with the distance from the edge of the facility to an off-site hypothetical well where potential radiation exposures are assumed to occur, determines the total distance that the radionuclides need to travel in the groundwater aquifer to cause a radiation dose. A decrease in the footprint of the disposal facility would shorten the distance from the midpoint of the waste zone to the off-site well. This shorter distance would increase the radionuclide concentrations in the groundwater because there would be less dilution and less decay in transit, and it would result in somewhat higher doses from the use of this groundwater.

An important parameter in the modeling analysis is the actual area assumed to be occupied by the waste itself relative to the entire footprint occupied by the waste disposal facility. This area affects the amount of water that could infiltrate into the disposal units and leach radionuclides from the waste containers. Changes to the design of the disposal facility could result in changes to the area potentially exposed to infiltrating water. A larger disposal area would allow more water infiltration and result in more radionuclides leaching out to deeper soils. Alternatively, a smaller area (with a subsequent greater depth of waste disposal) would result in a shorter soil column beneath the disposal units through which radionuclides leaching from the disposal area would need to travel to reach the groundwater table. The overall effect that could result from changes in the geometrical configuration of the disposal cells needs to be assessed with regard to the time frame used to evaluate the potential impacts and the specific site in question. However, these changes would not add a significant amount of uncertainty to the results, unless major changes were made to the current conceptual facility designs used in these analyses.

2.8.3 Assumptions Used to Simulate the Integrity of Engineered Barriers and Waste Stabilizing Practices

The amount of data on the performance of waste packages, engineering controls (e.g., facility covers), and stabilizing processes (e.g., grouting) over an extended time period is limited. Even when data are available, it is difficult to predict the release rates of radionuclides over a very long time period by using these data. The potential impacts on groundwater are evaluated over a very long time period in this EIS (10,000 years or longer to obtain peak doses and LCF risks and the times they would occur). How and when the waste packages, engineering controls, and stabilization agents would begin to degrade and how this degradation would progress over time are very difficult to determine.

For this EIS, it is assumed that the engineered controls would remain intact for the first 500 years after closure of the disposal facility and that during this time, essentially no infiltrating water would reach the wastes from the top of the disposal facility. It is assumed that after 500 years, the amount of infiltrating water that would contact the wastes would represent 20% of the site-specific natural infiltration rate for each of the sites evaluated, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate of the site area. It is also assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. It is assumed that after 500 years, radionuclide releases from the Other Waste would be controlled by the surrounding soil (i.e., the distribution coefficients or K_ds were revised from those reflecting cementitious systems to those for unsaturated soil at the sites).

The radionuclides in the disposed-of wastes would be available for leaching by infiltrating water. Many of the radionuclides in the GTCC LLRW and GTCC-like wastes have very long half-lives, so the 500-year period assumed for purposes of analysis in this EIS would not result in an appreciable reduction in the total hazard associated with these wastes as a result of radioactive decay, especially when the time it would take for these radionuclides to reach the hypothetical off-site receptor is considered. So although it is assumed that the effectiveness of the engineered controls and stabilizing agent would last 500 years, this time period is not sufficiently long enough to adequately reduce the hazards that the GTCC LLRW and GTCC-like waste would impose at some of the sites evaluated. The uncertainty is related to how much longer the engineered controls and stabilization process would remain effective for the sites at which the potential impacts are expected to be high.

In addition, global climate change impacts might add another aspect of uncertainty with regard to the long-term performance of the borehole, trench, and vault waste disposal facilities at the sites evaluated in this EIS. 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 provide a perspective on 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. As discussed previously, the water infiltration rate is one of the key input parameters that affect how much radioactivity could leach from waste in the disposal facility. On the basis of the global climate change predictions under a higher (i.e., worst-case) emission scenario (Karl et al. 2009), infiltration rates at the 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 rates at the sites located in the Northwest (e.g., Hanford Site and INL) would increase slightly. For sites in the Southeast (i.e., SRS), 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 GTCC waste disposal operations. 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/WIPP Vicinity, small changes would be expected. However, because the post-closure human health estimates presented in this EIS are for 10,000 years or more, and 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 post-closure period analyzed in this EIS.

As described in Section 1.4.1, the GTCC LLRW and GTCC-like wastes encompass three waste types for purposes of analysis in this EIS: activated metals, sealed sources, and Other Waste. The radionuclide release rate for activated metal is assumed to be 1.19×10^{-5}/yr in this analysis. This value is assumed to be conservative on the basis of experiments that were conducted on metal wastes (see further discussion in Appendix E). The release rates of radionuclides in the sealed sources were estimated by using the distribution coefficients (K_ds) for the unsaturated soil at the various sites.

In performing the long-term calculations, it was assumed that the Other Waste would be stabilized (e.g., by using grout or another similar material) prior to being placed in the disposal units. The release rates for this solidified Other Waste were assumed to be the same as those for cementitious systems. The use of solidification agents such as grout is consistent with current disposal practices for such wastes, which include a wide variety of materials that could compact or degrade without such measures.

The grout material assumed here to last 500 years might not last that long, or it might last longer. If the stabilizing agent lasted for a longer time, the estimated potential impacts on groundwater from the radionuclides leaching from the waste could be lower than the impacts presented in this EIS. Use of such a stabilizing agent was not assumed for the activated metal wastes and sealed sources, although such a practice would reduce the doses from these materials as well. Most of the long-term radiation doses and LCF risks associated with the groundwater pathway would be attributable to leaching of the Other Waste. The approach used in this EIS is assumed to be conservative and adds some uncertainty to the estimated doses.

2.8.4 Assumptions about Site Characteristics

The best available information was used for the other RESRAD-OFFSITE input parameters. These were determined on a site-specific basis, and most were obtained from previous analyses performed at these sites.

The modeling simulation conducted for this EIS is a simplified representation of more complex soil and groundwater processes, and this simplification adds uncertainty to the results. The release rates of radionuclides in sealed sources and in Other Waste were simulated with distribution coefficients assumed to be the same as those for the unsaturated soil at the various sites (for sealed sources) and cementitious systems (for Other Waste). The release rates for activated metal wastes were based on a conservative rate, as described above.

Because backfill soil would surround the waste containers in the disposal units, radionuclides released from the waste materials would have to travel through the surrounding soils before leaving the disposal area. Because the soil distribution coefficients are used to calculate the radionuclide release rates for sealed sources, it is assumed that the radionuclides would be released to the surrounding soil immediately upon contact with water. This approach is assumed to be conservative, and it adds a large uncertainty to the results presented in this EIS. In addition, the distribution coefficients used as input into the model calculations have inherent uncertainties associated with them, and it is difficult to assign values for the level and direction of uncertainty that exist in the distribution coefficients for each site and from site to site.

It is assumed in this EIS that a resident farmer would be located 100 m (330 ft) downgradient from the edge of the disposal facility and would develop a well as a source of drinking water. This assumption is considered to be conservative on the basis of current land use patterns at the sites evaluated in the EIS. At these sites, the distance from the edge of the disposal facility to such an individual (given the current configurations of the alternative sites evaluated in this EIS) would likely be much longer. Use of a more realistic distance would result in much lower doses than those presented in this EIS. This distance adds a great deal of uncertainty and conservatism to the results presented in this EIS.

Finally, the human health impacts (doses and LCF risks) on a hypothetical resident farmer are meant to serve only for comparison purposes in evaluating the relative effectiveness of the various disposal methods and sites. Further design considerations and site-specific modeling would be performed when implementation decisions were 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 the potential groundwater contamination and its associated human health impacts in the future.

2.9 FACTORS TO CONSIDER IN DEVELOPING A PREFERRED ALTERNATIVE

> The preferred alternative could be a combination of two or more alternatives, based on the characteristics of the waste, its availability for disposal, and other key factors.

DOE expects to develop a preferred alternative for inclusion in the Final GTCC EIS. Consistent with CEQ guidance, DOE's preferred alternative will be the alternative that would fulfill DOE's statutory mission and responsibilities and would consider (1) public comments received during the public comment period of this Draft EIS; (2) NRC's regulatory requirements for the disposal of LLRW as found in 10 CFR Part 61, DOE orders, and other applicable requirements; and (3) environmental, technical, economic and other findings presented in the GTCC EIS. This Draft EIS considers the public scoping comments on the NOI that were received, and it evaluates the conceptual designs for enhanced land disposal methods as alternatives to the deep geologic disposal method, which the NRC currently considers to be an acceptable method for disposing of GTCC LLRW. A summary of the public comments will be prepared and included in the Final GTCC EIS, and DOE will consider this summary in developing the preferred alternative.

In 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," the NRC classifies LLRW into four classes (Classes A, B, and C, and GTCC LLRW) on the basis of the concentrations of short-lived and long-lived radionuclides (10 CFR 61.55). By controlling isotope concentrations in each class, the NRC regulations seek to control potential radiation exposures to future receptors, including inadvertent human intruders (e.g., a water well driller) after the period of active institutional control has ended. The NRC states in 10 CFR 61.55 that GTCC LLRW is not "generally acceptable" for near-surface disposal, although the NRC recognizes in 10 CFR 61.7(b)(5) that "there may be some instances where waste with concentrations greater than permitted for Class C waste would be acceptable for near surface disposal with special processing or design."

The NRC regulations state that GTCC LLRW is to be disposed of in a geologic repository as defined in 10 CFR 60 or 63, unless proposals for an alternative method are approved by NRC under 10 CFR 61.55(a)(2)(iv). The NRC regulations identify one approved method for the disposal of GTCC waste (a geologic repository), but they allow DOE to plan for and develop an alternative method.

In addition to protecting individuals from inadvertent intrusion, the preferred disposal alternative must protect the general population and involved workers from potential releases of radioactivity during facility construction and disposal operations. Long-term impacts after completion of the disposal operations and closure of the disposal facility also need to be considered. DOE would develop the preferred alternative by considering these aspects along with the various other environmental resource areas discussed in this Draft EIS. DOE structured this EIS so that the preferred alternative could be identified on the basis of a waste type, site, and disposal method. The preferred alternative could be a combination of two or more alternatives and could include the No Action Alternative.

Sections 2.9.1 to 2.9.4 summarize key considerations related to the alternatives analyzed in this Draft EIS. These considerations include (1) public comments (Section 2.9.1), waste type characteristics (Section 2.9.2), (2) disposal method considerations (Section 2.9.3), and (3) disposal location considerations (2.9.4).

2.9.1 Public Comments

DOE will consider all comments postmarked or received during the 120-day comment period in identifying a preferred alternative that will be presented in the Final GTCC EIS. Comments postmarked after the comment period closes will be considered to the extent practicable.

2.9.2 Waste Type Characteristics

The three types of GTCC waste (activated metals, sealed sources, and Other Waste) come from different sources and have different physical, chemical, and radiological characteristics. In addition, some waste types differ in terms of when they would be available for disposal (see Section B.4 for discussion on assumed GTCC water generation rates). Thus, it might be appropriate to use different disposal methods for different waste types. Four key factors related to the three GTCC waste types that might determine whether one disposal method would be more appropriate than another include the following:

1. *Radionuclide inventory.* The GTCC wastes include a wide range of radionuclides. Sealed sources generally consist of one (or possibly a few) radionuclides, whereas activated metal waste and the Other Waste type contain a large number of radionuclides. Some of these radionuclides have relatively short half-lives (such as Sr-90 and Cs-137 that have half-lives of about 30 years), whereas others (such as Pu-239) have half-lives of more than 10,000 years. Both the total inventory and mix of radionuclides are important to consider when selecting an appropriate disposal method for a particular waste type.

   A number of TRU radionuclides decay to radioactive progeny, and the presence of these in-growth radionuclides needs to be addressed. Also, some radionuclides emit significant amounts of gamma radiation (such as Co-60 and Cs-137), whereas others emit very little or no such radiation. The activated metals are expected to have the highest gamma exposure rates of the three waste types, and the sealed sources are expected to have the lowest exposure rates. The Other Waste is divided into CH and RH wastes, because some of the Other Waste could contain significant concentrations of fission products and neutron activation products that could decay and release significant amounts of gamma radiation, whereas others might have very little of these products.

The concentrations of long-lived radionuclides in waste determine how long it will remain hazardous. Many of the GTCC-like wastes have long-lived TRU radionuclides, and so they will remain hazardous for many thousands of years. Similar wastes are currently being disposed of in a geologic repository (WIPP) because of this concern. Also, the relative mobility of the radionuclides in groundwater systems varies widely; some radionuclides (such as Tc-99 and I-129) are quite mobile, while radioactive metals tend to bind with the soil particles and move more slowly in the environment.

2. *Waste form stability.* While all of the GTCC wastes are solids, some are much more durable than others. Even though corrosion of the activated metal waste begins as soon as it comes in contact with water, these metals are assumed to retain their structural shape. The Other Waste would be stabilized in a grout matrix to improve its stability for a longer period of time. Sealed sources are also very robust and are expected to retain their form for long time periods. Waste form stability influences the ability of the disposal facility to contain the radioactive contaminants from leaching to the environment, with forms that could degrade more quickly being a long-term concern.

3. *Size.* Some GTCC activated metal wastes are large metallic items that can be disposed of more readily in a near-surface trench or vault than in a borehole or geologic repository (WIPP). Use of boreholes or a geologic repository might require more waste handling to make the physical size of the waste manageable than use of trenches or vaults. The need for treatment could result in greater worker doses.

4. *Availability for disposal.* While some GTCC wastes are currently in storage and available for disposal, many GTCC wastes will not be generated for several decades. The activated metal wastes are mainly associated with commercial nuclear power plants, and most of them are expected to operate for 20 years or more. Sealed sources represent a national security concern, so their disposal is a high priority.

On the basis of the above four factors, it is important to take into account the characteristics of a specific waste type with the site and disposal method under consideration to ensure the timely, cost-effective, and safe disposal of GTCC wastes. Sealed sources (which are generally small and durable) might be good candidates for borehole disposal, whereas other large wastes (such as activated metal waste) might be better suited for trenches and vaults. Many of the sealed sources recovered by GTRI/OSRP for national security or public health and safety reasons meet the criteria for disposal at existing DOE facilities. (When GTRI/OSRP recovers sealed sources, DOE typically takes ownership of the sources, and it may dispose of them at DOE facilities if they meet waste acceptance criteria for such facilities. The long-term hazards associated with these wastes might preclude the use of certain disposal sites and methods, especially those that could result in groundwater contamination.

2.9.3 Disposal Methods

Key factors to consider in identifying a preferred disposal method for GTCC LLRW and GTCC-like waste include (1) protecting the inadvertent human intruder, (2) leveraging operational experience, (3) minimizing institutional controls, and (4) achieving cost-effective disposal. Each of these factors is discussed here.

2.9.3.1 Inadvertent Human Intrusion

An inadvertent intruder is a person who might occupy the disposal site after closure and engage in normal activities, such as agricultural activities or the construction of buildings, or other pursuits in which the person might be unknowingly exposed to radiation from the waste (10 CFR 61.2). Human intrusion impacts might be mitigated by the waste form and packaging, institutional controls, and engineered and natural barriers (e.g., grouting and depth of disposal) (NRC 1981). All four disposal methods analyzed in this EIS include a combination of some or all these mitigation features, as discussed in Chapters 4 and 5 and Appendix D.

Disposal Method Considerations

Factor	Criterion
Inadvertent human intrusion	Favors methods that minimize the potential for inadvertent human intrusion
Construction and operational experience	Favors methods that have been successfully used in the past to manage similar wastes
Post-closure care	Favors methods that minimize the potential need for long-term maintenance after the facility has closed
Cost	Favors methods that result in cost-effective waste disposal

2.9.3.2 Construction and Operational Experience

All four disposal methods have been used to some degree in the United States or other countries to dispose of radioactive waste similar to the three waste types analyzed in the GTCC EIS.

- *Deep geologic disposal.* The DOE WIPP facility is currently the only operating deep geologic repository in the United States. Since it began operations in 1999, the facility has successfully received more than 64,000 m^3 (2,300,000 ft^3) of CH and RH TRU waste from DOE defense activities. This waste includes radioactive sealed sources, debris, and other waste similar to GTCC waste. Most of the GTCC-like waste is similar to waste currently being disposed of at WIPP, except that it may have originated from non-defense activities and therefore may not be authorized for disposal at WIPP under the WIPP LWA.

- *Boreholes.* DOE successfully demonstrated the use of borehole facilities to dispose of radioactive waste at NNSS (formerly NTS) during 1981−1989. The boreholes operated from 1984 through 1989 and received DOE waste similar to GTCC LLRW. Borehole disposal is receiving increased attention from the International Atomic Energy Agency as an option for disposal of disused sealed sources (IAEA 2005). Currently, there are no NRC-licensed borehole facilities in the United States. The advantages of the borehole method include these: (1) it may be amenable to receiving intermittent or low-volume waste like GTCC waste, (2) it is visually unobtrusive, (3) it has the potential for robust long-term isolation of wastes, and (4) no workers need to enter the disposal shafts, which thereby minimizes worker hazards. Boreholes also provide the greatest amount of natural shielding (the surrounding soil) of any of the three land disposal methods. A disadvantage of the borehole method is the low volume capacity of the borehole and the much higher volume of unused space surrounding each borehole. Consequently, a very large number of boreholes (approximately 930 boreholes) would be required to manage the entire GTCC waste volume. As mentioned above, the method might be better suited to specific waste types (e.g., sealed sources), for which fewer boreholes would be required.

- *Trenches.* Trenches are used for the disposal of LLRW in the United States and at a number of sites around the world. Commercial facilities dispose of Class A, B, and C LLRW in trenches and vaults. In addition, DOE uses trenches to dispose of its LLRW, including LLRW comparable to GTCC LLRW (e.g., Sr-90 radioisotope thermoelectric generators) on the basis of performance assessment analyses.[1] SRS currently disposes of large equipment (e.g., large cesium sources and other LLRW) in trenches using the components-in-grout technique. This technique allows for large equipment to be disposed in trenches and the waste form is surrounded with grout on all sides (bottom, sides, top). This approach will limit future subsidence and the release of radionuclides. The conceptual design for the trench that is evaluated in this EIS employs a deeper (11-m or 35-ft deep) and narrower (3-m or 10-ft wide) design than conventional belowground, near-surface radioactive waste disposal facilities in order to protect the facility from inadvertent human intrusion. Potential operational advantages of the trench include (1) its visual unobtrusiveness, (2) its ease of construction, and (3) the relative ease with which the wastes can be disposed of. Potential disadvantages include (1) the increased possibility of exposing workers to radiation hazards (i.e., more than that presented by boreholes), unless temporary covers or shields would be used, and (2) the possibility that this method might provide less protection from future intrusion into the wastes, as compared to boreholes and deep geologic disposal.

[1] A performance assessment is a systematic analysis of the potential risks posed by waste management systems to the public and the environment and the comparison of those risks to established performance objectives (e.g., protection against radiation exposure and release of radioactive material). The performance assessment is used to estimate (1) potential future doses to human receptors that consider transport pathways through which radionuclides might reach the environment and (2) the effectiveness of the engineered barrier system used to limit the influx of water, thereby reducing the resultant radionuclide doses.

- *Vaults*. Vaults similar to the design presented in the GTCC EIS have been operated by DOE at SRS and other DOE facilities for the disposal of LLRW. The disposal method is more commonly used in humid environments, where belowground disposal methods might be limited by shallow groundwater. The conceptual design for the vault includes thick reinforced concrete walls, floor, and ceilings. To further isolate the waste, an engineered cover system is included in the design. Potential advantages of the vault include these: (1) It can be inspected visually and more easily monitored than the other alternative land disposal methods; (2) because of its high visibility, inadvertent human intrusion is unlikely; and (3) it does not rely on waste packages for structural support (i.e., structural support is provided by the concrete cells). Potential disadvantages of the vault are these: (1) Its active maintenance requirements (including active institutional controls) are likely to be more extensive than those of the other methods because of its exposure to the elements; (2) the costs to construct and operate it are higher than those for the other alternative land disposal methods; (3) it has a higher potential for exposing workers to radiation hazards than the other land disposal methods, unless temporary shielding or waste covers are used; and (4) it could attract intentional intruders because of its visibility.

2.9.3.3 Post-Closure Care Requirements

Some disposal methods might need to rely more on post-closure care than others. Because an above-grade vault is exposed to the elements, it might require more active institutional controls than the trench, borehole, and deep geologic disposal methods, extending to times beyond the period of institutional control normally considered when evaluating the safety of waste management facilities (NCRP 2005). If post-closure care is not maintained, vaults could pose a greater potential for radiological exposures to the public (Rao et al. 1992; Kozak et al. 1993). Consequently, maintenance of institutional controls is considered particularly important for this technology to achieve post-closure safety. Long term post-closure care requirements for the trench, borehole, and deep geologic methods should be less than those for an above-grade vault (USACE Waterways Experiment Station 1984).

2.9.3.4 Construction and Operating Costs

The estimated cost to construct and operate a GTCC waste disposal facility ranges from $250 million for disposal at a new trench facility to $570 million for disposal at the WIPP geologic repository, as shown in Table 2.9.2-1 and Appendix D. The cost estimates for each disposal method are based on the assumption that all GTCC waste would be disposed of by that method, although different combinations of disposal methods could be used for the different waste types. Costs for facility permits, licenses, transportation, packaging, and post-closure activities are not included in the estimates.

2.9.4 Disposal Location Considerations

The GTCC EIS evaluates six federal sites for the potential disposal of GTCC waste, of which one is in a humid environment (SRS) and five are in semi-arid or arid environments

TABLE 2.9.2-1 Costs of GTCC Waste Disposal Alternatives[a]

Disposal Method	Cost to Construct Facility (in millions of $)[b]	Cost to Operate Facility (in millions of $)[c]	Total Cost to Construct and Operate Facility (in millions of $)
WIPP	14	560	570
Borehole	210	120	330
Trench	88	160	250
Vault	360	160	520

[a] Costs are rounded to two significant figures.

[b] Construction costs for the WIPP facility are for 26 new rooms. Construction costs for the borehole, trench, and vault disposal facilities are for 930 boreholes, 29 trenches, and 12 vaults (consisting of 130 total vault cells), respectively, and the supporting infrastructure.

[c] The operational cost for WIPP is based on the actual per-shipment cost for fiscal year 2008. Operational costs assume 20 years of facility operations for the borehole, trench, and vault disposal methods. On the basis of the assumed receipt rates, the majority of the wastes would be available for emplacement during the first 15 years of operations. The actual start date for operations is uncertain at this time and dependent upon, among other things, the alternative or alternatives selected, additional NEPA analysis as required, characterization studies, and other actions necessary to initiate and complete construction and operation of a GTCC waste disposal facility. For purposes of analysis in the Draft EIS, DOE assumed a start date of disposal operations in 2019. However, given these uncertainties, the actual start date could vary.

(Hanford, INL, LANL, NNSS, WIPP/WIPP Vicinity). In addition, the Draft GTCC EIS evaluates generic commercial locations in four regions of the United States.

On the basis of the results presented in this Draft EIS, key factors to be considered in identifying a preferred disposal location for GTCC LLRW are potential human health risks for the post-closure long-term phase (including potential cumulative human health impacts from the post-closure phase); cultural resources and tribal concerns; and existing laws, regulations, and other requirements.

2.9.4.1 Human Health Impacts

Human health impacts include the (1) potential exposure of workers and the general public to radiation during routine conditions and accidents and (2) direct impacts on workers and the public from industrial and transportation accidents. All potential impacts will be considered in developing a preferred alternative. A primary consideration is the potential long-term (post-closure) impacts on members of the general public who might be exposed to radioactive contaminants released from the waste packages that are transported in groundwater and migrate to an accessible location, such as a groundwater well. Consequently, potential cumulative long-term human health impacts at each of the sites evaluated would likewise be of primary consideration. For example, the long-term doses and LCF risks estimated for the GTCC proposed action for the Hanford Site should be considered relative to the findings presented in the *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (TC&WM EIS) issued in October 2009. According to the TC&WM EIS, receipt of off-site waste streams that contain specific amounts of certain isotopes, specifically I-129 and Tc-99, could cause an adverse impact on the environment. The TC-99 inventory from off-site waste streams evaluated in the TC&WM EIS shows impacts that are less significant than those of I-129. However, when the impacts of Tc-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 I-129 or Tc-99 at Hanford.

With regard to transportation impacts, the optimal location would be one that is close to the waste-generating sources. This location would minimize the overall transportation distance and would have the lowest potential impacts on human health. However, most of the waste generators are located in the eastern half of the United States, and these areas have more humid climates than do sites in the western part of the country. The more humid sites (SRS and generic Regions I and II) were shown to generally have greater long-term impacts from the groundwater pathway, and this concern is a major consideration in identifying an acceptable location for a GTCC waste disposal facility. Engineered controls would have to be used more at a disposal site in a humid environment than at one in an arid environment in order to minimize the long-term hazards to human health.

Disposal Location Considerations

Factor	Criterion
Human health risk	Favors alternatives that reduce human health risk to both workers and the public.
Cultural resources	Favors alternatives that avoid adverse impacts to known cultural sites.
Laws, regulations, and other requirements	Favors alternatives that would not be inconsistent with current laws and other requirements.

The natural site conditions are a very important factor in selecting a disposal location, and the post-closure results for the federal sites and generic (commercial) disposal locations indicate that conditions in arid regions of the country are more favorable for the conceptual land disposal designs evaluated in this EIS than those in other parts of the country. This does not mean that a site in a humid region could not be used for such a facility. Rather, a facility in a humid environment would have to rely more on engineering measures and institutional controls to ensure that the long-term hazards were maintained at acceptable levels. Results of the modeling calculations of the radiation doses and LCF risks are presented in Appendix E and Chapters 6 through 12 by waste type, disposal method, and location.

2.9.4.2 Cultural Resources and Tribal Concerns

Cultural resources include, among other things, definitive locations of traditional cultural or religious importance to specified social or cultural groups, such as American Indian tribes ("traditional cultural properties"). DOE has begun consultations with participating tribes who have cultural or historical ties to DOE sites being analyzed in this EIS. Tribal perspectives, comments, and concerns (e.g., environmental justice issues) identified during the consultation process will be considered by DOE in selecting and implementing a disposal alternative(s) for GTCC waste. Tribal perspectives, comments, and concerns are summarized in Section 1.8 and included in Chapters 6, 8, and 9 and Appendices A and G.

2.9.4.3 Laws, Regulations, and Other Requirements

A number of laws, regulations, and requirements apply to the disposal alternatives considered in this EIS, as identified in Chapter 13 and the site-specific chapters (4 and 6 through 12). These include requirements that generally apply to all proposed disposal locations (e.g., Archaeological and Historic Preservation Act) and requirements that apply to a specific site (e.g., WIPP LWA). DOE will consider all applicable requirements in developing a preferred alternative.

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3 ALTERNATIVE 1: NO ACTION

The Council on Environmental Quality's NEPA-implementing regulations require an analysis of the No Action Alternative to provide a baseline for comparison with the action alternatives (Alternatives 2 through 5). The No Action Alternative would not be responsive to the national security concerns related to management of disused or unwanted sealed sources.

Under the No Action Alternative for this EIS, DOE would take no further action to develop disposal capability for the GTCC LLRW. For the GTCC-like waste, DOE could, under its existing authorities, pursue other disposition paths. Therefore, under the No Action Alternative, there would be no environmental and human health consequences at any of the potential federal sites or facilities or at the generic commercial sites either from the construction of a GTCC LLRW disposal facility or facilities or from waste disposal operations (such as those evaluated for the action alternatives), since such waste-disposal-related activities would not be conducted. Under the No Action Alternative, it is assumed that any new GTCC LLRW and GTCC-like waste would continue to be stored at the various locations where the wastes were either already being stored or at the locations where they would be generated.

Environmental consequences under the No Action Alternative would result from the continuation of the practices currently used to manage these wastes for both the short term and the long term. DOE did not evaluate the cumulative impacts of the No Action Alternative, since such an evaluation would involve making speculative assumptions about environmental conditions and future activities at the many locations where the GTCC LLRW and GTCC-like waste could be stored.

A description of the No Action Alternative is provided in Section 3.1 to establish the basis for identifying the potential environmental consequences discussed in Section 3.5. Section 3.2 provides a detailed description of current practices used to store the different types of waste that make up the GTCC LLRW, and Section 3.3 does the same for the GTCC-like waste. The waste generation times and locations are discussed in Section 3.4.

3.1 DESCRIPTION OF THE NO ACTION ALTERNATIVE

Under the No Action Alternative, current practices for storing GTCC LLRW and GTCC-like waste would continue. The GTCC LLRW generated by commercial nuclear reactors (mainly activated metal waste) would continue to be stored at the various nuclear reactor sites that generate this waste. Figure 3.1-1 shows the general locations of the currently operating commercial nuclear reactors in the United States.

The second type of GTCC LLRW waste, sealed sources, would continue to be stored at licensee locations. Sources recovered by GTRI/OSRP for national security or public health and safety reasons would continue to be stored at LANL or off-site contractor facilities pending disposal, and if they meet disposal criteria for DOE facilities, would continue to be disposed of in those facilities. The inventory of GTCC-like sealed sources in storage includes only those

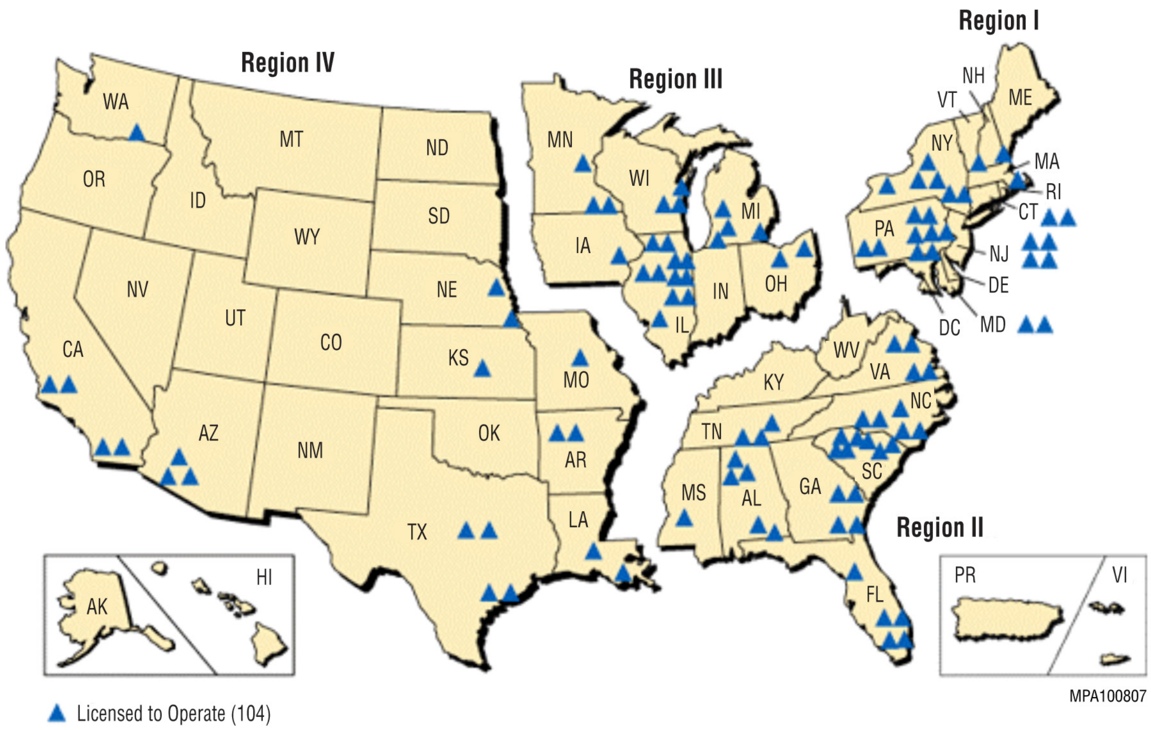

FIGURE 3.1-1 Map Showing Locations of Nuclear Reactors in Four NRC Regions

sealed sources that may not have an identified disposal path. The projected inventory for GTCC-like sealed sources does not include sources that may, in the future, be recovered by GTRI/OSRP. Any such sources are the responsibility of the licensees until the point at which they are recovered by GTRI/OSRP; therefore, they are included in the projected inventory for commercial GTCC sealed sources.

The third type of waste — Other Waste — would also remain stored and managed at the generator or other interim storage sites.

In a similar manner, all stored waste and projected GTCC-like waste (activated metals, sealed sources, and Other Waste) would remain at current DOE storage and generator locations until DOE developed other disposal paths. It is further assumed that the stored waste would be actively managed for 100 years after all the waste was generated and placed in storage. This 100-year time frame is assumed for the analysis of short-term impacts. This time frame is consistent with that typically implemented as an active institutional control period for similar facilities (i.e., as discussed in 10 CFR 61.59).

3.2 CURRENT PRACTICES FOR MANAGING GTCC LLRW

Current practices for managing the three GTCC LLRW waste types — activated metals, sealed sources, and Other Waste — are described in Sections 3.2.1 through 3.2.3. In this EIS, GTCC LLRW and GTCC-like wastes are presented as being in one of two groups, as described in Section 1.4.1. Group 1 consists of wastes that are either already in storage and awaiting disposal or projected to be generated by currently operating facilities. Group 2 consists of wastes that might be generated in the future at facilities that might or might not exist now or from actions that might or might not take place. A much greater level of uncertainty is associated with the estimated volumes and radionuclide activities of Group 2 wastes.

3.2.1 GTCC LLRW Activated Metal Waste

Wastes from a number of decommissioned reactors have already been generated and are currently being stored by the nuclear utilities that own the reactors, generally at the site at which the wastes were generated or at other reactor sites owned by the same utility. The activated metal wastes are stored in spent fuel storage pools or in heavily shielded containers, in the same manner as SNF is currently being stored in independent spent fuel storage installations (ISFSIs).

Three major ISFSI design configurations exist. The canisters are housed (1) vertically in below-ground-level, reinforced concrete vaults; (2) vertically in reinforced concrete casks resting on concrete storage pads; or (3) horizontally within reinforced concrete vaults. In all cases, the SNF or activated metal is contained in large stainless-steel canisters that are welded shut. These storage units are generally located inside a fenced area within the restricted access area at the reactor site, in accordance with conditions specified in the existing NRC license (see Figure 3.2.1-1). Under the No Action Alternative for this EIS, this practice would continue to be used to store these wastes.

Most of the GTCC LLRW activated metals would be generated in the future when the currently operating reactors (as well as those planned to be built in the near future) were decommissioned. Under the No Action Alternative, DOE assumed that if there was no disposal facility, wastes would be stored indefinitely at either the reactor site or at another nearby secured facility.

3.2.2 GTCC LLRW Sealed Source Waste

The possession and the use of radioactive materials in sealed sources in the commercial sector are regulated under licenses issued by the NRC and NRC Agreement States. Some sealed sources (those not considered GTCC LLRW) can be disposed of at commercial LLRW disposal facilities when no longer needed, but licensees in 36 states currently do not have access to commercial disposal for sealed sources. Although those in the remaining 14 states are able to dispose of sealed sources, disposal may be limited because of differing requirements. For sources meeting the definition of GTCC LLRW, however, there is no commercial disposal path available. Therefore, sealed sources in the commercial sector that are classified as GTCC LLRW and that have no beneficial future use would continue to be stored. It is assumed this practice would continue indefinitely under the No Action Alternative.

FIGURE 3.2.1-1 Activated Metal Waste in Storage

NNSA Global Threat Reduction Initiative's Off-Site Source Recovery Project (GTRI/OSRP)

The Global Threat Reduction Initiative's Off-Site Source Recovery Project (GTRI/OSRP) grew out of early efforts at LANL to recover and disposition excess Pu-239 sealed sources that were distributed in the 1960s and 1970s under the Atoms for Peace Program. After the terrorist attacks of 2001, the interagency community began to recognize the threat posed by excess and unwanted radiological materials, particularly those that could not be disposed of at the end of their useful life. Because of their high activity and portability, these sources can be used in radiological dispersal devices (RDDs) commonly referred to as "dirty bombs," resulting in economic impacts amounting to billions of dollars and significant social disruption. GTRI/OSRP's mission expanded to include recovery of material based on national security considerations. DOE has a Memorandum of Understanding (MOU) with the NRC that provides for coordination between the two agencies regarding management of sealed sources. Under this MOU, the NRC notifies GTRI/OSRP when it learns of orphan sources, and GTRI/OSRP expedites the recovery of these sources. GTRI/OSRP also recovers non-orphan disused sources on the basis of recovery prioritization criteria developed in coordination with the NRC.

In addition, under the GTRI/OSRP, DOE recovers, stores, and disposes of, as appropriate, unwanted or excess sealed sources in response to national security or public health and safety threats. This program would continue under the No Action Alternative. Sources recovered by the GTRI/OSRP that were not eligible for disposal at a DOE facility would continue to be stored.

Finally, some sealed sources requiring management as GTCC LLRW would be recycled. In some cases, owners of Cs-137 irradiators would have the option of returning them to the manufacturers. However, some irradiator manufacturers are out of business. Moreover, the return of irradiators to manufacturers that would still be in business and interested in recycling the material could be cost-prohibitive for some licensees. In other cases, if the irradiators were still usable, they might be put to use elsewhere. Similarly, isotope shortages have resulted in some large Am-241 sealed sources being remanufactured and reused by industry.

3.2.3 GTCC LLRW Other Waste

The Other Waste type consists of GTCC LLRW that does not fall into one of the other two types (i.e., Other Waste is not activated metal or a sealed source) (see Section 1.4.1.3). There is generally little commercially generated GTCC LLRW in the Group 1 Other Waste type, and such waste is generally stored at the point of generation or sent to a waste broker for consolidation and storage with other similar wastes. Two sites, one in Virginia and one in Texas, are currently storing GTCC LLRW Other Waste. Under the No Action Alternative, this waste would continue to be stored.

Most of the Group 2 waste in this waste type would be associated with the possible exhumation of two disposal areas at the West Valley Site in New York as part of future decommissioning actions at the site. In addition, Group 2 Other Waste would be generated by future Mo-99 production activities. For purposes of this EIS, it is assumed that this waste would be generated and stored at the sites that generated the waste. Since much of the Group 2 waste would be associated with the West Valley Site and if a decision was made to exhume the waste, it is likely that additional waste storage facilities would need to be provided at that site to manage these wastes.

3.3 CURRENT PRACTICES FOR MANAGING GTCC-LIKE WASTE

As described in Section 1.4.1, GTCC-like waste is waste that is similar to GTCC LLRW but is owned or generated by DOE. Most of this waste meets the DOE definition of TRU waste and may not have originated from defense activities, such that it may not be authorized for disposal at WIPP under current legislation and has no other currently identified path to disposal. The current approach for managing the three types of GTCC-like waste is described as follows.

3.3.1 GTCC-Like Activated Metal Waste

GTCC-like activated metal waste has characteristics similar to those of commercially generated GTCC LLRW activated metal waste. It is produced in reactors and other types of facilities that use high-energy neutrons. There is a relatively small volume of this waste type that is GTCC-like waste when compared with the volume that is generated in the commercial sector by the nuclear utility industry. This waste is being stored at the DOE sites (INL and ORNL) where it is generated, and it is expected that this practice would continue under the No Action Alternative. Wastes generated from new facilities constructed in the future would be stored in a similar manner under the No Action Alternative.

3.3.2 GTCC-Like Sealed Source Waste

As is the case for the activated metal waste, there is much less GTCC-like sealed source waste than GTCC LLRW sealed source waste. Waste in this category that is not eligible for disposal at a DOE facility is generally stored at the site where it was used. Under the No Action Alternative, it is assumed that this approach for storing these wastes would continue indefinitely.

3.3.3 GTCC-Like Other Waste

Most of the GTCC-like Other Waste consists of waste associated with the decontamination and decommissioning of facilities at the West Valley Site (Group 1 and Group 2 wastes) and waste associated with the planned DOE Pu-238 production project (Group 2 wastes). Some of the West Valley waste has already been generated and is in storage at the site, while the rest would be generated in the future. Much of the waste from these two projects may be DOE non-defense-generated TRU waste. Under the No Action Alternative, the GTCC-like Other Waste from the West Valley Site, Pu-238 production project, and any additional wastes from existing facilities or new facilities that would be constructed in the future would be stored indefinitely at the site at which it was generated.

3.4 WASTE GENERATOR LOCATIONS AND GENERATION TIMES

3.4.1 Waste Generator Locations

The GTCC LLRW and the GTCC-like waste that make up the inventory evaluated in this EIS are generated at various locations. The volumes of GTCC LLRW and GTCC-like wastes are summarized in Table 1.4.1-2. Under the No Action Alternative, it would be necessary to store these wastes indefinitely after they were generated.

Table 3.4-1 lists the currently licensed commercial nuclear power reactors that are the source of most of the GTCC LLRW activated metal discussed above in Sections 3.1 and 3.2. Sealed sources are being used throughout the country at medical facilities and hospitals,

TABLE 3.4-1 Locations of Operating, Shut-Down, and Proposed Commercial Reactors

Reactor Name	Approximate Location	No. Operating	No. Shut Down	No. Proposed
BWRs				
Browns Ferry	Decatur, AL	3		
Brunswick	Southport, NC	2		
Clinton	Clinton, IL	1		
Columbia Generating Station	Richland, WA	1		
Cooper	Nebraska City, NE	1		
Dresden	Morris, IL	2	1	
Duane Arnold	Cedar Rapids, IA	1		
Edwin I. Hatch	Baxley, GA	2		
Fermi-2	Newport City, MI	1		1
Grand Gulf-1	Vicksburg, MS	1		1
Hope Creek-1	Wilmington, DE	1		
James Fitzpatrick	Oswego, NY	1		
LaSalle County	Ottawa, IL	2		
Limerick	Philadelphia, PA	2		
Monticello	Minneapolis, MN	1		
Nine Mile Point	Oswego, NY	2		1[a]
Oyster Creek-1	Toms River, NJ	1		
Peach Bottom	Lancaster, PA	2		
Perry-1	Painesville, OH	1		
Pilgrim-1	Plymouth, MA	1		
Quad Cities	Moline, IL	2		
River Bend-1	Baton Rouge, LA	1		1
Susquehanna	Berwick, PA	2		
Vermont Yankee-1	Brattleboro, VT	1		
Big Rock Point	Charlevoix, MI		1	
GE VBWR	Sunol, CA		1	
Humboldt Bay-3	Eureka, CA		1	
La Crosse	Genoa, WI		1	
Pathfinder	Sioux Falls, SD		1	
Victoria County Station	Victoria City, TX			2
PWRs				
Arkansas Nuclear	Russellville, AR	2		
Beaver Valley	McCandless, PA	2		
Braidwood	Joliet, IL	2		
Byron	Rockford, IL	2		
Callaway	Fulton, MO	1		1
Calvert Cliffs	Annapolis, MD	2		1
Catawba	Rock Hill, SC	2		
Comanche Peak	Glen Rose, TX	2		2
Crystal River-3	Crystal River, FL	1		
D.C. Cook	Benton Harbor, MI	2		
Davis-Besse	Toledo, OH	1		
Diablo Canyon	San Luis Obispo, CA	2		
Fort Calhoun	Omaha, NE	1		
Ginna	Rochester, NY	1		

TABLE 3.4-1 (Cont.)

Reactor Name	Approximate Location	No. Operating	No. Shut Down	No. Proposed
PWRs (Cont.)				
H.B. Robinson-2	Florence, SC	1		
Indian Point	New York City, NY	2	1	
Joseph M. Farley	Dothan, AL	2		
Kewaunee	Green Bay, WI	1		
McGuire	Charlotte, NC	2		
Millstone	New London, CT	2	1[b]	
North Anna	Richmond, VA	2		1[c]
Oconee	Greenville, SC	3		
Palisades	South Haven, MI	1		
Palo Verde	Phoenix, AZ	3		
Point Beach	Manitowoc, WI	2		
Prairie Island	Minneapolis, MN	2		
Salem	Wilmington, DE	2		
San Onofre	San Clemente, CA	2	1	
Seabrook-1	Portsmouth, NH	1		
Sequoyah	Chattanooga, TN	2		
Shearon Harris-1	Raleigh, NC	1		2
South Texas Project	Bay City, TX	2		2[d]
St Lucie	Ft. Pierce, FL	2		
Summer	Columbia, SC	1		2
Surry-1	Newport News, VA	2		
Three Mile Island-1	Harrisburg, PA	1		
Turkey Point	Miami, FL	2		2
Vogtle	Augusta, GA	2		2
Waterford-3	New Orleans, LA	1		
Watts Bar-1	Spring City, TN	1		
Wolf Creek-1	Burlington, KS	1		
Haddam Neck	East Hampton, CT		1	
Maine Yankee	Wiscasset, ME		1	
Rancho Seco	Herald, CA		1	
Saxton	Saxton, PA		1	
Yankee-Rowe	Rowe, MA		1	
Zion	Warrenville, IL		2	
Alternate Energy Holdings	Bruneau, ID			1
Amarillo Power	Amarillo, TX			2
William Lee (Duke)	Charlotte, SC			2
MidAmerican	Payette County, ID			1
Bellefonte	Scottsboro, AL			2
PPL Generation	Berwick, PA			1
Levy	Levy County, FL			2
Unannounced	Unknown			1
Total		104	16	33

[a] Proposed reactor is a pressurized water reactor (PWR).

[b] Shut-down reactor is a boiling water reactor (BWR).

[c] Proposed reactor is a BWR.

[d] Proposed reactors are BWRs.

industrial facilities, and universities, and some of these sources that are no longer needed are being stored at commercial storage and staging locations. It is not possible to identify the specific locations where the sealed sources are being used or stored. Most of these sources are probably close to the larger population centers in the country. GTCC-like activated metal wastes, sealed sources, and Other Waste are generated and/or stored at INL, LANL, ORR, the West Valley Site, and a commercial facility in Lynchburg, Virginia (see Appendix B, Table B-2).

Most of the Other Waste is associated with the West Valley Site or located at other DOE sites (ORR and INL). Two commercial facilities (in Virginia and Texas) are being used to store GTCC LLRW Other Waste. In addition, Other Waste would be generated in the two planned Mo-99 production projects (GTCC LLRW) and the planned Pu-238 production project (GTCC-like waste). The wastes from these planned projects are included in Group 2, and it is assumed that they would be stored at the facilities that generated them until a disposal facility became available.

3.4.2 Waste Generation Times

GTCC LLRW and GTCC-like waste have been and are continuing to be generated. Figure 3.4.2-1 shows the assumed timeline for the receipt of waste for disposal (see Section B.4 for additional discussion). The actual start date for operations is uncertain at this time and dependent upon, among other things, the alternative or alternatives selected, additional NEPA analysis as required, characterization studies, and other actions necessary to initiate and complete construction and operation of a GTCC disposal facility. For purposes of analysis in the Draft EIS, DOE assumed a start date of disposal operations in 2019. However, given these uncertainties, the actual start date could vary. The GTCC LLRW and GTCC-like waste are stored as they are generated, since there is no licensed facility that can accept GTCC LLRW for disposal and since there is currently no disposal path for the GTCC-like waste. This practice would continue indefinitely under the No Action Alternative.

Disused sealed sources would continue to be generated and stored by commercial licensees. Although some GTCC LLRW activated metal waste from decommissioning nuclear reactors is currently in storage, most of this waste type will not be generated and available for disposal for several decades. In the future, if no disposal facility was available to accept the waste, utilities would have to continue storing this waste in a manner consistent with their NRC licenses. The Other Waste (such as that from the West Valley Site) would continue to be managed at the generator site or at some other location.

GTCC-like waste at the DOE sites would continue to be stored in accordance with the *Radioactive Waste Management Manual*, DOE M 435.1-1 (DOE 1999) and other DOE requirements.

3.5 POTENTIAL CONSEQUENCES OF THE NO ACTION ALTERNATIVE

This section focuses on potential short- and long-term impacts on human health from continued management of the GTCC LLRW and GTCC-like waste at current storage and

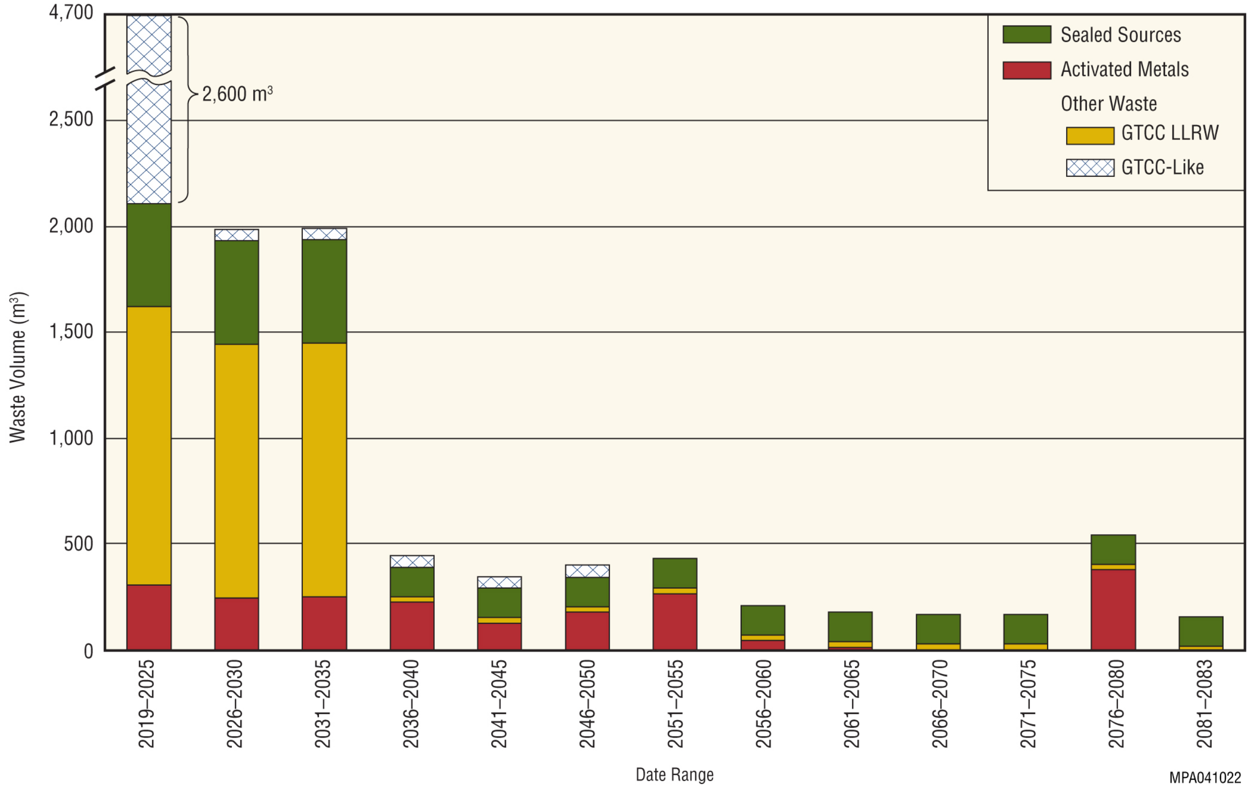

FIGURE 3.4.2-1 Assumed Timeline for Receipt of Waste for Disposal

generator sites. Under the No Action Alternative, it is assumed that the current facility operations at the storage and generator sites would continue for the short term and result in minimal impacts on most resource areas (e.g., air quality, geology, water resources, ecological resources, socioeconomics, land use, transportation, and cultural resources). The main concerns are associated with the human health impacts that could occur from storage of this waste.

Short-term impacts are assumed to be the impacts that would last for 100 years after the wastes were generated and placed in storage. This time frame is consistent with the typical active institutional control period assumed for such facilities. Long-term impacts are those assumed to last for a period from 100 to 10,000 years after generation and placement in storage. The short-term impacts are expected to be mainly occupational doses from maintenance and monitoring activities. No off-site releases are expected for the short term, because the waste packages would contain the radioactive materials and because monitoring of the site and nearby vicinity would identify any needs for corrective action. It is possible that the public could be exposed to external gamma radiation from the stored wastes if individuals were to venture close enough to the stored wastes, but it is expected that such exposures would be low and not result in any significant LCF risk.

Long-term impacts are those associated with the potential release of contaminants to the environment and with the subsequent exposure to nearby individuals. Because it is assumed that the site would not be monitored for the long term, there would be no worker doses during this time period. Also, although airborne releases from degraded containers could occur, it is expected that the dispersion of any released radionuclides by the wind would greatly decrease the air concentrations. The highest doses would therefore probably be those associated with the migration of radionuclides to groundwater that would subsequently be used by members of the general public. For this assessment, the exposed individual is assumed to be a hypothetical resident farmer located 100 m (330 ft) downgradient from the storage facility.

For evaluating long-term impacts, no credit is taken for maintenance of the stored wastes beyond 100 years. That is, it is assumed for analysis purposes in this EIS that after 100 years, water could contact the radioactive contaminants in the waste packages and leach radionuclides from the wastes, and that these radionuclides could then move toward the underlying groundwater system. For this EIS, it is assumed that the activated metals and Other Waste would stay within the NRC region in which the facility that generated the wastes was located, and the sealed sources would be divided in the four NRC regions in proportion to the number of NRC-licensed facilities within each region.

For purposes of analysis of the long-term impacts, wastes from the GTCC inventory that are assumed to be generated within a given NRC region are assumed to be stored at a single facility in that region, and this storage facility is assumed to have a footprint of 300 × 300 m (1,000 × 1,000 ft). It is recognized that these simplifying assumptions do not represent the current situation, and GTCC wastes are currently stored throughout the region at a number of locations. However, this approach is assumed to be reasonable for estimating the potential radiation doses and LCF risks to address the long-term impacts associated with the No Action Alternative. It needs to be emphasized that the approach used for analysis of the No Action Alternative differs from that used for the action alternatives, in which the entire GTCC LLRW and GTCC-like waste inventory is assumed to be disposed of at each site by using one of the disposal methods (i.e., for the No Action Alternative, only portions of the GTCC inventory are assumed to be stored in each region).

The results of the long-term assessment for the No Action Alternative for the first 10,000 years following the 100-year institutional control period are presented in Tables 3.5-1 and 3.5-2. Figures 3.5-1 through 3.5-7 illustrate the results for a time period extending to 100,000 years. The tables provide the radiation doses and LCF risk in the four NRC regions for the various waste types, and the figures illustrate the radionuclides expected to be the significant dose contributors. In some figures, the time and dose scales are linear, and in others, they are logarithmic, in order to better illustrate the results.

The results presented in these two tables and seven figures reflect the doses that could occur from the groundwater pathway after the 100-year institutional control period assumed. During the institutional control period, the site would be monitored, and corrective actions would be taken if off-site releases were detected. However, it is assumed that after this time period, all monitoring activities would cease, and any releases could thus be undetected.

Because the radionuclide mix for each waste type (i.e., activated metals, sealed sources, and Other Waste) is different, the peak doses and LCF risks for each waste type do not necessarily occur at the same time. In addition, the peak doses and LCF risks for the entire

TABLE 3.5-1 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater within 10,000 Years after the Institutional Control Period for the No Action Alternative[a,b]

	GTCC LLRW				GTCC-Like Waste				
NRC Region[c]/ 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
Region I	120	73,000	3,800	26,000	0.0	0.0	97,000	270,000	470,000
Region II	7.5	0.0	0.0	850	0.052	0.0	0.0	0.0	860
Region III	5.4	120	0.0	0.0	0.0	0.0	0.0	0.0	120
Region IV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[a] These doses are associated with the use of contaminated groundwater by a resident farmer located 100 m (330 ft) from the edge of the storage facility. All values are given to two significant figures. The times for the peak annual doses for NRC Regions I, II, and III were calculated to be about 3,700, 98, and 1,100 years, respectively, after the assumed institutional control period of 100 years. No doses from the groundwater pathway were calculated to occur within 10,000 years in Region IV for the No Action Alternative. The primary contributors to the dose are GTCC LLRW sealed sources, GTCC LLRW Other Waste - RH, and GTCC-like Other Waste - RH. The primary radionuclides contributing to the dose are C-14, I-129, Np-237, and isotopes of uranium, plutonium, and americium.

[b] The values given in this table represent the maximum or peak annual dose to the hypothetical resident farmer when the assumed entire GTCC waste inventory for a particular region is considered. The values in the waste-type-specific columns provide the doses associated with each waste type at the time of the maximum or peak annual dose for the entire inventory. These contributions do not necessarily represent the maximum or peak dose that could result from each of these waste types separately. Because of the different radionuclide mixes and activities for each of the waste types, the maximum or peak annual dose that could result from each waste type individually could occur at a different time. The peak annual doses that could result from each of the waste types when considered separately are presented in Table E-21. This information is discussed in Sections 3.5.1 through 3.5.6.

[c] Region I includes the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Washington, D.C. Region II includes the states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. Region III includes the states of Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin. Region IV includes Alaska, Arizona, Arkansas, California, Colorado, Hawaii, Idaho, Kansas, Louisiana, Missouri, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

TABLE 3.5-2 Estimated Annual LCF Risks from the Use of Contaminated Groundwater within 10,000 Years after the Institutional Control Period for the No Action Alternative[a,b]

NRC Region[c]/ Waste Group	GTCC LLRW				GTCC-Like Waste				Peak Annual LCF Risks
	Activated Metals	Sealed Sources	Other Waste – CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	
Region I	7E-05	4E-02	2E-03	2E-02	0E+00	0E+00	6E-02	2E-01	3E-01
Region II	4E-06	0E+00	0E+00	5E-04	6E-08	0E+00	0E+00	0E+00	5E-04
Region III	3E-06	7E-05	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	7E-05
Region IV	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00

[a] All values are given to one significant figure. The times for the peak annual LCF risks for NRC Regions I, II, and III were calculated to be about 3,700, 98, and 1,100 years, respectively, after the assumed institutional control period of 100 years. No LCFs from the groundwater pathway were calculated to occur within 10,000 years in Region IV for the No Action Alternative. The primary contributors to the LCF risk are GTCC LLRW sealed sources, GTCC LLRW Other Waste - RH, and GTCC-like Other Waste - RH. The primary radionuclides contributing to the LCF risk are C-14, I-129, Np-237, and isotopes of uranium, plutonium, and americium.

[b] The values given in this table represent the maximum or peak annual LCF risk to the hypothetical resident farmer when the assumed entire GTCC waste inventory for a particular region is considered. The values in the waste-type-specific columns provide the risks associated with each waste type at the time of maximum or peak annual LCF risk for the entire inventory. These contributions do not necessarily represent the maximum or peak LCF risk that could result from each of these waste types separately. Because of the different radionuclide mixes and activities for different the waste types, the maximum or peak LCF risk that could result from each waste type individually could occur at a different time. This information is discussed in Sections 3.5.1 through 3.5.6.

[c] Region I includes the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Washington, D.C. Region II includes the states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. Region III includes the states of Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin. Region IV includes Alaska, Arizona, Arkansas, California, Colorado, Hawaii, Idaho, Kansas, Louisiana, Missouri, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

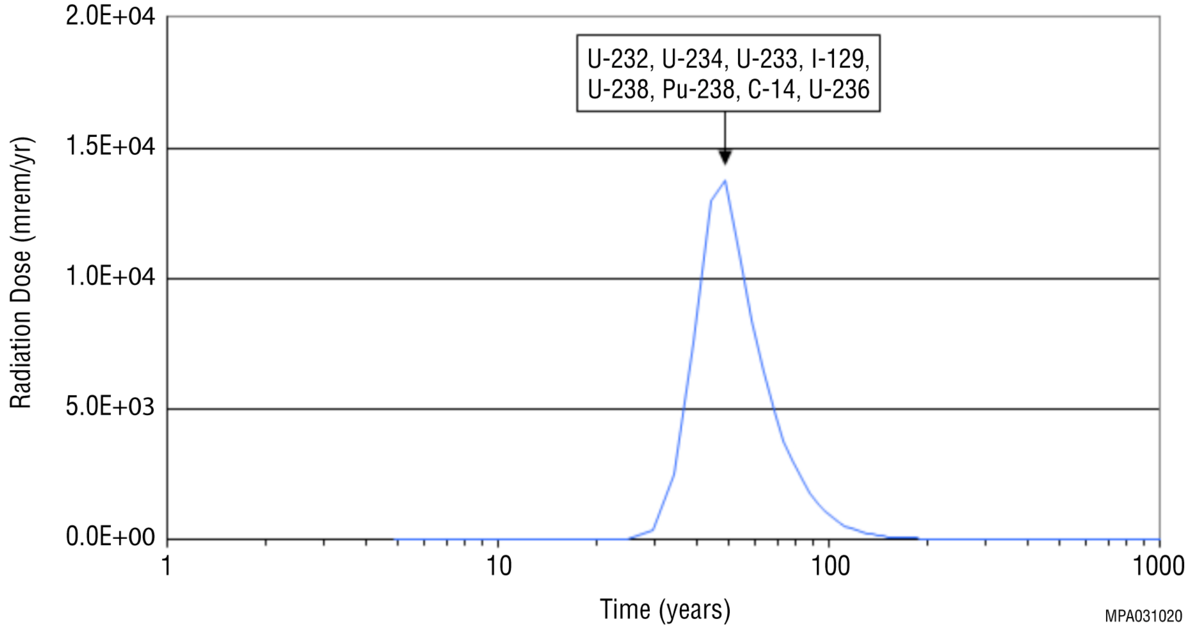

FIGURE 3.5-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 1,000 Years after the Institutional Control Period in NRC Region I for the No Action Alternative

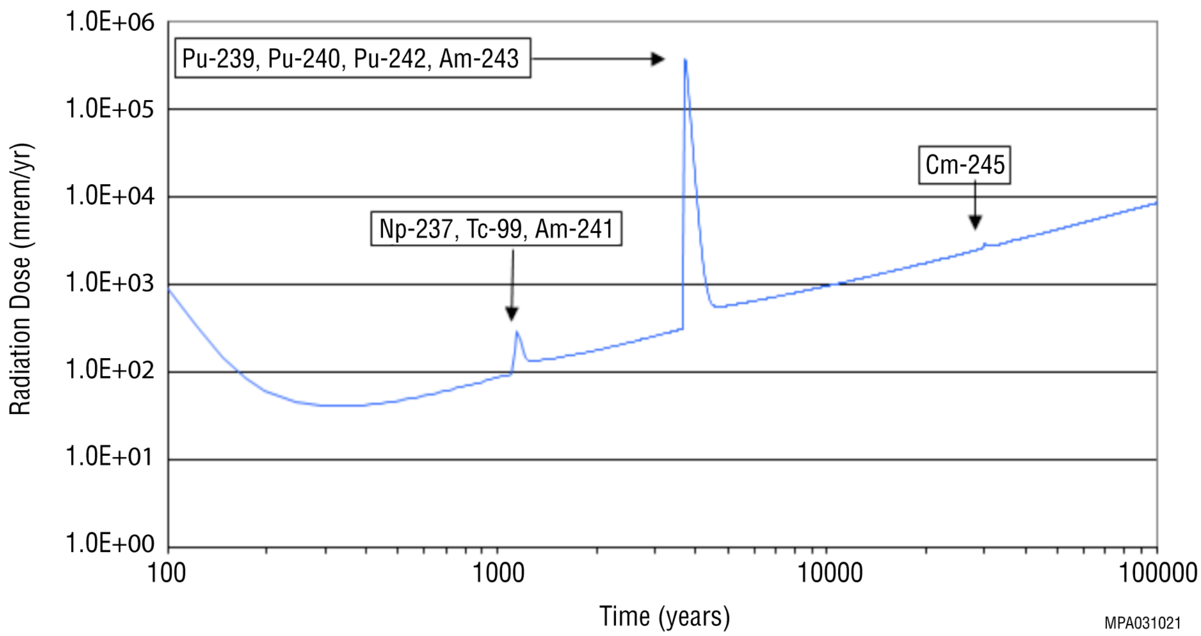

FIGURE 3.5-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years after the Institutional Control Period in NRC Region I for the No Action Alternative

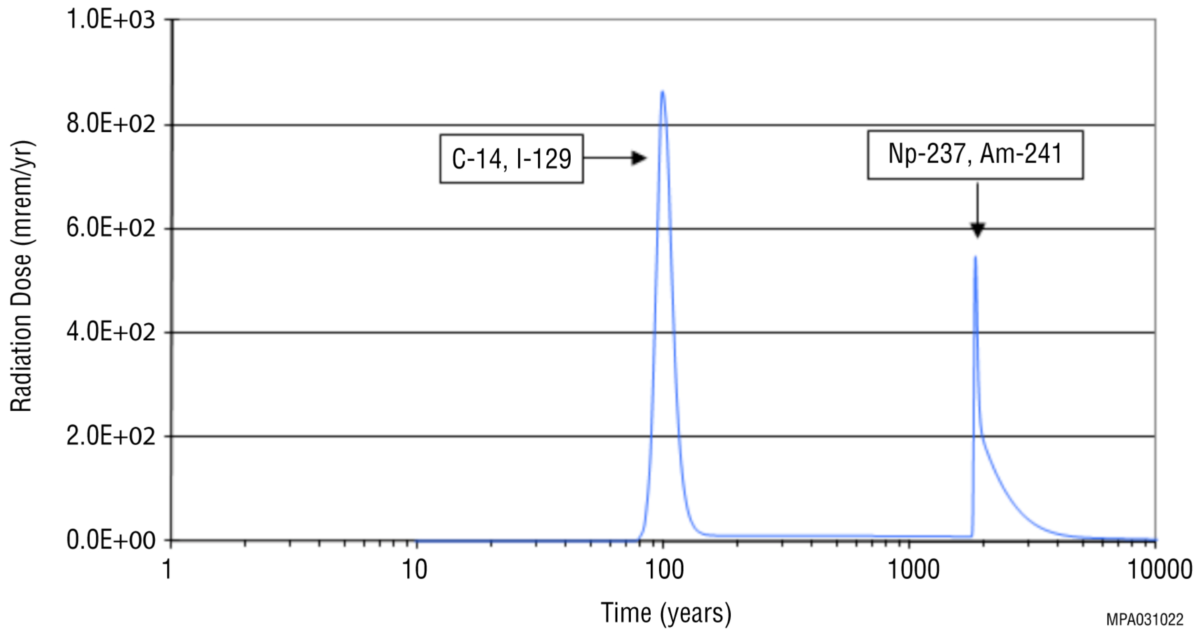

FIGURE 3.5-3 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years after the Institutional Control Period in NRC Region II for the No Action Alternative

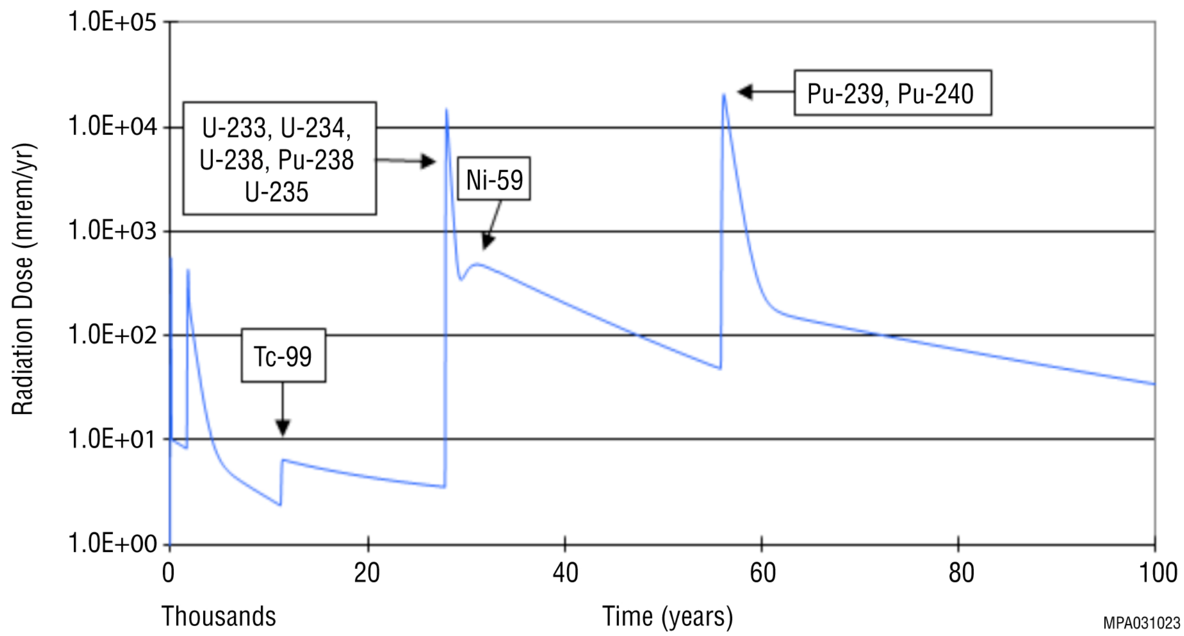

FIGURE 3.5-4 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years after the Institutional Control Period in NRC Region II for the No Action Alternative

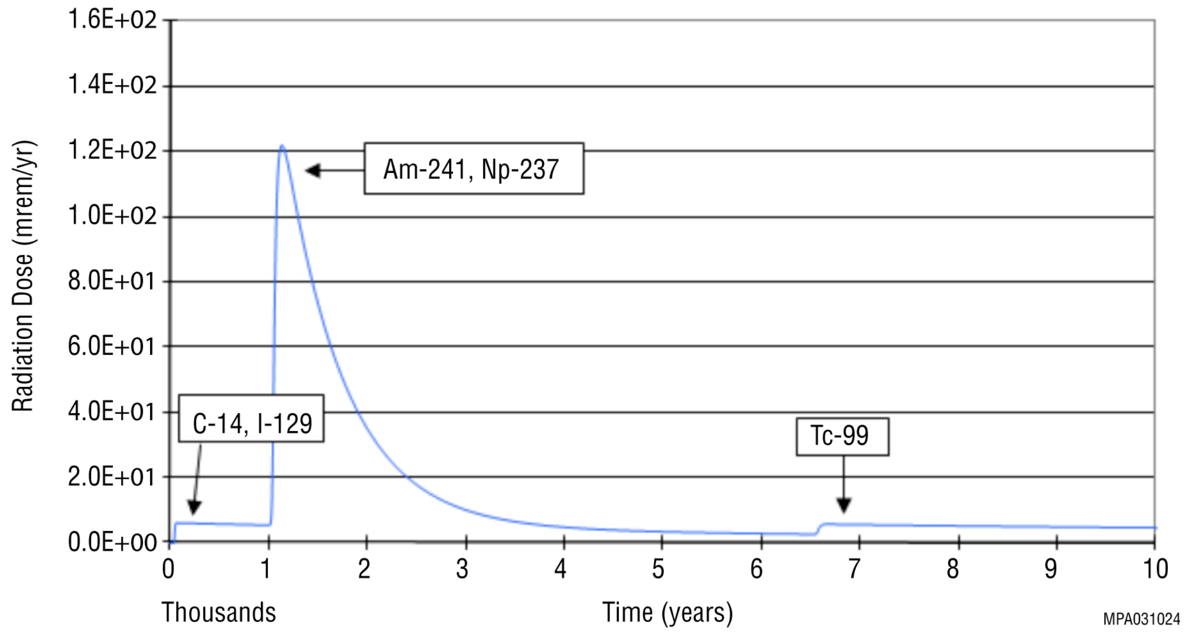

FIGURE 3.5-5 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years after the Institutional Control Period in NRC Region III for the No Action Alternative

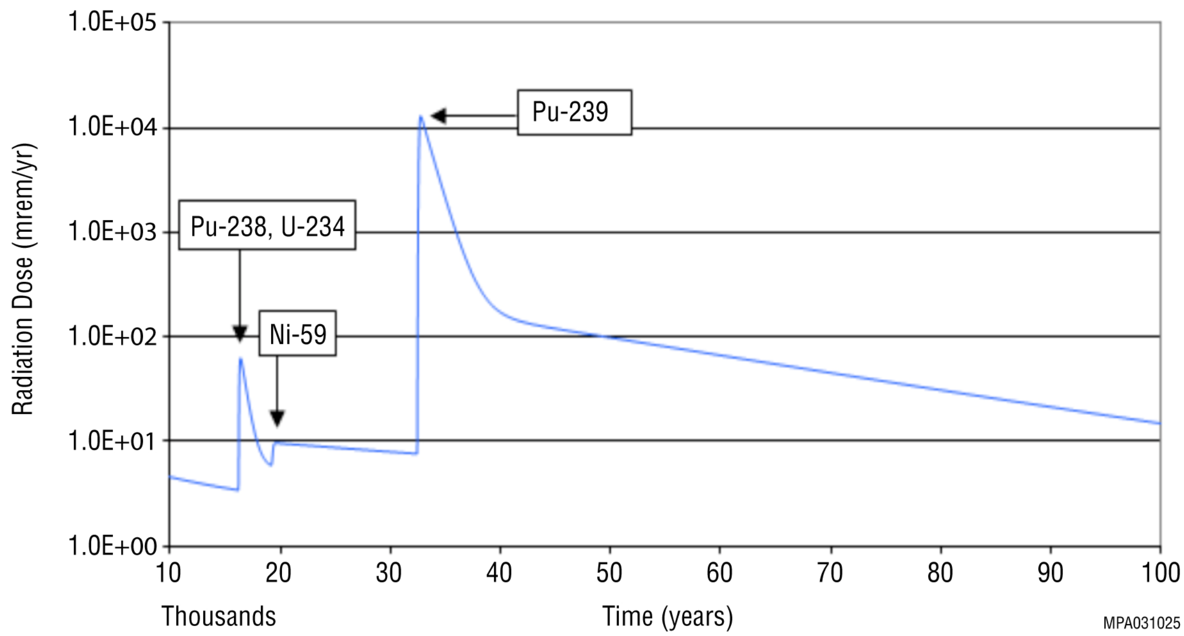

FIGURE 3.5-6 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years after the Institutional Control Period in NRC Region III for the No Action Alternative

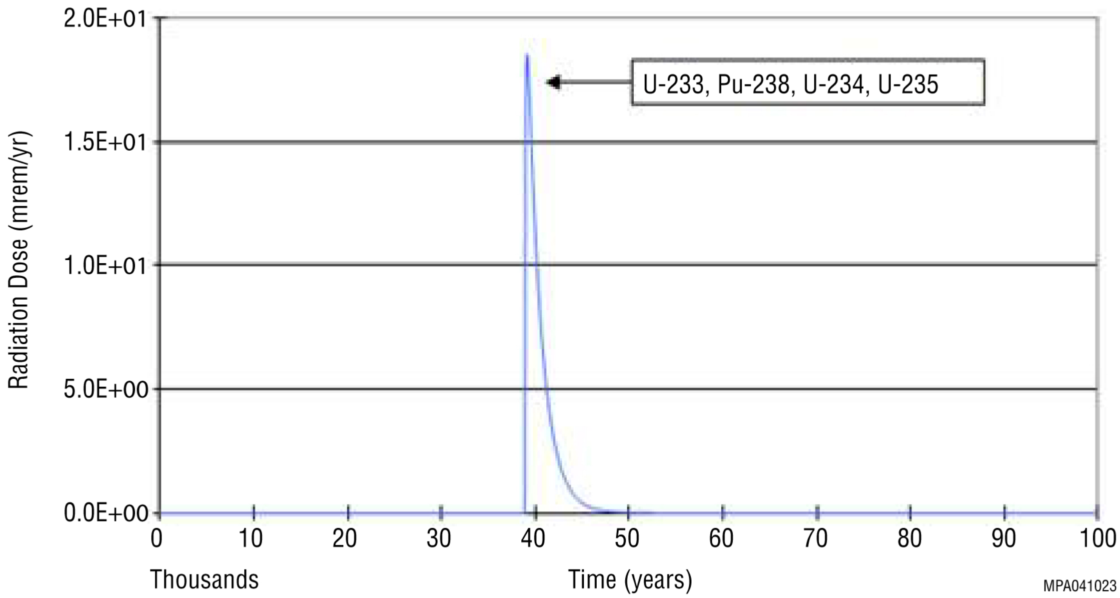

FIGURE 3.5-7 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years after the Institutional Control Period in NRC Region IV for the No Action Alternative

GTCC waste inventory considered as a whole could be different than those for the individual waste types. The results presented in Tables 3.5-1 and 3.5-2 are for the entire GTCC waste inventory assumed for that region, and the contributions of the individual waste types given in these tables are those that occur at the time of peak doses and LCF risks for the given inventory. The peak annual doses that could result from each of the waste types when considered separately are presented in Table E-21.

The estimated doses and LCF risks for the hypothetical resident farmer scenario evaluated to assess the long-term impacts for the No Action Alternative are presented in two ways in this EIS. The first presents the peak dose and LCF risk when long-term storage of the entire GTCC waste inventory is considered. These are provided in Tables 3.5-1 and 3.5-2. The second presents the peak dose and LCF risk for each waste type considered on its own. These results are presented in Sections 3.5.1 through 3.5.6, which focus on those waste types that have peak doses and LCF risks at different times than those presented in the two tables.

It was calculated that radionuclides would not reach the groundwater table in NRC Region IV within 10,000 years, so the results presented in Tables 3.5-1 and 3.5-2 have zeroes for this region for all waste types. Radionuclides were calculated to reach the groundwater table and a well located 100 m (330 ft) downgradient at about 40,000 years in NRC Region IV (see Figure 3.5-7). The peak annual dose in this region was determined to be about 19 mrem/yr, largely due to uranium and plutonium isotopes and their radioactive decay products. There is a high degree of uncertainty with regard to estimates that extend so far into the future.

The highest radiation doses and LCF risks for the four regions evaluated are associated with NRC Region I. This region has the largest portion of the GTCC waste inventory assumed (due to the presence of the waste from the West Valley Site). The West Valley Site accounts for about 56% of the entire GTCC EIS waste inventory, and much of this waste meets the DOE definition of TRU waste. The total estimated volume of GTCC LLRW at the West Valley Site is about 4,300 m^3 (150,000 ft^3), and the volume of GTCC-like waste is estimated to be about 2,200 m^3 (78,000 ft^3).

Another reason for the higher doses and LCF risk in NRC Region I is because a disposal facility in that region would likely be in a generally humid environment with a relatively short distance to the groundwater table. These properties would probably result in higher radiation doses and LCF risks, especially when compared with the more arid sites expected in NRC Region IV.

The peak annual dose in NRC Region I within 10,000 years was calculated to be 470,000 mrem/yr, and this dose would occur about 3,700 years after termination of the institutional control period (assumed to be 100 years). This dose is assumed to result if an exposure pathway to the contaminated groundwater is possible and if the resident farmer scenario realistically represents this exposure. This dose would be largely attributable to plutonium isotopes and Am-243 (which decays to Pu-239) and would result from the long-term storage of GTCC LLRW sealed sources containing plutonium and Am-243 and from the Other Waste. The Other Waste would contribute about 84% to this peak annual dose and be associated mainly with the West Valley Site. In addition to this peak annual dose at 3,700 years in the future, there would be a high dose (about 14,000 mrem/yr) in the very near term from C-14, I-129, Pu-238, and uranium isotopes, because it is assumed in this analysis that C-14, I-129, and uranium would dissolve completely in water. It was calculated that this dose would occur about 50 years following the institutional control period.

The peak annual doses in NRC Regions II and III would be lower than that for Region I, but they would exceed 100 mrem/yr. The peak annual dose within 10,000 years in NRC Region II was calculated to be 860 mrem/yr and to occur about 98 years following the institutional control period. This peak dose would be largely attributable to C-14 and I-129, with GTCC LLRW Other Waste - RH being the main contributor. The peak annual dose within 10,000 years in NRC Region III was calculated to be 120 mrem/yr and to occur about 1,100 years in the future. This dose would be largely attributable to Np-237 and Am-241 (which decays to Np-237), with GTCC LLRW sealed sources being the main contributor to this dose. Much larger doses were calculated to occur in these two NRC regions in the very long term (see Figures 3.5-4 and 3.5-6), largely due to uranium and plutonium isotopes. There is a very large degree of uncertainty in estimates that range this far into the future.

An additional discussion of these short-term and long-term impacts in terms of the specific types of wastes being addressed in this EIS is provided here, as follows.

3.5.1 GTCC LLRW Activated Metal Waste

As shown in Table 3.4-1 and Figure 3.1-1, the activated metal waste would be retained for storage at some or all of the 84 locations having commercial nuclear reactors. This total would include the 33 assumed new, yet-to-be-licensed reactors. It is assumed that the wastes would be stored in secure locations at these sites in accordance with NRC licenses for an indefinite period of time.

3.5.1.1 Short-Term Impacts

Under the No Action Alternative, it is expected that short-term impacts would be the same as those at sites with ISFSIs having stored wastes and that storage practices would be protective of human health and the environment. Monitoring and maintenance of these waste storage areas would continue, and any required maintenance would be performed in a manner consistent with the existing NRC licenses. These wastes could also be stored at other NRC-approved facilities, and it is expected that this option would also have minimal impacts on the environment. Because the activated metals would be in closed (welded shut) stainless-steel canisters, no releases of radioactive material to the air, ground, or water are anticipated for the short term. Should an accidental release occur, best management practices and site operating procedures would ensure that any contaminant releases to the air would be minimal and comply with NRC licensing requirements.

Minimal adverse impacts on the health of the workers and the general public are expected. The short-term human health impacts would be a result of the low levels of radiation from the stored activated metals in their shielded canisters. Since the activated metals would come from a decommissioned reactor, most ISFSIs with activated metal canisters would be at decommissioned reactor sites, unless the waste had been shipped elsewhere for interim storage. Therefore, most human exposure at these locations would result primarily from stored SNF rather than stored activated metals, because the number of activated metal canisters might only be about 10% or less of the number of SNF canisters in ISFSIs. Annual occupational involved worker collective doses from surveillance and maintenance activities at a single ISFSI are estimated to be on the order of 1 to 4 person-rem per year (Pacific Gas and Electric Company 2001; Prairie Island 2008; Surry Power Station 2002). Such doses would depend on the size and type of the ISFSI. In addition, the actual impact from activated metal storage would likely be less and would depend on the number of activated metal canisters and their locations and external dose rates relative to those of the SNF canisters present.

Some reactor sites have more than one reactor, with one or more having been decommissioned and one or more still in operation. Thus, impacts would also occur to nearby worker populations at an active reactor site with an ISFSI. Such noninvolved worker exposures would depend on the size of the ISFSI, the relative locations (i.e., distance) and shielding afforded by the nearby work area(s), and the number of nearby noninvolved workers. Potential annual collective doses to noninvolved workers at a reactor site from a collocated ISFSI have been estimated to reach as high as about 10 person-rem (Prairie Island 2008).

While the radiation field from an ISFSI is generally low, potential public exposure is possible, depending on distance and the local site characteristics (e.g., elevation contours, vegetation). The annual collective external dose to the public from an ISFSI could exceed 1 person-rem (Prairie Island 2008) if a sufficiently large local population was located close enough to the site. Again, most exposure would result from SNF rather than from any GTCC activated metals present at the ISFSI. None of these doses is expected to result in an LCF.

3.5.1.2 Long-Term Impacts

As discussed previously, the NRC license requires storage facilities or areas to be maintained in a manner that is safe for the environment and the general public until a path to disposal is identified. Continued storage of activated metal waste at the 84 reactor (generator) sites would entail a continued risk of intruder access (i.e., both inadvertent human intruder and intentional acts such as sabotage) at each of the sites.

For the long-term evaluation of the No Action Alternative in this EIS, the following assumptions apply: (1) maintenance activities at these storage facilities would not be conducted after the active institutional control period (i.e., after 100 years), (2) the storage containers would start to degrade to the extent that potential radionuclide releases could occur, (3) these radionuclides would then reach the groundwater and move downgradient off-site, and (4) a hypothetical individual would use and consume this contaminated groundwater in the future. These assumptions were made to allow for an assessment of the potential human health impacts in the future; they do not imply that such a situation is reasonable or likely to occur.

Once the containers would begin to degrade, other exposure pathways could also be relevant, including exposures from airborne releases and releases to surface waters in the site vicinity. There is a large amount of uncertainty with regard to these pathways and the likelihood of future exposures to nearby individuals. This analysis was limited to the groundwater pathway to allow for a comparison with the action alternatives in this EIS. Because releases are limited to a single environmental medium (groundwater), the estimate of the potential radiation doses and LCF risks is expected to be conservative, since the amount of radionuclides released to groundwater is maximized, and since there would probably be much less dilution in groundwater than in a nearby surface water feature, such as a stream, river, or lake, due to the smaller impacted volume. Any releases to the air would be dispersed quickly by wind, resulting in generally low concentrations.

To address the impacts associated with long-term storage of GTCC LLRW activated metals, an analysis was performed by using the RESRAD-OFFSITE computer code. This was done to allow for a comparison of the potential impacts (future radiation doses and LCF risks) under the No Action Alternative with those under the action alternatives. This approach involves calculating the future dose to a resident located 100 m (330 ft) downgradient of the perimeter of the storage area in the next 10,000 years (see also Section 5.3.4.3).

Radionuclides would not be released to the environment from the stored wastes until the waste containers degraded to the point that precipitation would be infiltrating into the containers, leaching the radionuclides for subsequent migration to groundwater. The maximum annual radiation dose to the highest exposed individual that could result from using and ingesting contaminated groundwater associated with the long-term storage of GTCC LLRW activated metal waste would range from 6.3 mrem/yr at 73 years following the assumed 100-year institutional control period in NRC Region III to 130 mrem/yr at 3,800 years in the future in NRC Region I. These doses are the peak doses for the LLRW activated metal waste type and are about 10% to 20% higher than those given in Table 3.5-1, which presents doses from the activated metal waste type but at the time of the peak dose for the entire waste inventory (i.e., doses are for a different time). Much of the radiation doses and LCF risks associated with the activated metals would be attributable to C-14 and plutonium isotopes and their radioactive decay products.

High doses and LCF risks could occur in the long term if these wastes remained in storage at these reactor sites for the indefinite future and no action was taken. The results given here are conservative but provide a perspective on the doses that could occur under this alternative.

3.5.2 GTCC LLRW Sealed Source Waste

Currently, disused sealed sources are stored at licensee locations (e.g., hospitals, laboratories, and industrial facilities) throughout the country pending the availability of a disposal path. As discussed in Section 3.1, the sources recovered by GTRI/OSRP are not included in the GTCC EIS inventory.

3.5.2.1 Short-Term Impacts

Sources awaiting disposition in the short term could pose an external radiation hazard that would have to be properly addressed. At facilities that routinely handle sealed sources with a

Disused or Unwanted Sealed Sources Present a National Security and Public Health Threat

<u>According to the National Nuclear Security Administration:</u>

"Every year, thousands of sources become disused and unwanted in the United States. While secure storage is a temporary measure, the longer sources remain disused or unwanted, the greater the chance that they will become unsecured or abandoned. Due to their high activity and portability, radioactive sealed sources … could be used in a radiological dispersal device (RDD), commonly referred to as 'dirty bombs.' An attack using an RDD could result in extensive economic loss, significant social disruption, and potential serious public health problems." (Source: NNSA News 2010, www.nnsa.energy.gov/mediaroom/pressreleases/01.14.10a)

An accidental release of cesium-chloride from a radioactive sealed source in Goiania, Brazil, in 1987 demonstrates the dangers that can result from unsecured or abandoned sources. An abandoned Cs-137 teletherapy unit (formerly used by a private radiography institute to treat cancer) was found by scrap metal scavengers in Goiania and sold to a junkyard. Believing the source material to be valuable, the junkyard owner distributed small pieces of the highly dispersible material to friends and family. Four people died within 2 months of the accident, approximately 250 people were contaminated, and more than 112,000 people were surveyed for contamination. The environment, including eighty-five houses, was also severely contaminated. (Sources: GAO 2003, www.gao.gov/new.items/d03638.pdf; National Research Council 2008, www.nap.edu/catalog/11976.html) strong gamma component, average annual dose rates to occupational workers range from tens to hundreds of millirem per person (NRC 2008). When the waste would be in storage (and not being handled), it is expected that occupational exposure values would be lower than these values would be when waste is handled for monitoring and surveillance purposes. Average worker doses would depend on the number and type of sources and the characteristics of the storage areas and monitoring program. Exposure to noninvolved workers might occur if their work areas were close to stored sources. These doses are not expected to result in an LCF.

3.5.2.2 Long-Term Impacts

For sealed sources stored at licensed locations, an assessment similar to that conducted for activated metal wastes (i.e., a regional storage concept) was done for their long-term storage under the No Action Alternative. The inventory of sealed sources is assumed to be divided among the four NRC regions in proportion to the number of licenses in each region. The RESRAD-OFFSITE computer code was used to calculate the future dose to a resident located 100 m (330 ft) downgradient of the storage area perimeter.

The maximum annual radiation dose to a hypothetical individual having the highest impacts from using and ingesting contaminated groundwater is estimated to be 120 mrem/yr at 1,100 years following the institutional control period in NRC Region III and 73,000 mrem/yr at 3,700 years in the future in NRC Region I. These values are the same as those presented in Table 3.5-1. The radionuclides that would result in most of the dose would be Np 237, Am-241, and plutonium isotopes and their radioactive decay products.

Very high doses and LCF risks could occur in the long term (after 10,000 years) if these wastes remained in storage at these sites indefinitely and no action was taken. The results given here are based on the following assumptions: (1) maintenance activities at these storage facilities would end at 100 years, (2) the storage containers would degrade to the extent that radionuclide releases would occur, (3) these radionuclides would then reach groundwater and move downgradient off-site, and (4) an individual would consume this contaminated groundwater in the future. This set of circumstances is very unlikely, but the results given here help provide a perspective on the doses that could occur under this alternative.

The estimated doses for the sealed sources are much larger than the doses for the activated metal wastes mainly because of the assumed higher leach rates. Should it be necessary to store sealed sources for a very long period of time, measures (such as the use of grout or other stabilizing material) would be taken to minimize the leachability of these wastes and thereby minimize the likelihood of these releases occurring. It is expected that such procedures would reduce the peak annual doses significantly (by a factor of 100 or more), such that the values would be comparable to those given above for the activated metal wastes. The No Action Alternative would not address potential national security concerns presented by the current lack of disposal capability for discussed GTCC sealed sources (NRC 2006).

3.5.3 GTCC LLRW Other Waste

Most of the waste in this waste type category would be associated with the possible exhumation of two disposal areas (i.e., NDA and SDA) at the West Valley Site. These wastes are included in Group 2 and would be generated only if a decision was made under NEPA to remove these wastes as part of decommissioning the West Valley Site. Under the No Action Alternative in this EIS, a disposal facility would not be made available for these wastes; hence, it would be necessary to store this GTCC LLRW in a secured facility at the site for an indefinite period of time. These wastes at the West Valley Site are addressed only for NRC Region I, which is the NRC region in which this site is located. Note that the input parameters for site characteristics are based on the regionalized input values in Tables E-20 and E-21 and may not necessarily be the same as site-specific values applicable to the West Valley Site.

The total volume of GTCC Other Waste in these two disposal areas is estimated to be about 3,500 m^3 (120,000 ft^3). Most of this waste is GTCC LLRW, with 31 m^3 (1,100 ft^3) (from the NDA) being GTCC-like waste. The GTCC wastes associated with the NDA and SDA are a result of previous commercial nuclear fuel processing activities and the disposal of radioactive waste from a number of commercial and government programs. These two areas are located adjacent to each other on the south plateau portion of the West Valley Site.

In addition to these wastes from the West Valley Site, a smaller volume of waste would be associated with two planned Mo-99 production projects. The total volume of GTCC LLRW associated with these two Mo-99 production projects would be 390 m^3 (14,000 ft^3). It is expected that these wastes would be stored at the production facilities until disposal capability would become available.

3.5.3.1 Short-Term Impacts

The short-term impacts are expected to be comparable to those from the storage of the activated metal waste but lower because the external gamma exposure rates associated with the GTCC LLRW Other Waste are generally lower than those associated with the activated metal waste. The annual radiation doses to involved workers performing surveillance and maintenance activities would probably not exceed 1 person-rem/yr (based on the information provided for storage of activated metal waste in Section 3.5.1.1). The annual collective external dose to the public is also not expected to exceed 1 person-rem. Most of these impacts are expected to occur within NRC Region I because the West Valley Site is there. None of these doses are expected to result in an LCF.

3.5.3.2 Long-Term Impacts

To address the impacts associated with long-term storage of GTCC LLRW Other Waste, an analysis was performed by using the RESRAD-OFFSITE computer code. This was done to allow for a comparison of the potential impacts (future radiation doses and LCF risks) under the No Action Alternative with those under the action alternatives. This approach involves calculating the future dose to a resident located 100 m (330 ft) downgradient of the perimeter of the storage area in the next 10,000 years (see also Section 5.3.4.3). The approach used for this analysis is generally the same as that described for the activated metal wastes (see Section 3.5.1.2).

Radionuclides would not be released to the environment from the stored wastes until the waste containers degraded to the point that precipitation would be infiltrating into the containers, leaching the radionuclides for subsequent migration to groundwater. The maximum annual radiation dose to an individual from the use and ingestion of contaminated groundwater from the long-term storage of GTCC LLRW Other Waste in NRC Region I was calculated to be 30,000 mrem/yr and to occur about 3,700 years in the future. A much lower peak dose was calculated for NRC Region II; the maximum annual dose in this NRC region was calculated to be 850 mrem/yr and to occur 98 years after termination of institutional controls. These values are the same as those given in Table 3.5-1. These doses and LCF risks would be largely attributable to uranium and plutonium isotopes and their radioactive decay products.

High doses and LCF risks could occur in the long term if no action was taken and these wastes remained in storage at these sites for the indefinite future. The results given here are conservative but provide a perspective on the doses that could occur under this alternative.

3.5.4 GTCC-Like Activated Metal Waste

The total volume of GTCC-like activated metal waste is estimated to be about 13 m^3 (460 ft^3). Under the No Action Alternative, this small volume of waste and other GTCC-like activated metal waste would continue to be securely stored at the DOE sites where the waste was generated. The impacts under the No Action Alternative for these wastes are expected to be much smaller than those for GTCC LLRW activated metal waste described in Section 3.5.1.1 for the short term and Section 3.5.1.2 for the long term because the volume of waste would be much lower. It is estimated that there would be a small radiation dose of 0.14 mrem/yr to the hypothetical resident farmer in NRC Region II at 120 years after termination of institutional controls. This peak dose is solely attributable to this waste type and is about three times higher than that given in Table 3.5-1, which represents the peak dose for the entire GTCC waste inventory.

3.5.5 GTCC-Like Sealed Source Waste

There would be a very small amount of GTCC-like sealed source waste in the EIS inventory (0.83 m^3 [29 ft^3]). In contrast, the estimated total volume of GTCC LLRW sealed source waste would be about 2,900 m^3 (100,000 ft^3). The impacts under the No Action Alternative for the GTCC-like sealed sources are expected to be much smaller than those for GTCC LLRW sealed sources discussed in Section 3.5.2.1 for the short term and Section 3.5.2.2 for the long term because the volume of waste would be much lower.

3.5.6 GTCC-Like Other Waste

Most of the waste in this waste type category would be associated with decontamination and decommissioning the West Valley Site. Some of this waste would be in Group 1, and some would be in Group 2. The total volume of GTCC-like Other Waste is estimated to be about 2,800 m^3 (99,000 ft^3), and all but 590 m^3 (21,000 ft^3) would be associated with cleanup of the West Valley Site. The remaining amount would be associated with the planned DOE Pu-238 production project (380 m^3 or 13,000 ft^3 in Group 2) and wastes from several DOE sites (210 m^3 or 7,400 ft^3 in Group 1).

Under the No Action Alternative in this EIS, a disposal facility would not be made available for these wastes; hence, it would be necessary to store this GTCC-like Other Waste in a secured facility at the generating site for an indefinite period of time. Most of this waste is in NRC Region I, which is the NRC region in which the West Valley Site is located. The same approach as that used for GTCC LLRW Other Waste was used for the GTCC-like Other Waste.

3.5.6.1 Short-Term Impacts

The short-term impacts are expected to be comparable to those from storage of the activated metal waste, but lower because of the generally lower external gamma exposure rates associated with Other Waste than with activated metal waste. The annual radiation doses to involved workers performing surveillance and maintenance activities would probably not exceed 1 person-rem/yr (based on the information provided for storage of activated metal waste in Section 3.5.1.1). In addition, the annual collective external dose to the public would not exceed 1 person-rem/yr. It is expected that these impacts would occur largely within NRC Region I because the West Valley Site is there. None of these doses are expected to result in an LCF.

3.5.6.2 Long-Term Impacts

To address the impacts associated with long-term storage of GTCC-like Other Waste, an analysis was performed by using the RESRAD-OFFSITE computer code. This was done to allow for a comparison of the potential impacts (future radiation doses and LCF risks) under the No Action Alternative with those under the action alternatives. This approach involves calculating the future dose to a resident located 100 m (330 ft) downgradient of the perimeter of the storage area in the next 10,000 years (see also Section 5.3.4.3). The approach used for this analysis is generally the same as that described for the activated metal waste (see Section 3.5.1.2).

Radionuclides would not be released to the environment from the stored wastes until the waste containers degraded to the point that precipitation would be infiltrating into the containers, leaching the radionuclides for subsequent migration to groundwater. The maximum annual radiation dose to an individual that could result from using and ingesting contaminated groundwater associated with the long-term storage of GTCC-like Other Waste in NRC Region I was calculated to be about 370,000 mrem/yr and to occur about 3,700 years in the future. In NRC Region II, the maximum annual dose was calculated to be 380 mrem/yr and to occur

1,800 years in the future. These doses are the peak doses for the GTCC-like Other Waste type. The value for NRC Region II differs from that given in Table 3.5-1, which presents doses from the GTCC-like Other Waste type but at the time of the peak dose for the entire GTCC waste inventory (i.e., doses are for a different time). The value for NRC Region I is the same as that given in Table 3.5-1. The doses and LCF risks would be largely attributable to Np-237, Am-243, and uranium and plutonium isotopes and their radioactive decay products.

High doses could occur in the long term if these wastes remained in storage at these sites for the indefinite future and no action was taken. The results given here are conservative but provide a perspective on the doses that could occur under this alternative.

3.6 REFERENCES FOR CHAPTER 3

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4 ALTERNATIVE 2: DISPOSAL IN A GEOLOGIC REPOSITORY AT THE WASTE ISOLATION PILOT PLANT

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from disposal of GTCC LLRW and GTCC-like waste at the Waste Isolation Pilot Plant (WIPP). Section 4.1 describes the WIPP alternative (Alternative 2). The affected environments for various environmental resource areas evaluated for this alternative are discussed in Section 4.2. The potential environmental and human health consequences from the construction of the additional underground rooms and from the operations associated with emplacing the waste containers in these rooms are discussed in Section 4.3. A summary of the potential impacts at the WIPP site area from the proposed action is presented in Section 4.4; Section 4.5 deals with cumulative impacts. Section 4.6 describes the irreversible and irretrievable commitment of resources associated with this alternative. Statutory and regulatory requirements specific to WIPP are discussed in Section 4.7. Federal and state statutes and regulations and DOE Orders relevant to WIPP are discussed in Chapter 13 of this EIS. Impact assessment methodologies used for this EIS are described in Appendix C.

4.1 DESCRIPTION OF ALTERNATIVE 2

Under Alternative 2, it is assumed that GTCC LLRW and GTCC-like wastes would be received at WIPP and be disposed of by using the same technologies and methods currently used there for the disposal of defense-generated TRU waste. The exception is emplacement of activated metal and Other Waste that are RH wastes. These wastes are assumed to be managed as CH waste and would be emplaced in room floors instead of in wall spaces. It is assumed that all of the surface (aboveground) facilities at WIPP would be available for managing these wastes, and no additional surface facilities would need to be constructed. On the basis of current mining experience in the area, it is assumed that the existing mine shafts, shaft stations, and underground haul routes and tunnels would be functional during the period projected for the disposal of GTCC LLRW and GTCC-like waste. The incremental impacts on the environment and human health from the construction of additional underground rooms and from the operations involved with disposing of the GTCC LLRW and GTCC-like waste at WIPP are evaluated in this EIS to allow for comparison with other alternatives. Should WIPP be identified as the preferred option for disposal of these wastes, further evaluation and analysis of alternative technologies and methods to optimize the transport, handling, and emplacement of the wastes would be conducted to identify those technologies and methods that would minimize to the extent possible any potential impacts on human health or the environment. Follow-on WIPP-specific NEPA evaluation and documentation, as appropriate, would be conducted to examine in greater detail the potential impacts associated with the disposal of GTCC LLRW and GTCC-like wastes at WIPP.

4.1.1 Facility Location and Background

WIPP is the nation's only underground repository for the permanent disposal of defense-generated TRU waste. DOE issued an EIS for WIPP in 1980 (DOE 1980), and this was followed by two supplemental EISs. The first supplement issued in 1990 (DOE 1990) and the second supplement issued in 1997 (DOE 1997) focused on impacts from waste disposal operations. Impacts from operations are periodically re-evaluated as required by DOE NEPA regulations. This re-evaluation occurs at least every five years and utilizes the supplement analysis process to consider whether any significant new circumstances or changes to the WIPP program could cause substantial changes to the environmental impacts predicted in the second supplement. The latest re-evaluation was completed in 2009 (DOE 2009). Construction of WIPP began in the 1980s. A site and preliminary design validation study that was initiated in 1981 provides the foundation for the mine plan design and construction (DOE 1983). The first shipment of CH TRU waste was received at WIPP on March 26, 1999, and the first shipment of RH TRU waste was received on January 23, 2007. The total capacity for disposal of TRU waste established under the WIPP Land Withdrawal Act (LWA) is 175,675 m^3 (6.2 million ft^3). The Consultation and Cooperative Agreement with the State of New Mexico (1981) established a total RH capacity of 7,080 m^3 (250,000 ft^3), with the remaining capacity for CH TRU at 168,500 m^3 (5.95 million ft^3). In addition, the WIPP LWA limits the total radioactivity of RH waste to 5.1 million curies. Current plans include receipt and emplacement of TRU waste in 10 waste disposal panels through FY 2030.

The WIPP site is located in Eddy County in the Chihuahuan Desert of southeastern New Mexico (Figure 4.1.1-1). The site is about 42 km (26 mi) east of Carlsbad in a region known as Los Medaños, a relatively flat, sparsely inhabited plateau with little surface water. The WIPP site encompasses approximately 41 km^2 (16 mi^2) under the jurisdiction of DOE pursuant to the WIPP LWA (see P.L. 102-579), which was signed into law on October 30, 1992. This law transferred responsibility of the WIPP withdrawal area from the Secretary of the Interior to the Secretary of Energy. The land is permanently withdrawn from all forms of entry, appropriation, and disposal under the public land laws and is reserved for uses associated with the purposes of WIPP.

The WIPP site covers 16 sections (each section is one square mile) of federal land in Township 22 South, Range 31 East, and is divided into four areas under DOE control (Figure 1.4.3-2). A chain-link fence surrounds the innermost “Property Protection Area,” which includes all of the surface facilities. Surrounding this inner area is the “Exclusive Use Area,” which is surrounded by a barbed-wire fence. Enclosing these two areas is the “Off-Limits Area,” which is unfenced to allow livestock grazing but, like the other two areas, is patrolled and posted against trespassing or other land uses. Beyond the Off-Limits Area, the land is managed under the traditional public land use concept of multiple uses, but mining and drilling are restricted. The boundary of WIPP was set to extend at least 1.6 km (1 mi) beyond any underground development (Sandia 2008a). WIPP includes all of the necessary surface and subsurface facilities to manage waste handling and disposal operations.

4.1.2 Surface Support Facilities

A map of surface structures at WIPP is shown in Figure 4.1.2-1. There are 50 permanent buildings, several trailers, and various structures used for storage. The site buildings provide a total of 31,060 m^2 (334,400 ft^2) of office and industrial space. There are three basic types of structures at WIPP: surface structures, shafts, and underground structures. The surface facilities

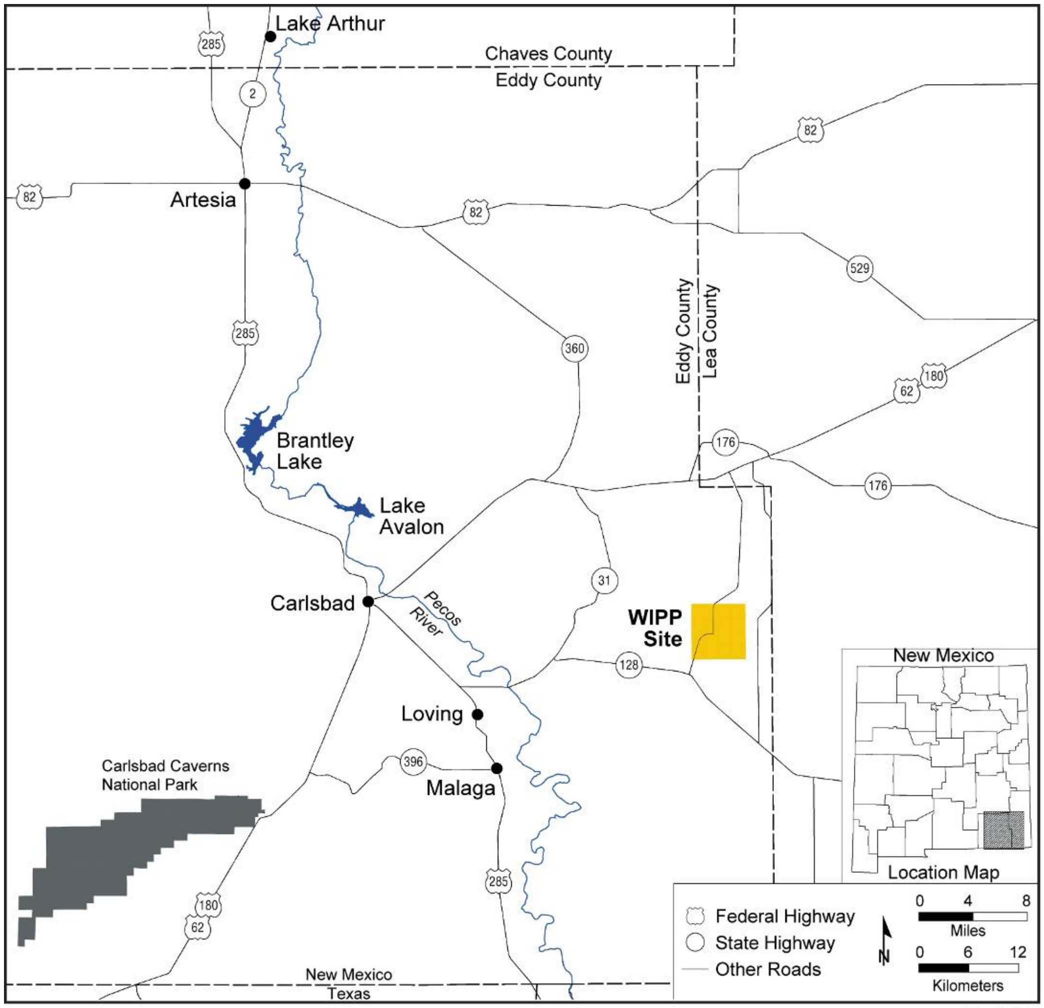
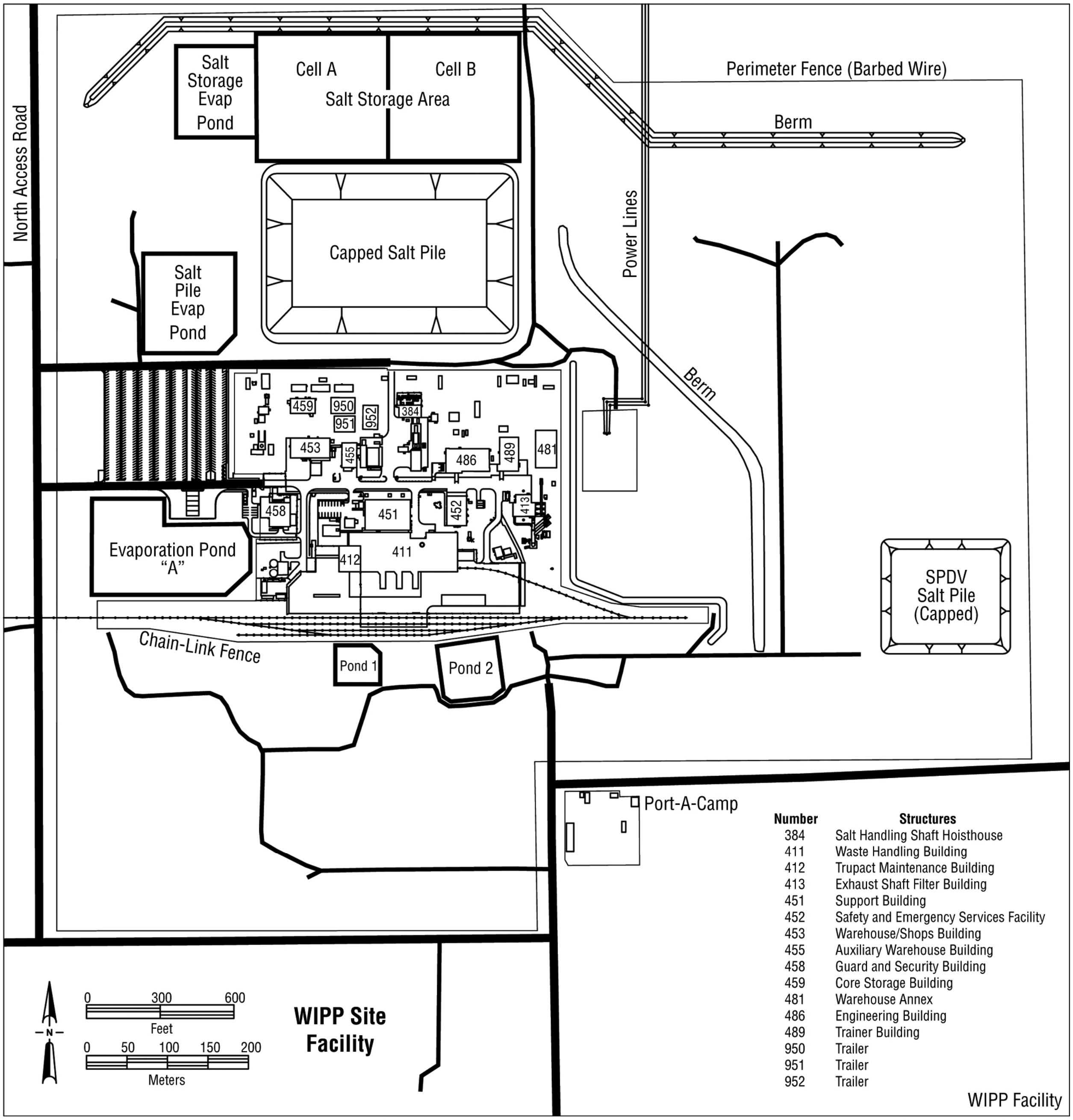


FIGURE 4.1.1-1 Location of WIPP in Eddy County, New Mexico (Source: DOE 2006a)

at WIPP are used to accommodate the personnel, equipment, and support services required for the receipt, preparation, and transfer of TRU waste from the surface to the underground disposal area. The primary surface structure is the Waste Handling Building (WHB), which is divided into the CH-TRU waste handling area, RH-TRU waste handling area, and support areas.

There are two surface locations where TRU waste is being managed and stored, as shown in Figure 4.1.2-2. The first area is the Waste Handling Building Container Storage Unit (WHB Unit) for TRU radioactive mixed waste management and storage. The WHB Unit consists of the WHB CH Bay and the RH Complex. The second area designated for managing and storing TRU waste is the Parking Area Container Storage Unit (Parking Area Unit), an outside container storage area that extends south from the WHB to the rail siding. The Parking Area Unit provides storage space for up to 50 loaded CH packages and 8 loaded RH packages on an asphalt and concrete surface. It is assumed that the surface structures currently at the WIPP would be used



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2 **FIGURE 4.1.2-1 Map of Aboveground Infrastructure and Major Surface Structures at WIPP**

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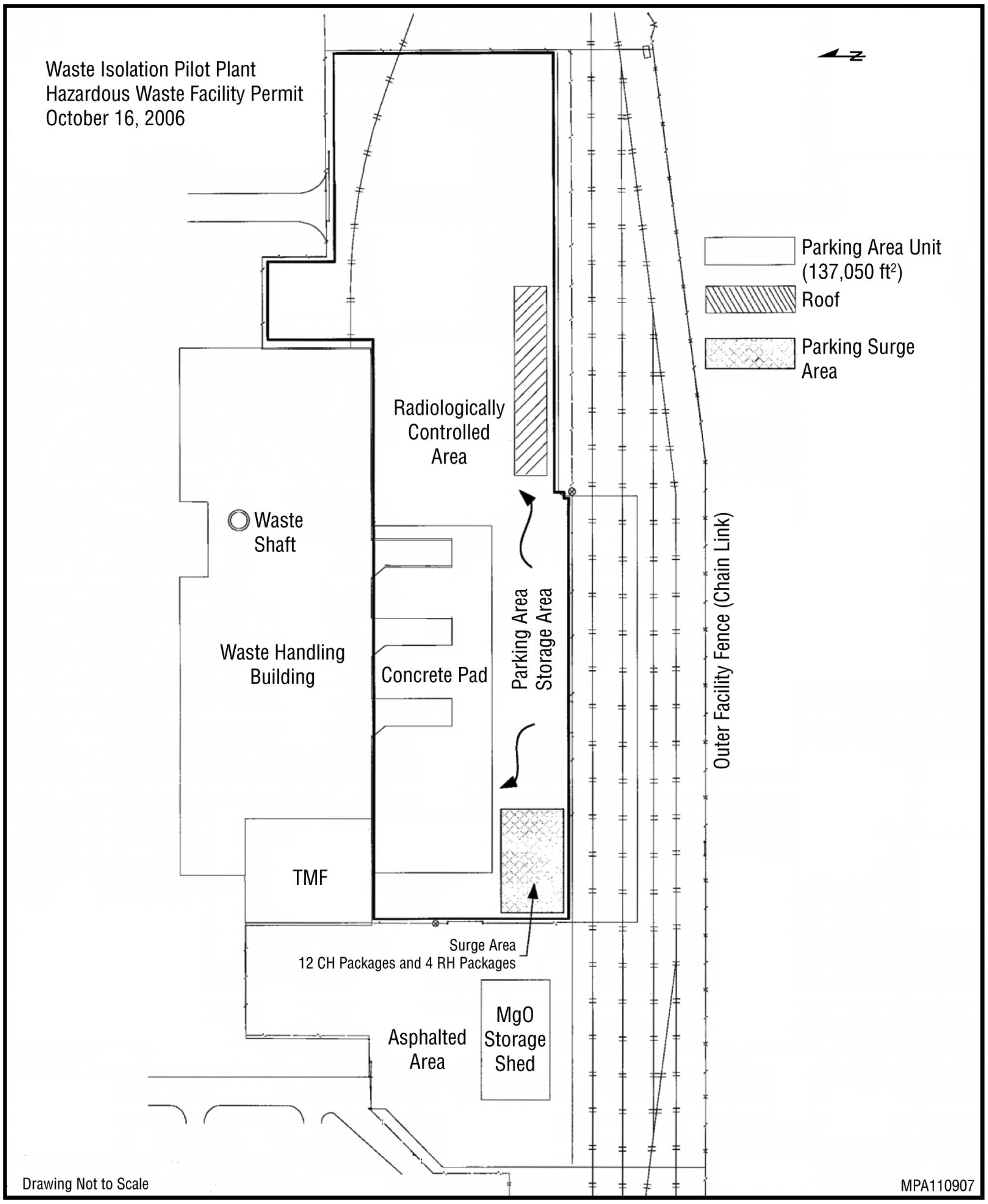


FIGURE 4.1.2-2 Container Storage Areas at the Waste Handling Building and Parking Area at WIPP (Source: DOE 2006b)

for the disposal of GTCC LLRW and GTCC-like waste and that construction of new surface structures would not be needed.

Other major WIPP buildings or structures include the (1) Exhaust Shaft Filter Building, which houses the high-efficiency particulate air (HEPA) filters, building filtration units, exhaust fans, supply-air handling units, motor control centers, and air lock; (2) Water Pump House, which contains water pumps and space for water chlorination equipment and chemical storage;

(3) Support Building, which houses general support services; (4) Salt Storage Area or “salt pile,” which consists of a 12-ha (30-ac) area north of the property protection area that houses salt excavated from the repository; and (5) detention basins and sewage treatment ponds.

4.1.3 WIPP Underground

The WIPP disposal area is located in a salt formation about 655 m (2,150 ft) beneath the ground surface. Figures 4.1.3-1 and 4.1.3-2 illustrate the subsurface layout of WIPP. These underground facilities include the waste disposal area, access tunnels, and associated support facilities. The waste disposal area is composed of a series of panels containing disposal rooms. Each waste panel consists of seven rooms. Each room is about 91-m (300-ft) long, 10-m (33-ft) wide, and 4-m (13-ft) high. Pillars between rooms are 30-m (100-ft) thick. Eight waste panels are separated from each other and from the main entries by nominally six 61-m (200-ft) pillars. In addition to the eight panels, the main north-south and east-west access drifts in the panel regions are available for waste disposal. These have been designated as Panels 9 and 10 for permitting and modeling purposes.

The underground is connected to the surface by four vertical shafts: the waste shaft, salt handling shaft, exhaust shaft, and air intake shaft. The waste, salt handling, and air intake shafts have permanently installed hoists capable of moving personnel, equipment, and waste between the surface and the underground repository.

Mining of the shafts and underground passages within the repository gives rise to a disturbed rock zone (DRZ) that is important to repository performance. The DRZ forms as a consequence of unloading the rock in the vicinity of the excavation. Increased permeability is created by microfractures along grain boundaries and by bed separation along lateral seams. The DRZ development begins immediately after excavation and continues as salt creeps into the opening. The plastic property of the salt allows the DRZ to heal when a back-stress is applied. Continued creep closure will allow the salt to come in contact with the waste that is applying the back-stress, thereby healing the salt fractures and returning the properties of the salt to properties that are similar to those of the original, intact salt.

In addition to the natural barriers provided by the geology of the WIPP repository, engineered barriers are included in the design to provide additional confidence that the repository will isolate the waste. EPA regulations required both natural and engineered barriers to be used at WIPP. Four features that meet the definition of an engineered barrier are incorporated at WIPP: shaft seals, panel closures, backfill, and borehole plugs. Shaft seals and borehole plugs will limit migration of liquid and gases in the WIPP shafts and boreholes. Panel closures will limit the communication of brine and gases among the waste panels and to the accessible environment. The designs of the shaft seals, borehole plugs, and panel closures use common engineering materials that have low permeability, appropriate mechanical properties, and durability, with the intent to reduce the movement of water and radionuclides toward the accessible environment after WIPP closure.

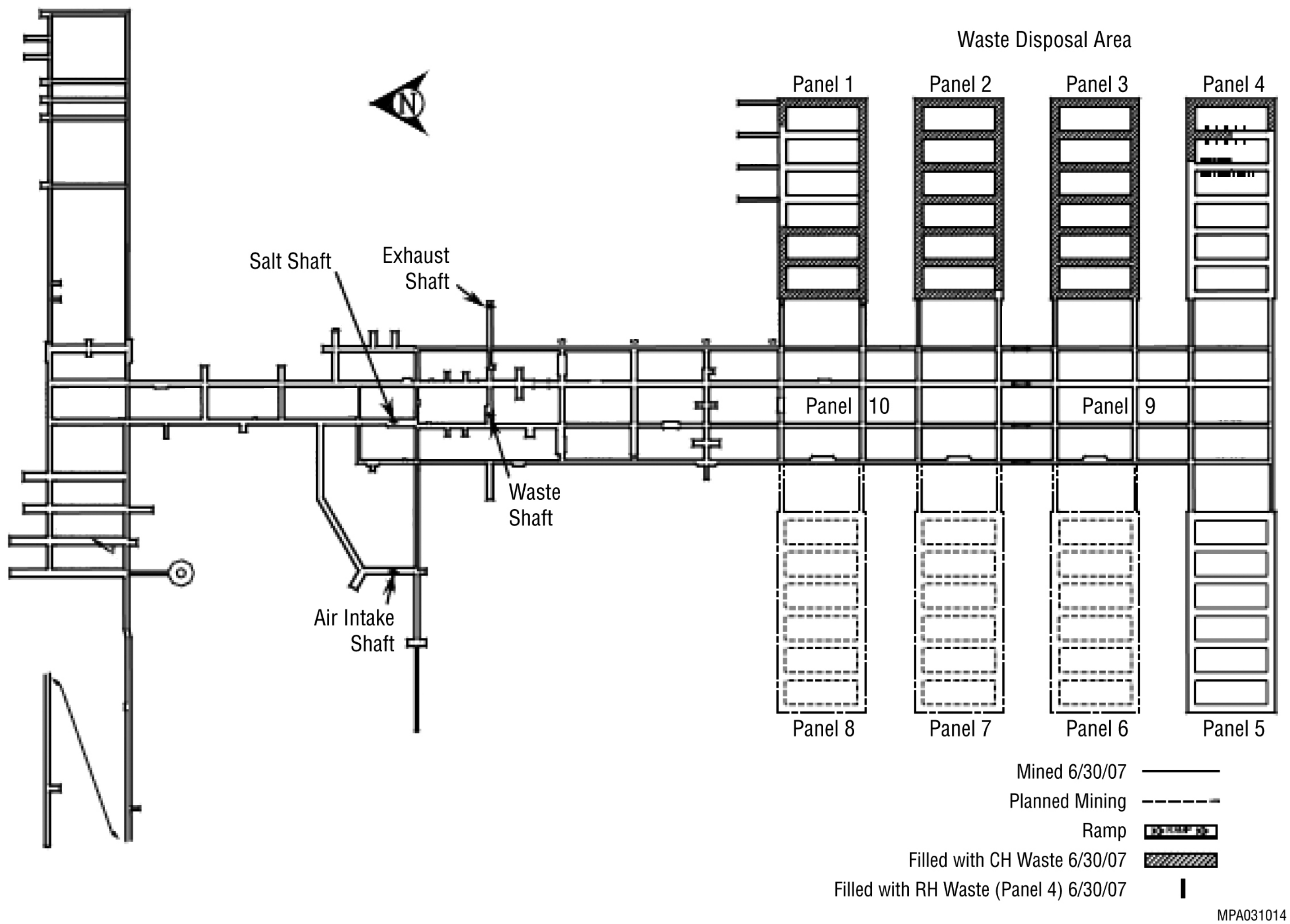
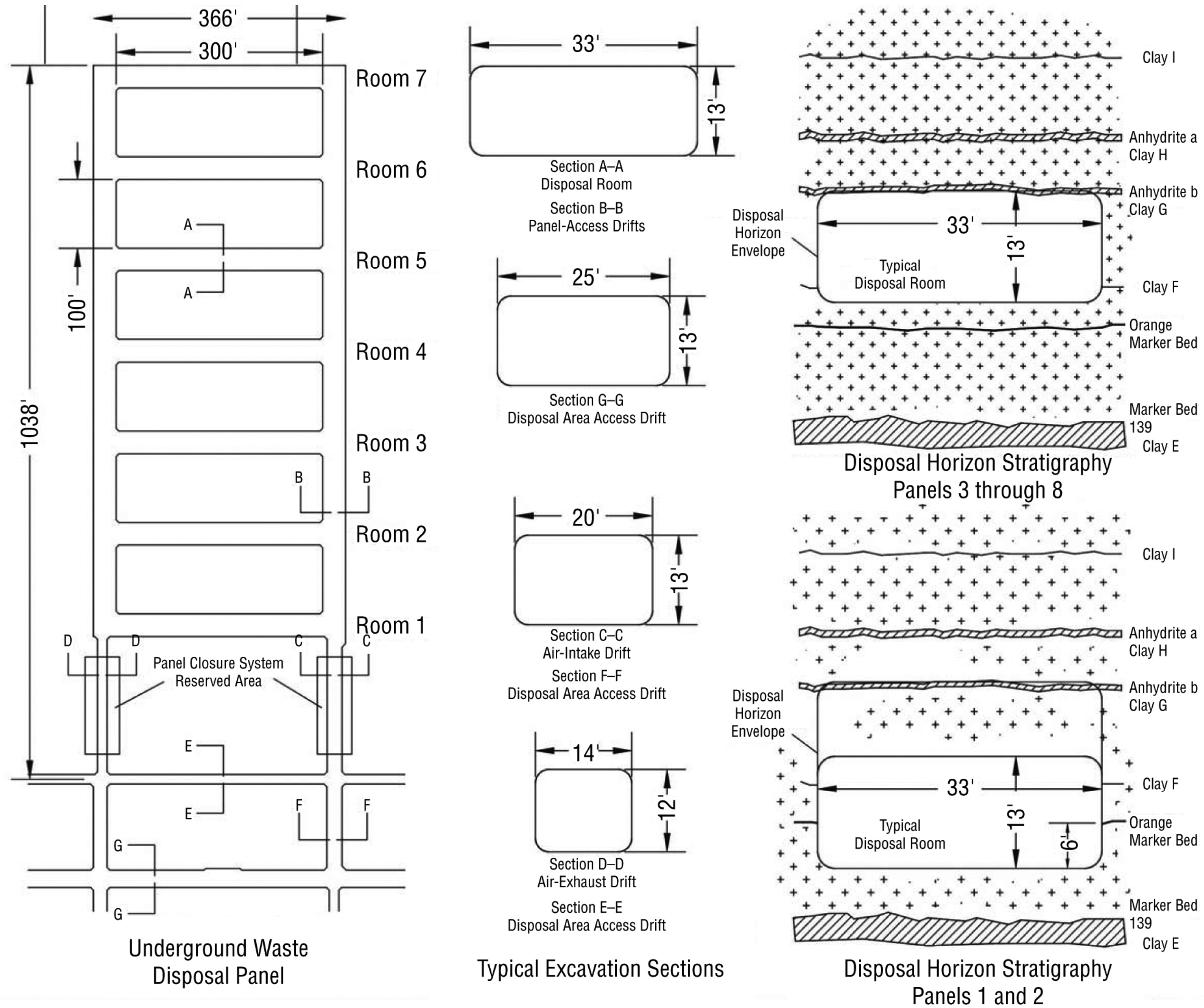


FIGURE 4.1.3-1 Layout of the Current (2010) Waste Disposal Region at WIPP



Note: Figure is not to scale
All dimensions shown are nominal

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FIGURE 4.1.3-2 Individual Panel Layout and Dimensions (Source: DOE 2004a)

4.1.4 Construction and Disposal Operations for GTCC LLRW and GTCC-Like Waste at WIPP

Discussions on the construction of additional rooms and disposal operations at WIPP are provided in Sections 4.1.4.1 and 4.1.4.2, respectively.

4.1.4.1 Construction

DOE has submitted a planned change request to use shielded containers for safe emplacement of selected RH TRU waste streams on the floor of the repository. The use of the shielded containers will enable DOE to significantly increase the efficiency of transportation and disposal operations for RH TRU waste at WIPP. Consistent with this planned change request, this EIS assumes that all RH waste would be placed in shielded containers and managed as if it was CH waste by being emplaced on floor space (instead of wall space, as is currently practiced at WIPP). This approach would be taken in order to minimize the number of additional rooms that would be needed for emplacement of the GTCC waste inventory. It is estimated that about 26 additional rooms would be needed to emplace the GTCC LLRW and GTCC-like waste (Group 1 and 2 volumes totaling 12,000 m^3 [420,000 ft^3]) (Sandia 2008a,b, 2010a).

Underground rooms are constructed by conventional mining techniques that use an electric-powered continuous miner rather than blasting. The mined salt is transported underground by diesel-powered haul trucks; once there, the salt is placed on the salt hoist and lifted to the surface. It is estimated that about 560,000,000 kg (or 560,000 t) of salt would be generated in the process of mining the underground rooms needed to emplace the GTCC LLRW and GTCC-like waste. The salt generated would be stored at the Salt Storage Area (Sandia 2008a).

Figure 4.1.4-1 shows a conceptual location of the 26 additional waste disposal rooms needed. The exact locations and orientations of these rooms would be determined on the basis of mining engineering, safety, and other factors.

For the purpose of this EIS, the number of years of construction is assumed to be 20 years. Information on the number of workers needed for construction, the amount of water used, the amount of waste generated, and the cost to construct the additional underground disposal rooms is provided in the appropriate topic areas of Section 4.3. Additional details on this information can be found in Sandia (2008a). Supplemental information on air emissions during construction is presented in Appendix D, Section D.9. These estimates were used to make the evaluations presented in Section 4.3 for the various environmental resource areas.

4.1.4.2 Disposal Operations

The GTCC waste inventory in Groups 1 and 2 would result in approximately 63,000 waste disposal containers (Sandia 2010a). The types of containers used would depend on the types of waste in the inventory. A stack of waste emplaced at WIPP is typically composed of

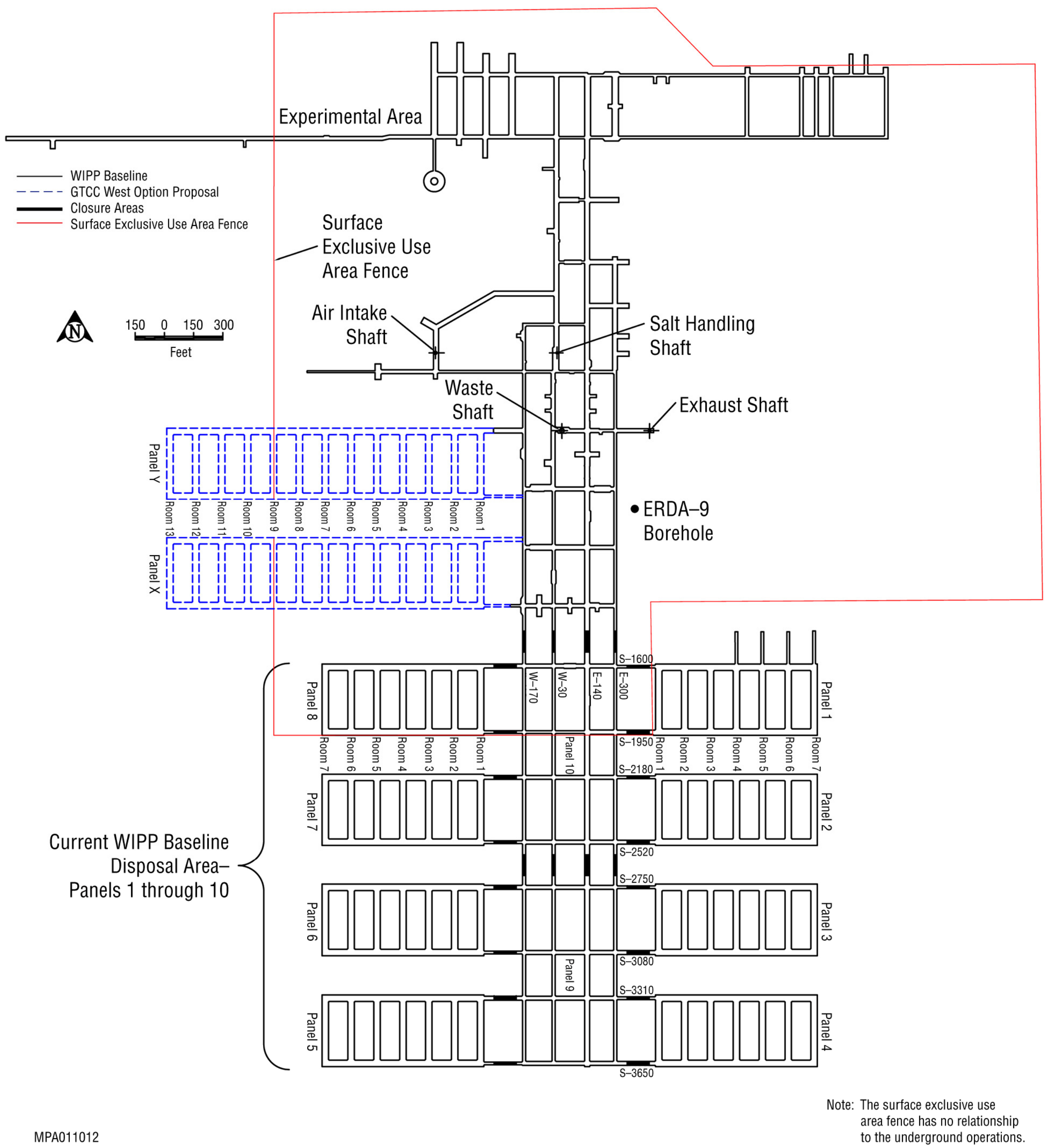

FIGURE 4.1.4-1 Conceptual Locations of 26 Additional Waste Disposal Rooms

three assemblies of various combinations; for example, three 7-packs in a stack or one SWB and two 7-packs in a stack.

Table 4.1.4-1 shows the various types of waste, the types of containers, the number of disposal containers, the number of stacks, and the number of rooms that would be needed. These estimates (and the supporting assumptions discussed in this section) are intended as input for the evaluations in this EIS only; the amounts could vary during actual implementation. In addition, random emplacement of GTCC LLRW and GTCC-like waste at WIPP rooms is assumed.

For GTCC LLRW and GTCC-like waste, it is assumed that activated metals would be managed as CH waste and would be packaged and emplaced in yet-to-be-developed, half-shielded activated metal canisters (h-SAMCs). The h-SAMCs would be designed to provide sufficient radiation shielding to allow for safe handling during waste disposal operations. These containers are also assumed to be emplaced in a 7-pack configuration. These 7-packs would be heavy assemblies and therefore would not be stacked on top of each other. It is also assumed that no waste would be placed on top of these 7-pack assemblies. It is expected that the current WIPP waste handling system (e.g., waste hoist and underground forklift) could accommodate GTCC waste packages, but they could be modified, if necessary. The WIPP waste hoist is rated to 45 tons, significantly more than the maximum weight of the shielded container packages, which weigh approximately 30,000 kg (66,000 lb). The RH underground forklift is rated at 41 tons. It may be assumed that the current WIPP waste handling system can accommodate the GTCC packages, but it is likely that some minor modification would be necessary.

For sealed sources, it is assumed that this type of waste would be contained in 208-L (55-gal) drums, except for the Cs-137 irradiators. A large number of containers could be generated if sources were not consolidated to the maximum extent allowable under the WIPP waste acceptance criteria (WAC) assumed in this EIS. The waste containers would be emplaced at WIPP as 7-packs similar to the configuration used for the activated metal h-SAMCs. These 7-packs would then be stacked three high. Figure 4.1.4-2 shows this configuration. The Cs-137 irradiators would be emplaced at WIPP in bundles of four as 4-packs. The weight of these 4-pack assemblies would not allow them to be stacked on top of one another. Although bagged magnesium oxide (MgO) is currently placed on top of each stack at WIPP, it is expected that this practice would not be needed for GTCC waste disposal at WIPP. The placement of bagged MgO is related to potential carbon dioxide generation caused by the degradation of cellulosic, plastic, and rubber (CPR) materials. TRU waste is mostly debris waste that contains large quantities of CPR materials. CPR is not expected to be a large component of the GTCC waste. There may be small amounts of plastic and rubber in GTCC packaging materials. However, plastic and rubber degradation is very uncertain and is modeled to occur in only 25% of the WIPP performance assessment vectors (less of an impact on performance). Anoxic corrosion of steel generates hydrogen, and MgO does not sequester hydrogen. In addition, MgO addresses a specific 40 CFR Part 191 engineered barrier requirement (assurance requirement) for WIPP. 10 CFR Part 61 does not address multiple assurance requirements as specifically as do 40 CFR Parts 191 and 194. It states that a sufficient depth or an engineered structure (engineered barrier) lasting 500 years can be used to inhibit an inadvertent intruder (in addition to the need for 100-year active institutional controls).

TABLE 4.1.4-1 Number of Containers, Stacks, and Rooms for GTCC LLRW and GTCC-Like Waste Emplacement at WIPP[a]

Description	Container Type	No. of Containers	Containers per Stack	No. of Stacks	No. of Rooms
Group 1					
GTCC LLRW					
Activated metals - RH					
Past/present commercial reactors	h-SAMC	12,595	7	1,800	4.5
Sealed sources - CH					
Small	55-gal drum	8,702	21	410	0.8
Cesium irradiators	Self-contained	1,435	4	360	0.7
Other Waste - CH	55-gal drum	203	21	9.7	0.02
Other Waste - RH	h-SAMC	172	7	25	0.1
GTCC-like waste					
Activated metals - RH	h-SAMC	70	7	10	0.02
Sealed sources - CH					
Small	55-gal drum	4	21	0.2	0.05
Other Waste - CH	55-gal drum	173	21	8.2	0.02
Other Waste - CH	SWB	381	3	130	0.2
Other Waste - RH	h-SAMC	3,654	7	520	1.3
Group 1 total		27,389	7	3,300	7.6
Group 2					
GTCC LLRW					
Activated metals - RH					
New BWRs	h-SAMC	956	7	140	0.3
New PWRs	h-SAMC	4,789	7	680	1.7
Additional commercial waste	h-SAMC	3,736	7	530	1.3
Other Waste - CH	SWB	829	3	280	0.5
Other Waste - RH	Shielded container	20,348	3	6,800	12
Other Waste - RH	h-SAMC	323	7	46	0.1
GTCC-like waste					
Other Waste - CH	SWB	261	3	87	0.2
Other Waste - RH	h-SAMC	4,441	7	630	1.6
Group 2 total		35,683		9,200	18
Total Groups 1 and 2		63,072		13,000	26

[a] CH = contact handled, h-SAMC = half-shielded activated metal canister, RH = remote handled, SWB = standard waste box. Number of containers was obtained from Sandia (2010a). All values except those in the "No. of Containers" column have been rounded to two significant figures.

FIGURE 4.1.4-2 Disposal of Contact-Handled Transuranic Waste in Typical 208-L (55-gal) Drum 7-Packs at WIPP (bagged magnesium oxide chemical buffer is on top of each stack) (Source: DOE 2007)

With regard to the category referred to as Other Waste, Other Waste - CH would be contained either in 208-L (55-gal) drums or in standard waste boxes (SWBs). The SWBs would be stacked three high for final disposal. Other Waste - RH would be contained either in h-SAMCs or lead-shielded containers.

DOE Order 231.1A, "Environmental Safety and Health Reporting," Order 450.1, "Environmental Protection Program," and DOE/EH 0173T, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," will require any GTCC disposal facility to monitor environmental factors, such as potential hazardous material releases, radioactive releases, and the environmental impacts of facility operations.

The number of workers needed for the disposal operations, water usage, waste generated, and cost to complete the emplacement of waste in the underground disposal rooms can be found in Sandia (2008a). Supplemental information on air emissions during operations is presented in Appendix D, Section D.9. These estimates are used in the evaluations presented in Section 4.3 for the various disciplines.

4.2 AFFECTED ENVIRONMENT

This section describes the affected environment for the various environmental resource areas evaluated for the disposal of GTCC LLRW and GTCC-like waste at WIPP.

4.2.1 Climate, Air Quality, and Noise

4.2.1.1 Climate

Located in Eddy County in the Chihuahuan Desert of southeastern New Mexico, the regional climate around the WIPP site is semiarid, characterized by warm temperatures, low precipitation and humidity, and a high rate of evaporation (DOE 1997).

A wind rose for 2006 at the 10-m (33-ft) level of the WIPP on-site meteorological station, which is located about 600 m (2,000 ft) northeast of the WHB, is presented in Figure 4.2.1-1. About 40% of the time, winds blew inclusively from the east-southeast to south-southeast, with the highest winds from the southeast (DOE 2007). Wind speeds categorized as calm (less than 0.5 m/s [1.1 mph]) occurred less than 0.5% in 2006. Winds of 3.71 to 6.30 m/s (8.30 to 14.1 mph) were the most prevalent, occurring about 36% of the time.

For the 1986–2007 period, the annual average temperature at the WIPP site was 17.9°C (64.3°F) (WRCC 2008). December was the coldest month, averaging 7.2°C (44.9°F) and ranging from –1.3°C to 15.6°C (29.6°F to 60.1°F), and July was the warmest month, averaging 28.4°C (83.2°F) and ranging from 20.6°C to 36.4°C (69.1°F to 97.5°F). For the same period, the highest temperatures reached 50.0°C (122°F) and the lowest reached –17.2°C (1°F). Days with a maximum temperature of higher than or equal to 32.2°C (90°F) occurred about one-third of the

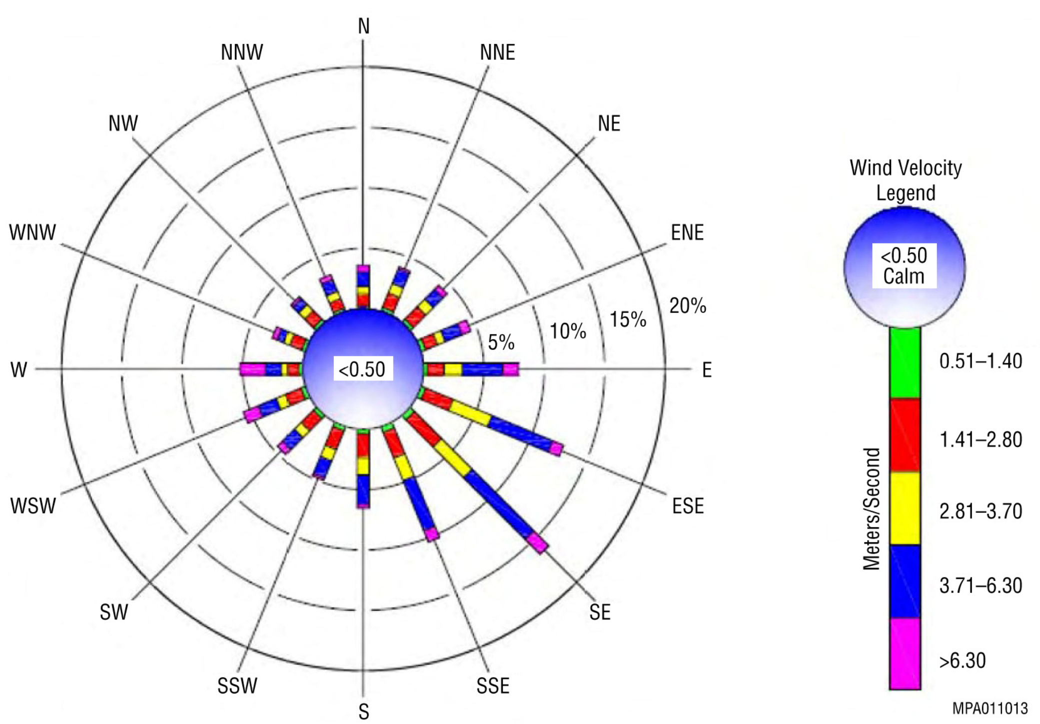

FIGURE 4.2.1-1 Wind Rose at the 10-m (33-ft) Level for the WIPP Site in 2006 (Source: DOE 2007)

time, while those with a minimum temperature of less than or equal to 0°C (32°F) occurred about 20% of the time.

Annual precipitation at the WIPP site averages about 33.8 cm (13.32 in.) (WRCC 2008). Precipitation is the highest in summer and tapers off markedly in winter. About 60% of the precipitation from June through September is in the form of high-intensity, short-duration thunderstorms, sometimes accompanied by hail (DOE 2004b). Rains are brief but occasionally intense and can result in flash flooding in arroyos and along the floodplains. Measurable snow is rare and, if it occurs, remains on the ground for only a short time. Light snow typically occurs from December to January, and the annual average snowfall in the area is about 2.3 cm (0.9 in.).

Strong winds are common and can blow from any direction, creating potentially violent windstorms that carry large volumes of dust and sand (DOE 2004b). In late winter and spring, there are strong west winds and dust storms. On rare occasions, a tropical hurricane may cause heavy rain in eastern and central New Mexico as it moves inland from the western part of the Gulf of Mexico, but there is no record of serious wind damage from these storms (WRCC 2008).

Tornadoes in the area surrounding the WIPP site, which is located on the edge of the tornado alley in the central United States, are common but less frequent and destructive than those in the tornado alley. For the period 1950–2008, 512 tornadoes were reported in New Mexico (an average of about 9 tornadoes per year; they occurred mostly at lower elevations in eastern New Mexico next to Texas (NCDC 2008). For the same period, a total of 52 tornadoes (an average of about 1 tornado per year) were reported in Eddy County, which includes the WIPP site. However, most tornadoes occurring in Eddy County were relatively weak (i.e., 49 were F0 or F1, and three were F2 on the Fujita tornado scale). No deaths and 29 injuries were associated with these tornadoes.

Fujita Scale of Tornado Intensities

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

4.2.1.2 Air Quality and Existing Air Emissions

The Clean Air Act Amendments (CAAA) of 1990 provides for the preservation, protection, and enhancement of air quality. Both the State of New Mexico and the EPA have authority for regulating compliance with portions of the CAAA. On the basis of an initial 1993 air emissions inventory, the WIPP site is not required to obtain Clean Air Act permits (DOE 2007). WIPP was required to obtain a New Mexico Air Quality Control Regulation 702 operating permit (recodified in 2001 as 20.2.72 *New Mexico Administrative Code* [NMAC], "Construction Permits") for two backup diesel generators at the site in 1993. There have been no activities or modifications to the operating conditions of the diesel generators that would require reporting under the conditions of the permit in 2006.

Annual emissions for major facility sources and total point and area sources for 2002 for criteria pollutants and VOCs in Eddy County, New Mexico, including the WIPP site, are presented in Table 4.2.1-1 (EPA 2008a). Data for 2002 are the most recent emission inventory data available on the EPA website. Area sources consist of nonpoint and mobile sources. Point sources account for most total sulfur dioxide (SO_2) and nitrogen oxides (NO_x) emissions in the county; SO_2 is emitted equally from industrial fuel combustion and from petroleum and related industries, and NO_x is emitted mostly from industrial fuel combustion. For carbon monoxide (CO) and particulate matter with a diameter of 10 μm or less (PM_{10}), area sources account for most of total emissions in the county; for volatile organic compounds (VOCs) and PM with a diameter of 2.5 μm or less ($PM_{2.5}$), emissions from area sources are higher than those from point sources. CO is emitted from on-road sources. PM_{10}/$PM_{2.5}$ are emitted from miscellaneous sources, and VOCs are omitted from many different activities, with the highest contribution coming from petroleum and related industries.

Among criteria pollutants (SO_2, nitrogen dioxide [NO_2], CO, O_3, PM_{10} and $PM_{2.5}$, and lead), the New Mexico State Ambient Air Quality Standards (SAAQS) are identical to the National Ambient Air Quality Standards (NAAQS) for NO_2 (EPA 2008b; 20.2.3 NMAC), as shown in Table 4.2.1-2. The State of New Mexico has established more stringent standards for SO_2 and CO but has 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 still retained the standard for total suspended particulates (TSP), which used to be one of the criteria pollutants but was replaced by PM_{10} in 1987.

TABLE 4.2.1-1 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds from Selected Major Facilities and Total Point and Area Source Emissions in Eddy County Encompassing the WIPP Site[a]

	Emission Rates (tons/yr)					
Emission Category	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Eddy County						
Agave Gas Plant[b]	*2,099*	*2.0*	*0.6*	*20.2*	*0.0*	*0.0*
Artesia Gas Plant	*838*	*919*	*301*	*52.6*	*1.9*	*1.9*
Empire Abo Plant	*0.0*	*29.1*	*1.0*	*2.2*	*1,307*	*1,143*
Indian Basin Gas Plant	*2,040*	*361*	*396*	*60.4*	*2.4*	*2.2*
Navajo Refining Co.–Artesia	*1,975*	*387*	*394*	*1,204*	*187*	*112*
Total point sources	7,515	6,661	5,399	3,444	1,847	1,569
Total area sources	268	1,776	20,326	4,778	25,479	3,175
County total	7,783	8,437	25,725	8,222	27,326[b]	4,744

[a] Emissions for selected major facilities are total point and area sources for 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.

Source: EPA (2009)

TABLE 4.2.1-2 National Ambient Air Quality Standards (NAAQS) or New Mexico State Ambient Air Quality Standards (SAAQS) and Highest Background Levels Representative of the WIPP Area, 2003–2007

			Highest Background Levels	
Pollutant[a]	Averaging Time	NAAQS/ SAAQS[b]	Concentration[c,d]	Location (Year)
SO_2	1-hour	75 ppb	–[e]	–
	3-hour	0.50 ppm	0.017 ppm (3.4%)	Artesia, Eddy Co. (2006)
	24-hour	0.10 ppm	0.004 ppm (4.0%)	Artesia, Eddy Co. (2006)
	Annual	0.02 ppm	0.001 ppm (5.0%)	Artesia, Eddy Co. (2007)
NO_2	1-hour	0.100 ppm	–	–
	24-hour	0.10 ppm	–	–
	Annual	0.05 ppm	0.006 ppm (12%)	Artesia, Eddy Co. (2003)
CO	1-hour	13.1 ppm	9.6 ppm (73%)	Albuquerque, Bernalillo Co. (2003)[f]
	8-hour	8.7 ppm	3.5 ppm (40%)	Albuquerque, Bernalillo Co. (2004)[f]
O_3	1-hour	0.12 ppm[g,h]	0.086 ppm (72%)	Carlsbad, Eddy Co. (2006)
	8-hour	0.075 ppm[h]	0.076 ppm (101%)	Carlsbad, Eddy Co. (2006)
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 $\mu g/m^3$ [h]	88 $\mu g/m^3$ (59%)	Hobbs, Lea Co. (2003)
$PM_{2.5}$	24-hour	35 $\mu g/m^3$ [h]	18 $\mu g/m^3$ (51%)	Hobbs, Lea Co. (2005)
	Annual	15.0 $\mu g/m^3$ [h]	7.3 $\mu g/m^3$ (49%)	Hobbs, Lea Co. (2007)
Lead[i]	Calendar quarter	1.5 $\mu g/m^3$ [h]	0.03 $\mu g/m^3$ (2.0%)	Bernalillo Co. (2003)[f]
	Rolling 3-month	0.15 $\mu g/m^3$ [h]	–	–
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; second-highest for 1-hour, 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 New Mexico are not representative of the WIPP 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 4.2.1-2 (Cont.)

[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] Values are NAAQS. No SAAQS exists.

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

Sources: EPA (2008a, 2009); 20.2.3 NMAC (refer to http://www.nmcpr.state.nm.us/nmac/parts/title20/20.002.0003.pdf)

The WIPP site is located in Eddy County. Currently, the entire county, including the WIPP site, is designated as being in attainment for all criteria pollutants (40 CFR 81.332). The whole state is designated as an attainment area, except for a small portion in the south-central part of the state, Anthony (adjacent to El Paso, Texas), which is not in attainment for PM_{10}.

Seven classes of EPA-regulated pollutants have been monitored at WIPP since August 1986. Monitoring results indicated that air quality around the WIPP site usually met state and federal standards, except for occasional exceedances of TSP during periods of high wind and blowing sands and infrequent exceedances of SO_2 (DOE 1997). On October 30, 1994, DOE, after notifying the EPA, terminated on-site monitoring of criteria pollutants at the WIPP site because there was no longer a regulatory requirement to do so. Currently, VOC monitoring is performed to comply with the provisions of the WIPP Hazardous Waste Facility Permit. In 2006, three of the nine target compounds were detected above the method reporting limit (DOE 2007). The most substantial results were at least three orders of magnitude below the lower action level as described by the Hazardous Waste Facility Permit.

To establish representative background concentrations for the WIPP site, nearby urban or suburban measurements were used. The highest concentration levels for SO_2, NO_2, PM_{10}, and $PM_{2.5}$ around the WIPP site are less than or equal to 59% of their respective standards in Table 4.2.1-2 (EPA 2008b). However, the highest O_3 concentrations are a little higher than the applicable standards in the area. No measurement data for CO and lead around the WIPP site are available, but those values are expected to be lower. They would be lower for CO because of the distance from urban areas and major highways, and they would be lower for lead because of the distance from industrial processes, such as smelters.

The WIPP site and its vicinity are classified as Prevention of Significant Deterioration (PSD) Class II areas. The nearest Class I area is Carlsbad Caverns National Park, about 61 km (38 mi) west-southwest of WIPP (40 CFR 81.421). Guadalupe Mountains National Park in Texas is about 100 km (62 mi) west-southwest of WIPP (40 CFR 81.429). There are no facilities currently operating at the WIPP site that are subject to PSD regulations.

4.2.1.3 Existing Noise Environment

The State of New Mexico and Eddy County have established no quantitative noise-level regulations.

The major noise sources associated with disposal operations at WIPP include traffic noise from site workforce vehicles, salt haulage vehicles, and waste transport vehicles; from the WHB during normal operations; and from infrequent emergency diesel generator testing. The Final EIS for WIPP reported that an overall sound pressure level of 50 dBA might occur 120 m (400 ft) away as a result of normal operations. Because the WIPP facility is more than 2.4 km (1.5 mi) from the fence line, generator noise is inaudible at the fence line and hence at any nearby residence.

The ambient noise level in the WIPP area before construction was 26 to 28 dBA, similar to wilderness natural background noise levels (DOE 1997). For the general area surrounding the WIPP site, the countywide day-night sound level (L_{dn}) based on population density is estimated to be 33 dBA for Eddy County, typical of the lower end of the range for rural areas (33–47 dBA) (Eldred 1982).

4.2.2 Geology and Soils

The WIPP repository is located in the Salado Formation, a massive bedded salt unit, about 655 m (2,150 ft) below the ground surface. The following sections provide an overview of the regional geologic setting and stratigraphy, with an emphasis on the Salado Formation and the formations directly above and below it.

4.2.2.1 Geology

4.2.2.1.1 Physiography. WIPP is located in southeastern New Mexico, in the Pecos Valley Section of the Great Plains physiographic province (Figure 4.2.2-1). The terrain throughout the province varies from plains and lowlands to rugged canyons. In the immediate vicinity of WIPP, numerous small mounds formed by wind-blown sand characterize the land surface. A 410,000- to 510,000-year-old layer enriched in calcium carbonate material, the Mescalero caliche, is typically present beneath the surface layer of sand. The caliche layer overlies a 600,000-year-old volcanic ash layer (DOE 1996b). The Mescalero caliche can be found over large portions of the Pecos River drainage area and is generally considered to be an indicator of surface stability (DOE 1980).

A high plains desert environment characterizes the area. Because of the seasonal nature of the rainfall, most surface drainage is intermittent. The Pecos River, 16 km (10 mi) southwest of the WIPP boundary, is a perennial river and the master drainage for the region. A natural divide lies between the Pecos River and the WIPP site. As a result, the Pecos drainage system

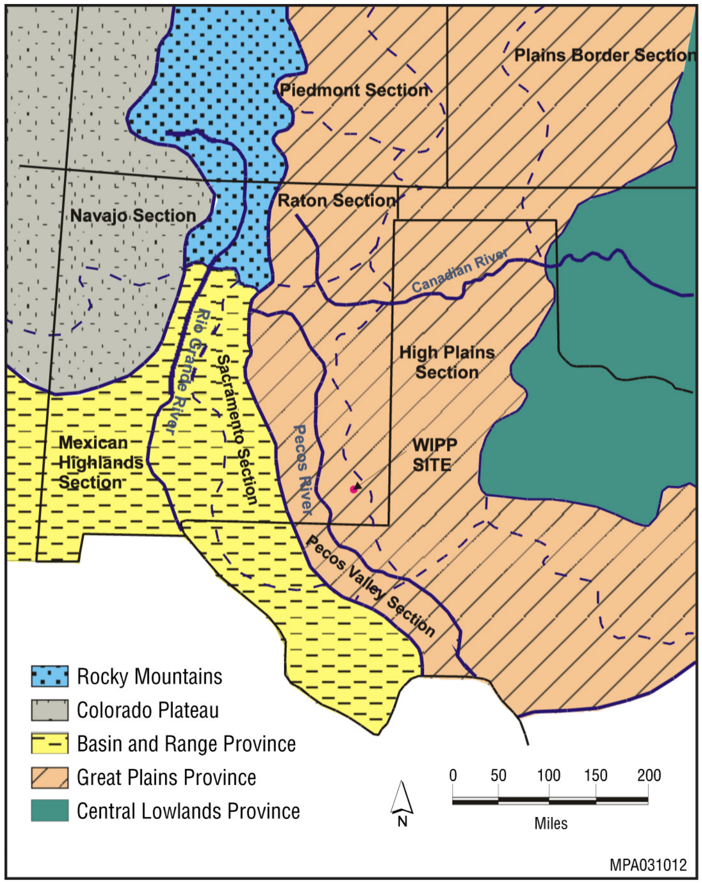

FIGURE 4.2.2-1 Location of the WIPP Site within the Great Plains Province in Southeastern New Mexico (Source: DOE 1997)

does not currently affect the site. Local surface drainage features include Nash Draw and the San Simon Swale.

4.2.2.1.2 Topography. The topography of the Pecos Valley section ranges from flat plains and lowlands to rugged canyon lands, with elevations of 1,830 m (6,000 ft) mean sea level (MSL) in the northwest, 1,520 m (5,000 ft) MSL in the north, 1,220 m (4,000 ft) MSL in the east, and 610 m (2,000 ft) MSL in the south. The valley has an uneven rock floor, resulting from differential weathering of limestones, sandstones, shales, and gypsums. The Pecos Valley section is drained mainly by the Pecos River, the only perennial stream in the region. The Pecos drainage system flows to the southeast; its closest point is about 16 km (10 mi) from the WIPP site. The Pecos River Valley shows characteristic lowland topography marked by widespread karst topography, with solution-subsidence features (e.g., sinkholes) resulting from dissolution of Permian rocks from the Ochoan Series (Powers et al. 1978; Mercer 1983).

The land surface of the WIPP site is hummocky, with numerous eolian sand ridges and dunes, and it slopes gently from an elevation of about 1,090 m (3,570 ft) MSL at its eastern boundary to about 990 m (3,250 ft) MSL along its western boundary. An extensive layer of hard caliche (the Mescalero caliche) lies between the surficial sand deposits and the underlying Gatuña Formation. It ranges in age from about 510,000 years at its base to 410,000 years at the top (Powers et al. 1978; DOE 1997).

4.2.2.1.3 Site Geology and Stratigraphy. The WIPP site is located in the northern portion of the Delaware Basin, a structural basin underlying present-day southeastern New Mexico and western Texas that contains a thick sequence of sandstones, shales, carbonates, and evaporites. The WIPP repository is located at a depth of approximately 655 m (2,150 ft) in rocks of Permian age. The sediments accumulated during the Permian period represent the thickest portion of the sequence in the northern Delaware Basin and are divided into four series (Figure 4.2.2-2). From oldest to youngest, these series are the Wolfcampian, Leonardian, Guadalupian, and Ochoan. The Ochoan Series consists of extensive evaporite deposits; the series is divided into four formations. From oldest to youngest, these formations are Castile, Salado (the lower part of which contains the WIPP repository), Rustler, and Dewey Lake.

The following sections describe the geologic formations important to understanding the long-term performance of WIPP, starting with the host rock for the WIPP repository (the Salado

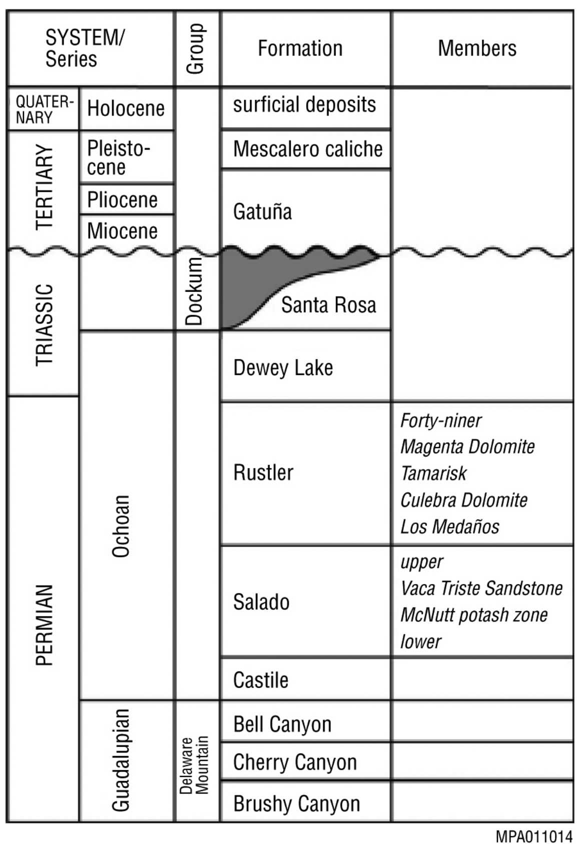

FIGURE 4.2.2-2 Stratigraphic Column for the WIPP Site and Surrounding Area (Source: EPA 2006)

Formation), the formations below the Salado (the Castile and Bell Canyon Formations), and the formations above the Salado (the Rustler, Dewey Lake, Santa Rosa, and Gatuña Formations).

Salado Formation. The Permian Salado Formation is a massive bedded salt formation that is predominantly halite (sodium chloride) and is thick and laterally extensive. DOE selected the Salado Formation as the site of the WIPP repository for several geologically related reasons (DOE 1980, 1990): (1) the Salado halite units have very low permeability to fluid flow, which impedes groundwater flow into and out of the repository; (2) the Salado is regionally widespread; (3) the Salado includes continuous halite beds without complicated structure; (4) the Salado is deep with little potential for dissolution; (5) the Salado is near enough to the surface that access is reasonable; and (6) the Salado is largely free of mobile groundwater, when compared with existing mines and other potential repository sites.

The Salado Formation ranges in thickness from approximately 540 to 646 m (1,770 to 2,120 ft). The Salado is composed of four members. From oldest to youngest, they are the Lower Member, the McNutt Potash Member, the Vaca Triste Sandstone, and the Upper Member. The WIPP repository is located in the Lower Member and in the thickest part of the Salado Formation.

Castile Formation. The Permian Castile Formation directly underlies the Salado Formation and typically consists of three relatively thick anhydrite/carbonate units and two thick halite units in the WIPP area. It is approximately 390-m (1,280-ft) thick and is present from approximately 810 to 1,200 m (2,660 to 3,940 ft) bgs at the site, which is approximately 155 m (509 ft) below the level of the repository. The more brittle anhydrite units of the Castile are locally fractured, and the fracture zones are relatively permeable and act as zones for accumulation of brine trapped in the Castile since the Permian (DOE 1997).

Bell Canyon Formation. The Permian Bell Canyon Formation underlies the Castile Formation and is composed of a layered sequence of sandstones, shales, siltstones, and limestones near the WIPP site. It is also the uppermost target of hydrocarbon exploration in the local area. It is approximately 350-m (1,150-ft) thick and is present from approximately 1,200 to 1,550 m (3,940 to 5,090 ft) bgs at the site. The top of the Bell Canyon is approximately 545 m (1,790 ft) below the level of the repository.

Rustler Formation. The upper Permian Rustler Formation lies above the WIPP repository and directly overlies the Salado Formation. It is divided into five members. From the base of the Rustler Formation, these members are the Los Medaños, the Culebra Dolomite, the Tamarisk, the Magenta Dolomite, and the Forty-niner. The Culebra consists of locally argillaceous and arenaceous, well to poorly indurated dolomicrite with numerous cavities (vugs), fractures, and silty zones. The Magenta is a silty, gypsiferous, laminated dolomite. The other three members contain layers of claystone or mudstone sandwiched between layers of anhydrite/gypsum. In the southeast corner of the WIPP site and farther to the east, halite beds are also present in the non-dolomite members of the Rustler Formation. The Rustler Formation is approximately 94-m (310-ft) thick and is present from approximately 164 to 257 m (538 to 843 ft) bgs at the WIPP site. The top of the formation dips to the east-northeast across much of the WIPP site (Powers 2009). Its base is approximately 400 m (1,312 ft) above the level of the repository. The Rustler Formation contains the most extensive water-bearing units in the WIPP site area.

Dewey Lake Formation. The Dewey Lake Formation overlies the Rustler Formation at WIPP and is Permo-Triassic in age. It consists largely of reddish-brown siltstones and claystones, with lesser amounts of very fine to fine sandstone. Sediments are typically cemented with sulfates (gypsum and anhydrite). The formation generally thickens across the WIPP site from west to east to a maximum thickness of more than 183 m (600 ft) in the eastern part of the Delaware Basin east of the site. At the WIPP site, it is approximately 146-m (480-ft) thick and occurs from approximately 16 to 162 m (52 to 532 ft) bgs. The base of the Dewey Lake is approximately 495 m (1,623 ft) above the level of the repository. The surface water from Dewey Lake is primarily used for livestock watering and irrigation (Powers 2009).

Santa Rosa Formation. The Triassic Santa Rosa Formation, the basal formation of the Dockum Group, overlies the Dewey Lake Formation and consists of light reddish-brown sandstones and conglomerates, siltstone, and claystone. The Santa Rosa Formation is several hundred feet thick east of the WIPP site, but it thins to the west. It is about 12-m (40-ft) thick near the center of the WIPP site and is absent in the western third of the site as a result of erosion. The Santa Rosa is used as a source of groundwater to the east of the WIPP site (DOE 1996b; Powers 2009).

Gatuña Formation. The Miocene-Pleistocene Gatuña Formation overlies the Santa Rosa Formation and is somewhat similar in lithology and color, although the Gatuña is also characterized by a wide range of lithologies (coarse conglomerates to gypsum-bearing claystones). The upper Gatuña contains a 600,000-year-old volcanic ash layer (DOE 1996b). The formation is generally less than 15-m (50-ft) thick across the WIPP site and occurs at depths of 4.6 to 6.1 m (15 to 20 ft) bgs. The Gatuña Formation is in turn overlain by the Mescalero caliche and surficial sand deposits (Powers 2009).

Mescalero Caliche and Other Surface Deposits. The Mescalero caliche is a pedogenic carbonate unit that is continuous across the WIPP site, with thicknesses of up to 1.8 m (6 ft). The unit is exposed in places but may also underlie dune sand (to depths of up to 6.1 m [20 ft]). The continuity of the Mescalero is disrupted by erosion and solution and by plant growth. Funnel-like features called “flowerpots” can be seen throughout areas where the unit is well-exposed; mesquite and creosote bush root systems are found in some of these features. The presence of the Mescalero caliche indicates general stability across the land surface, since it took about 100,000 years to form and developed about 500,000 years ago (Powers 2009).

Above the Mescalero is the Berino soil, a thick, reddish, semiconsolidated sand containing little carbonate, ranging in thickness from centimeters (inches) to 0.30 to 0.61 m (1 to 2 ft). The Berino soil is likely derived from wind-blown material modified by pedogenic processes. It is often found in flowerpots and as a thin soil veneer on the surface of the Mescalero caliche (Powers 2009).

4.2.2.1.4 Seismicity. No surface displacement or faulting younger than early Permian has been reported, indicating that tectonic movement since then, if any, has not been noteworthy. No mapped Quaternary (last 1.9 million years) or Holocene (last 10,000 years) faults exist closer to the site than the western escarpment of the Guadalupe Mountains, about 100 km (60 mi) to the west-southwest (DOE 1997).

The strongest earthquake on record within 290 km (180 mi) of the site was the Valentine, Texas, earthquake of August 16, 1931 (DOE 1997), with an estimated Richter magnitude of 6.4. A modified Mercalli intensity of V was estimated for this earthquake's ground shaking at WIPP. At Intensity V, ground shaking is felt by nearly everyone; a few instances of cracked plaster occur; and unstable objects are overturned. This is the strongest ground-shaking intensity known for the WIPP site.

From November 1974 to August 2006, the largest earthquake within 300 km (184 mi) of the WIPP site occurred on April 14, 1995 (based on a search of the U.S. Geological Survey [USGS] National Earthquake Information Center data). It was located 32 km (20 mi) east-southeast of Alpine, Texas (approximately 240 km [150 mi] south of the site) and was assigned a Richter magnitude of 5.7. It was the largest event within 300 km (184 mi) of the site since the Valentine, Texas, earthquake, and had no effect on any structures at WIPP (Sanford et al. 1995). From 1974 to 2006, recorded earthquakes within a 300-km (184-mi) radius of WIPP have ranged from magnitude 2.3 to 5.7 (USGS 2010).

4.2.2.1.5 Volcanic Activity. The nearest potentially active volcanoes are in the Zuni-Bandera volcanic field in northwestern New Mexico. Volcanoes in this area are of the cinder cone (basaltic) type. They have not been active in at least 2,000 years and are considered to be dormant (New Mexico Bureau of Geology and Mineral Resources 2008).

4.2.2.2 Mineral and Energy Resources

4.2.2.2.1 Hydrocarbons. Prior to 1970, most commercially related drilling in the WIPP area targeted shallow oil (1,200 to 1,400 m [3,940 to 4,590 ft] in depth) in the Bell Canyon Formation. From 1970 to the mid-1980s, most drilling near WIPP focused on gas exploration in the deeper Morrow and Atoka Formations (approximately 4,000 m [13,100 ft]). During the late 1980s and early 1990s, commercial oil was discovered in the Permian Cherry Canyon and Brushy Canyon Formations, which lie below the Bell Canyon Formation described above. These discoveries were made at locations adjacent to the eastern and northeastern boundary of WIPP, at a depth of approximately 2,100 to 2,400 m (6,890 to 7,870 ft). These formations are the primary exploration and development targets in the Permian Basin, one of the most actively explored areas in the United States (Broadhead et al. 1995).

Oil and gas exploration drilling activities in the New Mexico portion of the Permian Basin (in which the WIPP site is located) have fluctuated considerably since 1997. As many as 57 rigs were working in the basin in late 1997, but the maximum number dropped to about 15 in 2000. The maximum rig count increased to approximately 65 in 2001, dropped to the low 30s in 2002, and then steadily increased to approximately 60 in 2005. It is assumed that hydrocarbon exploration drilling activities in the region of the WIPP site will continue for the foreseeable future (*Crossroads* 2005).

Within and immediately around the WIPP Land Withdrawal Boundary (LWB), significant reserves of recoverable oil and gas may be present in the Morrow and Atoka Formations and in shallower Bell Canyon and Cherry Canyon Formation reservoirs (Broadhead et al. 1995).

4.2.2.2.2 Potash. Bedded potash (a mixture of several soluble oxide, sulfate, and chloride compounds containing potassium, used chiefly in fertilizers) was discovered in Eddy County, New Mexico, in 1925. By 1944, New Mexico was the largest domestic potash producer, representing 85% of consumption. Development continued through the 1950s and 1960s, reversed in the 1970s, and had declined by the mid 1990s.

Since 1997, potash mining activities in the region of the WIPP site have continued. Approximately 1,500,000 tons of potash were produced in 1997, and production has slowly declined since that time. In 2005, approximately 1,000,000 tons were produced (NMEMNRD 2006).

The majority of actively mined and potential resources of potash ore are found in the 37-m-thick (120-ft-thick) McNutt Member of the Salado Formation, which is the host for 11 ore zones.

4.2.3 Water Resources

4.2.3.1 Surface Water

There are no natural surface water bodies within the boundaries of the WIPP site. Widespread eolian (sand dune) deposits that are of Holocene age or older indicate that little surface drainage has developed within and around the site. The nearest significant surface water body, Laguna Grande de la Sal, is located about 13 km (8 mi) west-southwest of the site in Nash

Draw,[1] where there are shallow brine ponds. Small, man-made earthen livestock watering holes (called "tanks") occur around the WIPP site, particularly to the south, but are not hydrologically connected to the formations overlying the WIPP repository. The watering holes are constructed to hold runoff and not allow it to infiltrate. There may be minor leakage through the unsaturated zone beneath them that eventually reaches a Dewey Lake water table. The predominant use of surface water in the region is for livestock watering and irrigation (DOE 1997, 2008a; Powers 2009).

The Pecos River is the only perennial stream in the region (Figure 4.1.1-1). The river flows to the south-southeast and is, at its closest point (the Malaga Bend), about 16 km (10 mi) west of the WIPP site. The WIPP site is within the Pecos River drainage basin, although a natural divide lies between the Pecos River and the WIPP site. As a result, the Pecos drainage system does not currently affect the site. At least 90% of the mean annual precipitation at the WIPP site (30 cm [12 in.]) is lost by evapotranspiration, although precipitation rates may exceed evapotranspiration during intense thunderstorms that produce runoff and percolation. The average annual streamflow of the Pecos River at Malaga Bend (from 1938 through 2008) was 4.6 m^3/s or cms (164.5 ft^3/s or cfs) (USGS 2009). The maximum recorded streamflow (with a monthly mean of 119 cms [4,200 cfs]) occurred in August 1996 at the Malaga Bend; its maximum elevation was 90 m (300 ft) below the surface elevation of the WIPP site (USGS 2009; DOE 1997, 2006a).

Surface water samples collected along the Pecos River and from various tanks around the WIPP site are routinely analyzed for radionuclides, including U, Pu, Am, K-40, Co-60, Cs-137, and Sr-90. In 2007, uranium and plutonium concentrations were compared to baseline levels observed between 1985 and 1989. The highest concentrations of U-234, U-235, and U-238 detected in the Pecos River and surrounding tanks were found to fall within the ranges of baseline levels. Pu-238, Pu-239, and Pu-240 were not detected. Am-241 was found in water (at 1.14×10^{-3} Bq/L) from Tut tank, northwest of the border of the WIPP site (but no baseline data were available for comparison). The only other radionuclide exceeding its baseline value was K-40, found in a sample from an on-site sewage lagoon at 148 Bq/L (the baseline value for K-40 was 76 Bq/L) (DOE 2008a).

4.2.3.2 Groundwater

4.2.3.2.1 Water-Bearing Units. Several water-bearing zones have been identified and extensively studied at and near the WIPP site. Limited amounts of potable water are found in the middle Dewey Lake Formation and the overlying Triassic Dockum Group (Santa Rosa Sandstone) in the southern part within the WIPP LWB. Two water-bearing units in the Rustler Formation, the Culebra and Magenta Dolomite Members, produce brackish to saline water at the WIPP site and surrounding locations. Another very-low-transmissivity, saline water-bearing

[1] Nash Draw is a surface depression, about 32-km (20-mi) long and 8- to 19-km (5- to 12-mi) wide, located about 6 km (3.7 mi) to the west of the WIPP site (Lorenz 2006). The valley is notable for its karst features and for exposures of some of the geologic units underlying the WIPP region.

zone occurs along the contact between the Rustler and Salado Formations (DOE 2008a). Mercer (1983) reports no evidence of water in the Gatuña Formation or surficial materials at the WIPP site. Figure 4.2.3-1 shows the stratigraphic relationships of these aquifer units.

Lower Water-Bearing Horizons (below Salado Formation). The Castile Formation is the basal unit of the Ochoan series and represents the oldest of the water-bearing units at the WIPP site. The term "water-bearing horizons" is used in this discussion because nothing below the Salado can properly be termed an aquifer. The formation is about 390-m (1,280-ft) thick and lies about 244 m (800 ft) below the level of the repository. It consists of three thick anhydrite units interbedded with halite and acts as an aquitard between the overlying Salado Formation and the underlying water-bearing sandstones, shales, and limestones of the Bell Canyon Formation (Guadalupian series). No regional groundwater flow system appears to be present in the Castile Formation in the WIPP site area. Fracturing within an anhydrite layer of the upper Castile has

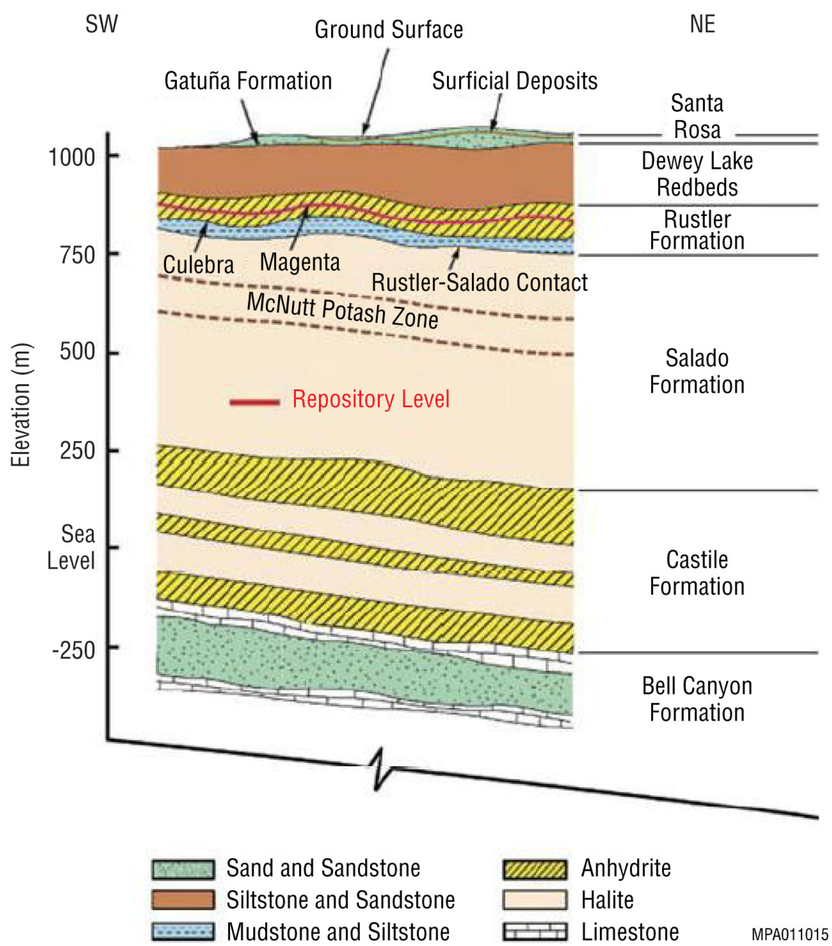

FIGURE 4.2.3-1 Stratigraphy of Aquifer Units at the WIPP Site (DOE 2008b)

created isolated, high-permeability regions (brine reservoirs) that contain brine at higher-than-hydrostatic pressure (Popielak et al. 1983; DOE 1996a, 1999, 2008a).

Salado Formation (WIPP Repository Horizon). The WIPP repository lies entirely within the massive halite beds of the Salado Formation, a regional aquiclude.[2] Estimated hydraulic conductivities range from 10^{-16} to 10^{-11} m/s for impure halite intervals and from 10^{-13} to 10^{-10} m/s in anhydrite (Roberts et al. 1999; Beauheim and Roberts 2002). Although the hydraulic conductivity of the Salado Formation is extremely low, it is not dry. Brine content within the Salado is estimated at 1–2% by weight, and thin clay seams have been observed to contain up to 25% brine by volume (DOE 1999).

Occurrence of groundwater in the Salado Formation is restricted because halite does not have primary porosity, solution channels, or open fractures. No evidence of circulating water has been found in the unit; however, small pockets of brine (e.g., in Marker Bed 139, which is an anhydrite rather than a halite) and nonflammable gas have been found. Inflow of brine into the repository excavation has been observed in boreholes and from “weeps,” which are localized brine seeps issuing from the surfaces of the repository walls, floors, and roofs. The volumes of brine observed from these occurrences have been small, and flow into the repository ceased within three years of initial observation. Nevertheless, for the long term, it is reasonable and conservative to consider that there may be brine near the repository that would flow toward and into the repository, albeit at a low rate (DOE 1996a, 2008a).

Brine inflow is a concern for the repository in that the brine would provide necessary moisture for the degradation of certain waste material components and gas generation.

Upper Water-Bearing Horizons (above the Salado Formation). Directly above the Salado Formation in Nash Draw is a zone of dissolution residue capable of transmitting water. The transmissivity of this interval, referred to as the Rustler-Salado contact, decreases from Nash Draw eastward to the WIPP site area. Small quantities of brine were found in this zone in WIPP site test holes (DOE 2008a).

The 95-m (310-ft) thick Rustler Formation, which directly overlies the Salado Formation, ranges in depth from 164 to 257 m (538 to 843 ft) at the WIPP site. Its base is about 398 m (1,310 ft) above the level of the repository. The five members of the Rustler Formation are described in Section 4.2.2.1.3. In ascending order, these members are the Los Medaños Member, Culebra Dolomite Member, Tamarisk Member, Magenta Dolomite Member, and Forty-niner Member. Only the Culebra and Magenta Dolomite Members have enough transmissivity to produce water to wells. The other three members act as aquitards (DOE 1996a).

The Culebra Dolomite Member of the Rustler Formation is composed predominantly of fractured, microcrystalline dolomite and ranges in thickness from 5.8 to 12.5 m (19 to 41 ft) in the WIPP site region. It is the first significant water-bearing unit above the Salado Formation at

[2] An aquiclude is a hydrologic unit that contains groundwater but does not transmit it.

the WIPP site. Regional flow of groundwater in the Culebra Dolomite is generally to the south. Because of its lateral continuity and high transmissivity (as high as 10^{-3} m^2/s [DOE 2008b]), it is considered to be the most likely pathway for radionuclide releases from the repository to the accessible environment. Estimates of hydraulic conductivity in the Culebra Dolomite vary widely, but in general, they decrease from 10^{-4} m/s in Nash Draw to 10^{-14} m/s east of the WIPP site (DOE 1999). These conductivity variations are believed to be controlled by the relative abundance of pore-filling cements, stress-relief fracturing, and fracturing related to dissolution of the upper Salado Formation rather than by primary depositional features of the unit. Porosities measured in core samples from the Culebra range from 0.03 to 0.30 (Kelley and Saulnier 1990; TerraTek, Inc. 1996). Although the dolomite matrix provides most of the unit's storage capacity, fluid movement occurs mainly through fractures and vugs. Recent studies of the Culebra show that it is a heterogeneous system with anisotropic characteristics, suggesting variability of fracture orientations on a local scale, especially in the WIPP site area (DOE 2008a; Lorenz 2006). These studies support the interpretation that the Culebra Dolomite and other members of the Rustler Formation are unkarsted strata (Lorenz 2006; DOE 2008b).

The Magenta Dolomite Member of the Rustler Formation is above the Culebra Dolomite and is separated from it by the Tamarisk Member. The Magenta is about 8-m (26-ft) thick and consists of fine-grained gypsiferous dolomite. The Magenta Dolomite is less transmissive (about 10^{-7} m^2/s [DOE 2008b]) than the Culebra Dolomite, having hydraulic conductivities one to two orders of magnitude less than those of the Culebra in most locations (from 10^{-9} to 10^{-3} m/s). Like those of the Culebra Dolomite, its hydraulic conductivities increase to the west toward Nash Draw. The hydraulic gradient of the Magenta also increases toward the west, ranging from 0.003 to 0.0038 on the east side of the WIPP site to 0.0061 along its west side (DOE 1997, 1999).

The reddish-brown fine sandstone, siltstone, and silty claystone of the Dewey Lake Red Beds Formation overlie the Rustler Formation. The formation is about 150-m (490-ft) thick at the center of the WIPP site, thinning to the west. The upper portion of the Dewey Lake consists of a fairly thick (up to 80 m [164 ft]) unsaturated zone. Just below this zone is a saturated zone perched above a cementation change from carbonate (above) to sulfate (below). The saturated zone, which makes up the middle portion of the Dewey Lake, occurs at depths of about 50 to 80 m (164 to 262 ft). In this zone, water is transmitted through open fractures. Below it, fractures tend to be completely filled with gypsum (DOE 1999, 2008a).

The Santa Rosa Formation thins from being 66-m (217-ft) thick along the eastern WIPP site boundary to zero near the center of the WIPP site. Anthropogenic water (e.g., irrigation water) has been found in the formation in the center part of the WIPP site. The Gatuña Formation unconformably overlies the Santa Rosa. It ranges in thickness from about 6 to 9 m (19 to 31 ft) and consists of silt, sand, and clay, with deposits formed in localized depressions. Saturation in the Gatuña occurs in discontinuous perched zones. This water may also have an anthropogenic source (DOE 1999, 2008a).

4.2.3.2.2 Groundwater Quality. Groundwater samples from monitoring wells in the Culebra Member of the Rustler Formation have been characterized as saline to brine, with total dissolved solid concentrations ranging from 4,000 to 360,000 mg/L. Water from the Culebra has been classified as Class III water by EPA guidelines and is not acceptable for human consumption or for agricultural purposes (Richey et al. 1985; DOE 2007). DOE (2007) reports there is no WIPP-related contamination in groundwater from the Culebra Member.

Groundwater in the overlying Dewey Lake Formation is of better quality, with an averaged total dissolved solids value of 3,350 mg/L. This water has been classified as Class II water by EPA guidelines and is suitable for livestock consumption (DOE 2007).

4.2.3.3 Water Use

The WIPP site water supply is categorized as a nontransient, noncommunity system for reporting and testing requirements. Water service for the WIPP facility is furnished by the City of Carlsbad from a City-owned waterline that originates at the Double Eagle South Well Field 31 mi (50 km) north of the facility. The volume capacity of the waterline is such that it meets all water requirements for the operation of the WIPP facility. As specified in a bill of sale transferring this waterline from DOE to the City in June of 2009, Carlsbad will provide up to 25 million L/yr (6.6 million gal/yr) water to the WIPP facility free of charge for the next 100 years. Annual water use at the WIPP site is approximately 20 million L/yr (5.4 million gal/yr) (Sandia 2008a).

The City of Carlsbad is serviced by two separate well fields: Sheep's Draw and Double Eagle. Approximately 98% of Carlsbad's water is supplied by groundwater pumped from nine wells located 11 km (7 mi) southwest of Carlsbad in an area called Sheep's Draw in the foothills of the Guadalupe Mountains. The other 2% comes from the Double Eagle water system. The Double Eagle well system is located near Maljamar, New Mexico. It serves the Ridgecrest Subdivision, Connie Road, Blackfoot Road, Hobbs Highway Industrial Park Area, Brantley Lake State Park, and the WIPP site. In 2007, the city of Carlsbad's water supply system pumped 9.5 billion L (2.5 billion gal) of water (Carlsbad 2008a).

The Double Eagle system that supplies water to the WIPP site has 29 wells in two well fields (north and south). Twelve of the wells are operational in the north well field; two are operational in the south well field. The south well field is the main source of water for the WIPP site and a handful of other users. Double Eagle water is withdrawn from the Ogallala Aquifer (Carlsbad 2008a,b). The Double Eagle system has a total capacity of approximately 9.5 billion L/yr (2.5 billion gal/yr). Existing storage facilities include a 11.4 million L (3 million gal) reservoir, a 1.6 million L (0.42 million gal) reservoir, and a 3.8 million L (1 million gal) reservoir. A 7.6 million L (2 million gal) reservoir has also been added to the South Well Field. In 2004, the reservoir capacity was too small to meet the system demands. In order to maintain pressure and flow requirements, the wells were operated continuously (Tully 2004). If operated at capacity, the two south well field wells would produce about 1.4 billion L (360 million gal) of water annually. There is a recommendation to install six new large-diameter wells, three in each well field, once well design is completed (Carlsbad 2008b).

4.2.4 Human Health

The dose limit for WIPP operations is given in 40 CFR Part 191, Subpart A, and requires that the combined annual dose equivalent to any member of the general public in the vicinity of the site not exceed 25 mrem/yr to the whole body, 75 mrem/yr to the thyroid, and 25 mrem/yr to any other critical organ. Potential radiation exposures of the off-site general public can occur as a result of three pathways: (1) air transport, (2) water ingestion, and (3) ingestion of game animals. Of these three pathways, only the air pathway is considered to be credible. Elevated concentrations of radionuclides have not been detected in groundwater or game animals in the site vicinity.

The estimated highest dose to an individual receptor from airborne releases was estimated to be less than 7.0×10^{-6} mrem/yr effective dose equivalent in 2007 (DOE 2008a). This individual receptor is assumed to reside 7.5 km (4.7 mi) west-northwest of the site. This dose is well below the standard of 10 mrem/yr given in 40 CFR Part 61, Subpart H. A hypothetical individual residing at the site fence line in the northwest sector is estimated to receive a dose of less than 1.5×10^{-4} mrem/yr for the whole body and 1.5×10^{-3} mrem/yr to the critical organ. These values are well below the dose limits for WIPP operations given 40 CFR Part 191, Subpart A.

The potential collective dose to the 100,000 people living within 80 km (50 mi) of WIPP was calculated to be 2.2×10^{-5} person-rem/yr in 2007 (DOE 2008a). Assuming this dose was distributed uniformly to all individuals living within 80 km (50 mi) of the site, the average dose to each person would be about 2.2×10^{-7} mrem/yr. This is an extremely small fraction of the average dose to members of the general public of 620 mrem/yr from all natural background and man-made sources of radiation exposure (NCRP 2009).

Before operations started at WIPP for receipt and disposal of TRU waste, estimates were developed for the doses that could be expected to occur to workers (Bradley et al. 1993). The estimated doses for each worker during normal CH waste handling operations at WIPP were estimated to be as follows: Waste handlers receive 0.70 rem/yr, radiation control technicians receive 0.60 rem/yr, and an average individual receives 0.68 rem/yr. The estimated annual doses to these three categories of workers for handling all TRU (CH and RH) waste are given as 0.79 rem/yr, 0.87 rem/yr, and 0.81 rem/yr, respectively. The average individual represents the dose associated with the range of activities at WIPP and is thus a composite (or average) worker. The WAC for WIPP limits the contact dose rate to 200 mrem/h for CH wastes and 1,000 rem/h for RH wastes. The project has a self-imposed limit of 1 rem/yr for worker exposure at WIPP, which is lower than the occupational exposure limit of 5 rem/yr given in DOE Order 5400.5.

Data on actual operations at WIPP indicate that workers are receiving very low doses from external gamma radiation (Jierree 2009; McCauslin 2010b). The total annual worker dose commitment for the years 1999 through 2009 was 12.4 person-rem (or an average of about 1.1 person-rem/yr) and ranged from a low of 0.331 person-rem/yr to a maximum of 2.298 person-rem/yr. Of the more than 1,100 workers who were monitored for radiation exposure in 2009, 68 had reportable doses. Most of the individuals who had reportable doses were waste handlers and radiological control technicians.

These occupational doses are lower than the preoperational estimates noted above. These low occupational doses reflect both the good radiation control practices at WIPP and the safe design of the waste handling equipment and remote handling processes for RH wastes. In addition, most of the waste disposed of at WIPP has been CH waste having low contact dose rates. For purposes of analysis in this EIS, all of the GTCC waste would be managed in the same manner as CH waste for disposal at WIPP.

4.2.5 Ecology

The WIPP site area is characterized by large, stabilized sand dunes. It is located within a transition area between the northern extension of the Chihuahuan Desert (desert grassland) and the southern Great Plains (short-grass prairie) and shares the vegetative characteristics of both areas (DOE 1980). More than 100 species of plants have been identified within the WIPP LWB (DOE 1993). Numerous species of forbs and perennial grasses are present. The dominant shrubs include shinnery oak (*Quercus havardii*), mesquite (*Prosopis glandulosa*), sand sagebrush (*Artemisia filifolia*), dune yucca (*Yucca campestris*), and smallhead snakeweed (*Gutierrezia microcephala*) (DOE 1980, 1997). Russian thistle is a nonnative species that is commonly established in disturbed areas (DOE 1980).

No wetlands occur on the WIPP site or in the immediate vicinity of the site.

More than 45 mammal species (including 15 bat species) occur within Lea and Eddy Counties, with 39 species occurring in the WIPP site area (DOE 1980). Mule deer, pronghorn, and coyote are among the larger mammals found in the area (DOE 1980, 1997).

More than 120 species of birds have been documented on or near the WIPP site (DOE 1980). Common bird species include the loggerhead shrike, pyrrhuloxia (*Cardinalis sinuatus*), and black-throated sparrow (*Amphispiza bilineata*) (DOE 1997). The availability of nesting sites may limit bird populations in the project area (DOE 1980).

Twenty-three reptile and 10 amphibian species occur in the area (DOE 1980, 1993). Most desert amphibians are generally seen only following spring or summer rains (DOE 1993).

The two-county region lies within the drainage basin of the Pecos River. However, the only permanent aquatic habitats near the WIPP site include earthen watering ponds for livestock (DOE 1997). These man-made livestock watering holes, which are not hydrologically connected to the formations overlying the WIPP site, are located several miles away (DOE 2007). Two salt pile evaporation ponds, a detention basin, and two man-made ponds occur within the developed portions of the WIPP site. However, these ponds do not provide productive aquatic habitats.

The endangered, threatened, and other special-status species reported from the area of Eddy and Lea Counties are listed in Table 4.2.5-1. (Special-status aquatic species and species that primarily occur near major aquatic habitats are not included, because no aquatic habitats in which those species occur are located near the WIPP site.) None of the species listed in Table 4.2.5-1 were observed within the WIPP LWB in 1996, and there is no designated critical habitat for federally listed species at the WIPP site (DOE 1997). Critical habitat for the gypsum

TABLE 4.2.5-1 Federally and State-Listed Threatened, Endangered, and Other Special-Status Species in Eddy and Lea Counties, New Mexico

Common Name (Scientific Name)	Status[a] Federal/State
Plants	
Chapline's columbine (*Aquilegia chaplinei*)	SC/SSC
Five-flowered rockdaisy (*Perityle quinqueflora*)	SC/SSC
Gray sibara (*Sibara grisea*)	SC/SSC
Great sage (*Salvia summa*)	SC/SSC
Guadalupe mescal bean (*Sophora gypsophila* var. *guadalupensis*)	SC/SSC
Guadalupe milkwort (*Polygala rimulicola* var. *rimulicola*)	SC/SSC
Guadalupe penstemon (*Penstemon cardinalis regalis*)	SC/SSC
Guadalupe pincushion cactus (*Escobaria guadalupensis*)	SC/SSC
Guadalupe valerian (*Valeriana texana*)	SC/SSC
Gypsogenus ringstem (*Anulocaulis gypsogenus*)	SC/SSC
Gypsum milkvetch (*Astragalus gypsodes*)	SC/SSC
Gypsum wild-buckwheat (*Eriogonum gypsophilum*)	T/SE
Hershey's cliff daisy (*Chaetopappa hersheyi*)	SC/SSC
Kuenzler hedgehog cactus (*Echinocereus fendleri* var. *kuenzleri*)	E/SE
Lee's pincushion cactus (*Escobaria sneedii* var. *leei*)	T/SE
McKittrick pennyroyal (*Hedeoma apiculatum*)	SC/SSC
Rubber rabbitbush (*Ericameria nauseosa* var. *texensis*)	SC/SSC
Scheer's pincushion cactus (*Coryphantha scheeri* var. *scheeri*)	SC/SE
Shining coralroot (*Hexalectris nitida*)	SC/SE
Sneed pincushion cactus (*Coryphantha sneedii* var. *sneedii*)	E/ST
Sparsely-flowered jewelflower (*Streptanthus sparsiflorus*)	SC/SSC
Tharp's blue-star (*Amsonia tharpii*)	SC/SE
Villous muhly (*Muhlenbergia villiflora* var. *villosa*)	SC/SSC
Wright's water-willow (*Justicia wrightii*)	SC/SSC
Yellowseed fiddleleaf (*Nama xylopodum*)	SC/SSC
Invertebrates	
Ovate vertigo (*Vertigo ovata*)	-/ST
Reptiles	
Arid land ribbon snake (*Thamnophis proximus diabolicus*)	-/ST
Mottled rock rattlesnake (*Crotalus lepidus lepidus*)	-/ST
Sand dune lizard (*Sceloporus arenicolus*)	C/ST
Birds	
American peregrine falcon (*Falco peregrinus anatum*)	-/ST
Arctic peregrine falcon (*Falco peregrinus tundrius*)	-/ST
Baird's sparrow (*Ammodramus bairdi*)	-/ST
Bald eagle (*Haliaeetus leucocephalus*)	-/ST
Bell's vireo (*Vireo bellii arizonae*)	-/ST
Broad-billed hummingbird (*Cyanthus latirostris*)	-/ST
Common ground-dove (*Columbina passerina*)	-/SE
Gray vireo (*Vireo vicinior*)	-/ST
Least tern (*Sterna antillarum athalassos*)	E-SE

TABLE 4.2.5-1 (Cont.)

Common Name (Scientific Name)	Status[a] Federal/State
Lesser prairie-chicken (*Tympanuchus pallidicinctus*)	C/-
Mexican spotted owl (*Strix occidentalis lucida*)	T/-
Northern aplomado falcon (*Falco femoralis septentrionalis*)	E/SE
Southwestern willow flycatcher (*Empidonax trallii extimus*)	E/SE
Varied bunting (*Passerina versicolor*)	-/ST
Mammals	
Black-footed ferret (*Mustela nigripes*)	E/-

[a] C (candidate): A species for which the USFWS 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 the necessity 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): Any species or subspecies whose prospects of survival or recruitment in New Mexico are in jeopardy.

SSC (state species of concern): A New Mexico plant species, which should be protected from land use impacts when possible because it is a unique and limited component of the regional flora.

ST (state threatened): Any species or subspecies that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range in New Mexico.

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

-: Not listed.

Sources: DOE (1997); New Mexico Department of Game and Fish (2006); New Mexico Rare Plant Technical Council (2007) wild-buckwheat (*Eriogonum gypsophilum*) is over 30 mi (48 km) from the WIPP site. Favorable habitat for the lesser prairie-chicken (*Tympanuchus pallidicinctus*), a federal candidate species, does occur within the WIPP LWB and other surrounding areas (DOE 2007). WIPP employees have instituted measures, in consultation with the BLM, to protect the lesser prairie-chicken and its habitat. They include the establishment of periods during which off-site field activities may not be performed during the species' breeding season (DOE 2007).

4.2.6 Socioeconomics

Socioeconomic data for WIPP describe an ROI surrounding the site composed of two counties: Eddy County and Lea County, New Mexico. The majority of WIPP workers reside in these counties (DOE 1997).

4.2.6.1 Employment

In 2005, total employment in the ROI stood at 36,541 and was expected to reach 37,567 by 2008. Employment grew at an annual average rate of 1.2% between 1995 and 2005 (U.S. Bureau of the Census 2008a). The economy of the ROI is dominated by the mining, trade, and service industries, with employment in these activities currently contributing almost 74% of all employment (see Table 4.2.6-1). The WIPP annual budget accounts for 1,095 full-time employees (Sandia 2008a).

TABLE 4.2.6-1 WIPP County and ROI Employment by Industry in 2005

	New Mexico			
Sector	Eddy County	Lea County	ROI Total	% of ROI Total
Agriculture[a]	1,077	877	1,954	5.3
Mining	2,839	2,160	4,999	13.7
Construction	1,079	1,348	2,427	6.6
Manufacturing	1,284	358	1,642	4.5
Transportation and public utilities	874	863	1,737	4.8
Trade	2,812	3,482	6,294	17.2
Finance, insurance, and real estate	834	952	1,786	4.9
Services	8,071	7,624	15,695	42.9
Other	10	3	13	0.0
Total	18,880	17,667	36,541	

[a] Source: USDA (2008).

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

4.2.6.2 Unemployment

Unemployment rates have varied across the counties in the ROI (Table 4.2.6-2). Over the 10-year period 1999–2008, the average rate in Eddy County was 5.1%, with a slightly lower rate of 4.7% in Lea County. The average rate in the ROI over this period was 4.9%, slightly lower than the average rate for the state of 5.0%. Unemployment rates for the first two months of 2009 were consistently higher than rates for 2008 as a whole; in Lea County, the unemployment rate increased to 3.8%, while in Eddy County, the rate reached 3.6%. The average rates for the ROI (3.7%) and for the state (5.4%) during this period were both higher than the corresponding average rates for 2008.

TABLE 4.2.6-2 WIPP Average County, ROI, and State Unemployment Rates (%) in Selected Years

Location	1999–2008	2008	2009[a]
Eddy County	5.1	2.8	3.6
Lea County	4.7	2.5	3.8
ROI	4.9	2.6	3.7
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)

4.2.6.3 Personal Income

Total personal income in the ROI stood at almost $3.2 billion in 2005 and was expected to reach $3.4 billion in 2008, growing at an annual average rate of growth of 2.8% over the period 1995 to 2005 (Table 4.2.6-3). ROI personal income per capita also rose over the same

TABLE 4.2.6-3 WIPP County, ROI, and State Personal Income in Selected Years

Location	1995	2005	Average Annual Growth Rate (%), 1995–2005	2008[a]
Eddy County				
Total personal income (2006 $ in millions)	1,183	1,542	2.7	1,650
Personal income per capita (2006 $)	22,609	30,072	2.9	31,597
Lea County				
Total personal income (2006 $ in millions)	1,208	1,616	3.0	1,743
Personal income per capita (2006 $)	21,333	28,528	3.0	30,317
ROI total				
Total personal income (2006 $ in millions)	2,390	3,158	2.8	3,393
Personal income per capita (2006 $)	21,946	29,262	2.9	30,926
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)

period and was expected to reach $30,926 in 2008, compared to $29,262 in 2005. Per capita incomes were higher in Eddy County ($31,597 in 2008) than elsewhere in the ROI.

4.2.6.4 Population

The population of the ROI was 107,169 in 2000 (U.S. Bureau of the Census 2008b) and was expected to reach 109,739 by 2008 (Table 4.2.6-4). In 2008, 57,508 people were living in Lea County (52% of the ROI total). Over the period 1990 to 2006, population in the ROI as a whole grew slightly, with an average growth rate of 0.3%, while population in New Mexico as a whole grew at a rate of 1.7% over the same period.

4.2.6.5 Housing

Housing stock in the ROI as a whole grew at an annual rate of 0.5% over the period 1990 to 2000 (Table 4.2.6-5), with total housing units expected to reach 46,743 in 2008. A total of 2,187 new units were added to the existing housing stock in the ROI between 1990 and 2000. On the basis of annual population growth rates, 6,741 vacant housing units were expected in the ROI in 2008, of which 1,534 were expected to be rental units available to construction workers at the proposed facility.

4.2.6.6 Fiscal Conditions

Further construction and operations at WIPP for GTCC LLRW and GTCC-like waste disposal would result in continued expenditures for local government jurisdictions, including counties, cities, and school districts. Table 4.2.6-6 presents information on expenditures by the various local government jurisdictions and school districts in the ROI.

TABLE 4.2.6-4 WIPP County, ROI, and State Population in Selected Years

Location	1990	2000	2006	Average Annual Growth Rate (%), 1990–2006	2008[a]
Eddy County	48,605	51,658	51,815	0.4%	52,231
Lea County	55,765	55,511	57,312	0.2%	57,508
ROI total	104,370	107,169	109,127	0.3%	109,739
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

TABLE 4.2.6-5 WIPP County, ROI, and State Housing Characteristics in Selected Years

Type of Housing	1990	2000	2008[a]
Eddy County			
Owner occupied	12,745	14,391	14,551
Rental	4,727	4,988	5,043
Vacant units	2,662	2,870	2,902
Total units	20,134	22,249	22,496
Lea County			
Owner occupied	13,809	14,301	14,816
Rental	5,497	5,398	5.592
Vacant units	4,027	3,706	3,839
Total units	23,333	23,405	24,247
ROI			
Owner occupied	26,554	28,692	29,366
Rental	10,224	10,386	10,636
Vacant units	6,689	6,576	6,741
Total units	43,467	45,654	46,743
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 4.2.6-6 WIPP County, ROI, and State Public Service Expenditures in 2006 ($ in millions)

Location	Local Government	School Districts
Eddy County	30.1	47.5
Lea County	68.1	48.4
ROI	98.2	95.9
New Mexico	6,754	2,500

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

4.2.6.7 Public Services

Further construction and operations at WIPP would continue the demand for employment 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. Demands would also continue on local physician services. Table 4.2.6-7 presents data on employment and levels of service (number of employees per 1,000 population) for public safety and general local government services. Table 4.2.6-8 provides staffing and level-of-service data for school districts. Table 4.2.6-9 provides data on medical employment.

TABLE 4.2.6-7 WIPP County, ROI, and State Public Service Employment in 2006

	Eddy County		Lea County	
Service	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	137	2.6	76	1.3
Fire protection[b]	64	1.2	90	1.6
General	712	13.7	679	11.8

	ROI		New Mexico	
Service	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	213	2.0	3,882	2.0
Fire protection	154	1.4	2,121	1.1
General	1,391	12.7	71,143	36.4

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

[b] Does not include volunteers.

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

TABLE 4.2.6-8 WIPP County, ROI, and State Education Employment in 2006

County	No. of Teachers	Level of Service[a]
Eddy County	653	12.6
Lea County	758	13.2
ROI total	1,411	12.9
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 4.2.6-9 WIPP County, ROI, and State Medical Employment in 2006

County	No. of Physicians	Level of Service[a]
Eddy County	92	1.8
Lea County	73	1.3
ROI total	165	1.5
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)

4.2.7 Environmental Justice

Figures 4.2.7-1 and 4.2.7-2 and Table 4.2.7-1 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer around WIPP from Census data for the year 2000 and 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 identify themselves as being part of one or more of the population groups listed in the table.

4.2.8 Land Use

There are four property areas defined within the 4,146-ha (10,240-ac) WIPP site (Figure 4.2.8-1):

- *Property Protection Area*. This is the 14-ha (35-ac) interior core of the site that is surrounded by a chain-link fence. It is under tight, 24-hour security.

- *Exclusive Use Area*. This 112-ha (277-ac) area is surrounded by a barbed-wire fence and restricted for the exclusive use of DOE and its contractors and subcontractors in support of the project. The area is marked with “no trespassing” signs and is patrolled by WIPP security personnel.

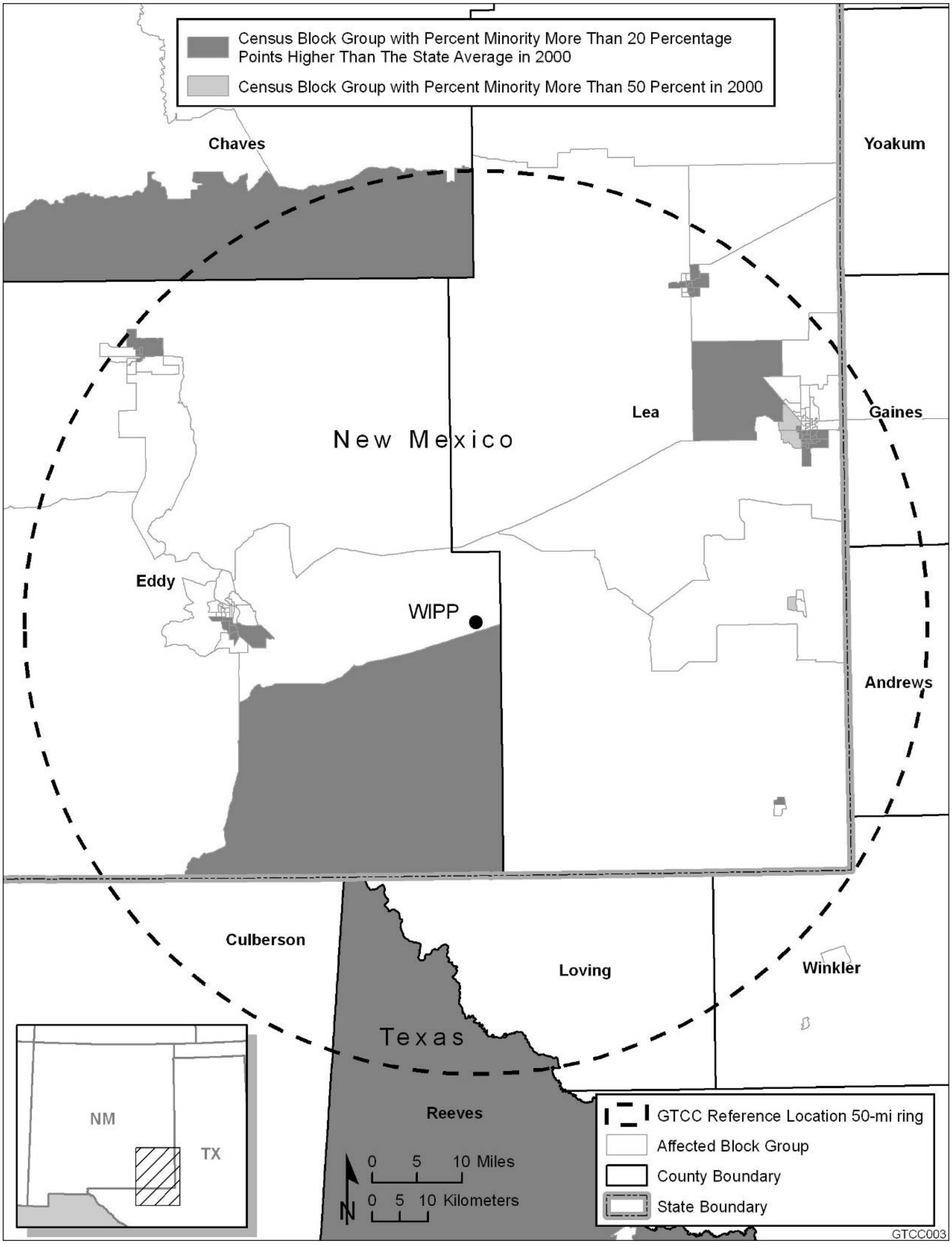

FIGURE 4.2.7-1 Minority Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the WIPP Site (Source: U.S. Bureau of the Census 2008b)

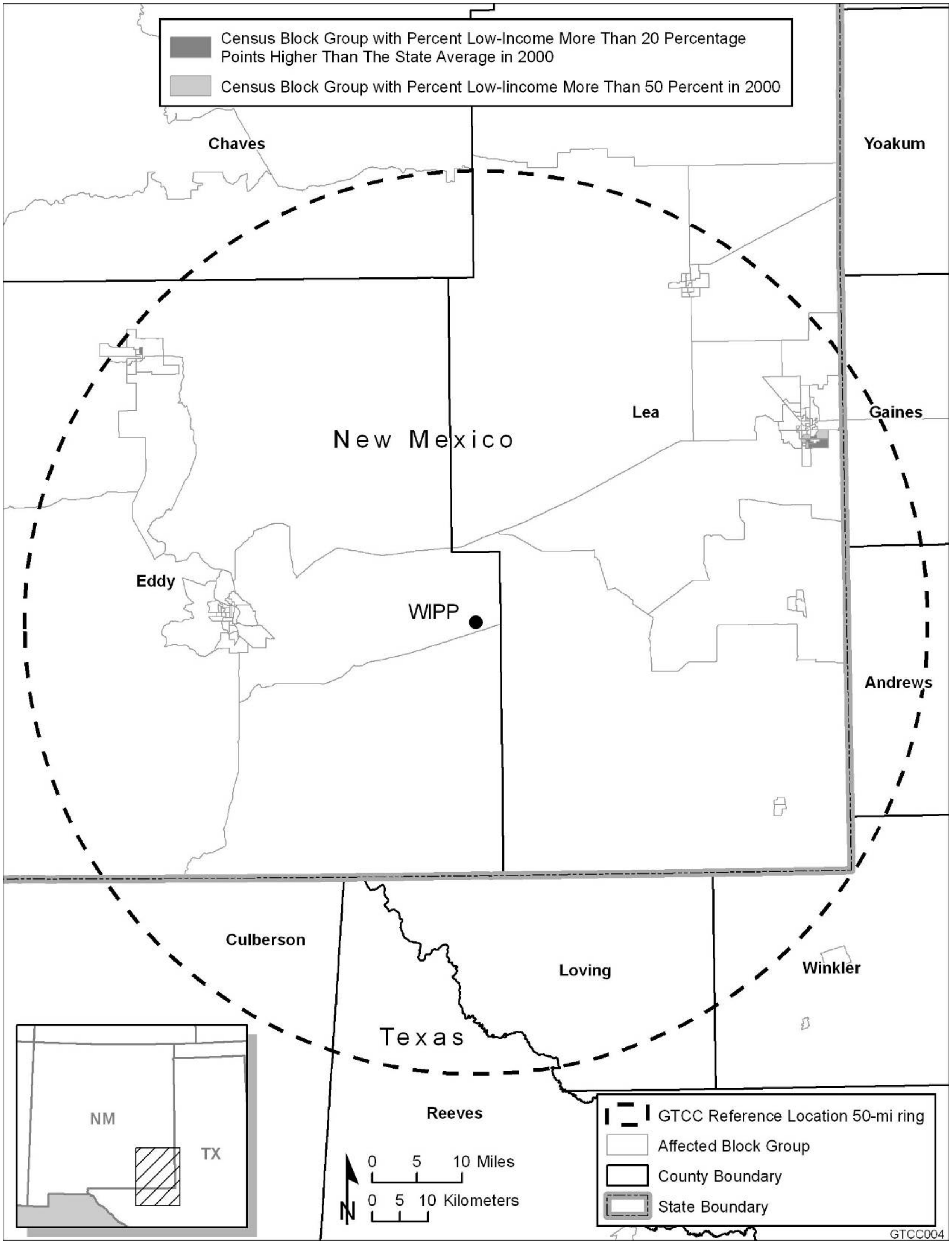

FIGURE 4.2.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the WIPP Site (Source: U.S. Bureau of the Census 2008b)

TABLE 4.2.7-1 Minority and Low-Income Populations in an 80-km (50-mi) Radius of WIPP

Population	New Mexico Block Groups	Texas Block Groups
Total population	107,411	8,171
White, Non-Hispanic	59,697	5,259
Hispanic or Latino	42,351	2,724
Non-Hispanic or Latino minorities	5,363	188
One race	4,242	135
Black or African American	3,006	87
American Indian or Alaskan Native	734	21
Asian	407	25
Native Hawaiian or other Pacific Islander	30	0
Some other race	65	2
Two or more races	1,121	53
Total minority	47,714	2,912
Percent minority	44.4%	35.6%
Low-income	20,076	1,444
Percent low-income	18.7%	17.7%
State percent minority	33.2%	29.0%
State percent low-income	18.4%	15.4%

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

- *Off-Limits Area*. This is a 588-ha (1,454-ac) area where unauthorized entry and introduction of weapons and/or dangerous materials are prohibited. Prohibition signs are posted at consistent intervals along its perimeter. Unless they pose a threat to security, safety, or the environmental quality of the WIPP site, grazing and public thoroughfares can occur in this area. This area is patrolled by WIPP security personnel to prevent unauthorized activities or use.

- *WIPP Land Withdrawal Boundary (LWB)*. This 4,146-ha (10,240-ac) area delineates the perimeter of the WIPP site. This boundary was established to extend at least 1.6 km (1.0 mi) beyond any WIPP underground development.

Except for the facilities within the boundaries of the posted 112-ha (277-ac) Exclusive Use Area, surface land use remains largely unchanged from its pre-1992 multiple land use designation. Those who wish to conduct activities that might affect lands that are under the jurisdiction of WIPP but outside the Property Protection Area are required by the WIPP Land Management Plan (LMP) to prepare a land use request (DOE 2007). Mining and drilling for reasons other than to support WIPP activities are prohibited within the WIPP site except at two 129-ha (320-ac) tracts of land within the WIPP LWB that are leased for oil and gas development. These adjoining lease tracts occupy Section 31 in the far southwest corner of the WIPP site (DOE 1993).

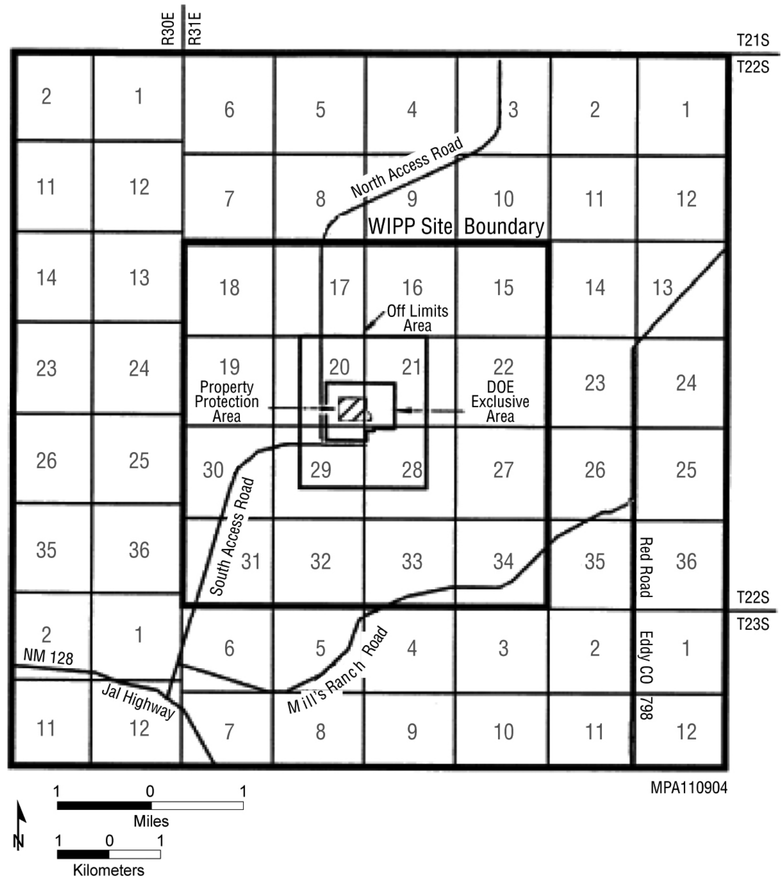

FIGURE 4.2.8-1 Four Property Areas within the WIPP Boundary (Source: DOE 1997)

Portions of two grazing allotments administered by BLM (DOE 1993) occur within the WIPP site boundary. Nearly 5.2% of one 22,493-ha (55,581-ac) allotment overlaps the WIPP site but does not include areas that are posted “no trespassing.” About 9.5% of the other 31,393-ha (77,574-ac) grazing allotment overlaps the remainder of the WIPP site boundary, including the Exclusive Use Area that is posted against trespassing and fenced to prevent grazing (DOE 1993).

The WIPP LMP focuses on management protocols for the following: administration of the plan, environmental compliance, wildlife, cultural resources, grazing, recreation, energy and mineral sources, land and realty, reclamation, security, industrial safety, emergency management, maintenance, and work control (DOE 1993).

Most land in the vicinity of the WIPP site is managed by BLM. Land use in the surrounding area includes livestock grazing, potash mining, oil and gas development, and recreation (e.g., hunting, camping, hiking, off-highway vehicle operation, horseback riding, and bird watching) (DOE 1993, 2007). The dominant land use in the WIPP vicinity is for cattle grazing; smaller amounts of land are used for oil and gas extraction and potash mining. There is little privately owned land near WIPP, although two ranches are located within 16 km (10 mi) of the site (DOE 1997). The only agricultural land within 48 km (30 mi) is irrigated farmland along the Pecos River, near the municipalities of Carlsbad and Loving. Little, if any, dry-land farming takes place near WIPP (DOE 1980).

The region is popular for recreation, providing opportunities for hunting, camping, hiking, and bird watching. The area has a very low population density, and there are approximately 25 residents at various locations within 16 km (10 mi) of the site. The nearest community is the village of Loving, New Mexico, which is located 29 km (18 mi) west-southwest of WIPP. This community has an estimated population of about 1,300 residents.

4.2.9 Transportation

The WIPP site can be reached by rail or highway. Rail access to WIPP is provided by a rail line connecting with a spur of the Burlington Northern Santa Fe (BNSF) Railroad near the Mosaic Potash Nash Draw Mine, 9.6 km (6 mi) southwest of the site. The rail line includes an adjacent service road. The railroad and service road were constructed on an easement width of 46 m (150 ft).

The WIPP site can also be accessed by the North and South Access Roads constructed for the WIPP project (Figure 4.2.9-1). The WIPP LMP (DOE 1993) gives information about the aboveground infrastructure at WIPP. Realty components originally constructed and currently maintained and/or utilized in the operation of WIPP that are under custodial right-of-way (ROW) reservations include, but are not limited to, the North Access Road, South Access Road, and the Access Railroad (DOE 2002). The ROWs, corridors, and realty components are shown in Figure 4.2.9-1.

4.2.9.1 North Access Road

The North Access Road is a private road granted, for perpetuity, under ROW Reservation NM 55676 on August 24, 1983. The North Access Road is approximately 21 km (13 mi) in length, with an easement width of 37 m (120 ft). Use of this road is restricted to DOE personnel, agents, and contractors of DOE on official business related to the WIPP project or to BLM personnel, permittees, licensees, or lessees. Signs are placed and maintained at the turnout of US 62/180 stating the restrictions on access. Persons desiring access to Highway 128 can use Lea County Line Road immediately to the east. ROW Reservation NM 55676 was amended on April 22, 1988, to facilitate the construction of livestock fencing along either side of the subject road.

4.2.9.2 South Access Road

The South Access Road, formerly Eddy County Road 802, is a private road granted under ROW Reservation NM 123703. Terms for the ROW expire on December 31, 2039, and terms are subject to renewal. The South Access Road is approximately 6.4 km (4 mi) in length, with an

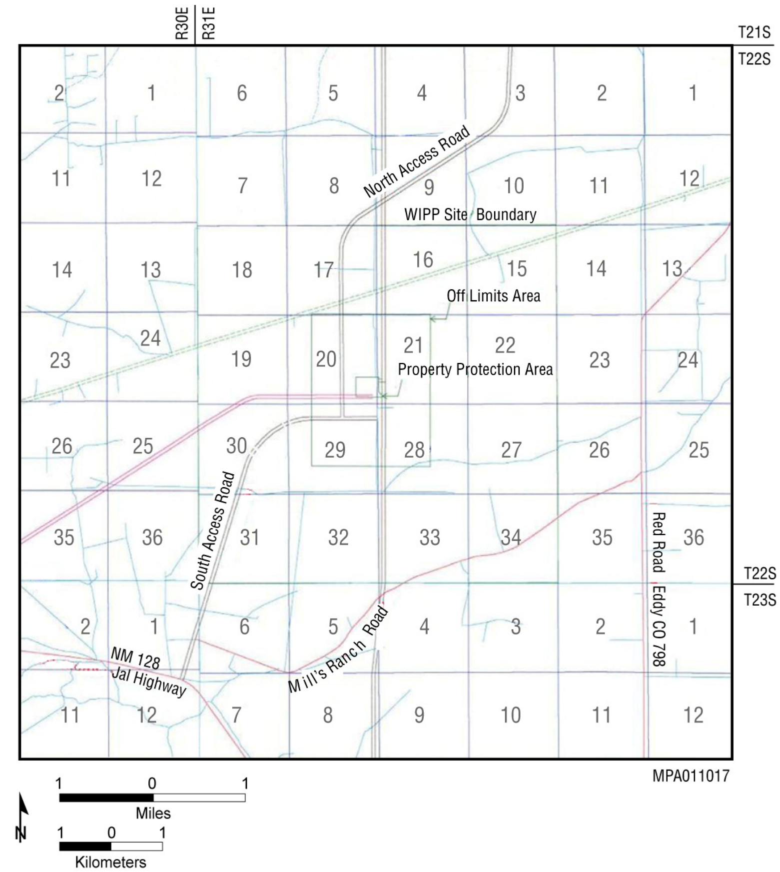

FIGURE 4.2.9-1 Access and Rights-of-Way for the WIPP Site (Source: DOE 2002)

easement width of 43 m (140 ft). On January 27, 2010, Eddy County relinquished ROW NM 46130 that was held by the County for Eddy County Road 802. Multiple-use access for the South Access Road will be allowed unless it is determined that access by industry or the general public represents a significant safety risk to WIPP personnel or to the public. Upon determination, general access of the South Access Road may be restricted at the boundary of the 580-ha (1,450-ac) Off-Limits Area in accordance with DOE Manual 470.4-2, "Physical Protection" (DOE 2005).

4.2.9.3 Access Railroad

Rail access to the WIPP site is possible by a rail line connecting with a spur of the BNSF Railroad near the Mosaic Nash Draw Mine 9.7 km (6 mi) southwest of the site. This section of rail, which was constructed under the auspices of ROW Reservation NM 55699 granted on September 27, 1983, is approximately 8 km (5 mi) in length. It consists of an adjacent frontage road in addition to the rail. Both the railroad and service road were constructed on an easement width of 46 m (150 ft).

4.2.10 Cultural Resources

From about 10,000 B.C. to the late 1800s, southeastern New Mexico was inhabited by aboriginal hunters and gatherers who subsisted on various wild plants and animals. In the late 1800s, the region was settled by ranchers and farmers. Known archeological sites in the vicinity of WIPP are primarily the remains of prehistoric camps and short-term settlements. These areas are generally marked by hearth features, scattered burned rock, flaked stone projectile points, and cutting and scraping tools, pottery fragments, and ground stone implements. Locations generally represent short-term, seasonal occupations by small, nomadic groups of hunters and gatherers who used the plants and animals in the dune lands east of the Pecos River. In a few cases, sites with evidence of structures have been reported, probably associated with occupations of several weeks to months.

Historic remains or features (more than 50 years old) are rare but have occasionally been identified. These include features and debris related to yearly ranching in the twentieth century, including fences that may still be in use. The majority of historic sites identified to date include elements that could contribute to their eligibility for the *National Register of Historic Places* (NRHP).

With few exceptions, cultural resources known or anticipated in the area covered by the WIPP LWB are significant; they must be identified, recorded, assessed through an inventory, and considered in any plan of development for the area. When compared with most other portions of southeastern New Mexico, the locations (and nature) of cultural resources within the WIPP LWB can be described relatively well on the basis of an intensive inventory of portions of the area, limited excavation, and other investigative work on some sites.

Several surveys have been completed in the WIPP LWB, and 59 archeological sites and 91 isolated occurrences (single artifact or only a few artifacts, or isolated features that can be fully recorded in the field) have been identified to date. The sites and isolates identified are almost exclusively prehistoric. Only one site with both prehistoric and historic components was noted. Approximately 37% of the area within the WIPP LWB has been inventoried for cultural resources. Extrapolating the current number of resources located to date to the rest of the (unsurveyed) area indicates that about 99 additional sites and 153 isolates could be present at the site. The land within the WIPP LWB appears to represent a potentially significant contributor of cultural resources and should be regarded as such when land management decisions are made (DOE 2002).

4.2.11 Waste Management

Support structures at the WIPP facility used to manage waste generated from facility operations include a sewage treatment system. The sewage treatment system at WIPP is a zero-discharge facility consisting of two primary settling lagoons, two polishing lagoons, a chlorination system, and four evaporation basins. The facility is designed to dispose of domestic sewage and site-generated brine waters from observation well pumping and from underground dewatering activities at WIPP (Sandia 2008a).

4.3 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

As described previously, this alternative involves the construction of up to 26 additional underground rooms for emplacement of GTCC LLRW and GTCC-like waste at WIPP. This activity is the focus of the evaluation of potential consequences discussed here in Section 4.3.

4.3.1 Air Quality and Noise

This section describes potential air quality and noise impacts from the construction of additional rooms and waste disposal operations at WIPP. It is assumed that all the current aboveground facilities would be adequate for the surface handling and waste packaging that would be needed to prepare the wastes for transfer underground (Sandia 2008a). Thus, the only additional construction that would be needed to accommodate wastes would be to create the underground disposal space at WIPP. Construction and operational equipment and resources currently in use at WIPP would be employed.

4.3.1.1 Air Quality

4.3.1.1.1 Construction. There are two potential sources of air pollutant emissions from construction: (1) aboveground activities (e.g., emissions from haul trucks; from stockpiling at the Salt Storage Area; and from commuter, delivery, and support vehicles) and (2) underground activities (e.g., emissions from haul trucks and salt mining that would be released through the exhaust shaft). No air emissions are expected from electric-driven equipment, such as the continuous miner, salt hoist, and ventilation fans. Sources of 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 during the construction period would include fugitive dust and engine exhaust emissions from these activities.

Air emissions of criteria pollutants, VOCs, and CO_2 from construction activities are estimated for the average year, as shown in Table 4.3.1-1. Detailed information on emission factors, assumptions, and emission inventories is given in Appendix D. As shown in the table, total average yearly emission rates would be small when compared with emission totals for Eddy County, which encompasses WIPP. In terms of contribution to the total emissions, the highest average yearly emissions of $PM_{2.5}$ would be from salt mining activities, at about 0.030% of the total emissions.

Background concentration levels for PM_{10} and $PM_{2.5}$ at the WIPP site are well below the standards, less than 59% of NAAQS and SAAQS; PM_{10} and $PM_{2.5}$ estimates include diesel particulate emissions (see Table 4.2.1-2). All construction activities would occur about 3 km (2 mi) from the site boundary and thus would not contribute much to concentrations at the site boundary or the nearest residence. Construction activities would be conducted so as to minimize potential impacts of construction-related emissions on ambient air quality. Also, construction

TABLE 4.3.1-1 Average Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction under Alternative 2

Pollutant	Total Emissions (tons/yr)[a]	Construction Emissions (tons/yr)	
SO_2	7,783	0.23	(0.003)[b]
NO_x	8,437	1.4	(0.017)
CO	25,725	0.97	(0.004)
VOCs	8,222	0.14	(0.002)
PM_{10}[c]	27,327	1.8	(0.007)
$PM_{2.5}$[c]	4,744	1.4	(0.03)
CO_2		190	
County[d]	1.85×10^6		(0.010)
New Mexico[e]	6.50×10^7		(0.0003)
U.S.[e]	6.54×10^9		(0.000003)
Worldwide[e]	3.10×10^{10}		(0.000001)

[a] Total emissions in 2002 for Eddy County, in which WIPP is located. See Table 4.2.1-1 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 New Mexico, the United States, and worldwide in 2005.

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

permits typically require fugitive dust control by established standard dust control practices (primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles); and by implementing other recognized practices (e.g., temporary wind breaks, slowing down or stopping construction during high wind events).

Although O_3 levels in Carlsbad (about 42 km [26 mi] west of the WIPP site) exceeded the standard (see Table 4.2.1-2), Eddy County, including the WIPP site, is currently in attainment for O_3 (40 CFR 81.332). The WIPP site is located far from any major cities, and O_3 precursor emissions from waste disposal at WIPP would be relatively small, less than 0.017% and 0.005% of county total NO_x and VOC emissions, respectively. These emissions 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 continuously increased from approximately 280 parts per million (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).

Because CO_2 is stable in the atmosphere and is essentially uniformly mixed, its climatic impact does not depend on the geographic location of sources; 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 4.3.1-1, CO_2 emissions from construction would be less than 0.010%, 0.0003%, and 0.000003%, respectively, of 2005 county, state, and U.S. CO_2 emissions. In 2005, CO_2 emissions in the United States were about 21% of worldwide emissions (EIA 2008). The potential impacts from construction emissions on climate change would be small.

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 in nature.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and would not be applicable to the disposal of GTCC wastes at the WIPP site because the area is classified as being in attainment for all criteria pollutants (40 CFR 81.332).

4.3.1.1.2 Operations. As was the case for construction, criteria pollutants, VOCs, and CO_2 would be released into the atmosphere during operations. These emissions would result primarily from exhaust emissions from heavy equipment, such as forklifts and the waste transporter, both aboveground and underground. Estimated peak-year emissions of criteria pollutants, VOCs, and CO_2 for the WIPP alternative are presented in Table 4.3.1-2. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in the table, annual emissions from operations are estimated to be higher than those from construction, except for PM_{10}, $PM_{2.5}$, and NO_x emissions. Compared with annual emissions for Eddy County, the peak-year emissions of NO_x are the highest, about 0.031% of the total emission.

Because of the distance from the source to the boundary (about 3 km [2 mi]), emissions (including diesel particulate emissions) from operational activities would not contribute much to concentrations at the site boundary or the nearest residence. Therefore, it is expected that, except for O_3, concentration levels from operational activities would remain well below the NAAQS.

TABLE 4.3.1-2 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations under Alternative 2

Pollutant	Total Emissions (tons/yr)[a]	Operation Emissions (tons/yr)	
SO_2	7,783	0.48	(0.006)[b]
NO_x	8,437	2.6	(0.031)
CO	25,725	0.56	(0.002)
VOCs	8,222	0.23	(0.003)
PM_{10}[c]	27,327	0.24	(0.001)
$PM_{2.5}$[c]	4,744	0.22	(0.005)
CO_2		290	
County[d]	1.85×10^6		(0.016)
New Mexico[e]	6.50×10^7		(0.001)
U.S.[e]	6.54×10^9		(1×10^{-5})
Worldwide[e]	3.10×10^{10}		(2×10^{-6})

[a] Total emissions in 2002 for Eddy County, within which the WIPP is located. See Table 4.2.1-1 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, 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 New Mexico, the United States, and worldwide in 2005.

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

With regard to regional O_3, precursor emissions of NO_x and VOCs would be lower from operations than from construction (0.031% and 0.003% of the total county emissions, respectively). It is not anticipated that they would contribute much to regional O_3 levels. CO_2 emissions would be about 0.016% of the Eddy County emissions; thus, the potential impact on climate change would also be negligible.

PSD regulations are not applicable to waste disposal at WIPP because WIPP is not a major stationary source. In addition, general conformity, which applies only to federal actions taking place in a nonattainment or maintenance area, is also not applicable to the proposed action.

4.3.1.2 Noise

4.3.1.2.1 Construction. The only construction activities at WIPP would involve salt mining, and no site clearing and building construction are anticipated, as discussed in Section 4.3.1.1. For Alternative 2, the primary construction activities would include underground salt mining and stockpiling aboveground at the Salt Storage Area. Noise sources from construction activities would include those from the continuous miner, salt hoist, ventilation fans, and diesel-powered haul trucks operating aboveground and underground. The types of construction equipment and their noise levels are presented in Table 4.3.1-3.

With regard to a noise impact analysis, when a known noise-sensitive receptor (e.g., school or 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). Note that most of the activities would occur underground and would thus have a minimal impact on ambient noise levels. It is estimated that the highest composite noise levels from aboveground construction activities (e.g., a truck and three ventilation fans operating continuously) would be about 93 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 780 m (2,500 ft) from noise sources would be below the EPA guideline of 55 dBA as the L_{dn} for residential zones. This distance is well within the WIPP boundary, which is at least 3 km (2 mi) from the WIPP surface facilities, and no residential dwellings exist within this distance. The EPA guideline was established to protect against interference and annoyance due to outdoor activity (EPA 1974). Actual sound levels would be much lower because of air absorption and ground effects due to terrain and vegetation. Accordingly, noise from construction activities would be barely discernable or completely inaudible at the site boundaries and the nearest residences.

TABLE 4.3.1-3 Types of Construction Equipment and Their Typical Noise Levels at WIPP

Type of Construction Equipment	Capacity (hp)	Power	Typical Level at 15 m (50 ft) from a Source (dBA)
Continuous miner	720	Electric	74
Surface haul trucks	525	Diesel	88
Underground haul trucks	185	Diesel	84
Salt hoist	2,200	Electric	70
Ventilation fans	600	Electric	87

Sources: Barnes et al. (1977); Miller et al. (1984); Sandia (2008a); Vér and Beranek (2006); Yantek (2003)

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 could 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 interference with vibration-sensitive activities, which is around 65 VdB (Hanson et al. 2006). During the construction phase, no major construction equipment that could cause ground vibration would be used, and no sensitive structures are located nearby. Therefore, there would be no adverse vibration impacts from construction activities at the WIPP site.

4.3.1.2.2 Operations. During the operations phase, noise-generating activities within the WIPP site would include those from the primary activities of receiving, handling, and emplacing waste packages, and many of the activities would occur underground.

During facility operation, the operation of heavy equipment (e.g., a 41-ton forklift and three ventilation fans running continuously) would generate a combined noise level of about 92 dBA at a distance of 15 m (50 ft) from noise sources. This level would be 1 dB lower than the level during construction. On the basis of the same assumptions for construction, the noise level at a distance of 700 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 well within the WIPP boundary, which is at least 3 km (2 mi) from the WIPP surface facilities, and no residential locations exist within this distance. Accordingly, noise from operational activities would be barely discernable or completely inaudible at the site boundaries and the nearest residences.

4.3.2 Geology and Soils

To emplace GTCC LLRW and GTCC-like waste at WIPP, additional underground disposal rooms would be needed. It is assumed that the GTCC LLRW and GTCC-like waste would be disposed of in underground waste disposal rooms similar (if not identical) to those currently used for the disposal of TRU waste, and that this waste would be emplaced in disposal rooms adjacent to those currently planned for the WIPP repository. Because the room construction would involve the same techniques as those employed to develop the existing repository, geologic impacts would be the same as the impacts produced by historical construction activities, which were small.

4.3.3 Water Resources

Direct and indirect impacts on water resources at the WIPP repository could result from the construction of the additional rooms and the waste disposal operations carried out to emplace the GTCC waste inventory. Impacts from post-closure would not differ from any current impacts associated with the repository.

4.3.3.1 Construction

Construction of the additional 26 rooms at the WIPP repository would require about 460,000 L/yr (120,000 gal/yr) of water, assuming that water usage is 65,000 L (17,000 gal) per allocated WIPP disposal room and that about seven rooms or one panel can be constructed in a given year (Sandia 2008a). At the WIPP site, all water needs are met by using groundwater piped from the city of Carlsbad's water supply system. The Carlsbad Double Eagle South Well Field, which supplies water to WIPP, has an annual water production of about 1.4 billion L (360 million gal). Construction activities to accommodate GTCC waste disposal at the WIPP repository would increase the site's annual water use (20 million L or 5.4 million gal) by about 2% and increase production at the South Well Field by about 0.03%. Although construction water would be obtained from the Double Eagle water system, which was operating continuously in 2004, the increased demand would be easily accommodated. Similarly, the 61-cm (24-in.) pipeline that carries water from the Double Eagle water system to WIPP would be able to transport the increased water effectively. Increased water demand could slightly lower the existing water table below the Double Eagle South Well Field. However, because the increased water demand would be very small, impacts on the water table's elevation and the direction of groundwater flow would be negligible.

Construction activities for the additional rooms at the WIPP repository would not disturb the ground surface. Because no land surfaces would be disturbed during construction, there would be no impacts on either surface water or groundwater resources. Similarly, there would be no impacts on surface water or groundwater quality during construction because there would be no liquid wastes produced, and underground spills would be limited to the interior of the repository, where timely and effective cleanup would occur.

4.3.3.2 Operations

In the peak operational year, GTCC waste shipments would be equivalent to the entire annual level of waste shipments that are currently handled at WIPP; as such, it is assumed that the quantity of water is the same amount used currently for WIPP operations, which is approximately 20 million L/yr (5.4 million gal/yr). Because the amount of water that would be used annually would be the same as the amount that is currently used, there would be no net increase in water use at the site and no additional water demand on the Double Eagle water supply system.

Nonhazardous liquids generated during waste disposal operations would be disposed of at on-site sanitary lagoons. Because of the dry climate, high rate of evaporation, size of the ponds (on the order of acres), and small volume of discharged water, impacts on groundwater resources would be negligible.

4.3.4 Human Health

The human health impacts assessed in this EIS for the disposal of GTCC LLRW and GTCC-like wastes at WIPP are the incremental impacts from use of this facility to dispose of these wastes. WIPP is currently being used to dispose of defense TRU wastes, and this activity is expected to continue. The human health impacts associated with current WIPP disposal operations are not included here but are addressed under cumulative impacts and in NEPA documents (e.g., DOE 1997, 1980) specifically prepared to address the construction and operation of WIPP.

For this EIS, WIPP is assumed to remain in operation for the number of years necessary to dispose of the entire volume of GTCC LLRW and GTCC-like wastes. Human health impacts are assessed for the construction, operations, and post-closure phases of this activity. Different types of hazards and potentially impacted individuals are addressed in these various phases. For this EIS, the assessment of impacts from using WIPP is limited to those associated with normal operations. The impacts from accidents at WIPP have been extensively evaluated and documented in safety analysis reports for CH and RH TRU wastes (DOE 2006c,d). The impacts from accidents involving much of the GTCC LLRW and essentially all of the GTCC-like waste (most of which meets the DOE definition of TRU waste) are addressed by those analyses. The GTCC waste types that may not be explicitly covered by the two safety analysis reports are the activated metal waste from decommissioning commercial nuclear reactors and the Cs-137 sealed sources. These two waste types are LLRW and not TRU wastes. The impacts from transportation of GTCC LLRW and GTCC-like wastes to WIPP are discussed separately in Section 4.3.9.

Some of the activated metal wastes from decommissioning commercial nuclear reactors would have contact dose rates near (or possibly above) 1,000 rem/h and thus could exceed the radiation dose limits currently allowable for disposal at WIPP. Additional shielding might be required in the waste packages for certain wastes to meet the current waste disposal requirements at WIPP. It is assumed that the Cs-137 sealed sources would be disposed of in their original shielded devices, which are very robust.

Even though some of the GTCC LLRW and GTCC-like wastes may have radiation dose rates above those for the TRU wastes currently being disposed of at WIPP, the safety envelope established for CH and RH wastes in the documented safety analysis reports (DOE 2006c,d) should be adequate for disposal of this waste at WIPP. The two safety analysis reports address a number of accidents, and appropriate engineering procedures, equipment, and controls are in place to mitigate the impact of these accidents to workers and members of the general public. These accidents address those that could occur from operational errors, equipment malfunctions, severe natural phenomena, and events external to the facility. Should WIPP be identified as the preferred alternative for disposal of GTCC LLRW and GTCC-like wastes, additional analyses would be performed as appropriate to address all aspects of waste disposal operations, including those associated with potential accidents.

The most significant human health impacts during normal operations would be the radiation doses and associated health risks to workers handling the wastes. The radiation doses to off-site individuals would be very low, because the actions taken to protect workers (e.g., use of shielding and remote handling equipment) would also serve to protect any nearby members of the public. The remote setting of the facility would limit the radiological impacts on nearby off-site individuals, and many of the operations occur underground. Hence, this assessment is limited to those impacts expected to be incurred by workers.

The physical hazards to workers are considered during the construction, operations, and post-closure 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-of wastes, which could reach individuals living near the site. These impacts are addressed in Section 4.3.4.3. During the operational phase, the radiation exposures of workers are considered in addition to the physical hazards associated with emplacement of the GTCC wastes at WIPP.

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. This is consistent with operations to date at WIPP. 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 generating site or during staging of the wastes prior to their shipment, and the impacts associated with these activities are not covered in this EIS.

4.3.4.1 Construction and Operations

4.3.4.1.1 Radiological Impacts. The involved workers would incur radiation doses when they were in the general proximity of the waste containers during handling and disposal activities. The external gamma exposure rates from the GTCC LLRW and GTCC-like waste packages would cover a very wide range. The wastes addressed in this EIS would range from those that could be managed directly because they have very low exposure rates to wastes that would have to be managed by using a large amount of shielding or remote handling equipment. For purposes of analysis in this EIS, it is assumed that all wastes would be placed in shielded containers (as necessary) to allow for their disposal as WIPP CH wastes (Sandia 2008a).

Because the procedures to be used to manage these wastes at WIPP and the exact activities that would be conducted by each involved worker (and their proximity to the waste containers) are not known at this time, it is difficult to calculate the dose to the workforce. For purposes of this EIS, information on the actual doses incurred by workers at WIPP as given in

Section 4.2.4 was used. This is a reasonable approach because all of the GTCC wastes will be managed as CH wastes at WIPP.

Worker doses at WIPP must be kept below 5 rem/yr, as given in 10 CFR Part 835. In addition, an administrative control limit has been set at 1 rem/yr for the project. The radiation exposures of the involved workers would be monitored for the duration of disposal activities. It is assumed that the current WIPP practices for keeping worker doses ALARA would remain in place for the duration of the disposal campaign. This practice would ensure that worker doses were kept low and that they would comply with all applicable DOE standards and policies.

A total of 68,748 m^3 (2,430,000 ft^3) of TRU waste was disposed of at WIPP as of June 2010. Of this total volume, 68,557 m^3 (2,420,000 ft^3) was CH waste, and the remainder was RH waste. A total of 134,112 containers were used to dispose of this waste. In contrast, the total volume of GTCC waste requiring disposal is about 12,000 m^3 (420,000 ft^3), and an estimated 63,072 containers will be needed for this purpose (see Table 4.1.4-1). The occupational dose to dispose of this waste was estimated to be 5.8 person-rem by using the total occupational worker doses for disposal of defense-generated TRU waste at WIPP through 2009 (12.4 person-rem) and pro-rating this value by the number of containers required for disposal of the GTCC wastes. This worker dose commitment would result in less than 1 LCF when a risk factor of 0.0006 LCF per person-rem is used (see Section 5.2.4.3).

The dose commitment to the workforce would be distributed among all workers involved in managing the wastes at WIPP over the entire time period that the facility was receiving and disposing of GTCC LLRW and GTCC-like wastes. Workers would likely be rotated so that different ones would perform these activities over time, so the maximum dose to any individual worker over the duration of the project would likely be no more than several hundred mrem. Wastes might be received intermittently over the operational time period. The dose to the highest-exposed worker in any given year would be well below the administrative limit set for WIPP of 1 rem/yr.

The dose to noninvolved workers would be much less than the dose to involved workers. The noninvolved workers (such as those in the administration building) would be some distance away from the waste packages. The external gamma dose rate from a waste package decreases rapidly with distance, a situation that minimizes the likelihood that noninvolved workers would incur a measurable dose. Also, there would likely be significantly fewer noninvolved workers than involved workers when wastes were being processed at the site to ensure compliance with the DOE ALARA requirement. The total dose to the uninvolved workforce is conservatively estimated to be less than 0.1 person-rem over the duration of the project and is not expected to result in any LCFs.

4.3.4.1.2 Nonradiological Impacts. The nonradiological human health impacts from accidents that could occur during construction and operational activities are assessed in this EIS. The physical consequences of these accidents are given here in terms of injuries and illnesses (as lost workdays) as well as the likelihood of worker fatalities. These impacts were estimated by using information compiled by DOE for ongoing TRU waste disposal activities at WIPP and estimates of the number of workers needed for all phases of this project.

DOE has maintained a record of all accidents and injuries that have resulted in lost workdays since TRU waste disposal operations were initiated at WIPP. In 2009, a total of 83 lost workdays occurred as a result of injuries at the site, and the average number of employees at the site was reported to be 1,330 (McCauslin 2010a). The workplace nonfatal injury rate (as lost workdays) can be calculated by dividing these two values; this rate is 6.2 per 100 full-time equivalent (FTE) workers. This rate was used for the construction and operations phases of the project. No fatalities have occurred at WIPP as a result of accidents.

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 rooms and panels at WIPP to dispose of the GTCC LLRW and GTCC-like wastes. These results are summarized in Table 4.3.4-1. The number of FTEs needed to develop the necessary disposal capacity at WIPP for the GTCC LLRW and GTCC-like wastes was based on information in Sandia (2008a,b). It is estimated that a total of 70 FTE workers would be needed during the construction phase at WIPP. The number of lost workdays due to injuries was calculated to be 4.3, and no fatalities are expected to occur during the construction activities at WIPP.

The same approach was used for the operations period, using the site-specific accident rate given above. The estimated number of FTE workers necessary to dispose of these wastes at WIPP is based on Sandia (2008a,b). For this assessment, the involved workers are considered to be the operators and technicians required to conduct the disposal operations. About 1,000 FTEs are estimated to be necessary to dispose of the total volume of GTCC LLRW and GTCC-like wastes (Sandia 2010b). The total number of lost workdays due to nonfatal injuries is calculated to be 62, and no fatalities are expected to occur (see Table 4.3.4-1).

The total recordable rate of work-related injuries over the past several years at WIPP has ranged from zero to 1.0 per 100 employees per year (Dotson 2009). The rate in 2009 was 0.48 per 100 employees per year, and there have been no occupational fatalities at the site from waste disposal operations. The recordable rate of work-related injuries at WIPP is lower than that for all DOE sites combined of 1.2 per 100 workers per year (McCauslin 2010a). It is assumed that the current WIPP practices for keeping worker injuries at very low levels would remain in place for the duration of the disposal campaign. This practice would ensure that worker health and safety were not compromised by using this facility to dispose of GTCC wastes.

4.3.4.2 Accidents

The health consequences that might result from exposure to radioactive materials from postulated facility accident scenarios during disposal of GTCC waste would be bound by

TABLE 4.3.4-1 Estimated Number of Full-Time Equivalent (FTE) Involved Workers, Nonfatal Injuries and Illnesses, and Fatalities Associated with Construction and Operations at WIPP

Workers, Injuries and Illnesses, and Deaths per Phase	Number
Construction	
Total FTEs[a]	70
Nonfatal injuries and illnesses[b]	4.3
Fatalities[c]	0
Operations	
Total FTEs[d]	1,000
Nonfatal injuries and illnesses[e]	62
Fatalities[f]	0

[a] The total number of FTE workers needed during construction was based on Sandia (2008a,b). These estimates provide the worker requirements for constructing the panels and rooms needed to dispose of the expected volume of GTCC LLRW and GTCC-like wastes.

[b] The number of nonfatal injuries and illnesses is given in terms of lost workdays and was estimated on the basis of data compiled by DOE for TRU waste disposal activities at WIPP in 2009 (McCauslin 2010a). The nonfatal injury and illness rate for involved workers was 6.2 per 100 FTEs.

[c] No fatalities occurred from all construction activities at the WIPP repository as of August 2010 (McCauslin 2010a). On the basis of this experience, no worker fatalities are anticipated for GTCC waste disposal activities at the WIPP repository.

[d] The total number of FTE workers during the operational phase is the estimated value for operators and technicians needed to dispose of GTCC LLRW and GTCC-like wastes at WIPP based on Sandia (2008a,b).

[e] The number of nonfatal injuries and illnesses is given in terms of lost workdays and was estimated on the basis of data compiled by DOE for TRU waste disposal activities at WIPP in 2009 (McCauslin 2010a). The nonfatal injury and illness rate for involved workers was 6.2 per 100 FTEs.

[f] No fatalities occurred from all waste disposal activities at the WIPP repository as of August 2010 (McCauslin 2010a). On the basis of this experience, no worker fatalities are anticipated for GTCC waste disposal activities at the WIPP repository.

accidents evaluated for WIPP (DOE 1997, 2006c,d). Any waste shipped to WIPP would be required to meet the WAC for disposal. The radionuclide activity limits set forth in the WAC are met by the GTCC LLRW and the GTCC-like waste containers assumed to be disposed of at the WIPP in this EIS. Therefore, the impacts estimated previously for WIPP, which are similar to the accident impacts assessed for the land disposal options in Chapters 6 through 12, are expected to be representative of what could occur during disposal operations for the GTCC LLRW and the GTCC-like waste at WIPP.

4.3.4.3 Post-Closure

The post-closure impacts of disposing of the GTCC LLRW and GTCC-like wastes were evaluated in the EIS in the same manner as was done for TRU wastes (i.e., by developing complementary cumulative distribution functions (CCDFs) based on performance assessments) (Sandia 2008c,d; 2010a). The post-closure impacts are limited to the potential radiation doses from the release of radionuclides from waste packages at WIPP and from their subsequent migration to groundwater. Once the radionuclides are in the groundwater, it is possible for members of the general public to be exposed to them by various ingestion pathways. The WIPP is a deep geologic disposal facility, and it would be sealed during decommissioning activities. This closure process precludes the release of radionuclides to the atmosphere.

Post-closure compliance of WIPP with regulatory limits is based on the cumulative releases of radionuclides to the accessible environment over a 10,000-year time horizon. The WIPP-related environmental standards for disposal are given in 40 CFR Part 191, Subpart B; environmental standards for groundwater protection are found in 40 CFR Part 191, Subpart C. The criteria for certification of compliance with the disposal standard are given in 40 CFR Part 194. The regulations set limits on the radiation doses to a member of the public in the accessible environment for 10,000 years of undisturbed performance, and they also set limits on the radioactive contamination of certain sources of groundwater for 10,000 years after disposal. Compliance with these requirements is demonstrated by presenting the results from long-term performance as CCDFs. The CCDFs represent the probability of exceeding various levels of cumulative releases caused by all significant processes and events.

The CCDF of total releases for the latest recertification of WIPP is given in Figure 4.3.4-1. The release limits (as stated in 40 CFR 191.13) are represented by the dotted line on the right in this figure. The solid line in Figure 4.3.4-1 shows the mean probability of the total cumulative releases, after the likelihood of different futures occurring at WIPP and the uncertainty in the calculation parameters have been addressed by using computer models that estimate the radionuclide release for each future. WIPP is in compliance when the total release (solid line) is to the left of the release limits (dotted line). If the mean total release line crosses the release limits line, then WIPP is not in compliance (Sandia 2008c). As seen in this figure, WIPP is in compliance with its regulatory limits for TRU waste disposal, as indicated by its recent recertification.

The CCDF for Group 1 GTCC LLRW and GTCC-like wastes is shown in Figure 4.3.4-2, along with the CCDF for the latest recertification of WIPP. The CCDF for Group 2 wastes is

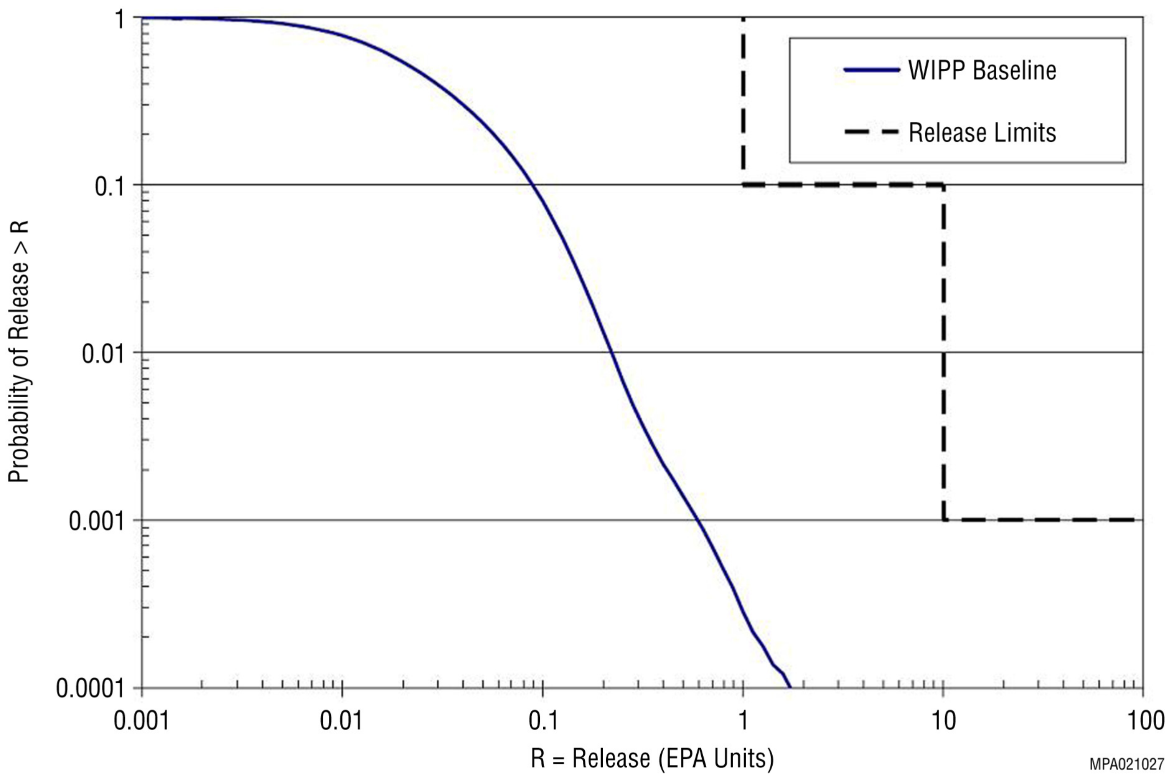

FIGURE 4.3.4-1 Mean Total Release CCDF for WIPP Recertification (Source: Sandia 2010a)

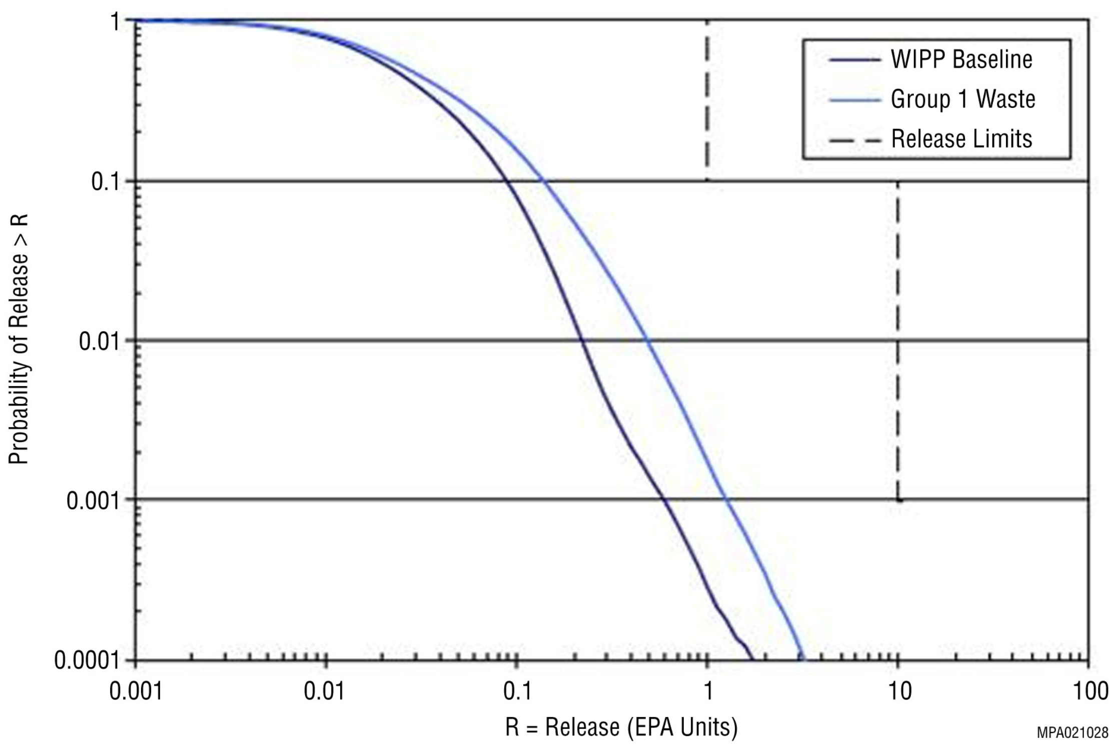

FIGURE 4.3.4-2 Mean Total Release CCDF for Group 1 Wastes (Source: Sandia 2010a)

shown in Figure 4.3.4-3, and the CCDF for the sum of Group 1 and Group 2 GTCC wastes is shown in Figure 4.3.4-4. As these figures illustrate, adding the GTCC LLRW and GTCC-like wastes to the WIPP inventory would increase the potential for radionuclide release from the repository (the curves move to the right), but in no case does the curve cross over the release limit line (Sandia 2010a).

This analysis demonstrates that the inventory of GTCC LLRW and GTCC-like wastes could be disposed of in WIPP in compliance with existing regulatory requirements. The details of this calculation are provided in Sandia (2008c,d; 2010a) and the references given in those documents.

4.3.4.4 Intentional Destructive Acts

GTCC LLRW and GTCC-like waste pose a potential terrorist threat because of their higher radioactivity in a given volume when compared with other LLRW. Such material could be incorporated into an RDD intended to cause societal disruption, including significant negative economic impacts. The consequences of an intentional destructive act (IDA) involving hazardous material depend on the material's packaging, chemical composition, radioactive and physical properties, accessibility, quantity, and ease of dispersion, and on the surrounding environment, including the number of people who are close to the event.

With regard to the deep geologic disposal of similar waste at WIPP, DOE had previously considered the potential impacts of IDAs (i.e., acts of sabotage or terrorism). The previous impacts estimated for WIPP would be no greater than the impacts of an accident as analyzed in the supplemental EIS (DOE 1997) and supplement analysis (DOE 2009) because the initiating forces and resulting quantities of radioactive or hazardous material that could be released by an IDA would be similar to those for the severe accident scenarios.

4.3.5 Ecology

The disposal of GTCC LLRW and GTCC-like waste would not require modifications to any WIPP surface facilities or the aboveground infrastructure. The existing facilities are assumed to be adequate to facilitate waste handling, storage, and transport to the underground rooms. WIPP can receive standard truck shipments and has a rail spur adjacent to the WHB. Current parking areas may be used for temporary storage or overflow of transport trailers within the property protection area. Additional paved areas not currently used for parking exist within the property protection area. There are also aboveground waste container storage areas within the WIPP CH and RH waste handling facilities. On the basis of the presence and type of existing facilities, it is assumed that no additional construction would be needed to accept, handle, or store GTCC LLRW and GTCC-like waste or transport them to the underground facility. Therefore, the impacts on ecological resources from disposal of GTCC LLRW and GTCC-like waste at the WIPP site would be very small potential increases in disturbance to wildlife habitat

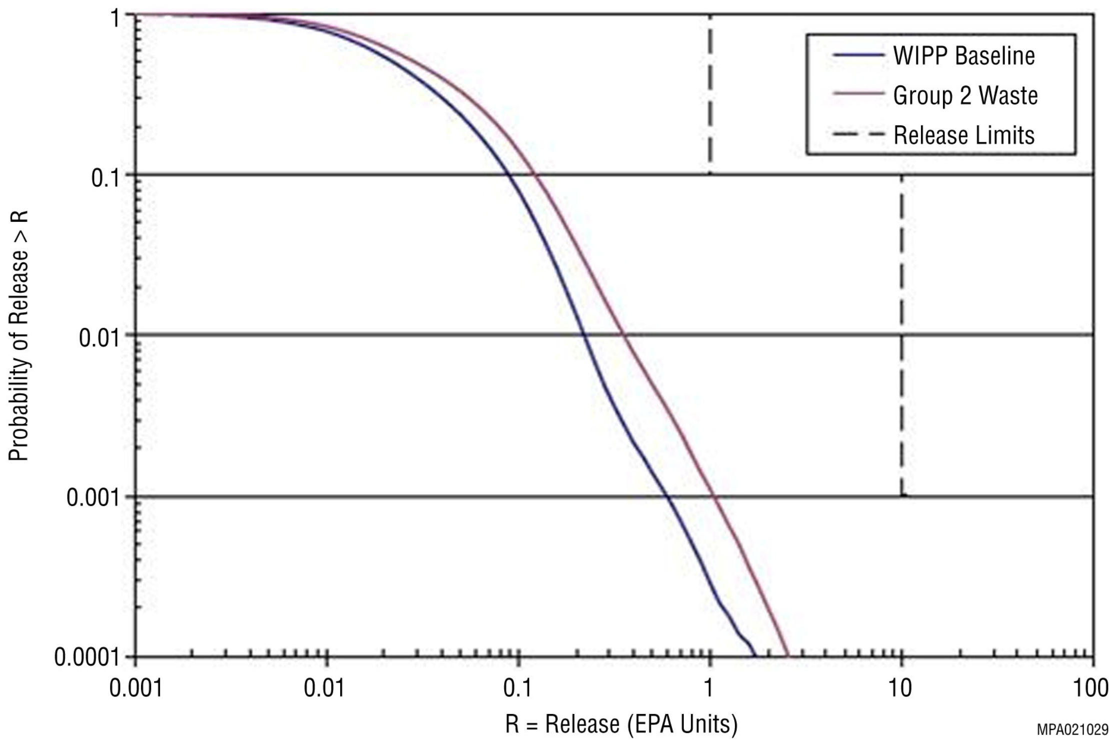

FIGURE 4.3.4-3 Mean Total Release CCDF for Group 2 Wastes (Source: Sandia 2010a)

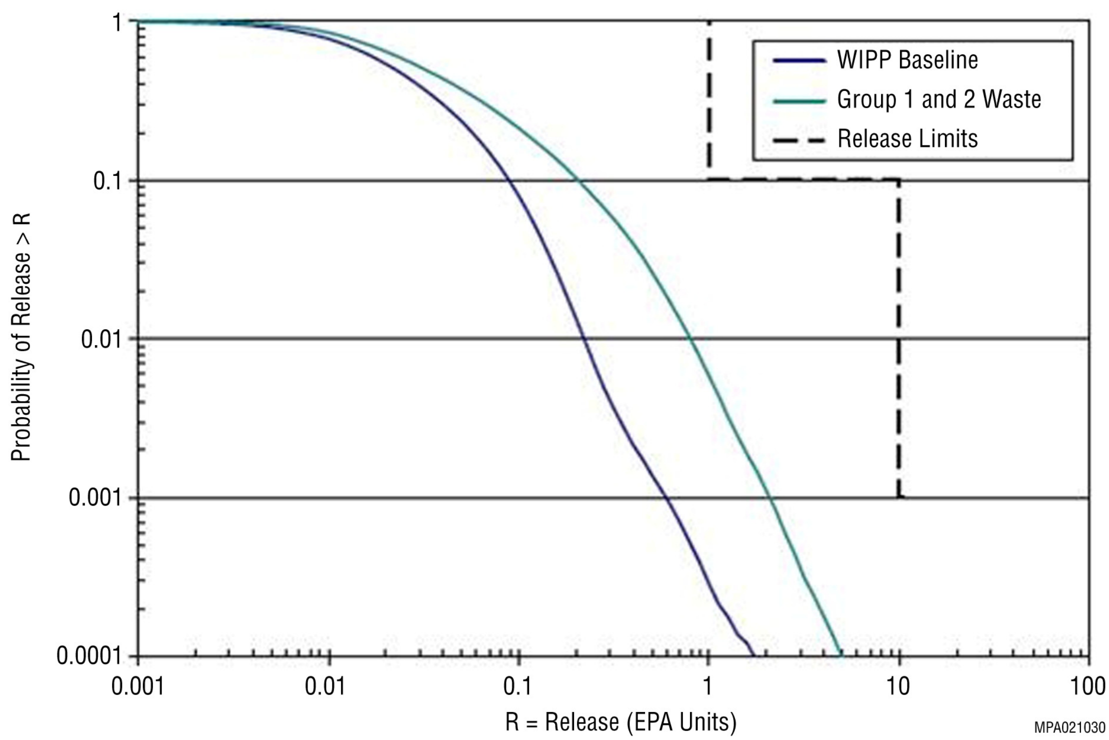

FIGURE 4.3.4-4 Mean Total Release CCDF for Groups 1 and 2 Wastes Combined (Source: Sandia 2010a)

or wildlife injuries or deaths from collisions with vehicles. Both impacts would be localized and are not expected to result in adverse population-level impacts.

4.3.6 Socioeconomics

The potential socioeconomic impacts from constructing additional underground rooms at WIPP to accommodate the GTCC LLRW and GTCC-like waste would be small. Construction activities would involve 58 employees in the peak construction year and an additional 72 indirect jobs in the ROI (Table 4.3.6-1). Because construction would be accomplished by using the existing workforce, no in-migration of workers or their families would occur during the construction period, so no impacts on housing, public finances, public service employment, or traffic would result.

The potential socioeconomic impacts from disposal operations to emplace GTCC LLRW and GTCC-like waste in underground rooms could be relatively large in the peak years of operations. Operational activities would require the same workforce as that currently employed at WIPP (i.e., about 1,123 direct jobs annually and an additional 1,218 indirect jobs in the ROI) (Table 4.3.6-1). It is estimated that operations associated with the disposal of GTCC LLRW and GTCC-like waste at WIPP would produce $104 million in income annually (the same amount as the current annual budget for WIPP). Because the waste disposal operations would be accomplished largely by using only the existing workforce, there would be no significant in-migration of workers or their families during the construction period; thus there would not be any impacts on housing, public finances, public service employment, or traffic.

4.3.7 Environmental Justice

4.3.7.1 Construction

No radiological risks and only very low chemical exposure and risk are expected during construction of the additional underground rooms at WIPP. Because the health impacts of the construction activities on the general population within the 80-km (50-mi) assessment area during construction would be negligible, impacts from construction on the minority and low-income population would not be significant.

4.3.7.2 Operations

Consistent with the assumption that incoming GTCC waste containers would only be consolidated for placement and that no repackaging would be necessary, there would be no measurable 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, there

TABLE 4.3.6-1 Effects of Construction and Operations on Socioeconomics at the ROI for WIPP[a]

Impact Category	Construction of Rooms	Operation
Employment (number of jobs)		
Direct	58	1,123
Indirect	72	1,218
Total	130	2,341
Income ($ in millions)		
Direct	1.6	64
Indirect	3.0	40
Total	4.6	104
Population (number of new residents)	None	None
Housing (number of units required)	None	None
Public finances (% impact on expenditures)		
Cities and counties[b]	None	None
Schools[c]	None	None
Public service employment (number of new employees)		
Local government employees[d]	None	None
Teachers	None	None
Traffic (impact on current levels of service)	None	None

[a] Impacts shown are for peak year of construction and operations.

[b] Includes impacts that would occur in the cities of Artesia, Carlsbad, Loving, Eunice, Hobbs, Jal, Lovington, and Tatum and in Eddy and Lea Counties.

[c] Includes impacts that would occur in the Artesia, Carlsbad, Loving, Eunice, Hobbs, Jal, Lovington, and Tatum school districts.

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

would be no disproportionately high and adverse impact on minority and low-income population groups within the 80-km (50-mi) assessment area.

4.3.7.3 Accidents

A release of GTCC waste at WIPP could cause minor impacts 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, the communities most likely to be affected would be minority or low-income, given the demographics within 80 km (50 mi) of WIPP.

If 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 by the wind. Although the overall risk would be very small, the greatest risk of exposure following an airborne release would be to the population groups residing to the northwest of the site.

4.3.8 Land Use

Use of WIPP for disposal of GTCC wastes would not change the multiple-use management of the surface area of the site. In general, the inclusion of GTCC LLRW and GTCC-like waste would not require modifications to any WIPP surface facilities or the aboveground infrastructure. It is assumed that the existing facilities would be adequate to facilitate waste handling, storage, and transport to the underground storage area at WIPP. WIPP can receive standard truck shipments and has a rail spur adjacent to the WHB. There are aboveground waste container storage areas within the WIPP CH and RH waste handling facilities. Current parking areas could be used for temporary storage or overflow of transport trailers within the property protection area. Additional paved areas that are not currently used for parking exist within the property protection area. Because the WIPP site is a designated waste disposal site, there would be no change in land use at the site that would result from the inclusion of GTCC LLRW and GTCC-like wastes. The oil and gas leases and livestock grazing that occur within the WIPP site would not be affected. Land use on areas surrounding the WIPP site would not be affected. Future land use activities that would be permitted within or immediately adjacent to WIPP would be limited to those currently allowable, which would not jeopardize the integrity of the facility, create a security risk, or create worker or public safety risks.

4.3.9 Transportation

The transportation of GTCC LLRW and GTCC-like waste necessary for the disposal of all such waste at WIPP was evaluated. Transportation of all cargo is considered for both truck and rail modes of transport as separate options for the purposes of this EIS. 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 4.3.9.1), (2) radiological risks to individuals receiving the highest impacts during routine conditions (Section 4.3.9.2), and (3) consequences to individuals and populations after the most severe accidents involving a release of radioactive or hazardous chemical material (Section 4.3.9.3).

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 all shipments to the WIPP repository was assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively, 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 corresponding truck shipments. The assignment of these dose rates is also based on the assumption that all of the GTCC LLRW and GTCC-like waste would be packaged in containers so as to meet contact-handling requirements. Impacts from accidents are dependent on the amount of radioactive material in a shipment and what fraction is released should an accident occur. The parameters used in the accident consequence analysis are described further in Appendix C, Section C.9.4.3.

4.3.9.1 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 transportation routes, (2) persons sharing the route, (3) persons at stops, 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 4.3.9-1 and 4.3.9-2, respectively. For the truck option, it is estimated that approximately 33,700 shipments resulting in about 90 million km (56 million mi) of travel would occur but not be expected to cause any LCFs to truck crew members or to the general public. About two accident fatalities are estimated to occur. One accident fatality and no LCFs are estimated for the rail option, in which approximately 11,800 railcar shipments would result in about 32 million km (20 million mi) of travel. The estimated total truck distance travelled of 90 million km (56 million mi) is approximately 0.05% of the total vehicle miles travelled (173,130 million km or 107,602 million mi) by heavy-duty trucks (gross vehicle weight of more than 11,800 kg or 26,000 lb) in the United States in one year (2002) (DOT 2005).

TABLE 4.3.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at WIPP[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	Number 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	12	39,600	0.082	0.0035	0.013	0.015	0.031	<0.0001	<0.0001	<0.0001	0.00092
Past PWRs	85	242,000	0.5	0.02	0.076	0.089	0.18	0.00013	0.0003	0.0001	0.0055
Operating BWRs	2,670	7,260,000	15	0.53	2.2	2.7	5.4	0.0031	0.009	0.003	0.17
Operating PWRs	9,830	23,800,000	50	1.7	7.3	8.8	18	0.01	0.03	0.01	0.54
Sealed sources - CH											
Small	209	360,000	0.15	0.031	0.2	0.26	0.49	0.017	<0.0001	0.0003	0.0091
Cesium irradiators	240	413,000	0.17	0.036	0.23	0.3	0.56	0.0028	0.0001	0.0003	0.01
Other Waste - CH	5	603	0.00025	<0.0001	0.00032	0.00043	0.00077	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - RH	172	477,000	0.98	0.04	0.15	0.18	0.36	<0.0001	0.0006	0.0002	0.011
GTCC-like waste											
Activated metals - RH	70	158,000	0.33	0.0074	0.046	0.058	0.11	<0.0001	0.0002	<0.0001	0.0039
Sealed sources - CH	1	1,720	0.00072	0.00015	0.00096	0.0012	0.0023	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	69	211,000	0.088	0.029	0.12	0.15	0.3	0.00097	<0.0001	0.0002	0.0044
Other Waste - RH	3,650	10,700,000	22	0.75	3.2	3.9	7.9	0.0022	0.01	0.005	0.22

TABLE 4.3.9-1 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	Number 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	956	1,650,000	3.4	0.094	0.48	0.61	1.2	0.00063	0.002	0.0007	0.039
New PWRs	4,790	11,100,000	23	0.8	3.4	4.1	8.3	0.0048	0.01	0.005	0.25
Additional commercial waste	3,740	11,600,000	24	0.82	3.5	4.3	8.6	<0.0001	0.01	0.005	0.24
Other Waste - CH	139	433,000	0.18	0.06	0.26	0.31	0.63	0.003	0.0001	0.0004	0.009
Other Waste - RH	2,590	7,730,000	16	0.55	2.3	2.8	5.7	0.0008	0.01	0.003	0.16
GTCC-like waste											
Other Waste - CH	44	117,000	0.049	0.016	0.069	0.084	0.17	0.0004	<0.0001	0.0001	0.0025
Other Waste - RH	4,440	13,300,000	27	0.94	4	4.9	9.9	0.0022	0.02	0.006	0.28
Total Groups 1 and 2	33,700	89,700,000	180	6.5	28	34	68	0.049	0.1	0.04	2

[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. Vehicle-related impacts were assessed for round-trip travel.

[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 4.3.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at WIPP[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		Physical Accident Fatalities
				Routine Public							
Waste	Number of Shipments	Total Distance (km)	Routine Crew	Off-link	On-link	Stops	Total	Accident[e]	Crew	Public	
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	7	21,300	0.034	0.011	0.00066	0.015	0.027	<0.0001	<0.0001	<0.0001	0.0017
Past PWRs	31	84,300	0.14	0.045	0.0027	0.065	0.11	0.00017	<0.0001	<0.0001	0.005
Operating BWRs	900	2,480,000	4.1	1.3	0.073	1.9	3.3	0.0019	0.002	0.002	0.1
Operating PWRs	3,300	8,620,000	15	4.8	0.25	6.9	12	0.0074	0.009	0.007	0.39
Sealed sources - CH											
Small	105	169,000	0.5	0.15	0.0075	0.37	0.53	0.00092	0.0003	0.0003	0.0059
Cesium irradiators	120	194,000	0.57	0.17	0.0085	0.42	0.6	0.00013	0.0003	0.0004	0.0068
Other Waste - CH	3	2,920	0.011	0.0023	0.00012	0.0085	0.011	<0.0001	<0.0001	<0.0001	0.00011
Other Waste - RH	58	181,000	0.29	0.12	0.0047	0.13	0.25	<0.0001	0.0002	0.0002	0.007
GTCC-like waste											
Activated metals - RH	24	59,300	0.1	0.024	0.0013	0.047	0.072	<0.0001	<0.0001	<0.0001	0.0028
Sealed sources - CH	1	1,610	0.0047	0.0014	<0.0001	0.0035	0.005	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	35	103,000	0.25	0.12	0.0068	0.18	0.3	0.00011	0.0001	0.0002	0.0042
Other Waste - RH	1,220	3,550,000	5.8	1.9	0.11	2.8	4.8	0.00025	0.003	0.003	0.14

TABLE 4.3.9-2 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	Number 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	320	670,000	1.2	0.38	0.02	0.6	1	0.00044	0.0007	0.0006	0.03
New PWRs	1,610	4,050,000	6.9	2.4	0.11	3.3	5.8	0.003	0.004	0.003	0.18
Additional commercial waste	1,250	3,690,000	6	2	0.12	2.9	5	<0.0001	0.004	0.003	0.16
Other Waste - CH	70	207,000	0.49	0.24	0.014	0.36	0.61	0.00036	0.0003	0.0004	0.0087
Other Waste - RH	1,240	3,630,000	5.9	2	0.11	2.9	5	<0.0001	0.004	0.003	0.15
GTCC-like waste											
Other Waste - CH	22	62,500	0.15	0.078	0.0038	0.1	0.18	<0.0001	<0.0001	0.0001	0.0025
Other Waste - RH	1,480	4,340,000	7.1	2.4	0.13	3.4	2.8	0.00023	0.004	0.002	0.18
Total Groups 1 and 2	11,800	32,100,000	54	18	0.98	26	42	0.015	0.03	0.03	1.4

[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. Vehicle-related impacts were assessed for round-trip travel.

[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.

4.3.9.2 Highest Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals may 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 for CH shipments are provided 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 entrance to the WIPP site and present for all 33,700 truck or 11,800 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.

4.3.9.3 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 is not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

4.3.10 Cultural Resources

No potential impacts on cultural resources are expected because construction, operations, and post-closure activities from GTCC LLRW and GTCC-like waste disposal would not involve any additional disturbance of land surface areas beyond the land already occupied by the existing footprint of the WIPP site.

4.3.11 Waste Management

Waste from emplacement of GTCC waste at WIPP would primarily be from disposal operations and include liquid and solid nonhazardous waste (primarily sanitary), solid hazardous waste, and sludge waste. Nonhazardous or sanitary waste flows by gravity to the facultative lagoon system. Nonhazardous solid or sludge waste is disposed of at a commercial sanitary landfill (Sandia 2008a). Solid hazardous waste is characterized, packaged, labeled, and manifested to off-site treatment, storage, and disposal facilities in accordance with the requirements of 40 CFR Part 262 (DOE 2002). Table 4.3.11 presents data on the waste that is generated from the construction of underground rooms and from waste disposal operations.

4.4 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences from the construction of additional rooms, disposal operations, and post-closure facility performance discussed in Section 4.3 are summarized here, as follows.

Air quality. Because of the distance of the emission sources from the WIPP site boundary (about 3 km [2 mi]), emissions from construction and operational activities would not contribute much to concentrations at the boundary and the nearest residence. Therefore, it is expected that concentration levels from operational activities would remain well below the NAAQS and SAAQS.

Noise. During the construction phase, most of the activities would occur underground. No major construction equipment that could cause ground vibration would be used, and no sensitive structures would be in close proximity. Therefore, there would be no adverse vibration impacts from construction activities at the WIPP site. Noise from operational activities would be barely discernable or completely inaudible at the site boundary and the nearest residence.

Geology. It is assumed that the GTCC LLRW and GTCC-like waste would be disposed of in underground waste disposal rooms similar to those currently used for the disposal of TRU waste and that they would be mined adjacent to the panels currently planned for the repository. Because the techniques used for room construction would be the same as those employed for developing the existing repository, geologic impacts would be the same as those produced by historical construction activities and would be negligible.

Water resources. Construction activities to allow for the disposal of GTCC waste in the WIPP repository would increase the site's annual water use of 15 million L (4 million gal) by about 2% and would increase production at the Carlsbad Double Eagle South Well Field by about 0.03%. Construction of the additional rooms at the WIPP repository would not disturb the ground surface. Because no land surfaces would be disturbed during construction, there would be no impacts on either surface water or groundwater resources. Similarly, there would be no impacts on surface water or groundwater quality during construction because there would be no liquid wastes produced and because underground spills would be limited to the interior of the repository, where timely and effective cleanup would occur. The waste disposal operations to emplace the GTCC waste inventory at the WIPP repository would require approximately 20 million L (5.4 million gal) of water. This quantity of water is the same as the amount used currently for WIPP operations because in the peak operational year, GTCC waste shipments would be emplaced at a level similar to the level for waste shipments currently being handled at WIPP. Because the quantity of water used annually would be the same as the amount that is currently used, there would be no net increase in water use at the site. Similarly, there would be no additional water demand on the Double Eagle water supply system.

TABLE 4.3.11-1 Waste That Is Generated from Construction and Operations under Alternative 2

Waste	Construction	Operations[a]
Liquid nonhazardous (sanitary) (L/yr)	NA[b]	830,000
Solid nonhazardous (sanitary) (tons/yr)	NA	23
Solid hazardous (including sludge) (tons/yr)	NA	8.6

[a] Assumed a total of 8,669 hoist trips and 20 years of operation, which is when the majority of GTCC LLRW and GTCC-like waste would be received. Estimates were based on Sandia (2008a).

[b] NA means not applicable.

Human health. It is estimated that the radiation dose commitment to the workforce would be 5.8 person-rem and would not produce any LCFs. The maximum dose to any individual worker would not exceed the administrative limit for waste disposal at WIPP of 1 rem/yr and would likely be no more than several hundred mrem over the entire duration of the disposal activities. A total of about 62 lost workdays due to occupational injuries and no fatalities are projected for the workforce who would be disposing of GTCC wastes under this alternative. 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 project of this size. No measurable radiation doses or LCFs are expected to occur to members of the general public residing near the site during or after site operations, according to the same modeling approach as that used in the recent recertification of WIPP.

Ecological resources. The only potential impacts on ecological resources from disposal of GTCC LLRW and GTCC-like waste at the WIPP site would result from minor increases in land disturbance and from collisions of animals with vehicles. Both would have only a localized impact on wildlife and are not expected to result in adverse population-level impacts.

Socioeconomics. Potential impacts from the construction of additional underground rooms at WIPP to accommodate the GTCC LLRW and GTCC-like waste would be relatively small. Construction activities would involve direct employment of 58 people in the peak construction year and an additional 72 indirect jobs in the ROI. Construction would also produce approximately $4.6 million in income in the peak construction year. Potential impacts from disposal operations could be relatively large. Operational activities would involve about 1,123 direct jobs annually and an additional 1,218 indirect jobs in the ROI. The operations at WIPP for emplacement of GTCC LLRW and GTCC-like waste would also produce $104 million in income annually. Because these operations at WIPP would be accomplished by using the existing workforce, no significant in-migration of workers or their families would occur; thus, there would be no resulting impacts on housing, public finances, public service employment, or traffic.

Environmental justice. Because the health impacts of the construction activities and disposal operations on the general population within the 80 km (50-mi) assessment area during construction would be negligible, impacts of construction on the minority and low-income population also would not be significant.

Land use. There would be no change in the land use at the WIPP site and its surrounding area from the inclusion of GTCC LLRW and GTCC-like wastes. The oil and gas leases and livestock grazing that occur within the WIPP site would not be affected.

Transportation. Shipment of all waste to WIPP by truck would result in approximately 33,700 shipments involving a total distance of 90 million km (56 million mi). No LCFs are expected to occur to truck crew members or the general public, but two accident fatalities could occur. For shipment of all waste by rail, 11,800 railcar shipments totaling 32 million km (20 million mi) of travel would be required. One accident fatality is estimated for rail shipment to WIPP, and no LCFs would result.

Cultural resources. No potential impacts on cultural resources are expected from the disposal of GTCC waste at WIPP, since the construction, operations, and post-closure activities associated with GTCC LLRW and GTCC-like waste disposal would not involve disturbance to land beyond that already occupied by the existing footprint of the WIPP site.

Waste management. Waste from GTCC waste emplacement at WIPP would primarily be from operations and include small quantities of nonhazardous solid and liquid waste and solid hazardous waste. The waste generated would not affect current waste management protocols at WIPP.

4.5 CUMULATIVE IMPACTS

Consistent with 40 CFR 1508.7, in this EIS, a cumulative impact is the impact on the environment that 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 person undertakes such actions. A cumulative impacts assessment accounts for both geographic (spatial) and time (temporal) considerations of past, present, and reasonably foreseeable actions. Geographic boundaries can vary by resource area, depending on the amount of time an impact remains in the environment, the extent to which such an impact can migrate, and the magnitude of the potential impact. The primary factor considered for the purpose of cumulative impacts analysis for this EIS is if the other actions would have some influence on the resources in the same time and space as those affected by the implementation of this alternative (construction of additional underground disposal rooms and the conduct of disposal operations for emplacement of the GTCC LLRW and GTCC-like waste) at WIPP.

> **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 those from other past, present, and reasonably foreseeable future actions.

The primary use of land within 16 km (10 mi) of the WIPP site is grazing, with lesser amounts of land used for oil and gas extraction and potash mining. Most of this land is managed and owned by BLM. Two ranches are located within 16 km (10 mi) of the WIPP site; the closest town, Loving, New Mexico, is about 29 km (18 mi) away. Most of the land within 50 km (30 mi) of the site is owned by either the federal government or the State of New Mexico. Within 80 km (50 mi) of the site, there is dry land farming and there is irrigated farming along the Pecos River; also, some forest, wetlands, and urban land can be found. At the time of the preparation of this EIS, no known large actions were being planned on BLM land.

The land use described above, in combination with the low potential impacts discussed in Section 4.3 for Alternative 2, indicate that cumulative impacts from the construction, operations, and post-closure phases of the proposed action at the WIPP site would be small and would not have a significant cumulative impact on area air quality, geology and soils, water resources, ecology, socioeconomics, environmental justice, cultural resources, and land use. Potential radionuclide concentrations that could be released from the facility are expected to be negligible. The post-closure performance analysis performed for emplacement of all GTCC LLRW and GTCC-like waste at WIPP demonstrates that disposal of these wastes would not result in human health impacts (see Section 4.3.4.3). Potential combined effects of transportation of GTCC waste to WIPP would likewise not have a significant cumulative impact on transportation (see Section 4.3.9).

On June 15, 2005, the NRC staff issued the *Environmental Impact Statement for the Proposed National Enrichment Facility in Lea County, New Mexico* (NRC 2005). This facility was constructed and is in operation. It is located about 59 km (37 mi) east of the WIPP site (town of Eunice). The distance from the WIPP site — combined with NRC staff findings as reported in NRC (2005), which stated that environmental impacts from this enrichment facility would be small to moderate — indicate that cumulative impacts from the possible GTCC waste disposal activities at WIPP in combination with the enrichment facility operations would likewise not result in a significant cumulative impact (including human health and transportation impacts).

4.6 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The resources that would be irreversibly and irretrievably committed for the disposal of GTCC LLRW and GTCC-like waste at WIPP would include the underground space, energy, raw materials, and other natural and man-made resources used to construct the additional rooms needed. The impacts from such a commitment of resources would be small, since the WIPP facility is already in place.

Energy expended would be in the form of fuel for equipment and vehicles and electricity for facility operation. Construction and operations would consume approximately 1.9 million L (490,000 gal) of diesel fuel. The electrical energy requirement would represent a small increase in the electrical energy demand of the area. Resources that would be committed irreversibly or irretrievably for GTCC waste disposal at WIPP would include materials that could not be recovered or recycled and materials that would be consumed or reduced to unrecoverable forms. It is expected that about 520,000 kg (510 tons) of steel would be committed to the construction of the additional disposal rooms. During operations, the proposed action would generate a small amount of nonrecyclable waste streams, such as hazardous wastes that would be subject to RCRA regulations. Generation of these waste streams would represent an irreversible and irretrievable commitment of material resources.

4.7 STATUTORY AND REGULATORY PROVISIONS RELEVANT TO THIS GTCC EIS

The WIPP LWA (P.L. 102-579) limits the use of WIPP to the disposal of TRU waste generated by atomic energy defense activities. In addition, P.L. 102-579 establishes certain limits on the surface dose rate, total volume, total radioactivity (curies), and maximum activity level (curies per liter averaged over the volume of the canister) for waste received at WIPP. The implementation of the WIPP alternative for GTCC LLRW and GTCC-like waste would require federal legislation to authorize acceptance of non-defense TRU and non-TRU waste and modification of the disposal capacity limits stipulated by P.L. 102-579 to authorize an increase in the total volume of all TRU waste and total curies of RH TRU waste received at WIPP. In addition, (1) a corresponding modification to the facility's RCRA permit with the New Mexico Environment Department (NMED); (2) a modification to the *Agreement for Consultation and Cooperation between Department of Energy and the State of New Mexico for the Waste Isolation Pilot Plant* (updated April 18, 1988), which sets limits on the total volume of RH TRU received at WIPP; and (3) compliance certification with the EPA might be required. Remote-handled GTCC LLRW and GTCC-like waste would be packaged in shielded containers and would not exceed the surface dose and curie-per-liter limits for RH waste in P.L. 102-579.

Implementation of the WIPP alternative would also require legislative changes for WIPP to be utilized as a disposal facility for GTCC LLRW consistent with the LLRWPAA direction that such a facility be licensed by the NRC. DOE plans to highlight these issues in the Report to Congress that will be submitted. The report will include a description of disposal alternatives evaluated in the GTCC EIS.

The total capacity for disposal of TRU waste established under the WIPP LWA is 175,675 m^3 (6.2 million ft^3). The Consultation and Cooperative Agreement with the State of New Mexico (1981) established a total RH capacity of 7,080 m^3 (250,000 ft^3), with the remaining capacity for CH TRU at 168,500 m^3 (5.95 million ft^3). In addition, the WIPP LWA limits the total radioactivity of RH waste to 5.1 million curies. For comparison, the GTCC LLRW and GTCC-like CH volume, RH volume, and RH total radioactivity are approximately 6,650 m^3 (235,000 ft^3), 5,050 m^3 (178,000 ft^3), and 157 million curies, respectively. On the basis of emplaced and anticipated waste volumes, the disposal of all GTCC LLRW and GTCC-like waste at WIPP would exceed the limits for RH volume and RH total activity. The majority of the GTCC LLRW and GTCC-like RH volume is from the Other Waste category (e.g., DOE non-defense TRU), and activated metal waste contributes to most of the RH activity. The WIPP LWA (P.L. 102-579) also limits disposal in WIPP to defense-generated TRU waste. Therefore, the implementation of the WIPP alternative for all GTCC LLRW and GTCC-like waste would require modification of the WIPP LWA to authorize acceptance of non-defense and non-TRU waste, an increase in the disposal capacity limit for RH total curies, and a change to the Consultation and Cooperative Agreement to authorize an increase in the total volume of all RH

TRU waste. In addition, a corresponding modification of the facility's RCRA permit with the NMED, a modification to the Agreement for Consultation and Cooperation between the U.S. Department of Energy and the State of New Mexico for the Waste Isolation Pilot Plant (updated April 18, 1988), which sets limits (identified above) on the total volume of RH TRU received at WIPP, and compliance certification with the EPA might be required. RH GTCC LLRW and GTCC-like waste would be packaged in shielded containers and would not exceed the surface dose and curies-per-liter limits for RH waste in the WIPP LWA.

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5 EVALUATION ELEMENTS COMMON TO ALTERNATIVES 3, 4, AND 5

This chapter presents information that is applicable to the three land disposal alternatives: Alternative 3 (borehole disposal), Alternative 4 (trench disposal), and Alternative 5 (vault disposal). Section 5.1 describes Alternatives 3 to 5 and the general approach and assumptions that were incorporated in developing the conceptual facility designs evaluated in this EIS. Section 5.2 summarizes the assessment approach and assumptions for developing the affected environment and consequence analyses for each environmental resource area. Section 5.3 discusses the environmental consequences and human health impacts that are common to all land disposal sites evaluated in Chapters 6 through 11. This chapter concludes with a discussion of the irreversible and irretrievable commitment of resources from construction and operations in Section 5.4, of the inadvertent human intruder scenario in Section 5.5, and of institutional controls in Section 5.6. These topics apply to all three disposal methods being evaluated under Alternatives 3 to 5, regardless of the site or disposal location.

5.1 DESCRIPTION OF ALTERNATIVES 3 TO 5

Sections 5.1.1 to 5.1.3 describe Alternatives 3 to 5, respectively. Details on the conceptual designs for the three land disposal facilities are presented in Section 5.1.4. At each of the six federal sites (Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity) to be evaluated under Alternatives 3 to 5, a parcel of land has been designated as the GTCC reference location for evaluation purposes in this EIS. These GTCC reference locations are generally near current waste disposal facilities at the sites. Figures showing the locations are provided in the site-specific chapters, Chapters 6 through 11. Figures that show the general footprints of the GTCC reference locations in order to provide perspective on where the locations are situated with regard to the sites as a whole are provided in Chapter 1 (Figures 1.4.3-4 through 1.4.3-9). Since no specific commercial disposal location has been identified for evaluation, no reference locations for the generic commercial disposal facilities at the four regions are presented in this EIS, and evaluations are hypothetical in nature.

The approximate size (44 ha or 110 ac) of the GTCC reference locations at the Hanford Site, INL, LANL, NNSS, and WIPP Vicinity was based on the space required for the borehole method because it requires the most space of the three land disposal methods evaluated for those sites (see Table 5.1-1 and Table 1.4.3-1). The approximate size (24 ha or 60 ac) of the GTCC reference location at SRS was based on the space required for the vault disposal method, because it is larger than the space required for the trench method and because the borehole method is not being considered for this site.

The size of the GTCC reference location depends primarily on the number of disposal units (i.e., the number of boreholes, trenches, or vaults) required to accommodate the total volume of waste. Less space would be required if only a portion of the GTCC waste inventory was disposed of by using a particular method. Table 5.1-2 summarizes the capacity of a single borehole, trench, or vault (each vault is made up of 11 vault cells) for emplacing the disposal containers assumed in this EIS. The numbers of disposal units (i.e., number of boreholes,

TABLE 5.1-1 Number of Disposal Units and Land Area Required for Land Disposal Methods

Land Disposal Facility	No. of CH Waste Disposal Units	No. of RH Waste Disposal Units	Total No. of Disposal Units[a]	Facility Size (ac)[b]
Borehole	420	510	930	110
Trench	7	22	29	50
Vault	34 cells[a]	92 cells	12	60

[a] For the vault method, there would be 12 vaults, each containing 11 disposal cells. Values presented were rounded to two significant figures.

[b] Required acreage presented for the borehole, trench, and vault disposal facility were rounded from 110.4, 46, and 63 acres, respectively.

TABLE 5.1-2 Number of Each Type of Disposal Container That Can Be Accommodated by One Disposal Unit[a]

Type of Container	Borehole	Trench	Vault Cell[b]
CH 55-gal drums	56	3,000	630
SWB	8	500	100
Cs irradiator	20	1,700	300
RH 55-gal drums	54[c]	1,200	290
AMCs	36	910	220

[a] Values presented were rounded to two significant figures.

[b] There are 11 vault cells per vault disposal unit.

[c] It is assumed that three RH drums would be packaged in an RH canister for borehole disposal, with 18 RH canisters per borehole.

trenches, or cells in a vault) needed for each land disposal method and for each waste group and container type are summarized in Table 5.1-3. Details on disposal containers and packing arrangements in the disposal units are also provided in Sections 5.1.1 to 5.1.3 and in Appendix D.

5.1.1 Alternative 3: Disposal in a New Borehole Disposal Facility

Alternative 3 would involve the construction, operations, and post-closure of a new borehole facility for disposal of the GTCC LLRW and GTCC-like waste inventory. GTCC

TABLE 5.1-3 Number of Disposal Units Required for Each Waste Type and Disposal Container[a]

Waste Type	Container Type	Containers: Stored	Containers: Projected	Containers: Total	Boreholes: Stored	Boreholes: Projected	Boreholes: Total	Vault Cells: Stored	Vault Cells: Projected	Vault Cells: Total	Trenches: Stored	Trenches: Projected	Trenches: Total
Group 1													
GTCC LLRW													
Activated metals - RH													
Past/present commercial reactors	AMC	170	2,300	2,500	4.6	64	68	0.8	11	11	0.2	2.5	2.7
Sealed sources - CH	55-gal[b] drum	0	8,700	8,700	0	160	160	0	14	14	0	2.9	2.9
Cesium irradiators - CH	Self-contained	0	1,400	1,400	0	72	72	0	4.8	4.8	0	0.9	0.9
Other Waste - CH	55-gal drum	200	0	200	3.6	0	3.6	0.3	0	0.3	< 0.1	0	< 0.1
Other Waste - RH	55-gal drum	160	5	160	2.9	< 0.1	3	0.5	< 0.1	0.6	0.1	< 0.1	0.1
GTCC-like waste													
Activated metals - RH	AMC	20	18	38	0.6	0.5	1.1	< 0.1	< 0.1	0.2	< 0.1	< 0.1	< 0.1
Sealed sources - CH	55-gal drum	1	3	4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Cesium irradiators - CH	Self-contained	0	0	0	0 0	0	0	0 0	0	0	0	0	0
Other Waste - CH	55-gal drum	170	0	170	3.1	0	3.1	0.3	0	0.3	< 0.1	0	< 0.1
Other Waste - CH	SWB	220	170	380	27	21	48	2.2	1.7	3.8	0.4	0.3	0.8
Other Waste - RH	55-gal drum	2,500	950	3,500	47	18	64	8.7	3.3	12	2.1	0.8	2.9
Group 2													
GTCC LLRW													
Activated metals - RH													
New BWRs	AMC	0	200	200	0	5.6	5.6	0	0.9	0.9	0	0.2	0.2
New PWRs	AMC	0	830	830	0	23	23	0	3.9	3.9	0	0.9	0.9
Additional commercial waste	AMC	0	2,000	2,000	0	55	55	0	9.2	9.2	0	2.2	2.2
Other Waste - CH	SWB	0	830	830	0	100	100	0	8.3	8.3	0	1.7	1.7
Other Waste - RH	55-gal drum	0	11,000	11,000	0	210	210	0	39	39	0	9.4	9.4
GTCC-like waste													
Other Waste - CH	SWB	0	260	260	0	33	33	0	2.6	2.6	0	0.5	0.5
Other Waste - RH	55-gal drum	0	4,200	4,200	0	78	78	0	15	15	0	3.5	3.5
Total Groups 1 and 2		3,400	33,000	37,000	89	840	930	13	110	130[c]	3	26	29

TABLE 5.1-3 (Cont.)

Waste Type	Container Type	Number of Containers			Number of Boreholes			Number of Vault Cells			Number of Trenches		
		Stored	Projected	Total	Stored	Projected	Total	Stored	Projected	Total	Stored	Projected	Total
Breakdown by Container Type for Groups 1 and 2													
	CH drum	380	8,700	9,100	6.7	160	160	0.6	14	14	0.1	2.9	3
	SWB	220	1,300	1,500	27	160	180	2.2	13	15	0.4	2.5	2.9
	Self-contained	0	1,400	1,400	0	72	72	0	4.8	4.8	0	0.9	0.9
	RH drum	2,700	17,000	19,000	49	310	360	9.3	57	67	2.2	14	16
	AMC	190	5,300	5,500	5.2	150	150	0.9	25	26	0.2	5.9	6.1
	Total	3,400	33,000	37,000	89	840	930	13	110	130	3	26	29

[a] AMC = activated metal canister, BWR = boiling water reactor, CH = contact handled, PWR = pressurized water reactor, RH = remote handled, SWB = standard waste box.

[b] 55 gal = 208 L.

[c] There are 11 vault cells per vault; therefore, 130 vault cells would require 12 vaults.

reference locations at five of the six sites are evaluated for this alternative: Hanford Site, INL, LANL, NNSS, and WIPP Vicinity. Alternative 3 is not evaluated for SRS because the depth required (i.e., about 40 m or 130 ft) for the borehole disposal method is incompatible with the shallow groundwater table present at this site. Borehole disposal is also evaluated for one of the generic commercial regional locations (in Region IV).

About 44 ha (110 ac) of land would be required to accommodate the approximately 930 boreholes needed to dispose of the waste packages containing the 12,000 m^3 (420,000 ft^3) of GTCC LLRW and GTCC-like waste. Fewer boreholes and less space would be required if only a portion of the inventory was disposed of by using boreholes. This acreage would include land required for support infrastructure (e.g., facilities or buildings for receipt and handling of waste packages or containers) and space for a retention pond to collect stormwater runoff and truck washdown water. Borehole disposal entails emplacement of waste in boreholes at depths deeper than 30 m (100 ft) but above 300 m (1,000 ft) bgs. Boreholes can vary widely in diameter (from 0.3 to 3.7 m [1 to 12 ft]), and the proximity of one borehole to another can vary depending on the design of the facility. The technology for drilling larger-diameter boreholes is simple and widely available. The current conceptual design employs boreholes that are 2.4 m (8 ft) in diameter and 40-m (130-ft) deep in unconsolidated to semiconsolidated soils, as shown here in Figure 5.1.1-1 and in Figure 1.4.2-1, with the spacing between boreholes being 30 m (100 ft).

A bucket auger would be used to drill the large-diameter borehole (see Figure 5.1.1-2), and a smooth steel casing would be advanced to the depth of the borehole during the drilling and construction of the borehole. The casing would provide stability to the borehole walls and ensure that waste packages would not snag or plug the borehole as they were lowered and that they would sit in an upright position when they reached the bottom. The upper 30 m (100 ft) of smooth steel casing would be removed upon closure of the borehole. In some cases where consolidated materials might be encountered, a more robust drilling technology, such as drilling a series of smaller boreholes next to each other with equipment designed to drill into rock formations, would be required. A casing would also be used in this latter case as an aid in placing the waste packages.

For a borehole, the packing arrangements assumed for CH waste are eight intervals (levels) of 208-L (55-gal) drum 7-packs, five intervals of Cs irradiator 4-packs, or eight intervals of one standard waste box (SWB). For RH waste, three intervals of two 3-packs of RH canisters or six intervals of two 3-packs of activated metal canisters (AMCs) are assumed. The waste packages would be placed into the borehole, and then a fine-grained, cohesionless fill (sand) would be used to backfill around the waste containers to fill voids. After the borehole was filled with the waste containers and backfill, a reinforced concrete layer would be placed over the waste packages to help mitigate any future inadvertent intrusion. It is anticipated that clean fill from construction would be used to backfill the borehole above the concrete layer. Each borehole could be capped with a cover system consisting of a geotextile membrane overlain by gravel, sand, and topsoil layers, similar to the cover system for trench disposal discussed in Section 5.1.3 and shown later for vault disposal in Figure 5.1.3-4. In the case of the borehole, the top of the cover system would be flush with or slightly elevated above the surrounding ground surface, depending on the final design. Details on borehole facility construction, operations, and facility integrity are provided in Section 5.1.4.

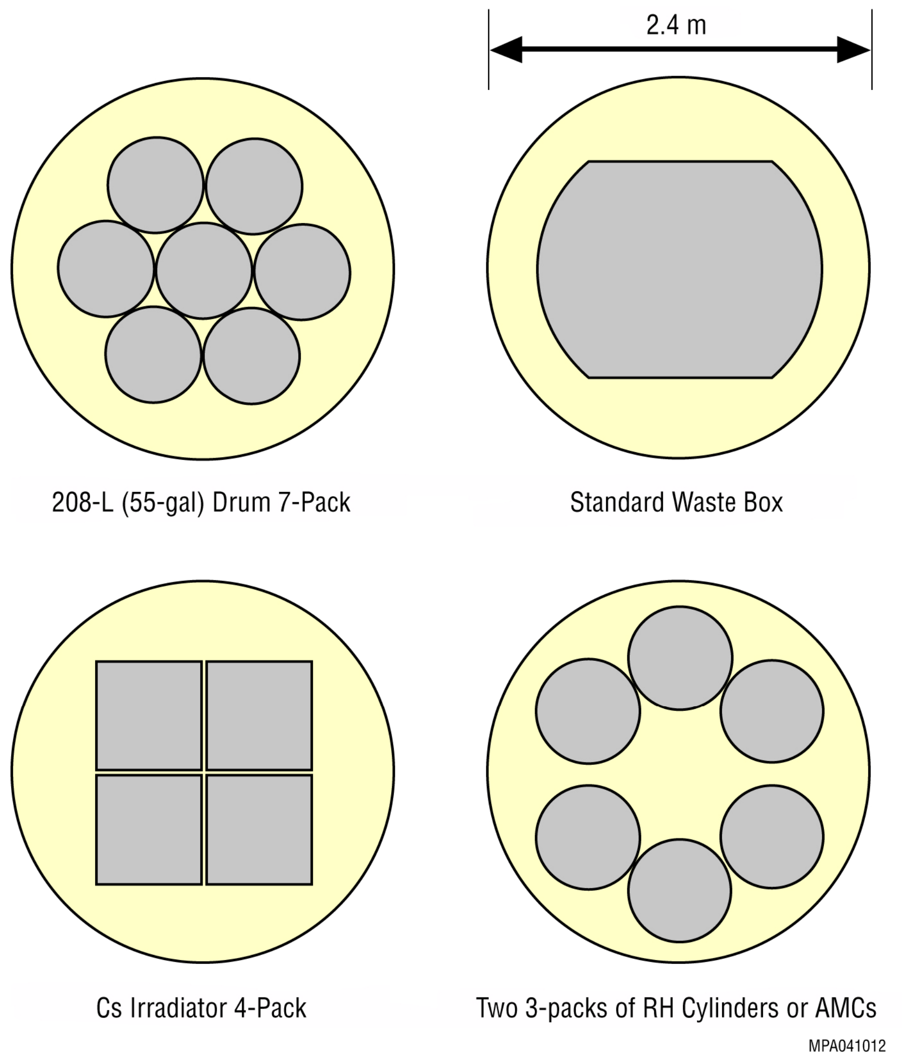


FIGURE 5.1.1-1 Top View of Single-Interval Packing Arrangements in 2.4-m-Diameter (8-ft-Diameter) Boreholes for Different Container Types

5.1.2 Alternative 4: Disposal in a New Enhanced Trench Disposal Facility

Alternative 4 would involve construction, operations, and post-closure of a new trench facility for disposal of the GTCC LLRW and GTCC-like waste included in Groups 1 and 2 of the inventory. GTCC reference locations at the six federal sites (Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity) and at the four generic regional locations for the hypothetical commercial disposal facilities are evaluated for this alternative.

To dispose of the entire 12,000 m^3 (420,000 ft^3) of GTCC LLRW and GTCC-like waste, the conceptual design would include 29 trenches occupying a footprint of about 20 ha (50 ac) (see Table 5.1-1). Fewer trenches and less space would be required if only a portion of the GTCC waste inventory was disposed of by using this method. The assumed 20-ha (50 ac) area

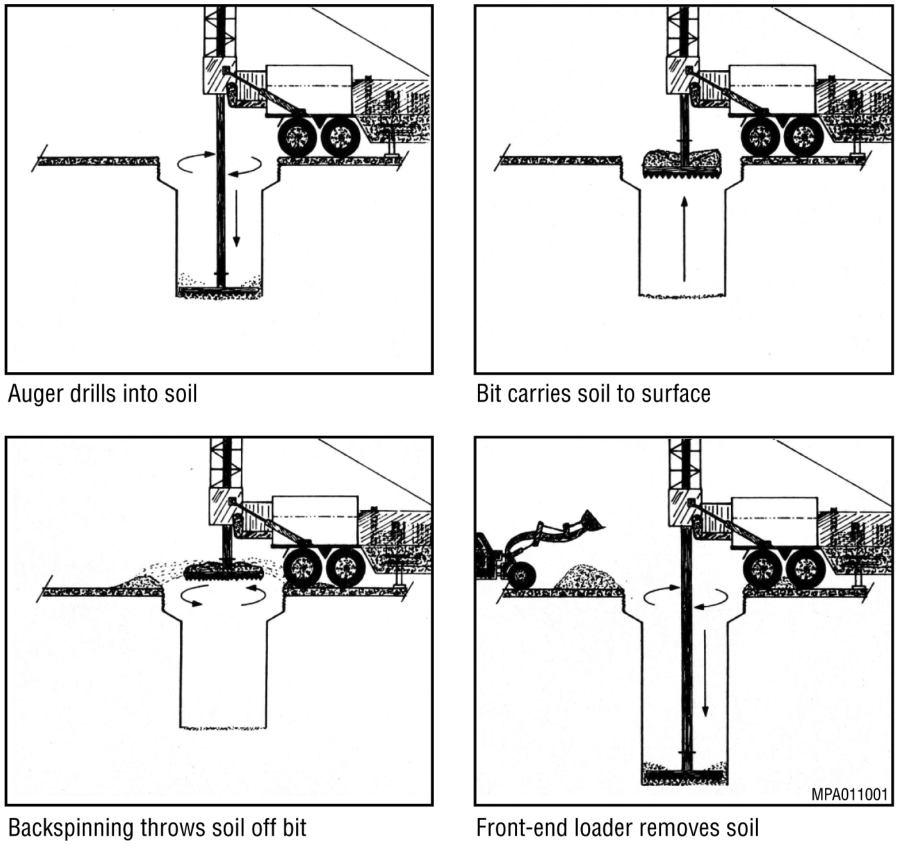
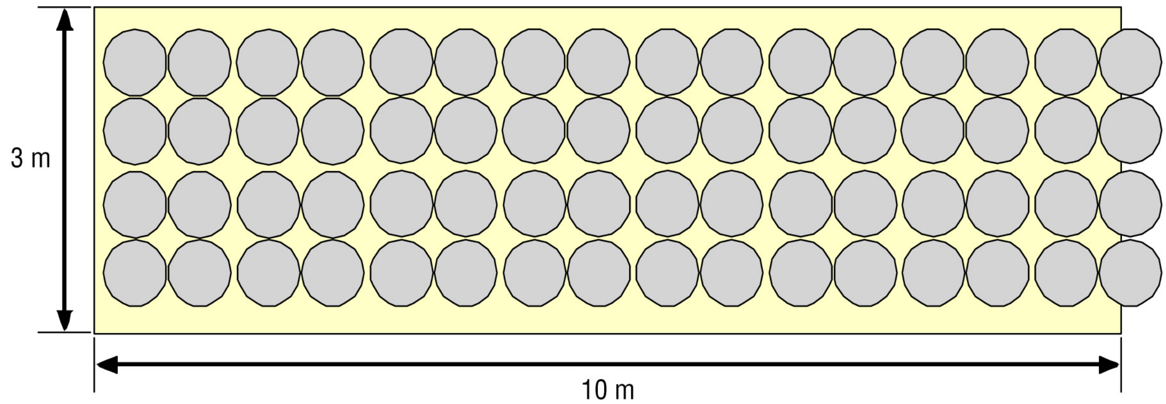


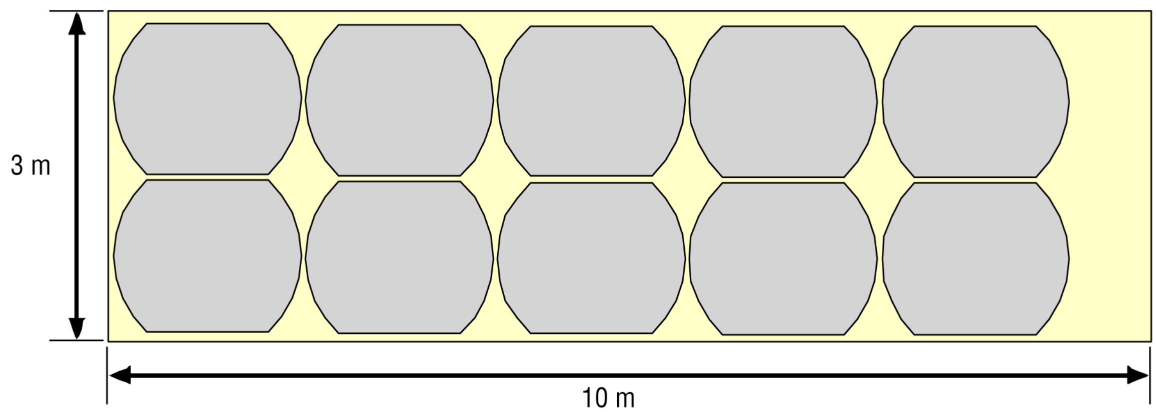
FIGURE 5.1.1-2 Process Schematic for Drilling a Large-Diameter Borehole by Using a Bucket Auger (Source: Sandia 2007)

would include land needed for supporting infrastructure (e.g., facilities or buildings for receipt and handling of waste packages or containers) and space for a retention pond to collect stormwater runoff and truck washdown water. Each trench would be approximately 3-m (10-ft) wide, 11-m (36-ft) deep, and 100-m (330-ft) long. The number of packages that would be needed to contain the waste inventory is given in Table 5.1-3. The information is presented on a waste type basis. After placement of wastes in the trench, an engineered barrier (a reinforced concrete layer) would be placed on top, and then backfill would be added to just below the surface level. Each trench could be capped with a cover system consisting of a geotextile membrane overlain by gravel, sand, and topsoil layers, similar to that shown for the vault design final cover system later in Figure 5.1.3-4. In the case of the trench, the top of the cover system would be flush with or slightly elevated above the surrounding ground surface, depending on the final design. The additional concrete layer would serve to deter inadvertent intrusion into the buried waste during the post-closure period.

During disposal operations for CH waste, one end of a trench would have a ramp to the surface to allow entry by a forklift carrying CH waste packages (a pallet of four drums, four Cs irradiators, or a single SWB) for emplacement. The assumed packing arrangement for 208-L (55-gal) drums and SWBs in a 10-m (33-ft) section of trench is shown in Figure 5.1.2-1.



Five layers of 600 208-L (55-gal) drums each; 3,000 drums per trench



Five layers of 100 SWBs each; 500 SWBs per trench MPA011002

FIGURE 5.1.2-1 Top View of a 10-m (33-ft) Section of a Trench Packed with Contact-Handled Waste

Additional features would be necessary in the trenches where RH waste would be buried to provide shielding for the workers once the waste was in place. The RH waste packages (AMCs, drums, and RH canisters containing drums) would be disposed of in vertical reinforced concrete cylinders with concrete shield plugs on the top of each cylinder. A mating flange would enable coupling of the bottom-loading transfer cask to a given cylinder for transfer of the waste package into the disposal unit. The transfer cask would be moved off of an on-site transport truck and into position by an overhead crane. Figure 5.1.2-2 shows a top view of a 10-m (33-ft) section of an RH waste disposal trench. Each cylinder would be able to hold up to three AMCs, four individual 208-L (55-gal) drums, or one RH canister. During trench closure, the engineered barrier would be placed directly on top of the concrete shield plugs.

Facility construction, operations, and post-closure activities assumed for the evaluation of the trench disposal method are discussed in Section 5.1.4 and Appendix D.

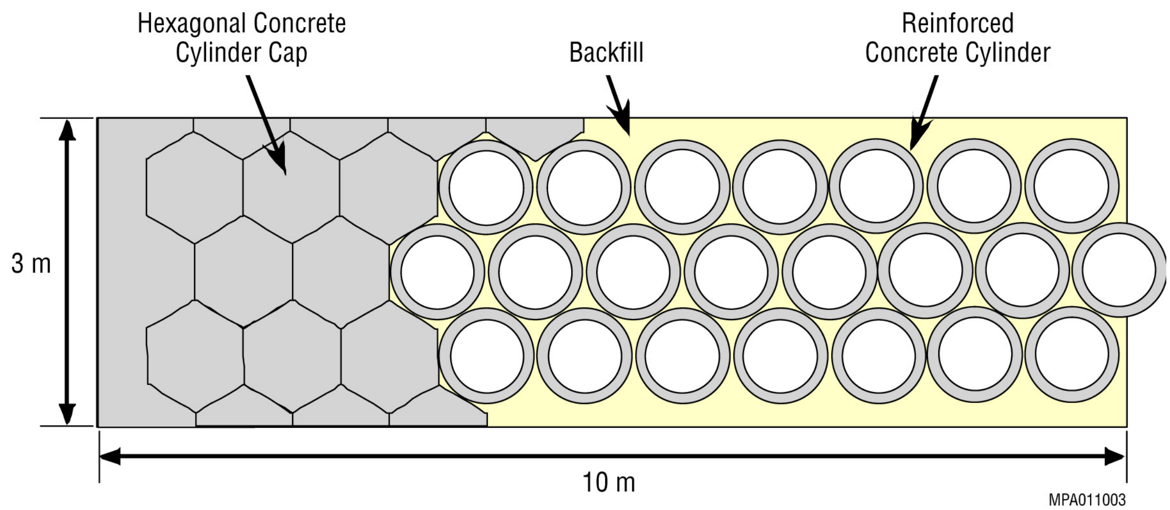


FIGURE 5.1.2-2 Top View of a 10-m (33-ft) Section of a Trench for Disposal of Remote-Handled Waste

5.1.3 Alternative 5: Disposal in a New Vault Disposal Facility

Alternative 5 would involve the construction, operations, and post-closure of a new vault facility for disposal of GTCC LLRW and GTCC-like waste included in Groups 1 and 2 of the inventory. GTCC locations at all six federal sites (Hanford Site, INL, LANL, NNSS, SRS, and WIPP Vicinity) and at the generic commercial sites for the four regions are evaluated for this alternative.

In the conceptual design for vault disposal of GTCC LLRW and GTCC-like waste, a reinforced concrete vault would be constructed near grade level, with the footings and floors of the vault situated in a slight excavation just below grade. The design is a modification of a disposal concept proposed by Henry (1993) for GTCC LLRW, and it is similar to a belowground vault LLRW disposal method (Denson et al. 1987) previously investigated by the USACE. A similar concrete vault structure is currently in use (mostly below grade) for the disposal of higher-activity LLRW at SRS (MMES et al. 1994).

The vault disposal facility would occupy a footprint of about 24 ha (60 ac) (see Table 5.1-1) to accommodate the 12 vaults required to dispose of the entire 12,000 m^3 (420,000 ft^3) of GTCC LLRW and GTCC-like waste. Each vault (excluding the interim and final cover) would be about 11-m (36-ft) wide, 94-m (310-ft) long, and 7.9-m (26-ft) tall, with 11 disposal cells situated in a linear array. Interior cell dimensions would be about 8.2-m (27-ft) wide, 7.5-m (25-ft) long, and 5.5-m (18-ft) high, with an internal volume of 340 m^3 (12,000 ft^3) per cell. Double interior reinforced concrete walls with an expansion joint would be included after every second cell. Figure 1.4.2-4 in Chapter 1 shows a schematic cross section of a vault cell.

The packing arrangement to be used for CH 208-L (55-gal) drums in a cell assumes the placement of 7-drum packs as received at the facility in a Transuranic Package Transporter-II (TRUPACT-II) Type B transportation package. Figure 5.1.3-1 shows the arrangement for the CH drums, with 18 7-drum packs per layer. If five layers were used, 630 drums could be accommodated in each cell. For SWBs, 20 SWBs could be arranged in one layer (Figure 5.1.3-2), with five layers for 100 SWBs in one vault cell. In addition, it is assumed that about 300 Cs irradiators (three layers of 10 by 10) could fit in one cell. SWBs, 7-drum packs, and 4-packs of irradiators would be taken off an on-site transport truck and loaded into the cell by an overhead crane.

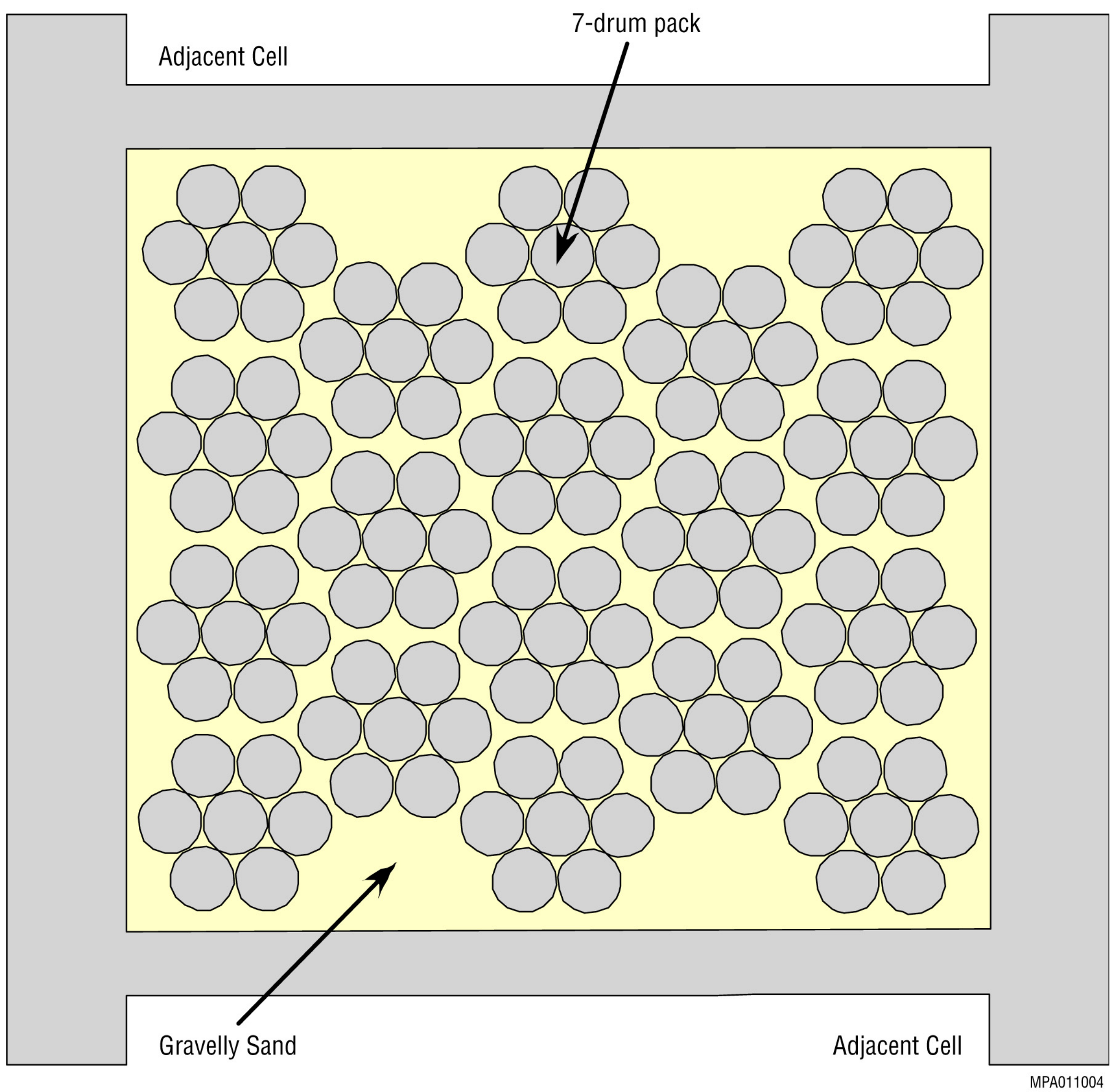


FIGURE 5.1.3-1 Single-Layer Packing Arrangement of Contact-Handled Waste in 208-L (55-gal) 7-Drum Packs in Vault Cells

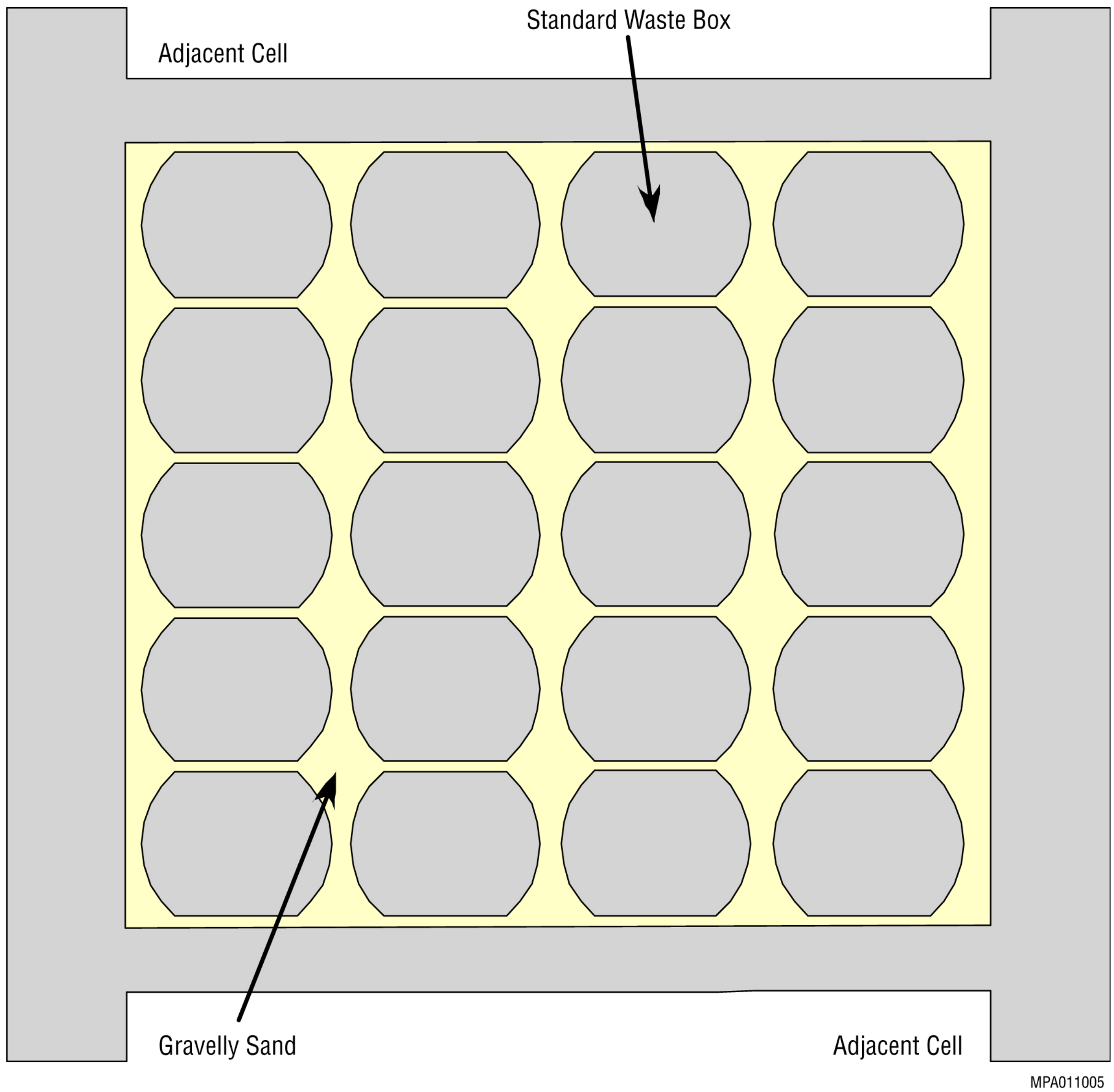


FIGURE 5.1.3-2 Single-Layer Packing Arrangement of Contact-Handled Waste in Standard Waste Boxes in Vault Cells

The vault cell design for disposal of RH waste would be similar to the trench design, as discussed in Section 5.1.2. RH AMCs, 208-L (55-gal) drums, or canisters would be loaded from a bottom-loading transfer cask into vertical concrete cylinders with thick concrete shield plugs within each cell. Figure 5.1.3-3 shows a view from the top of a vault cell. The cylinder loading would be the same as that for a trench: three AMCs, four 208-L (55-gal) drums, or one RH canister per cylinder.

Two engineered cover systems would be used for the vaults. Figure 5.1.3-4 provides a cross-sectional view of each. The first cover would either be installed after each vault was filled with waste and permanently closed, or it would be installed incrementally as the vault was being

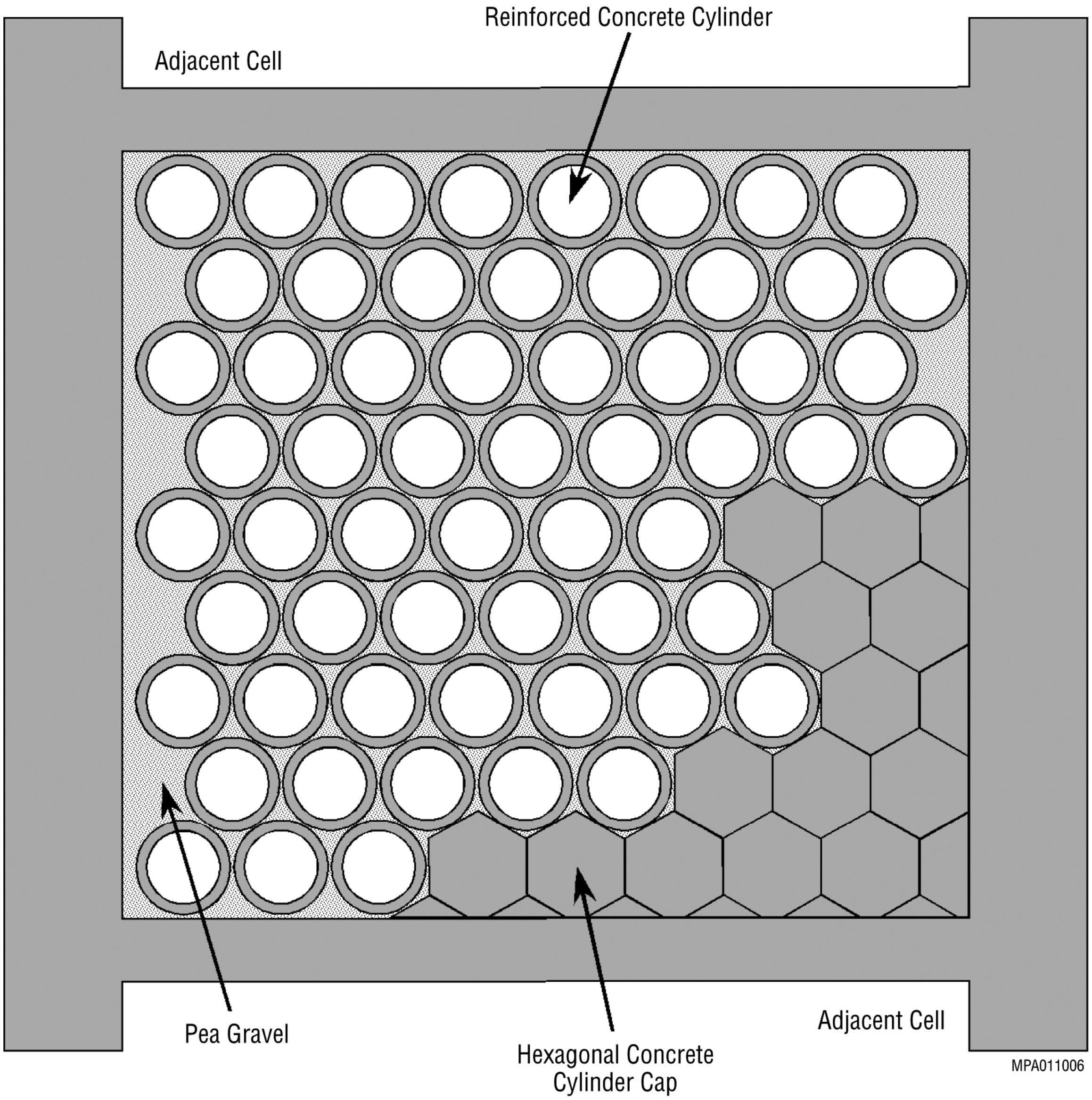


FIGURE 5.1.3-3 Top View of a Vault Cell for Disposal of Remote-Handled Waste

filled (this would be the interim cover with a rise-to-run of 1:3 from the vault edge to ground level). The second cover system would partially replace the interim cover prior to closure of the disposal facility (this would be the final cover with a rise-to-run of 1:5 from the vault edge to ground level). The final cover would span all of the vaults in the facility to preclude runoff from settling between vaults. As depicted in Figure 5.1.3-4, approximately the top 1.2 m (4 ft) of the interim cover would be removed (another option would be to leave it in place); the native soil that was removed would be used as fill between the vaults, along with additional soil; and the engineered cover, consisting of the geotextile, gravel, sand, and topsoil, would be placed on top.

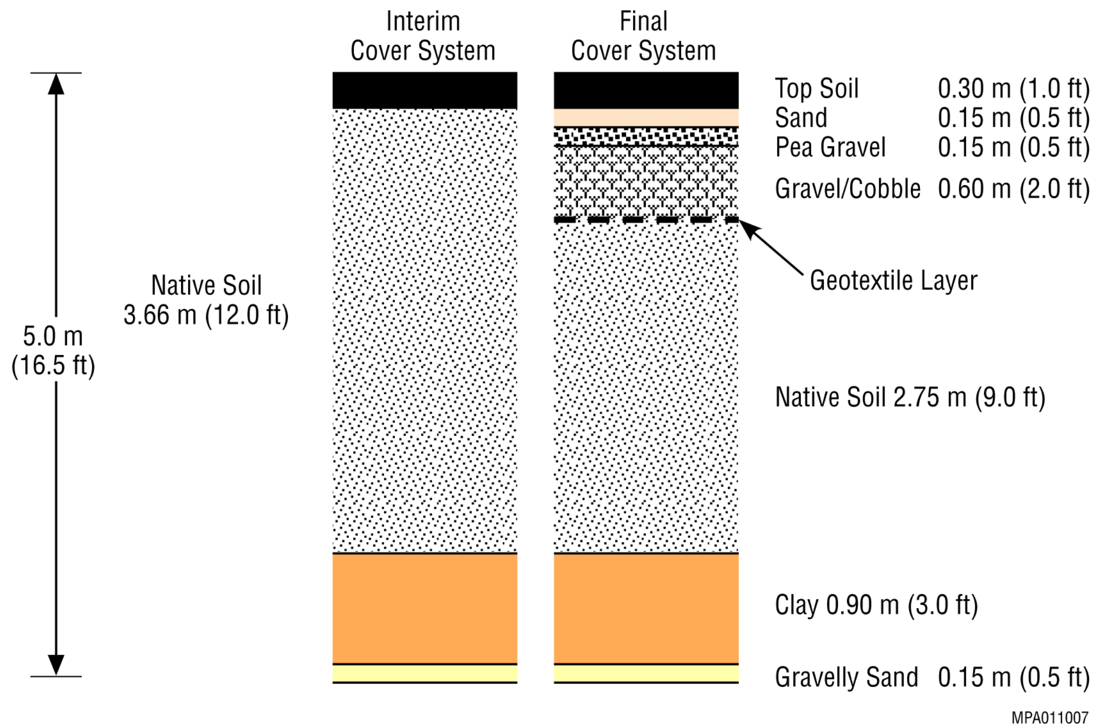


FIGURE 5.1.3-4 Conceptual Cover Systems for a Vault Disposal Facility (Source: Modified from Henry 1993)

A graded slope of 3% would be used over the top of the vaults. Both covers would have a minimum depth of 5 m (16 ft) over any portion of the vault, with a 15-cm (0.5-ft) layer of gravelly sand over the vault followed by a layer of clay that was 0.9-m (3-ft) thick, as shown in Figure 5.1.3-4. The next layer in the interim cover would consist of 3.7 m (12 ft) of native soil followed by 0.3 m (1 ft) of topsoil. In the final cover, the next layer over the clay layer would have 2.8 m (9 ft) of native soil, followed by a geotextile layer, 0.6 m (2 ft) of gravel, 15 cm (0.5 ft) of pea gravel, 15 cm (0.5 ft) of sand, and 0.3 m (1 ft) of topsoil (Henry 1993). If needed, rock armor could also be incorporated into the final cover to further protect against erosion. The total height of the vault system (i.e., vault and final cover system) would be 13 m (43 ft).

Construction, operations, and post-closure activities for the vault are also discussed next in Section 5.1.4 and in Appendix D.

5.1.4 Conceptual Facility Construction, Operations, and Integrity and Estimated Cost for the Borehole, Trench, and Vault Disposal Methods

A conceptual design for each of the three land disposal methods (borehole, trench, and vault) was developed to conduct an evaluation consistent with the objective of this EIS: to provide a comparative analysis of the general performance of these generic conceptual waste disposal facilities at the various GTCC reference locations evaluated.

The conceptual designs for the land disposal facilities were selected on the basis of current practices or concepts associated with the disposal of similar types of radioactive waste, as discussed in Section 1.4.2. It is assumed that the land disposal methods discussed in this chapter would accommodate the entire waste inventory. Thus, the estimated impacts of any given land disposal method and site are expected to bound other potential scenarios in which a disposal facility might be used to accommodate one or two of the waste types considered (e.g., activated metals, sealed sources, or Other Waste). Table 5.1-1 summarizes the estimated facility size for each disposal method. Figures 5.1.4-1, 5.1.4-2, and 5.1.4-3 provide conceptual full facility layouts for the borehole, trench, and vault methods, respectively. Figure 5.1.4-4 illustrates a cross section of the conceptual vault final cover system. A final cover system similar to that shown in Figure 5.1.4-4 for the vault design could be employed for the trench and borehole designs, depending on the local topology of the disposal area. In addition to the separate cover for each borehole or trench, a cover system that would span multiple boreholes or trenches could be added to maximize water runoff from the disposal area.

5.1.4.1 Disposal Facility Construction

Current industry construction practices were used as guidelines for assumptions about construction. It is assumed that initial site construction would take about 820 workdays spread over 3.4 years (240 workdays per year). The construction period would cover the time necessary

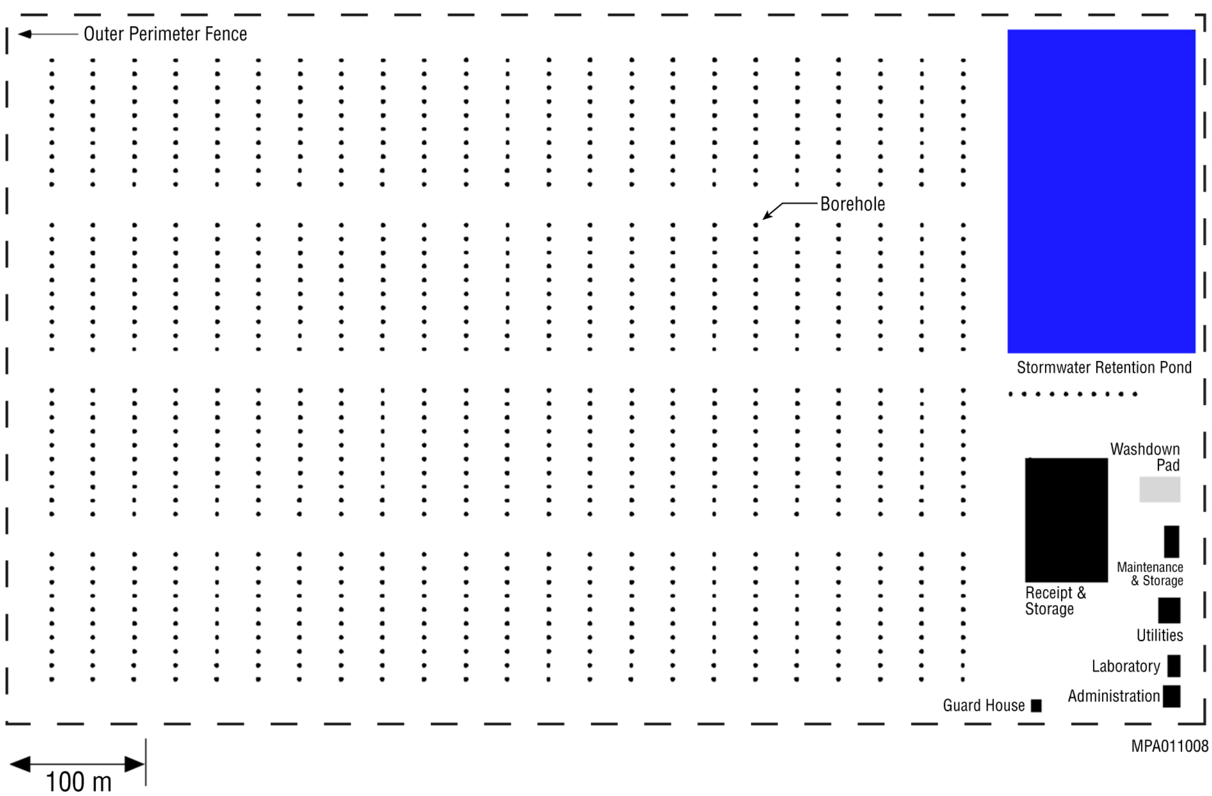


FIGURE 5.1.4-1 Layout of a Conceptual Borehole Disposal Facility

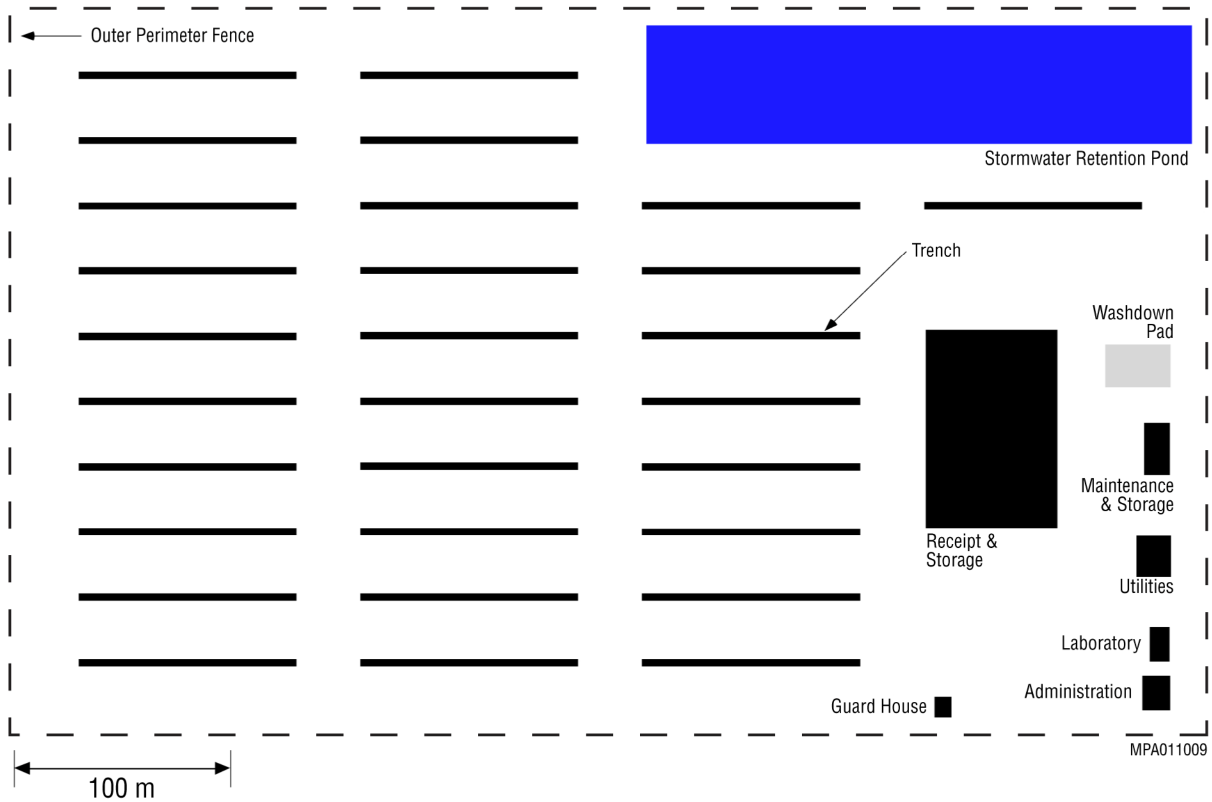


FIGURE 5.1.4-2 Layout of a Conceptual Trench Disposal Facility

for initial site preparation, infrastructure emplacement, and support structure construction. It is assumed that construction of the disposal units (borehole, trench, or vault) would occur in parallel with their operations over a 20-year period, when the majority of the waste is expected to be received. A period of 20 years is assumed for the construction of all disposal units. Assuming an average annual rate of construction, the estimated 20-year period would be slightly more than that necessary to accommodate the assumed receipt rate of the GTCC LLRW and GTCC-like waste for at least the first 15 years of disposal operations. Thus, the annual impacts from construction as presented in this EIS are considered to be slightly conservative but not unrealistic, because waste receipt rates could vary from year to year. In addition, it is expected that the majority of the waste (approximately 75% of the total waste) would be received for disposal within the first 20 years of operations.

5.1.4.2 Disposal Facility Operations

Disposal operations, including the number of workers required, are contingent on the availability and receipt of waste. Additional information about assumed GTCC waste generation rates or when waste would be received for disposal is provided in Section B.4. As a conservative approach, it is assumed that the disposal facilities would be standalone facilities operated on a continuous basis. In other words, they would not open periodically to receive a short shipping

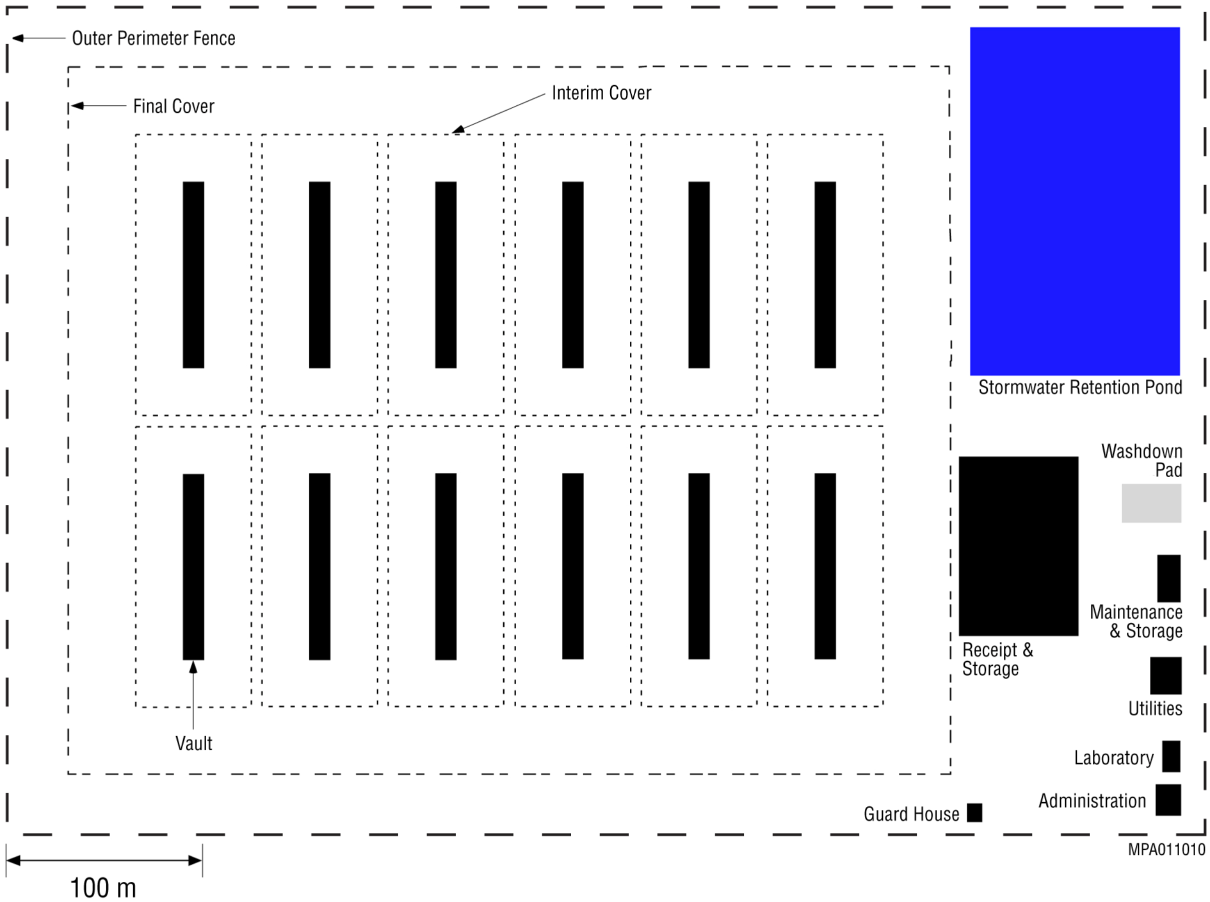


FIGURE 5.1.4-3 Layout of a Conceptual Vault Disposal Facility

campaign. Thus, the impacts assessed are considered to represent reasonable maximum values, because such a disposal facility could be collocated with another facility, and personnel, equipment, and supplies could be shared. If the collocation of facilities was selected in the future, impacts from the GTCC disposal facility would be correspondingly lower depending on the number of employees and costs associated with the overlapping of facilities. The minimum number of personnel assumed for continuous operation of the facility was determined on the basis of a time-motion analysis of operations associated with receiving and disposing of shipping containers (Argonne 2010).

It is assumed that disposal operations at the borehole, trench, or vault facilities would start in 2019 for the purposes of this EIS. On the basis of this starting point and assumptions about the availability of stored and projected waste, about shipping and packaging, and about on-site operations, the number of workers required for the land disposal methods was estimated. The actual start date for operations is uncertain at this time and dependent upon, among other things, the alternative or alternatives selected, additional NEPA analysis as required, characterization studies, and other actions necessary to initiate and complete construction and operation of a GTCC disposal facility. For purposes of analysis in the Draft EIS, DOE assumed a start date of disposal operations in 2019. However, given these

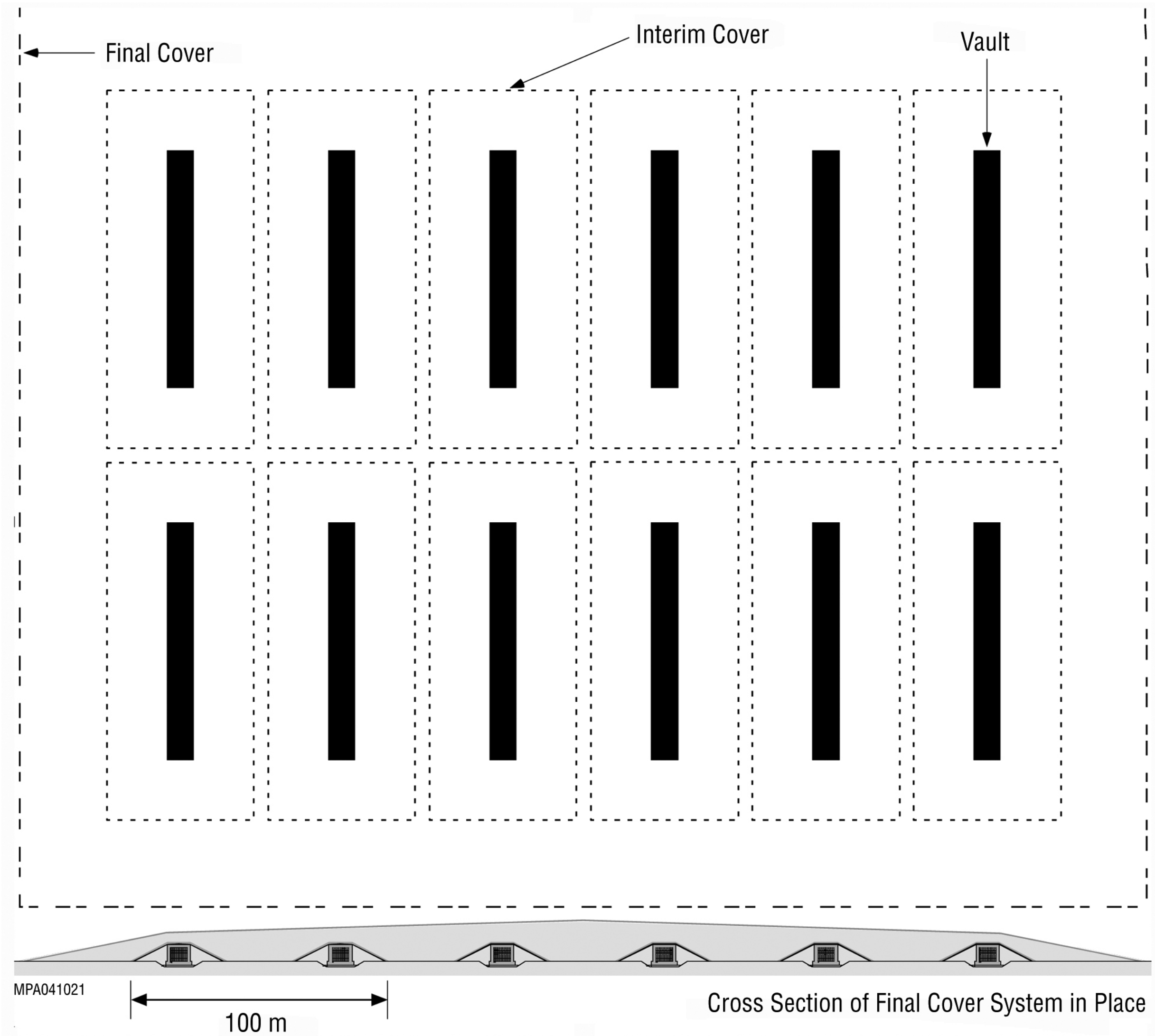


FIGURE 5.1.4-4 Cross Section of Vault Final Cover System (bottom) below Top View of Vault Disposal Area (both images are drawn to the same scale)

uncertainties, the actual start date could vary. In each case, it was estimated that approximately 570 shipments would be received annually through 2035, at which time fewer shipments would be expected on an annual basis. The number of waste containers for disposal of GTCC LLRW and GTCC-like waste at the land disposal (borehole, trench, and vault) facility is estimated to be about 37,000, as shown in Table 5.1-3.

If a GTCC waste disposal facility operated in conjunction with another facility and if supporting infrastructure could be shared and economies of scale could be realized, the actual impacts would be less than those presented in this chapter and in the site-specific chapters (Chapters 6 through 12) for the land disposal alternatives. This would be the case for the potential disposal of waste at WIPP (deep geologic disposal) that is being evaluated, for which additional workers and support facilities are not expected to be required; only additional time and disposal space would be needed if GTCC waste was disposed of at WIPP while it was already operating.

5.1.4.3 Disposal Facility Integrity

For the purposes of the EIS, the integrity of the land disposal facilities is assumed to be the same for the borehole, trench, and vault methods for the impact analyses. This approach allows for a comparison of the disposal methods on the basis of the general geophysical conditions at each site. All disposal methods incorporate an engineered cover to reduce water infiltration in the post-closure phase. (The Hanford Site is required to use lined disposal facilities. A GTCC waste facility, if implemented at Hanford, would thus include a liner or leachate collection system in its design.)

Consideration of additional engineered features, such as internal grouting of the waste in its disposal containers or grouting of the space between disposal containers in the disposal units, might reduce the leach rates of radionuclides into the groundwater and thereby reduce the potential peak impacts in the long term. An assumption that the third waste type, the Other Waste, would be grouted in disposal containers was incorporated into the post-closure analysis. For wastes like activated metals and sealed sources, which mostly contain radionuclides with shorter half-lives, this EIS does not assume grouting would be required because of the waste form.

5.1.4.4 Estimated Costs of Constructing and Operating the Borehole, Trench, and Vault Disposal Facilities

The estimated costs for the initial construction of the land disposal facilities and for their operation are discussed in detail in Appendix D. The same support functions would be necessary for all three disposal methods because the GTCC LLRW and GTCC-like waste would arrive at the disposal facility in the same packaging and disposal containers. The primary differences would be found in the actual waste disposal units themselves and the equipment used to emplace the waste. Thus, the primary difference in cost among the three methods would be in the cost of constructing the disposal units; similar costs are expected for operations. Construction of a vault facility is expected to have the highest cost because of the amount of material and labor involved in its construction. The estimated cost for operations is based on 20 years of operations, as discussed in Section 5.1.4.1 (approximately 75% of the total inventory is assumed to be received for disposal within the first 20 years of operation). Table 5.1.4-1 presents a summary of these estimates.

5.2 ASSESSMENT APPROACH AND ASSUMPTIONS

This section provides assessment approaches and assumptions for the environmental resource areas evaluated for Alternatives 3 to 5. Appendix C provides additional details on methodologies used for the impact analyses presented in this EIS. The generic commercial disposal locations are not evaluated for the environmental resource areas discussed in this section

TABLE 5.1.4-1 Estimated Costs to Construct and Operate the Land Disposal Facilities[a]

Disposal Method	Cost to Construct Facility (in millions of $)[b]	Cost to Operate Facility (in millions of $)[c]	Total Cost to Construct and Operate Facility (in millions of $)
Borehole	210	120	330
Trench	86	160	250
Vault	360	160	520

[a] Costs are rounded to two significant figures.

[b] Construction costs for the borehole, trench, and vault disposal facilities are for 930 boreholes, 29 trenches, and 12 vaults (consisting of 132 total vault cells) and the supporting infrastructure.

[c] Operational costs assume 20 years of facility operations for the borehole, trench, and vault disposal methods. On the basis of the assumed receipt rates, the majority of the wastes would be available for emplacement during the first 15 years of operations (assumed to start in 2019). The actual start date for operations is uncertain at this time and dependent upon, among other things, the alternative or alternatives selected, additional NEPA analysis as required, characterization studies, and other actions necessary to initiate and complete construction and operation of a GTCC disposal facility. For purposes of analysis in the Draft EIS, DOE assumed a start date of disposal operations in 2019. However, given these uncertainties, the actual start date could vary.

because each of the four regions encompasses a very large area for which a meaningful evaluation of the resource area is not possible. However, human health impacts for the long term are estimated by using region-specific input parameters. This estimate was done in order to provide information that could be used to distinguish the four regions from one another.

5.2.1 Climate, Air Quality, and Noise

5.2.1.1 Climate and Air Quality

This section provides general descriptions for the following federally based air quality programs likely to affect construction and operations of a disposal facility for GTCC LLRW and GTCC-like waste:

- National Ambient Air Quality Standards (NAAQS),

- Prevention of Significant Deterioration (PSD),

- Visibility protection,

- General conformity, and

- National Emissions Standards for Hazardous Air Pollutants (NESHAPs).

Specific details (such as state air standards) that differ among the GTCC reference locations are presented in the site-specific discussions of the affected environment (Chapters 6 through 12).

5.2.1.1.1 NAAQS. The EPA has set NAAQS for six criteria pollutants — including SO_2, NO_2, CO, O_3, PM (PM_{10} and $PM_{2.5}$), and lead — as shown in Table 5.2.1-1. Primary NAAQS specify maximum ambient (outdoor air) concentration levels of the criteria pollutants with the aim of protecting public health with an adequate margin of safety. Secondary NAAQS specify maximum concentration levels with the aim of protecting public welfare. The NAAQS specify different averaging times as well as maximum concentrations. Some of the NAAQS for averaging times of 24 hours or less allow the standard values to be exceeded a limited number of times per year. States can have SAAQS. SAAQS must be at least as stringent as the NAAQS, and they can include standards for additional pollutants. If a state has no standard corresponding to one of the NAAQS, the NAAQS apply.

> **Particulate Matter**
>
> Particulate matter (PM) is dust, smoke, and other solid particles and liquid droplets in the air. The size of the particulate is important and is measured in micrometers (μm). A micrometer is 1 millionth of a meter (0.000039 in.). PM_{10} is PM with an aerodynamic diameter that is less than or equal to 10 μm, and $PM_{2.5}$ is PM with an aerodynamic diameter that is less than or equal to 2.5 μm.

An area in which the measured air quality is above the NAAQS/SAAQS maximum concentration is called a nonattainment area. Nonattainment areas in which air quality has improved and is demonstrated to be below an NAAQS/SAAQS concentration can be redesignated as a maintenance area. These areas are required to adopt a maintenance plan that ensures air quality will not degrade in the area.

5.2.1.1.2 PSD. While the NAAQS (and SAAQS) place upper limits on the levels of air pollution, PSD regulations that apply to attainment areas place limits on the total increase in ambient pollution levels above established baseline levels for SO_2, NO_2, and PM_{10}, thus preventing "polluting up to the standard" (see Table 5.2.1-1). These allowable increases are smallest in Class I areas such as national parks and wilderness areas. The rest of the country is subject to larger Class II increments. States can choose a less stringent set of Class III increments, but none have done so. Major (large) new and modified stationary sources must meet the requirements for the area in which they are located and for any areas they impact. Thus, a source located in a Class II area that is near a Class I area would need to meet the more stringent Class I increment in the Class I area and the Class II increment elsewhere, as well as any other applicable requirements.

In addition to capping increases in criteria pollutant concentrations below the levels set by the NAAQS, the PSD program mandates stringent control technology requirements for new

TABLE 5.2.1-1 National Ambient Air Quality Standards and Maximum Allowable Increments for Prevention of Significant Deterioration

		NAAQS[b]		PSD Increments[d] (μg/m^3)	
Pollutant[a]	Averaging Time	Value	Type[c]	Class I	Class II
SO_2	1-hour	75 ppb	P	–[e]	–
	3-hour	0.5 ppm (1,300 μg/m^3)	S	25	512
	24-hour	0.14 ppm	P	5	91
	Annual	0.03 ppm	P	2	20
NO_2	1-hour	0.100 ppm	P	–	–
	Annual	0.053 ppm (100 μg/m^3)	P, S	2.5	25
CO	1-hour	35 ppm (40 mg/m^3)	P	–	–
	8-hour	9 ppm (10 mg/m^3)	P	–	–
O_3	1-hour	0.12 ppm[f]	P, S	–	–
	8-hour	0.075 ppm	P, S	–	–
PM_{10}	24-hour	150 μg/m^3	P, S	8	30
	Annual	–	–	4	17
$PM_{2.5}$	24-hour	35 μg/m^3	P, S	–	–
	Annual	15.0 μg/m^3	P, S	–	–
Lead[g]	Calendar quarter	1.5 μg/m^3	P, S	–	–
	Rolling 3-month	0.15 μg/m^3	P, S	–	–

[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, ppm = part(s) per million.

[b] Refer to 40 CFR Part 50 for detailed information on attainment determination and the reference method for monitoring.

[c] P = primary standard whose limits were set to protect public health; S = secondary standard whose limits were set to protect public welfare.

[d] Class I areas are specifically designated areas in which degradation of air quality is severely restricted under the Clean Air Act; they include national parks, wilderness areas, monuments, and other areas of special national and cultural significance. Class II areas have a somewhat less stringent set of allowable emissions.

[e] A dash indicates that no standard exists.

[f] On June 15, 2005, the 1-hour O_3 standard was revoked 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.

[g] On October 15, 2008, the EPA revised the lead standard from a calendar-quarter average of 1.5 μg/m^3 to a rolling 3-month average of 0.15 μg/m^3.

Sources: 40 CFR 52.21; EPA (2008)

and modified major sources. In Class I areas, federal land managers are responsible for protecting the areas' air-quality-related values (AQRVs), such as scenic, cultural, biological, and recreational resources. As stated in the Clean Air Act (CAA), the AQRV test requires the federal land manager to evaluate whether the proposed project will have an adverse impact on the AQRVs, including visibility. Even if PSD increments are met, if the federal land manager determines that there is an impact on an AQRV, the permit may not be issued.

5.2.1.1.3 Visibility Protection. Visibility was singled out for particular emphasis in the Clean Air Act Amendments of 1977 (CAAA). Visibility in a Class I area is protected under two sections of the Act. Section 165 provides for the PSD program (described above) for new sources. Section 169(A), for older sources, describes requirements for reasonably attributable single sources and regional haze requirements, which address multiple sources. Federal land managers have a particular responsibility to protect visibility in Class I areas. Even sources locating outside a Class I area may need to obtain a permit that assures no adverse impact on visibility within the Class I area, and existing sources may need to retrofit controls. EPA's 1999 Regional Haze Rule set goals of preventing future impairment and remedying existing impairment to visibility in Class I areas. States had to revise their State Implementation Plans to establish emission reduction strategies to meet a goal of natural conditions by 2064.

5.2.1.1.4 General Conformity. Under EPA's general conformity regulations (40 CFR Parts 51 and 93, April 5, 2010), federal departments and agencies are prohibited from taking actions in nonattainment and maintenance areas unless they first demonstrate that the actions would conform to the State Implementation Plan as it applies to criteria pollutants. Transportation-related projects are subject to requirements for transportation conformity. General conformity requirements apply to stationary sources. Conformity addresses only those criteria pollutants for which the area is in nonattainment or maintenance (for example, VOCs and NO_X for O_3). If annual source emissions are below specified threshold levels, no conformity determination is required. If the emissions exceed the threshold, a conformity determination must be undertaken to demonstrate that the action conforms to the State Implementation Plan. The demonstration process includes public notification and response and may require extensive analysis.

Volatile Organic Compounds

Volatile organic compounds (VOCs) are organic vapors in the air that can react with other substances, principally nitrogen oxides (NO_X), to form ozone (O_3) in the presence of sunlight.

Given the low emissions, general conformity is unlikely to affect management options for GTCC LLRW and GTCC-like waste.

5.2.1.1.5 NESHAPs. In addition to the criteria pollutants, the EPA regulates hazardous or toxic air pollutants specifically listed in the CAA, such as beryllium, cadmium, and radionuclides. These NESHAPs generally regulate emissions rather than ambient concentrations. The most important NESHAP for a GTCC disposal facility is for radionuclides (40 CFR Part 61, Subpart H), and it requires a demonstration that radionuclides other than radon released to the air from a DOE facility do not result in a dose to the public of more than 10 mrem/yr. Emissions from both traditional stacks and diffuse sources must be considered when demonstrating compliance.

5.2.1.2 Noise

This section provides general descriptions of noise and vibration associated with construction and operation of a GTCC disposal facility.

Any pressure variation that the human ear can detect is considered sound; noise is unwanted sound. Sound is described in terms of amplitude (perceived as loudness) and frequency (perceived as pitch). Sound pressure levels are typically measured with logarithmic decibel (dB) scale. To account for human sensitivity to frequencies of sound (i.e., humans are less sensitive to lower and higher frequencies and most sensitive to sounds between 1 and 5 kHz), A-weighting (denoted by dBA) is widely used and is correlated with a human's subjective reaction to sound (Acoustical Society of America 1983, 1985). To account for variations of sound with time, the equivalent-continuous sound level (L_{eq}) is used. L_{eq} is the continuous sound level during a specific time period that would contain the same total energy as the actual time-varying sound. For example, L_{eq} (1-h) is the 1-hour equivalent-continuous sound level. In addition, human responses to noise differ depending on the time of the day (e.g., there is more annoyance over noise during nighttime hours). The day-night average sound level (L_{dn}) provides an average of the level over a 24-hour period after the addition of 10 dB to sound levels from 10 p.m. to 7 a.m. to account for the greater sensitivity of most people to nighttime noise. Generally, a 3-dB change is considered a just noticeable difference, and a 10-dB increase is subjectively perceived as a doubling in loudness and almost always causes an adverse community response.

The Noise Control Act of 1972, along with its subsequent amendments (Quiet Communities Act of 1978, 42 USC, Parts 4901–4918), delegates to the states the authority to regulate environmental noise and directs government agencies to comply with local community noise statutes and regulations. Many local noise ordinances are qualitative, prohibiting excessive noise or noise that results in a public nuisance. Because of the subjective nature of such ordinances, they are often difficult to enforce. However, a handful of states and counties have established quantitative noise-level regulations, which typically specify environmental noise limits based on the land use of the property receiving the noise.

The EPA has a noise guideline that recommends an L_{dn} of 55 dBA, which is sufficient to protect the public from the effect of broadband environmental noise in typically quiet outdoor and residential areas (EPA 1974). These levels are not regulatory goals, but they are "intentionally conservative to protect the most sensitive portion of the American population" with "an additional margin of safety." For protection against hearing loss in the general population from nonimpulsive noise, the EPA guideline recommends an L_{eq} of 70 dBA or less over a 40-year period.

Construction activities can result in varying degrees of ground vibration, depending on the equipment and methods employed. Construction activities that typically generate the most severe vibrations are blasting and impact pile-driving.

Three groundborne vibration impacts are of general concern: human annoyance, interference with vibration-sensitive activities, and damage to buildings. In evaluating ground-borne vibration, two descriptors are widely used.

- *Peak particle velocity (PPV).* Measured as distance per time (such as inches per second), PPV is the maximum peak velocity of the vibration and correlates with the stresses experienced by buildings.

- *Vibration velocity level (L_V).* This represents a 1-second average amplitude of the vibration velocity. It is typically expressed on a log scale in decibels (VdB), just as noise is measured in dB. This descriptor is suitable for evaluating human annoyance because the human body responds to average vibration amplitude.

A background vibration velocity level in residential areas is usually 50 VdB or lower, well below the threshold of perception for humans, which is around 65 VdB (Hanson et al. 2006). However, human response is not usually significant unless the vibration exceeds 70 VdB. For evaluating interference with vibration-sensitive activities, the vibration impact criterion for general assessment is 65 VdB. For residential and institutional land use (primarily only daytime use, such as at a school or church), the criteria range from 72 to 80 VdB and from 75 to 83 VdB, respectively (depending on event frequency). For potential structural damage effects, guideline vibration damage criteria for various structural categories are provided in Hanson et al. (2006), but damage to buildings would occur at much higher levels (0.30 cm/s [0.12 in./s] or higher, or approximately 90 VdB) than human annoyance and interference with vibration-sensitive activities.

5.2.2 Geology and Soils

The main elements in assessing impacts on geologic and soil resources at the GTCC reference locations being evaluated are the location and extent of the land being disturbed during construction and operations. Geologic and soil conditions at each of the GTCC reference locations are described in the affected environment sections for each site (Chapters 6 through 11). Surveys in the vicinity of these locations, including soil surveys, topographic surveys, and geologic and seismic hazard maps, were reviewed. Well log data from on-site (or near-site) wells and boreholes were also reviewed.

The EIS analysis evaluates impacts on critical geologic attributes, including access to mineral or energy resources, destruction of unique geologic features, and mass movement induced by construction. The impact analysis also evaluates regional geologic conditions, such as the earthquake potential. The analysis for soil resources evaluates impacts on specific soil attributes, including the potential for soil erosion and compaction by construction activities. Last, the determination of the relative magnitude of an impact for each of the reference locations is based on an analysis of both the context of the action and the intensity of the impact on a particular resource.

5.2.3 Water Resources

Hydrologic resources potentially affected by the proposed action include rivers, streams, and groundwater. Hydrologic conditions in the vicinity of each of the GTCC reference locations are described in the affected environment section for each of these locations. Impacts on surface water are presented as changes in runoff by comparing runoff areas with and without the GTCC disposal facility. The potential for surface water quality impacts is assessed on the basis of the disposal facility's location relative to rivers and streams, local runoff rates, and groundwater discharge.

Potential impacts on groundwater resources are evaluated as impacts on underlying aquifers relative to changes in groundwater depth, direction of groundwater flow, groundwater quality, and recharge rates. Impacts on groundwater depth and the direction of flow are assessed by comparing the existing use of water with the projected demand for water to operate the GTCC disposal facility.

5.2.4 Human Health

5.2.4.1 Affected Environment Assessment

Human health impacts discussed under the affected environment sections summarize the current radiation doses to on-site workers and the nearby off-site general public for each of the sites evaluated. Potential radiation exposures can result from environmental releases of radionuclides to groundwater and from airborne emissions that occur during the transport, storage, and disposal of radioactive wastes. For most sites, the radiation doses are reported for the highest-exposed individual for affected workers and members of the general public. In some cases, the average individual dose instead of the dose to the highest-exposed individual was reported by the site. Collective doses over the affected populations are also presented whenever data are available. These reported radiation doses are compared to radiation dose limits set by DOE or promulgated by regulatory agencies, and the expected radiation dose from natural background and man-made sources. The reported doses were estimated by using generally conservative exposure assumptions; in general, an individual is expected to receive a dose much lower than that reported in these site-specific documents.

Potential radiation doses reported in the human health portions of the affected environment sections for each site were estimated from environmental monitoring data or by using computer models that simulate environmental transport, dispersion, and distribution of radionuclides. The primary sources for the monitoring data and estimated doses were the annual environmental reports for each site. In addition to these reports, published site-specific EISs and DOE reports concerning radiation worker exposures were also referenced.

5.2.4.2 Assessment of Impacts on Human Health

The human health impacts associated with the waste handling, transportation, and disposal of GTCC LLRW and GTCC-like wastes are analyzed for all aspects associated with managing these wastes, from the point of generation, to the transportation of wastes to the disposal site, to the placement of wastes in the disposal facility, and to the long-term management of the closed facility. That is, this evaluation includes an assessment of potential environmental impacts for both the operational phase and post-closure phase of actions at the disposal sites. For purposes of analysis in the EIS, the wastes are assumed to be in a form that will allow for transportation and disposal with no additional treatment being required, consistent with the defined scope of the EIS.

The human health impacts are addressed for the three phases of the waste disposal site in this EIS: construction, operations, and post-closure. During the first two phases, the impacts consist of those from radiation exposure as well as nonradiation impacts. During the post-closure period, the impacts are limited to those associated with long-term releases from the disposal facilities. Direct physical intrusion, such as by a future inadvertent intruder into the disposal facilities after site closure, is not analyzed quantitatively in this EIS. The actual facility design would include barriers and other engineered features to preclude the likelihood of high impacts on future inadvertent intruders (see related discussion in Sections 5.5 and 5.6). The human health impacts include both those associated with routine activities and those from potential accidents.

The analysis does not address potential toxic chemical releases from the wastes; it is limited to radioactive constituents only. The radioactive hazards of these wastes are expected to exceed those associated with any toxic chemicals that might be present in the GTCC wastes. The impacts presented for the radioactive contaminants are expected to bound those that could occur from any hazardous chemicals in the wastes. The impacts associated with waste transportation are addressed separately in this EIS; see Section 5.2.9 for a discussion of the approach used to address these impacts.

5.2.4.3 Radiological Impacts

Management of the GTCC LLRW and GTCC-like waste involves the handling, transportation, and disposal of these radioactive wastes. Following completion of the useful life of the disposal facility, it would be decommissioned in accordance with applicable requirements at the time. A long-term monitoring and maintenance period would follow site decommissioning to ensure that the disposal facility was adequately containing the disposed wastes. These activities might result in workers and members of the general public being exposed to radiation and radioactive

Radiation

Radiation consists of energy, generally in the form of subatomic particles (neutrons, alpha particles, beta particles) or photons (x-rays and gamma rays) given off by unstable, radioactive atoms as they decay to reach a more stable configuration. Radiation can be classified as being in one of two categories: ionizing and non-ionizing (such as from a laser). The radiation from GTCC LLRW and GTCC-like waste is ionizing radiation. This type of radiation has sufficient energy to displace electrons from atoms or molecules when it interacts with matter (including the human body), creating ion pairs. Ionizing radiation can cause cell damage; this damage can be repaired by the cell, or the cell may die, or the cell may reproduce other altered cells that can lead to cancer.

materials. Radiation, either man-made or naturally occurring, is released when an unstable atom of an element (an isotope) transforms (decays) into a more stable configuration. The radiation that is released can be in the form of particles (e.g., neutrons, alpha particles, beta particles) or waves of pure energy (e.g., gamma rays and x-rays).

Key Concepts in Estimating Risks from Radiation

The health effect of concern from exposure to radiation at the levels expected from management of the GTCC LLRW and GTCC-like wastes is the induction of cancer. Radiation-induced cancers may take many years to develop following exposure and are generally indistinguishable from cancers caused by other sources. Current radiation protection standards and practices are based on the premise that any radiation dose, no matter how small, can result in detrimental health effects such as cancer, and that the number of effects produced is in direct proportion to the radiation dose. This concept is referred to as the "linear-no-threshold hypothesis" and is generally considered to result in conservative estimates (i.e., overestimates) of the health effects from low doses of radiation.

Radiation can be broadly classified into two categories: ionizing and non-ionizing radiation. Ionizing radiation is generally more energetic than non-ionizing radiation and can knock electrons out of molecules with which the particles or gamma rays and x-rays interact, creating ion pairs. Non-ionizing radiation, such as that emitted by a laser, is different in that it does not create ions when it interacts with matter but generally dissipates its energy in the form of heat. The radiation associated with GTCC LLRW and GTCC-like waste is ionizing radiation.

Ionizing radiation is a known human carcinogen, and the relationship between radiation dose and health effects is relatively well characterized for high doses of most types of radiation. Some of these cancers can be fatal, and this is referred to as latent cancer fatality (LCF) because the cancer may take many years to develop and cause death. Lower levels of exposure might constitute a health risk, but it is difficult to establish a direct cause-and-effect relationship because a particular effect in a specific individual can be produced by different processes. The features of cancers resulting from radiation are not distinct from those of cancers produced by other causes. Hence, the risk of cancer from chronic exposures of ionizing radiation must be extrapolated from data for increased rates of cancer observed at much higher dose rates. Chronic doses of low-level radiation have not been directly shown to cause cancer, although this assumption has been made in order to be protective.

The amount of energy deposited in ionizing radiation per unit mass of any material is the absorbed dose and is generally expressed in the unit of rad (for radiation absorbed dose). Certain types of radiation are more effective at producing ionizations than others. For the same amount of absorbed dose, alpha particles will produce significantly more biological harm than will beta particles or gamma rays. The dose equivalent approach was developed to normalize the unequal biological effects produced by different types of radiation. The dose equivalent is the product of the absorbed dose (in rad) and a quality factor that accounts for the relative biological effectiveness of the radiation. The dose equivalent is typically expressed in a unit called a rem (for roentgen equivalent man).

The dose delivered to internal organs as a result of radionuclides being systemically incorporated into the body may continue long after intake of the radionuclide has ceased. After being taken into the body, some radionuclides are eliminated fairly quickly, while others are incorporated into tissues or ultimately deposited in bones and can be retained for many years. This process is in contrast to external doses, which occur only when a radiation field is present. The committed dose equivalent was developed to account for doses to internal organs from radionuclides taken into the body. The committed dose equivalent is the integrated dose equivalent to specific organs for 50 years following intake.

The International Commission on Radiological Protection (ICRP) developed the concepts of effective dose equivalent (EDE) and committed effective dose equivalent (CEDE) to account for the differing cancer rates from chronic exposures to radiation by different organs and tissues in the body. The EDE and CEDE are weighted sums of the organ-specific dose equivalents and committed dose equivalents. The weighting factors used in these calculations are based on selected stochastic risk factors and are used to average organ-specific dose equivalents. The total effective dose equivalent (TEDE) is the sum of the EDE for external radiation and the 50-year CEDE for internal radiation. The calculated doses given in this EIS are the TEDEs, as defined here.

The most common forms of radiation associated with GTCC LLRW and GTCC-like waste are neutrons, alpha and beta particles, and electromagnetic radiation in the form of gamma rays and x-rays. Neutrons are one of the two components of an atom's nucleus (the other being the proton) and are often emitted by unstable TRU radionuclides, such as isotopes of plutonium, americium, and curium. An alpha particle consists of two protons and two neutrons and is identical to the nucleus of a helium atom. Beta particles can be either positive (positron) or negative (negatron); a negatron is identical to an electron. Gamma rays and x-rays have no electrical charge or mass and can travel long distances in air, body tissues, or other materials.

Ionizing radiation can impart sufficient localized energy to living cells to cause cell damage. This damage may be repaired by the cell, or the cell may die, or the cell may reproduce other altered cells, sometimes leading to the induction of cancer. An individual may be exposed to radiation from outside the body (external exposure) or, if the radioactive material has entered the body through inhalation or ingestion, from inside the body (internal exposure).

Everyone is exposed to radiation on a daily basis, primarily from naturally occurring cosmic rays, radioactive elements in the soil, and radioactive elements incorporated into the body (such as potassium-40 [K-40]). Man-made sources of radiation include medical x-rays and fallout from previous aboveground nuclear weapons tests and nuclear reactor accidents (such as the accident involving the Chernobyl nuclear reactor in the Soviet Union in 1986). Ionizing radiation causes biological damage only when the energy released during radioactive decay is absorbed by tissue.

Radiation exposures associated with management of GTCC LLRW and GTCC-like waste are generally expected to be limited to chronic effects. The main health concern associated with chronic exposure to radiation is an increased likelihood of developing cancer, and this impact is assessed in the EIS. Relatively large doses are required to cause acute effects, and potential mechanisms for such exposures include direct intrusion into the disposal units or workers being in the immediate vicinity of a large accidental release during operations. Acute doses above

25 rad delivered over a short time period can induce a number of deleterious effects, including nausea and vomiting, malaise and fatigue, increased body temperature, blood changes, epilation (hair loss), and temporary sterility; bone marrow changes have not been identified until the acute doses reach 200 rad (Cember 1983). Such exposures are highly unlikely for managing these wastes.

The EPA has developed dose conversion factors (DCFs) for internal and external exposures, and these factors are given in Federal Guidance Report (FGR) 11 (EPA 1988) and FGR 12 (EPA 1993). For internal exposures, the DCF represents the 50-year CEDE per unit intake of radionuclide, and for external exposures, the DCF represents the EDE per unit of time at 1 m (3 ft) above the ground surface per unit of activity concentration of the specified radionuclide. These DCFs given in the two EPA documents are based on the dosimetry models and results given in ICRP 26 (ICRP 1977) and ICRP 30 (ICRP 1979, 1980, 1981). These DCFs were developed on the metabolic and anatomical model of an adult male, the ICRP reference man weighing 70 kg (150 lb).

Dose Conversion Factors

Dose conversion factors (DCFs) represent the total effective dose equivalent (TEDE) per unit intake of radionuclide (internal exposure) or exposure to a unit concentration of radioactive material external to the body (external exposure). The DCFs are used — along with estimates of the amount of radioactive material taken into the body by inhalation and ingestion (for internal exposures) or estimates of the exposure to radioactive material that emits gamma rays or x-rays (for external exposures) — to estimate the TEDE. Updated DCFs have been developed by the ICRP and are used in this EIS to estimate radiation doses to workers and members of the general public.

The ICRP updated its radiation dosimetry models for members of the general public (spanning a range of ages, including adults) in ICRP 72 (ICRP 1996), and the concepts and models included in ICRP 72 are gaining wide acceptance in the scientific community. For this EIS, the DCFs given in ICRP 72 for adults are used to calculate the doses to workers and members of the general public (ICRP 1996). These are the most recent values and provide a reasonable estimate of doses for comparing the various alternatives evaluated in this EIS.

For the EIS, the radiological impacts were estimated by calculating the radiation doses to workers and members of the general public from the anticipated activities required under each alternative. These activities include those during the operations period, long-term monitoring and surveillance period, and long-term post-closure period. Doses were estimated for internal and external exposures that might occur during normal (or routine) operations and following hypothetical accidents. The analysis considered three groups of people: (1) involved workers, (2) noninvolved workers, and (3) members of the general public. These three cohorts are defined as follows:

- *Involved workers*. These are individuals working at the site (and transportation drivers) who are directly involved with the handling of the wastes. The main exposure mechanism would be from external gamma radiation.

- *Noninvolved workers*. These are individuals working at a disposal site who are not directly involved with the handling of the wastes. The main exposure pathway is also external gamma radiation (but at a greater distance).

- *Members of the general public*. These are persons living near the site. These individuals could receive a small external gamma radiation dose during the operation period, and they could be exposed to radioactive materials over the long term via the airborne and groundwater pathways.

For each of these groups, doses were estimated for the group as a whole (population or collective dose). For the noninvolved workers and general public, doses were also calculated for the highest-exposed individual (i.e., a hypothetical individual who could receive the greatest possible dose). In accordance with DOE policies, all radiation exposures and releases of radioactive material to the environment are required to be kept ALARA, a practice that has as its objective the attainment of dose levels as far below applicable limits as possible.

In addition to estimating the radiation doses (TEDE) for potentially impacted individuals, estimates were developed for the number of potential LCFs by using a health risk conversion factor. This factor relates the radiation dose to the potential number of expected LCFs on the basis of comprehensive studies of groups of people historically exposed to large doses of radiation, such as the Japanese atomic bomb survivors. For this EIS, a health risk conversion factor of 0.0006 LCF/person-rem was used. This value was identified by the Interagency Steering Committee on Radiation Standards as a reasonable factor to use in the calculation of potential LCFs associated with radiation doses as given in DOE guidance and recommendations (DOE 2003b, 2004c). This conversion factor is used to calculate the number of LCFs for the general population and for workers from the estimated radiation doses in this EIS.

This factor means that if a population of workers receives a total dose of 10,000 person-rem, on average, 6 additional LCFs will occur among the workers. In many situations, the estimated number of LCFs is less than 1. For example, if each of 100,000 people in the general public was exposed to 1 mrem (or 0.001 rem), the total dose would be 100 person-rem, and the estimated number of LCFs would be 0.06. This estimate of 0.06 needs to be interpreted statistically (i.e., as the average number of deaths if the same radiation exposure was applied to many groups of 100,000 people). In most groups, no one would incur an LCF from a dose of 1 mrem. In a very small percentage of groups (about 6%), 1 LCF would occur. In an extremely small percentage of groups, 2 or possibly more LCFs would occur. An LCF value of 0.06 can also be viewed as a 6% chance of 1 radiation-induced LCF in the exposed population.

These LCF estimates provided in the EIS are in addition to those from other causes. In 2008, the American Cancer Society estimated 566,000 people would die of cancer in the United States, and about three times that number (1,440,000) would be diagnosed with cancer (ACS 2008). Also, the likelihood of developing an LCF from background radiation is about 0.03, based on an average background radiation dose rate of 620 mrem/yr as given by the National Council on Radiation Protection and Measurements (NCRP 2009), a 70-year lifetime, and an LCF factor of 0.0006/rem. The 620 mrem/yr background radiation estimate given in NCRP (2009) includes about 310 mrem/yr from natural sources and 310 mrem/yr from man-made sources, including medical procedures and consumer products. This value is significantly larger than the previous NCRP estimate of 360 mrem/yr primarily because of the increased use of ionizing radiation in diagnostic and interventional medical procedures (NCRP 2009). In this EIS, estimates of LCFs are given to one significant figure.

A number of radionuclides present in GTCC LLRW and GTCC-like wastes occur naturally in the environment, including isotopes of uranium, thorium, and radium and their radioactive decay products. The radiological impacts given in this EIS are incremental to those from natural and man-made sources of radiation; that is, the impacts are those that an average individual would incur in addition to the 620 mrem/yr noted above. A decision on the disposal of GTCC wastes can thus be made on the basis of the radiological impacts from this activity, without considering the background radiation contribution.

One of the major sources of the dose from natural background radiation is indoor radon gas, largely because of its short-lived decay products. Most of this dose is due to radon-222, which has a 3.8-day half-life (see Table B-7). Radon-222 is a decay product of radium-226. The doses from the other two naturally occurring isotopes of radon (radon-219 and radon-220) are much lower than the dose from radon-222. The annual radiation dose from the decay products of radon-222 (referred to as radon progeny in this EIS) is estimated to be about 200 mrem/yr (NCRP 2009). This dose is from naturally occurring radon gas in soil, rock, and water that infiltrates into houses; in the houses, the gas's decay products (which are charged particles) can build up and attach to dust particles in the air.

Radium-226 is present in some GTCC wastes; thus, incremental releases of radon gas from the waste packages could occur following their disposal. This gas would not be released from the packages while they were intact but would instead decay to solid radionuclides. However, following disposal, the packages would eventually degrade, and radon gas in the packages could be released to the environment. This incremental radiation dose from radon gas is included in the post-closure impacts presented in the EIS.

5.2.4.4 Nonradiological Impacts

The nonradiological impacts are those that would result from similar activities being conducted for projects that do not involve radioactive materials. These impacts are not related to the radioactive characteristics of the wastes; they result from the physical hazards associated with these activities and are given in terms of the number of on-the-job fatalities and injuries that could occur to workers under the various alternatives. These workers include construction workers building the disposal facilities, transportation drivers, and workers moving the wastes from the transport vehicles and placing the packages in the disposal facility. The approach used to estimate the impacts on transportation is given separately in Section 5.2.9. These impacts were calculated by using industry-specific statistics from the Bureau of Labor Statistics (BLS), as reported by the National Safety Council. The injury incidence rates were for injuries involving lost workdays (excluding the day of injury).

The analysis calculated the predicted number of annual worker fatalities and injuries as the product of the appropriate annual incidence rate and the number of FTE employees required to implement the activities for the various alternatives. Estimates for the construction phase of the project were developed separately from those for the operations phase, since the types of activities that would occur are expected to be different. Construction would involve the use of large earth-moving equipment and could entail a number of construction activities, whereas the operations phase would be expected to use more specialized material-handling equipment, such as forklifts. Data for the construction industry in 2006 were used for the former, and data for the transportation and warehousing industry (excluding highway accidents) in 2006 were used for the latter.

The calculation of fatalities and injuries from industrial accidents was based solely on historical industry-wide statistics and therefore did not consider a threshold (i.e., any activity would result in some estimated risk of fatality and injury). The selected alternative for managing these wastes would be implemented in accordance with DOE and industry best management practices, thereby reducing fatality and injury incidence rates. For the construction phase, the number of lost workdays due to nonfatal injuries and illnesses was estimated by using a value of 6.0 per 100 FTE workers (BLS 2007a), and the estimated number of fatalities was estimated by using a value of 13.2 per 100,000 FTE workers (BLS 2007b); information was from the construction industry. For the operations phase, the number of lost workdays due to nonfatal injuries and illnesses was estimated by using a value of 8.0 per 100 FTE workers (BLS 2007a), and the number of fatalities was estimated by using a value of 7.4 per 100,000 FTE workers (BLS 2007b); information was from the transportation and warehousing (excluding highway accidents) industry.

5.2.5 Ecological Resources

> **Ecological Resources**
>
> Ecological resources include plant and animal species and the habitats on which they depend (e.g., forests, fields, wetlands, streams, and ponds).

This section provides an overview of the considerations and data used to describe the ecological resources at the alternative sites. The evaluation of the potential impacts from construction, operations, and post-closure of the GTCC disposal facility at each site depends on an adequate understanding of the ecological resources that exist at each alternative site. The ecological resources are described in the affected environment subsections for each alternative site. These descriptions cover the vegetation, wildlife, aquatic biota, special status species, and habitats at the DOE sites in general and within the areas designated for the GTCC disposal facility. The affected environment subsections address past activities and current species and habitat management actions that have influenced the ecological resources at each alternative site. The information presented for each site was primarily obtained from previous NEPA documents and from various environmental studies and resource and management documents prepared for the alternative sites.

The GTCC reference locations are found in five states (Idaho, New Mexico, Nevada, South Carolina, and Washington) across the continental United States. A wide variety of terrestrial habitats and, to a lesser extent, aquatic and wetland habitats occur in the vicinity of the alternative GTCC reference locations. General descriptions of terrestrial habitats throughout the conterminous United States are included in ecoregion descriptions. An ecoregion describes a broad landscape in which the ecosystems have a general similarity. It can be characterized by the spatial pattern and composition of biotic and abiotic features, such as vegetation, wildlife, physiography, climate, soils, and hydrology (EPA 2007). Level III ecoregions (EPA 2007) are used to describe ecosystems at a general level for each alternative site and are discussed in the ecological resource section provided for each alternative site in Chapters 6 through 11.

As a federal land manager, DOE is responsible for managing and conserving biota and their habitats on all of the alternative sites. Compliance with a number of federal laws, regulations, and Executive Orders would help protect ecological resources at the GTCC reference locations (see Chapter 13). In addition, state regulations could be applicable at the various potential disposal sites. The Endangered Species Act of 1973 (ESA), as amended, is among the major laws and regulations that would be applicable to ecological resources. The ESA is federal legislation that is intended to provide a means to conserve the ecosystems upon which endangered and threatened species depend and provide programs for the conservation of those species, thus preventing extinction of plants and animals. The relevant sections of the ESA that would apply to a GTCC disposal facility are Section 7 and Section 10(a)(1)(B).

Section 7 of the ESA requires all federal agencies, in consultation with the USFWS or the National Marine Fisheries Service (NMFS), to use their authorities to further the purpose of the ESA and to ensure that their actions are not likely to jeopardize the continued existence of listed species or result in destruction or adverse modification of critical habitat. The following definitions are applicable to the species listing categories under the ESA:

- *Endangered*. Any species that is in danger of extinction throughout all or a significant portion of its range.

- *Threatened*. Any species that is likely to become endangered within the foreseeable future throughout all or a significant part of its range.

- *Proposed for listing*. Species that have been formally proposed for listing as threatened or endangered by the USFWS or NMFS by notice in the *Federal Register*.

- *Candidate*. Species for which the USFWS or NMFS has sufficient information on their biological status and threats to propose them as threatened or endangered under the ESA, but for which development of a proposed listing regulation is precluded by other higher-priority listing actions.

- *Critical habitat*. Specific areas within the geographical area occupied by the species at the time it is listed, on which are found physical or biological features essential to the conservation of the species and which may require special management considerations or protection. Except when designated, critical habitat does not include the entire geographical area that can be occupied by the threatened, endangered, or other special status species.

Section 10(a)(1)(B) of the ESA allows for permits for incidental taking of threatened or endangered species. Such permits would be required, for example, where the potential exists for individuals of a listed species to be accidentally destroyed by land disturbance or by vehicular traffic, or when a nest of a listed species may need to be relocated.

Each state also identifies species that are of concern within its borders. Each state differs in the listing status designations that it uses and in its regulations for protecting these species. Some of these species are listed under the ESA. Project-specific assessments would consider impacts on these species prior to project development.

Five of the DOE sites (Hanford Site, INL, LANL, NNSS, and SRS) evaluated in this EIS serve to preserve regional biodiversity by providing a refuge for species that have been reduced by human activities in the surrounding region. Off-road driving, public access, and livestock grazing are prohibited at most of the alternative sites, thus providing additional protection to ecological resources.

The same six DOE sites are National Environmental Research Parks (NERPs) and also have other natural resource designations (Table 5.2.5-1). NERPs are outdoor laboratories that provide opportunities for environmental studies on protected lands that act as buffers around DOE facilities. These studies are used to (1) evaluate the environmental consequences of energy use and development and mitigation of these effects and (2) demonstrate possible environmental and land-use options (DOE 2007a).

5.2.6 Socioeconomics

Socioeconomic data for each site describe an ROI surrounding the site, which is made up of multiple counties. The ROI is used to assess the impacts of site activities on employment, unemployment, income, population, housing, community fiscal conditions, and community service employment. The ROI at each site is based on the residential locations of government workers directly related to site activities, and it encompasses the area in which these workers spend their wages and salaries.

5.2.7 Environmental Justice

Executive Order 12898 (February 16, 1994) formally requires federal agencies to incorporate environmental justice as part of their missions. Specifically, it directs them to address, as appropriate, any disproportionately high and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations.

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

Activity/ Resource	Amount Consumed or Involved[a,b] 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

Scenario Number	Accident Scenario[a]	Accident Description	Frequency Range: $>10^{-2}$/yr	Frequency Range: 10^{-4} to 10^{-2}/yr	Frequency Range: 10^{-6} to 10^{-4}/yr	Frequency Range: $<10^{-6}$/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.)

			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
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 (Strittholt 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

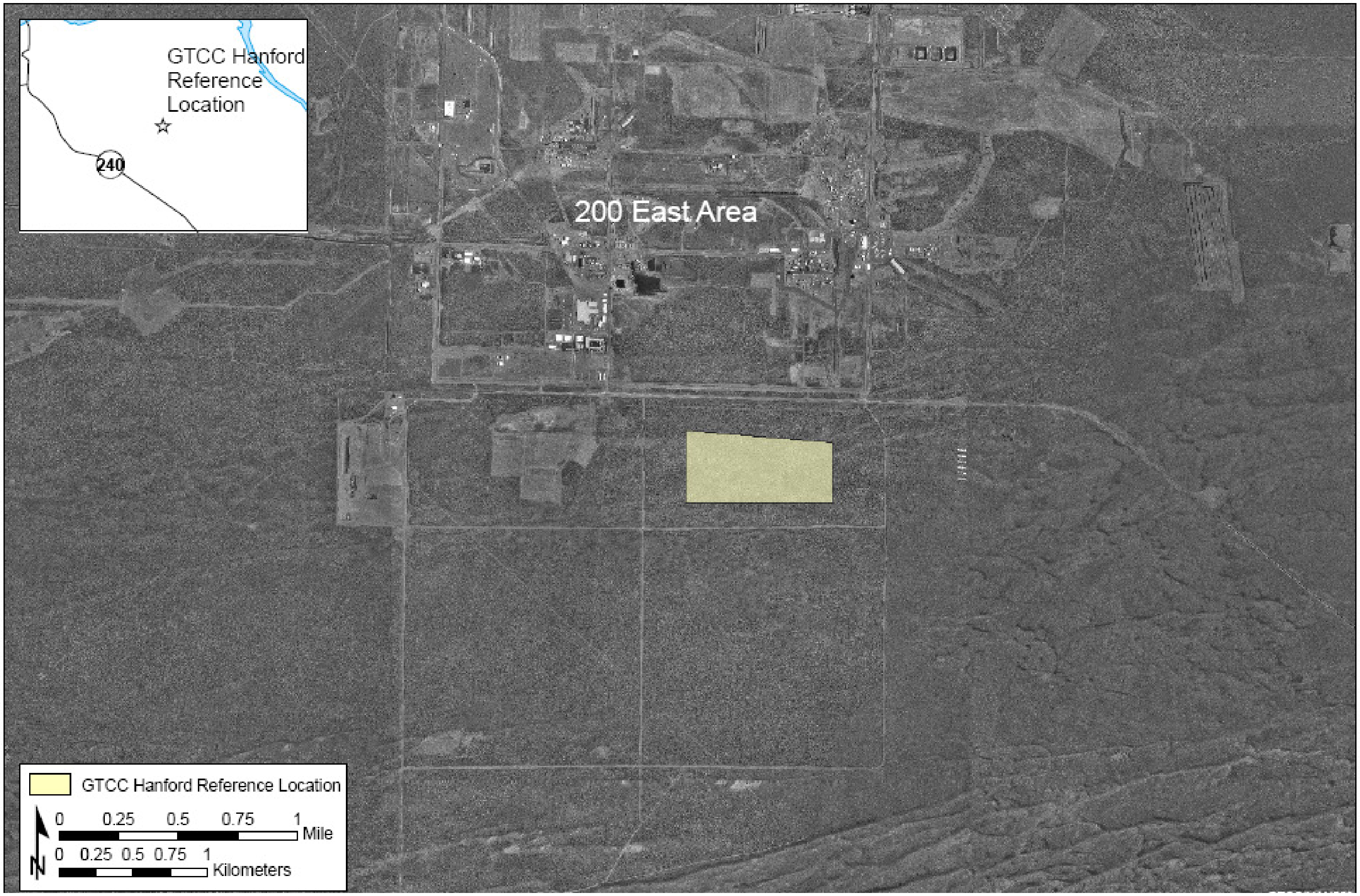

FIGURE 6.1-1 GTCC Reference Location at the Hanford Site

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.

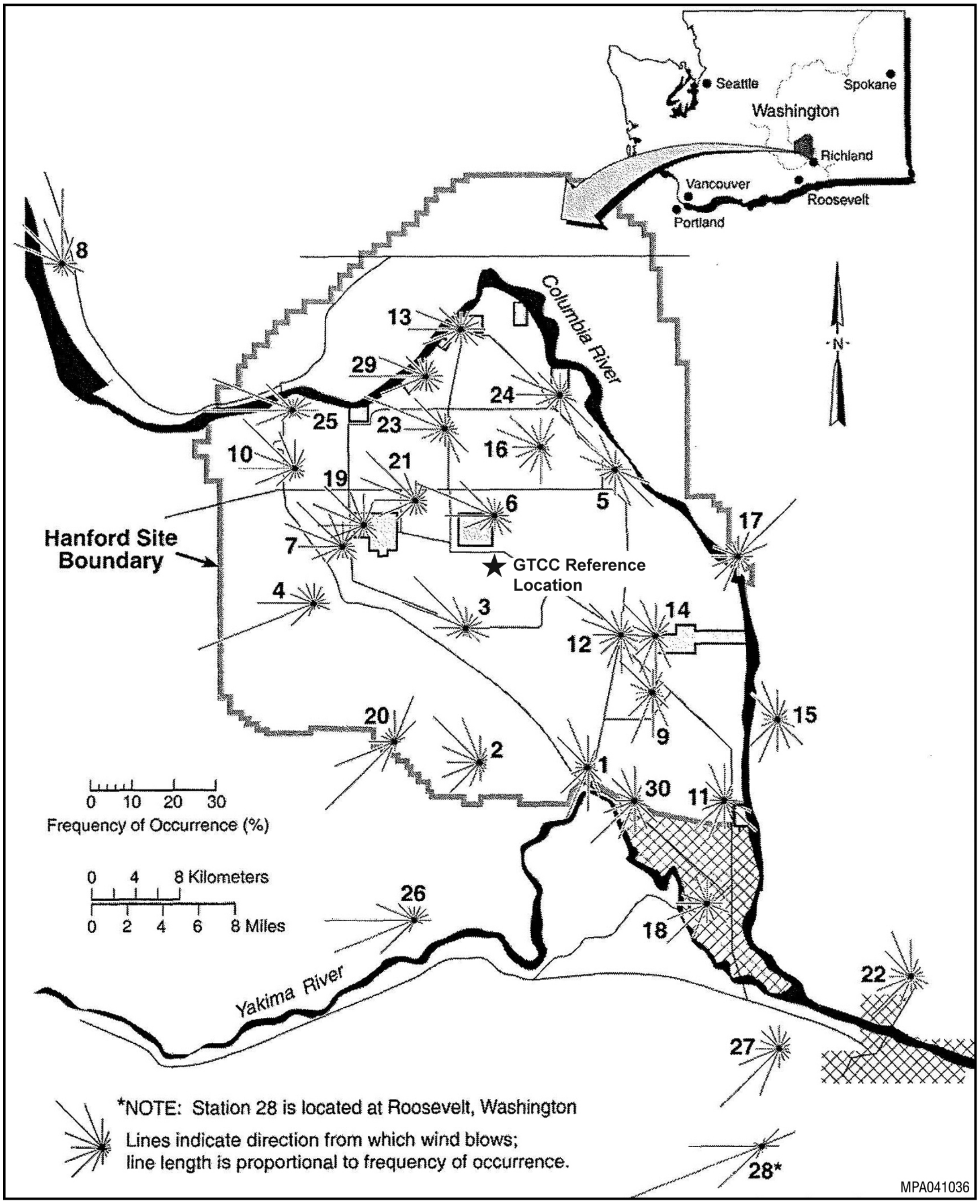

FIGURE 6.1.1-1 Wind Roses at the 9.1-m (30-ft) Level of the Hanford Meteorological Monitoring Network, Washington, 1982–2006 (Source: Burk 2007)

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

Continued on next page

> ***Continued***
>
> 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 $\mu g/m^3$	–	–
	Annual geometric mean	60 $\mu g/m^3$	–	–
PM_{10}	24-hour	150 $\mu g/m^3$	95 $\mu g/m^3$ (63%)	Kennewick, Benton Co. (2005)
	Annual	50 $\mu g/m^3$	24 $\mu g/m^3$ (48%)	Kennewick, Benton Co. (2003)
$PM_{2.5}$	24-hour	35 $\mu g/m^3$ [f]	42 $\mu g/m^3$ (120%)	Kennewick, Benton Co. (2004)
	Annual	15.0 $\mu g/m^3$ [f]	7.6 $\mu g/m^3$ (51%)	Kennewick, Benton Co. (2004)
Lead[i]	Calendar quarter	1.5 $\mu g/m^3$ [f]	0.03 $\mu g/m^3$ (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.

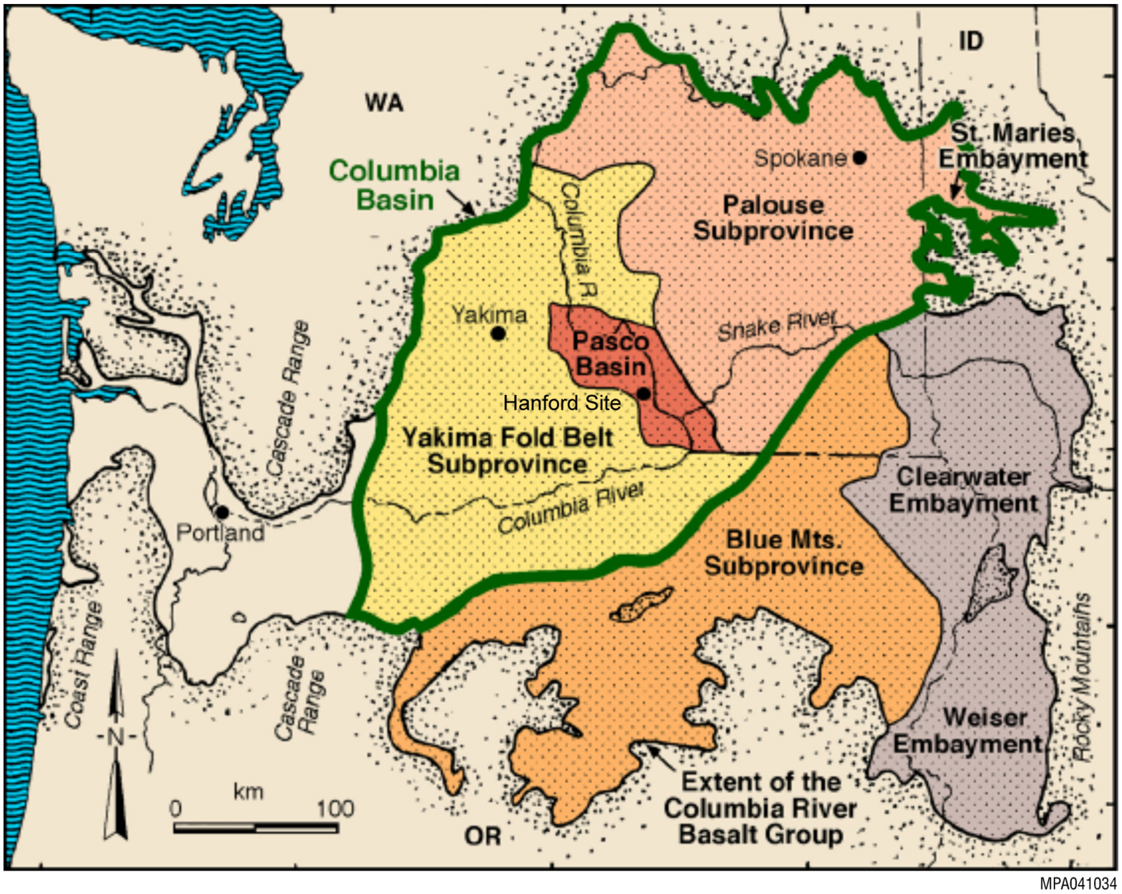

FIGURE 6.1.2-1 Location of the Hanford Site on the Columbia Plateau (Source: Modified from Chamness and Sweeney 2007)

(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.

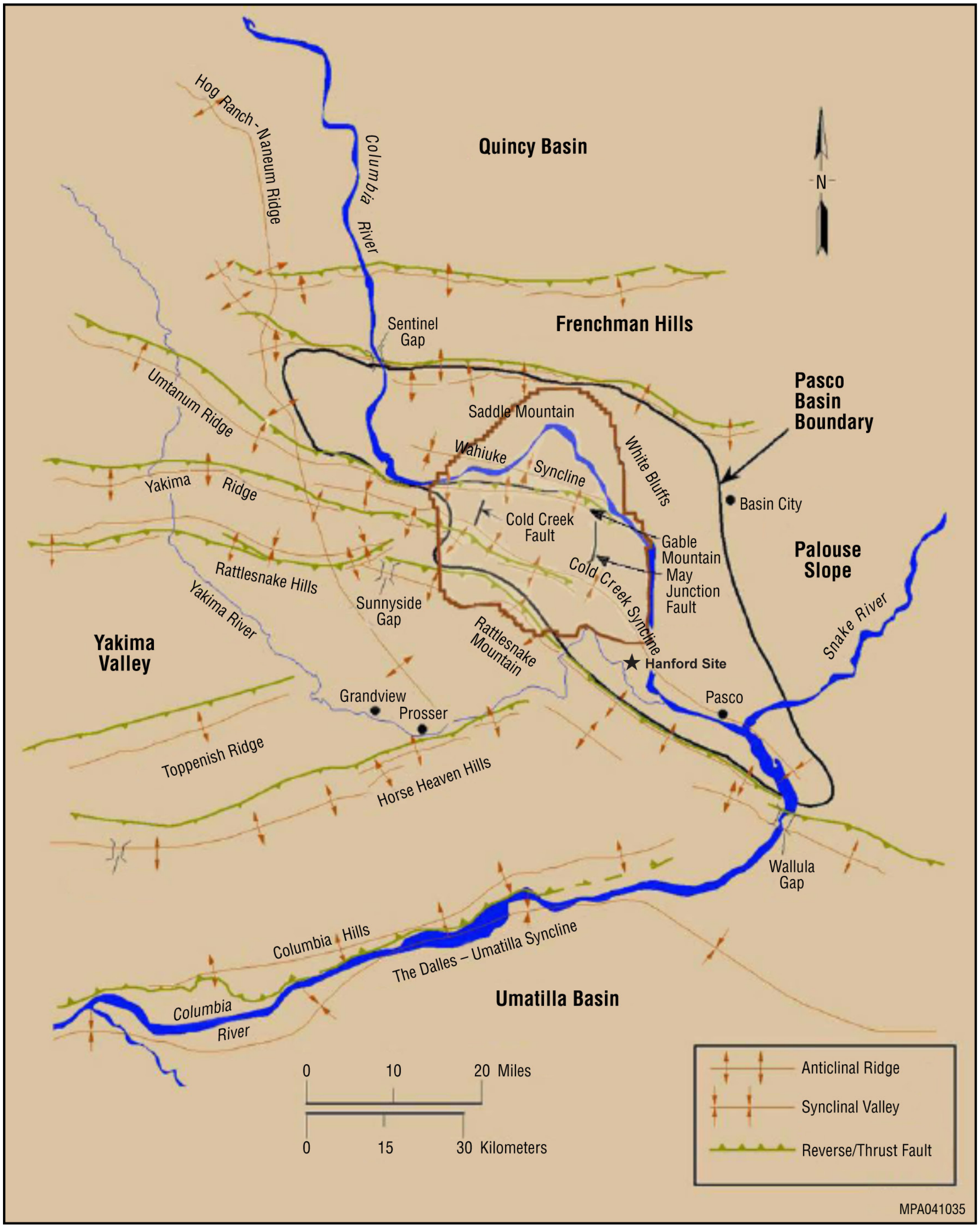

FIGURE 6.1.2-2 Physical Geology in the Vicinity of the Hanford Site (Source: Modified from Chamness and Sweeney 2007)

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.

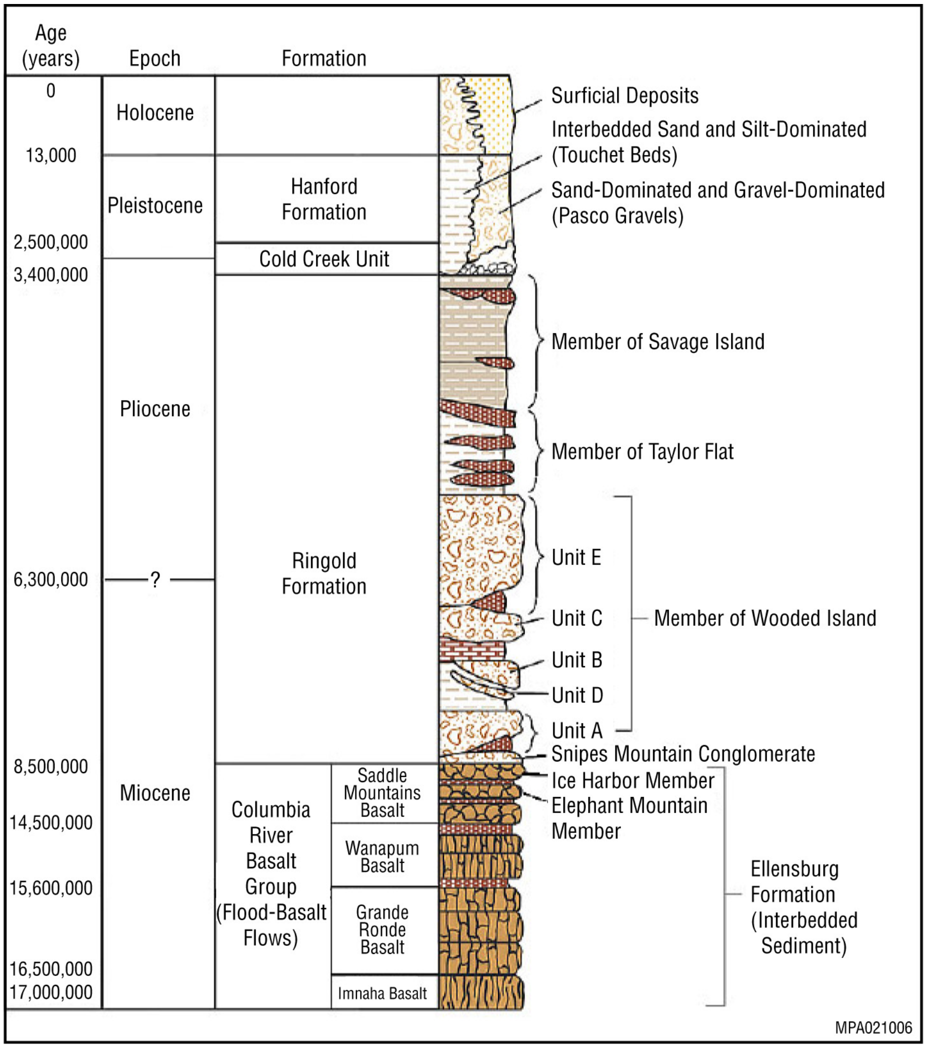

FIGURE 6.1.2-3 Generalized Stratigraphy of the Pasco Basin and Vicinity (Source: Chamness and Sweeney 2007)

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,

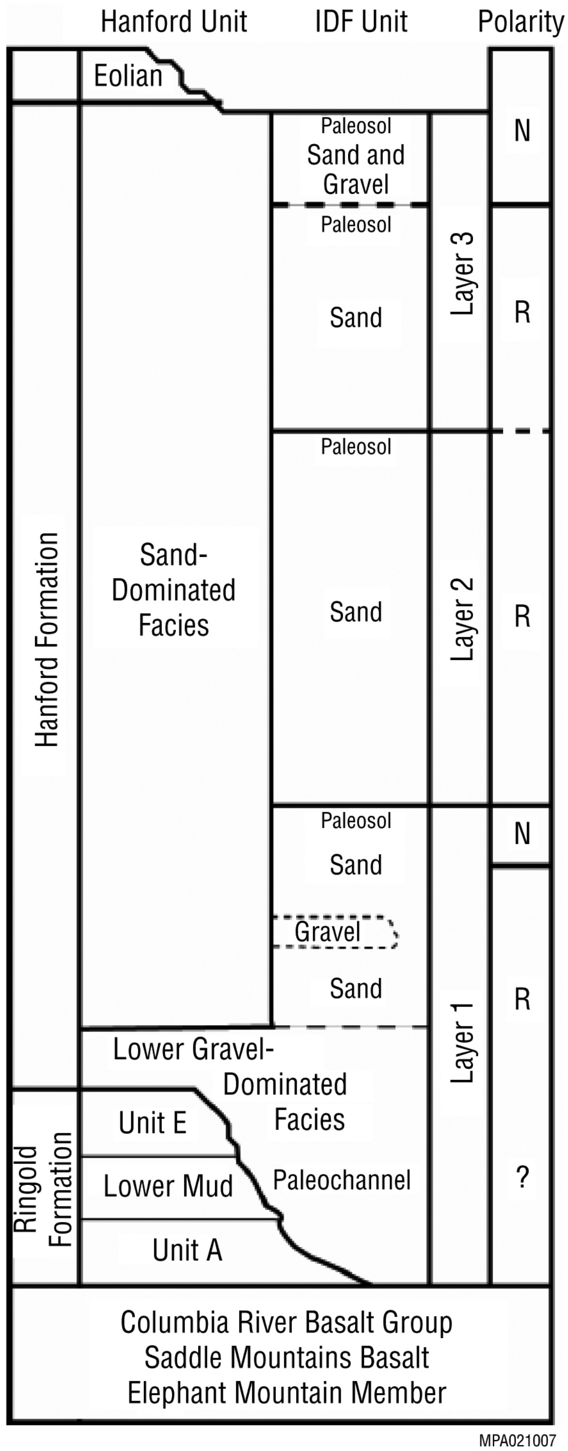

FIGURE 6.1.2-4 Stratigraphy at the IDF Site (Source: Reidel 2005)

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).

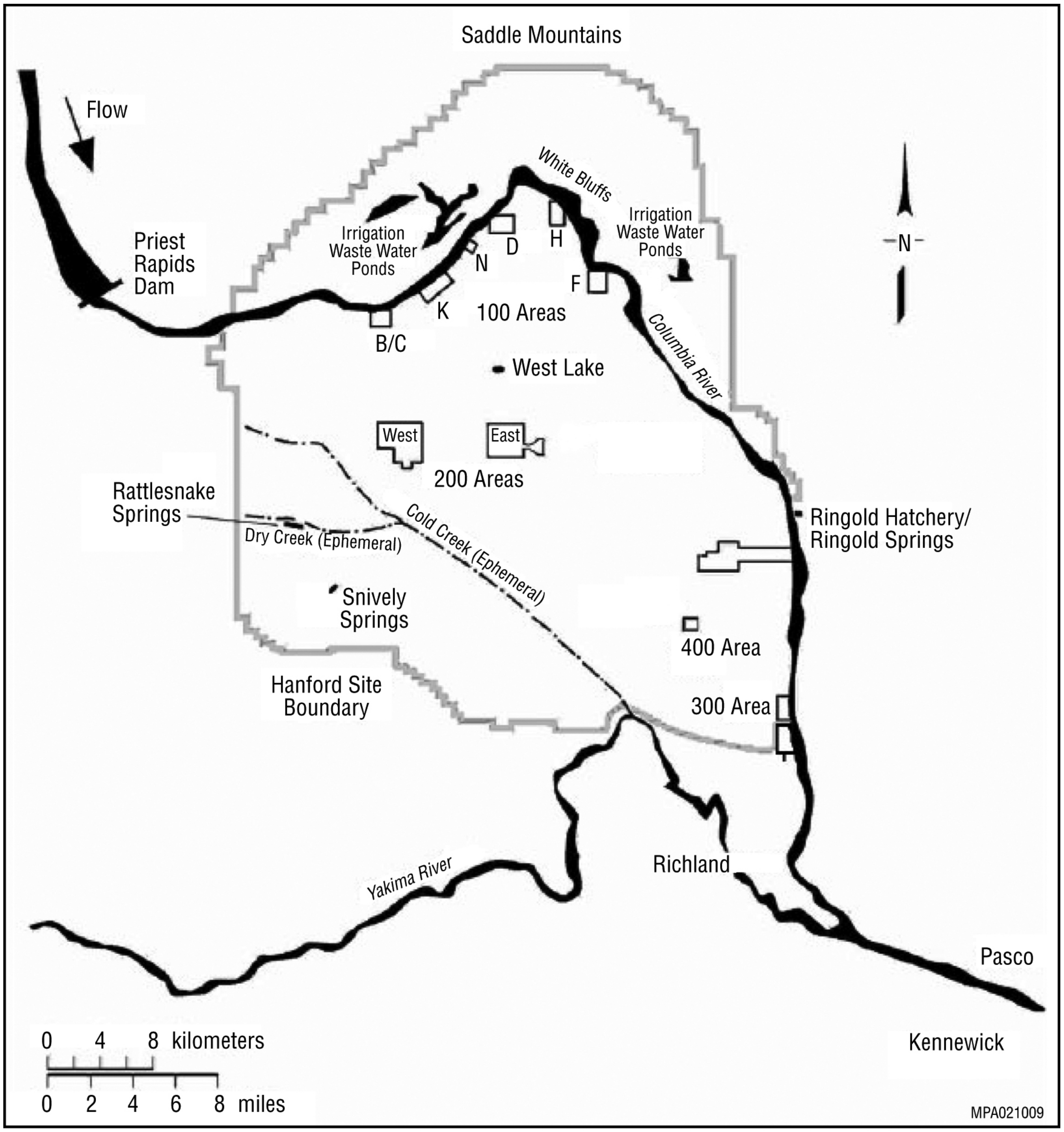

FIGURE 6.1.3-1 Surface Water Features on the Hanford Site (Source: Thorne and Last 2007)

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.

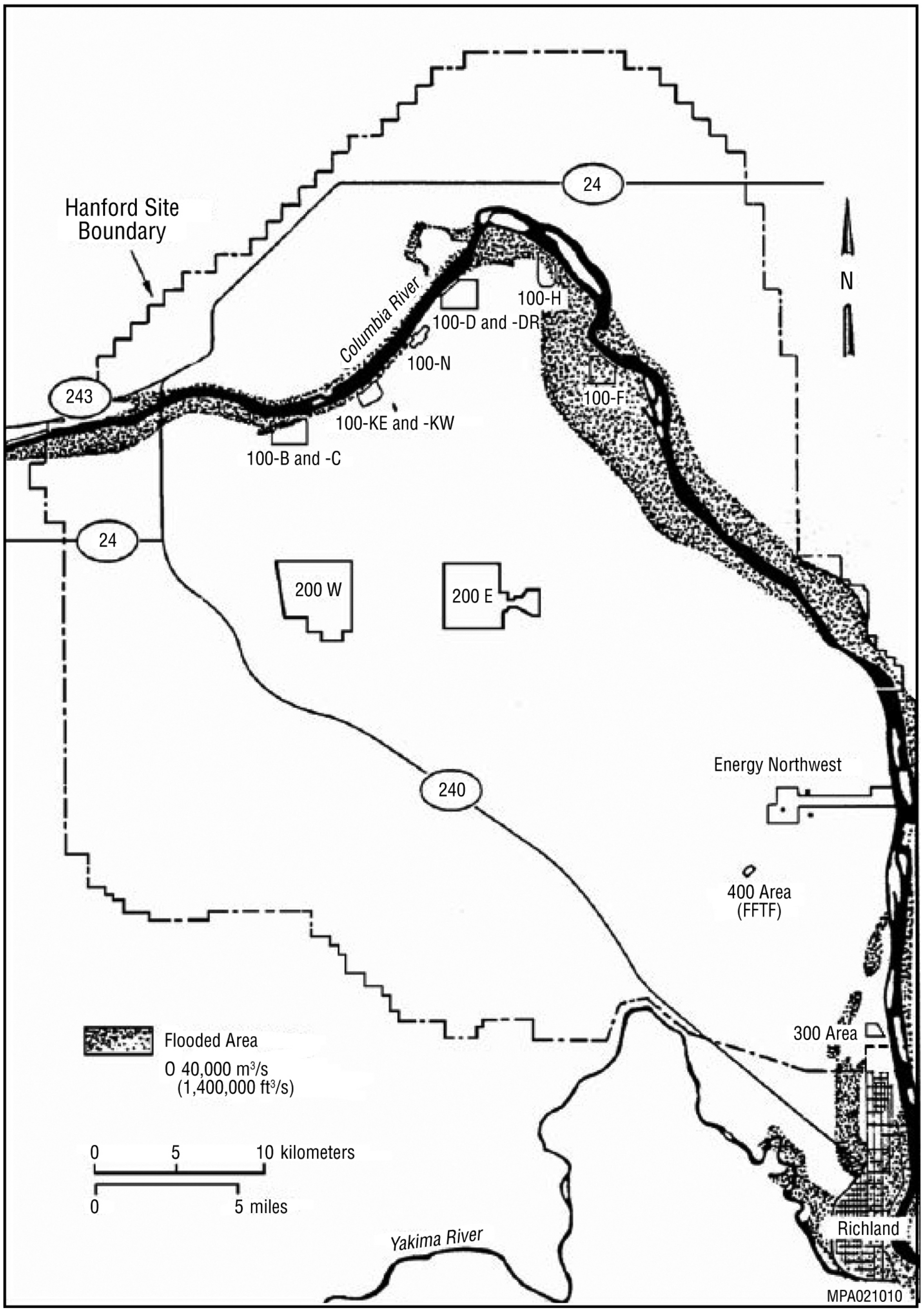

FIGURE 6.1.3-2 Flood Area for the Probable Maximum Flood on the Columbia River, Hanford Site (Source: Thorne and Last 2007)

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).

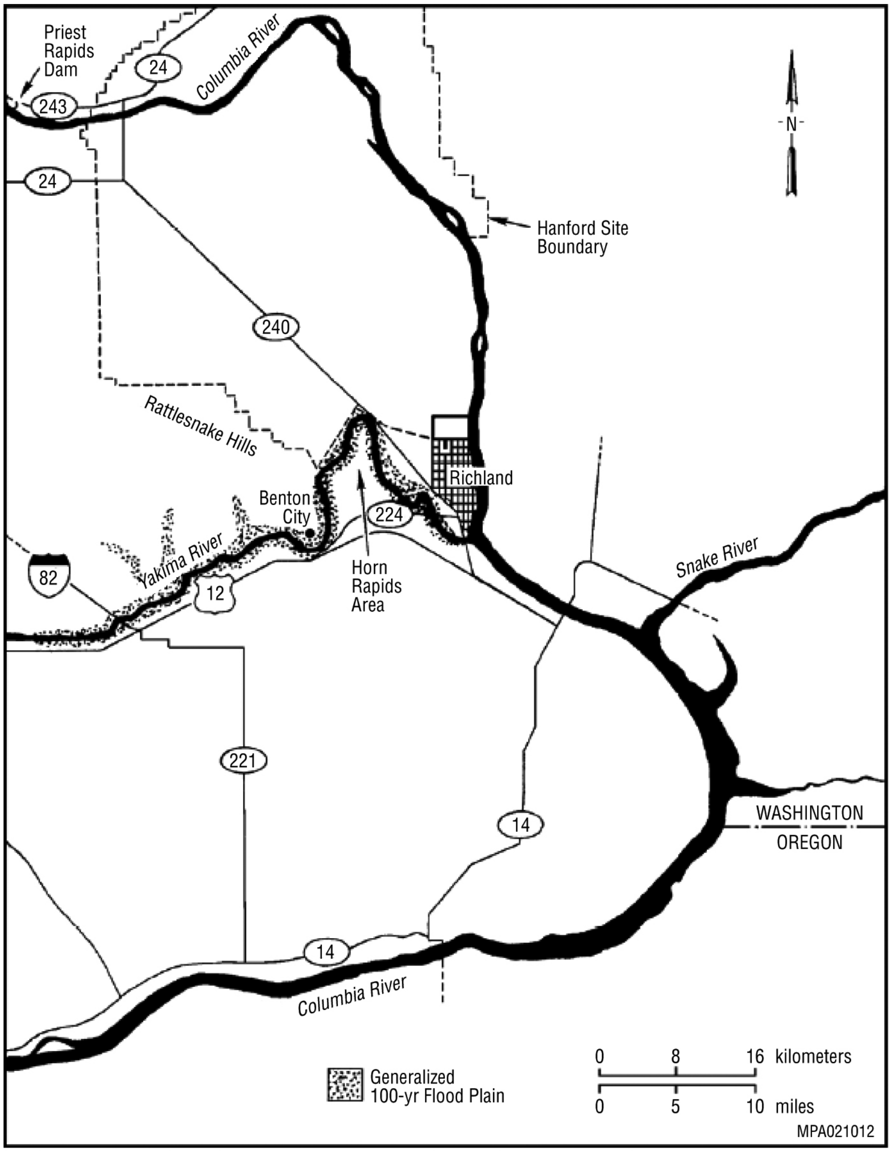

FIGURE 6.1.3-3 Flood Area from a 100-Year Flood of the Yakima River near the Hanford Site (Source: Thorne and Last 2007)

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).

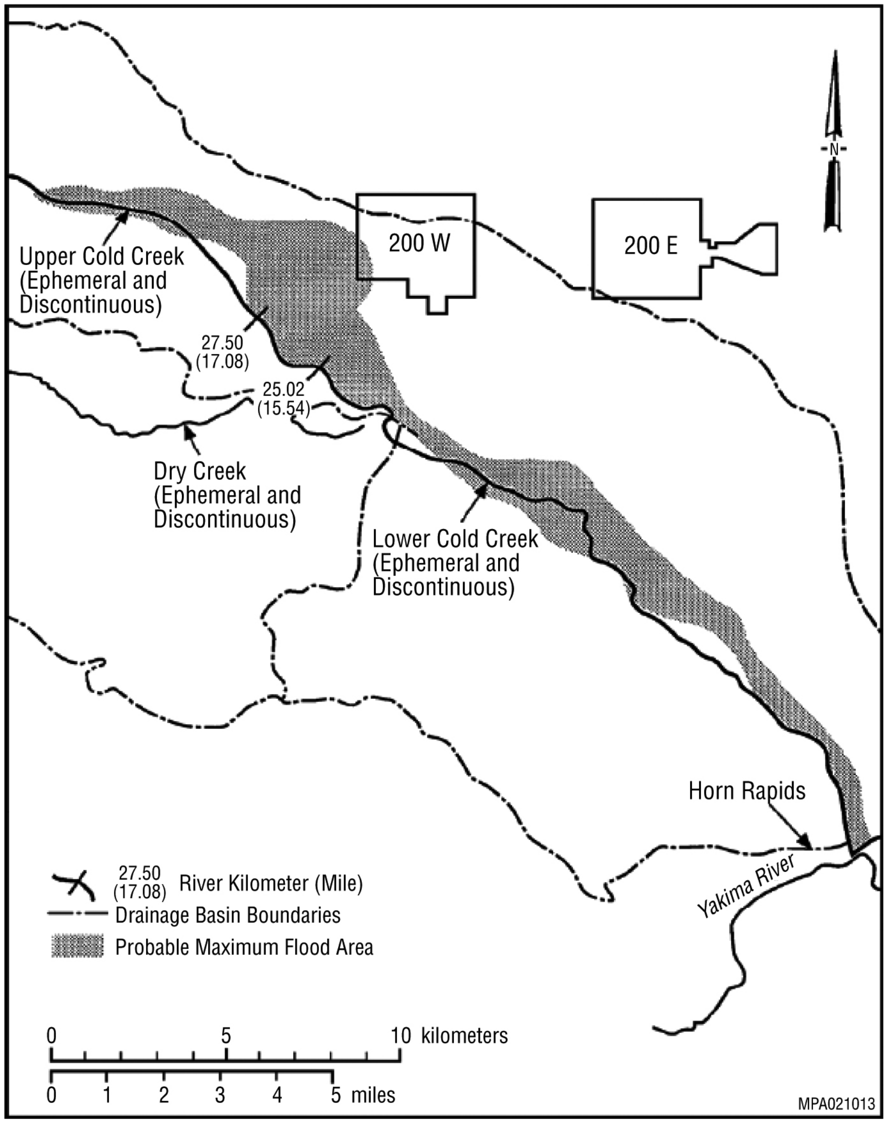

FIGURE 6.1.3-4 Extent of Probable Flood in Cold Creek Area, Hanford Site (Source: Thorne and Last 2007)

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

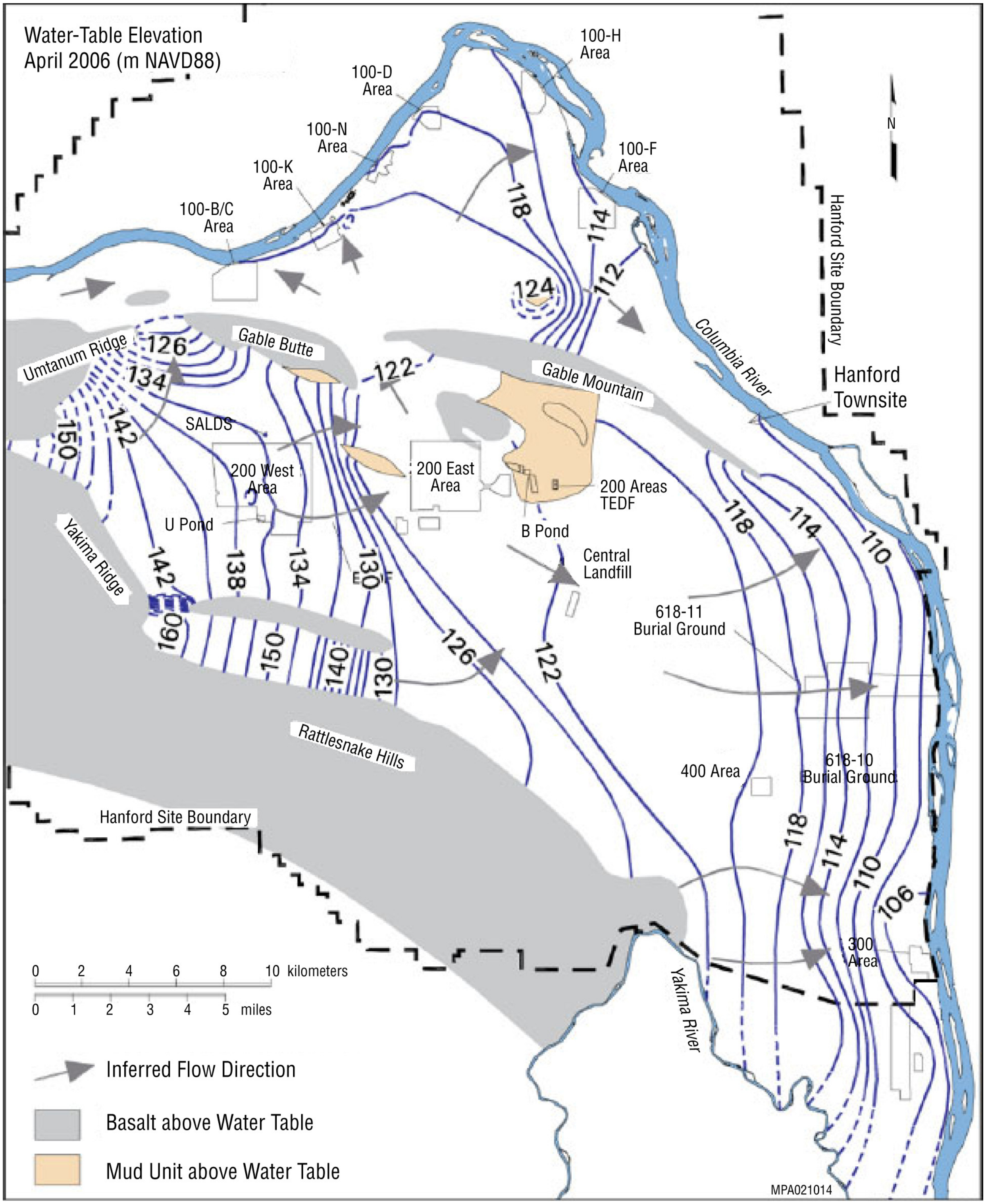

FIGURE 6.1.3-5 Water Table Elevations in Meters (1 m = 3.3 ft) and Inferred Groundwater Flow Directions for the Unconfined Aquifer at Hanford in March 2006 (Source: Hartman et al. 2007)

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).

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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

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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

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> 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.
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> 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.

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> 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).

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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

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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.)

[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)

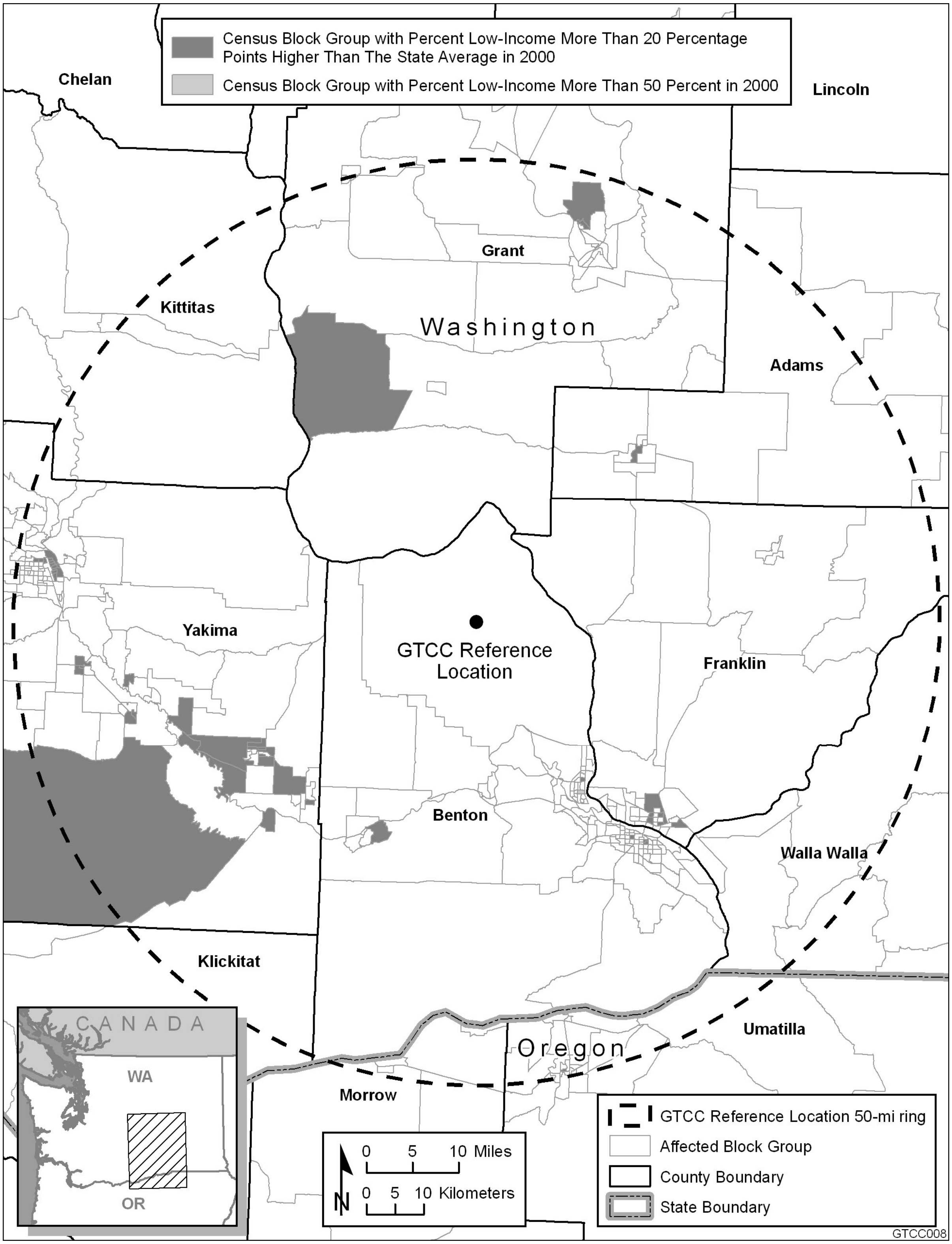

FIGURE 6.1.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at the Hanford Site (Source: U.S. Bureau of the Census 2008b)

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

Pollutant	Total Emissions (tons/yr)[a]	Construction Emissions (tons/yr)					
		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.

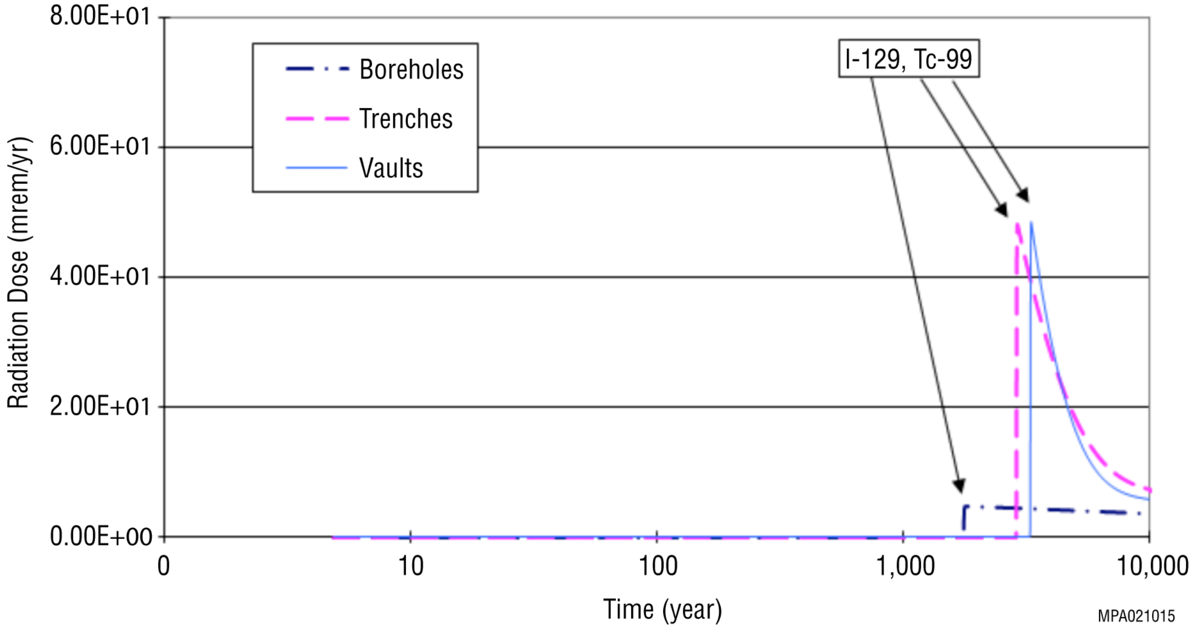

FIGURE 6.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal for the Three Land Disposal Methods at the Hanford Site

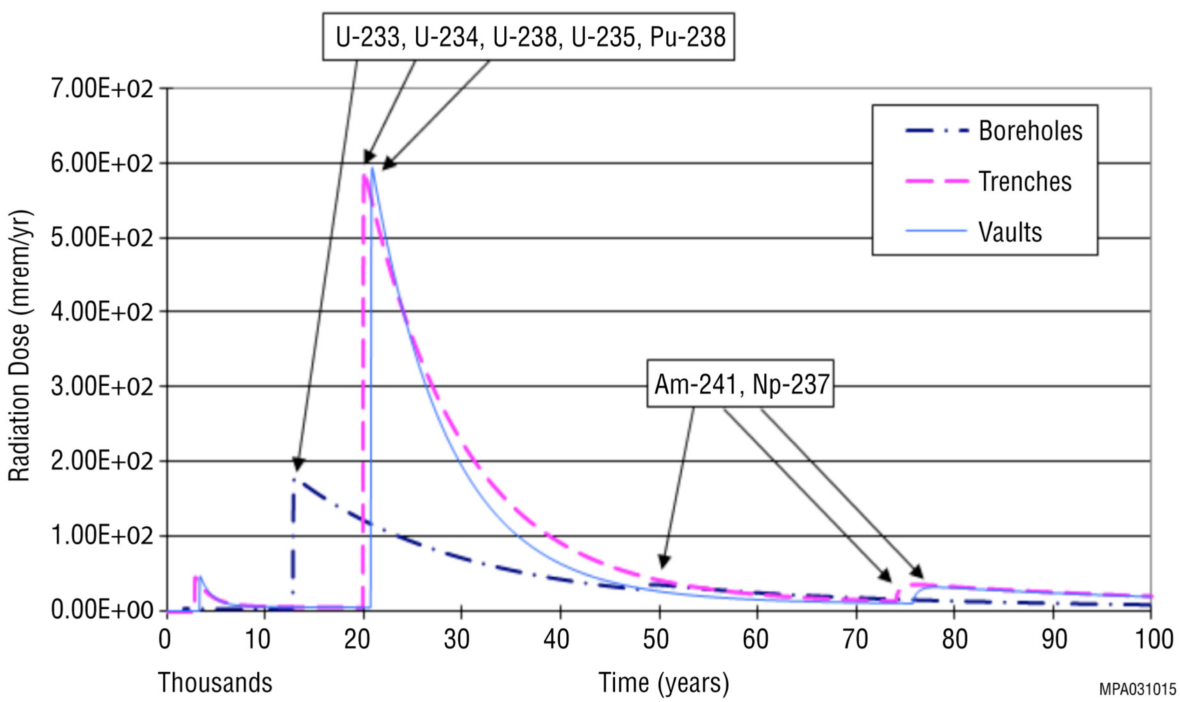

FIGURE 6.2.4-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Three Land Disposal Methods at the Hanford Site

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[e]	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[e]	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

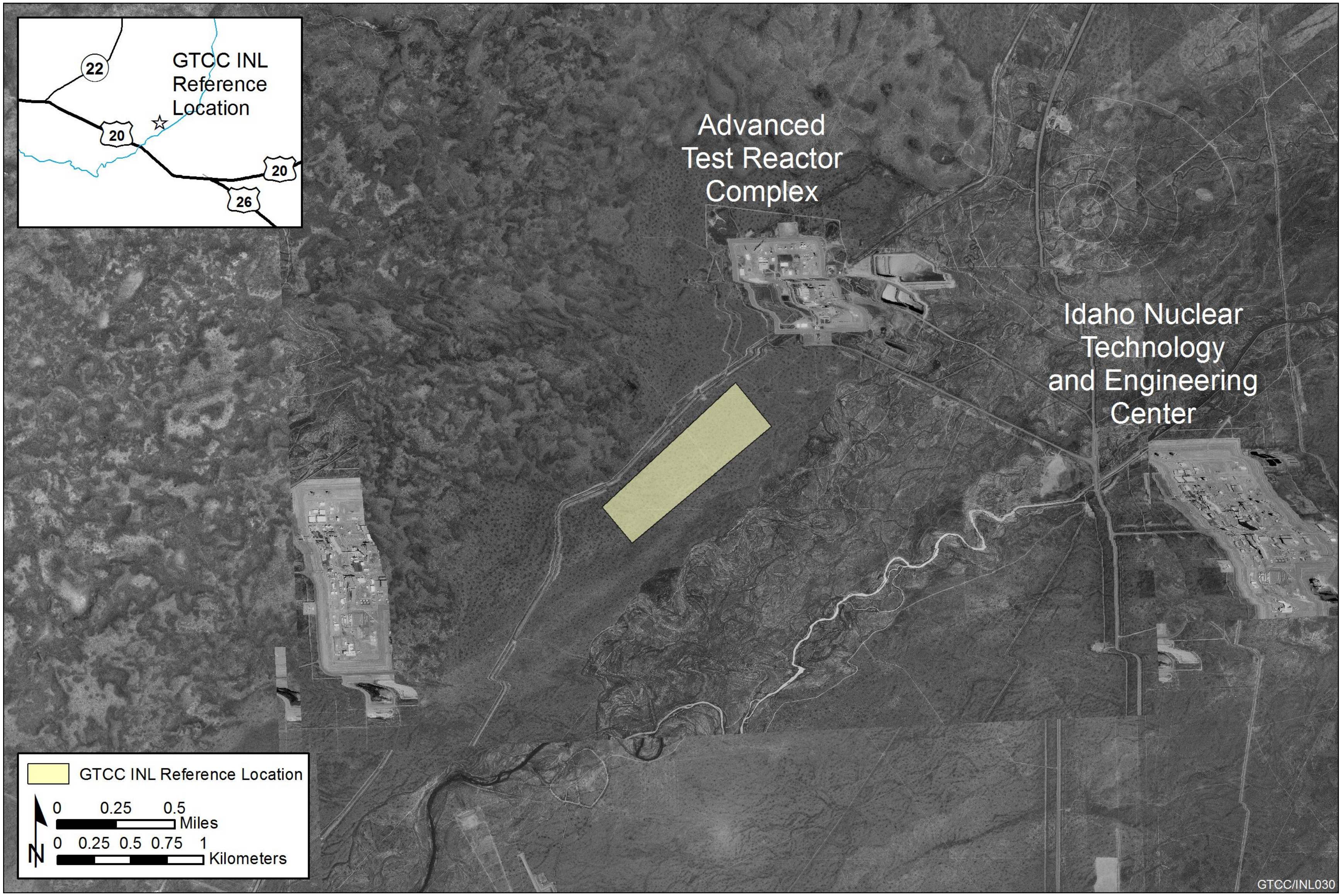


FIGURE 7.1-1 GTCC Reference Location at INL

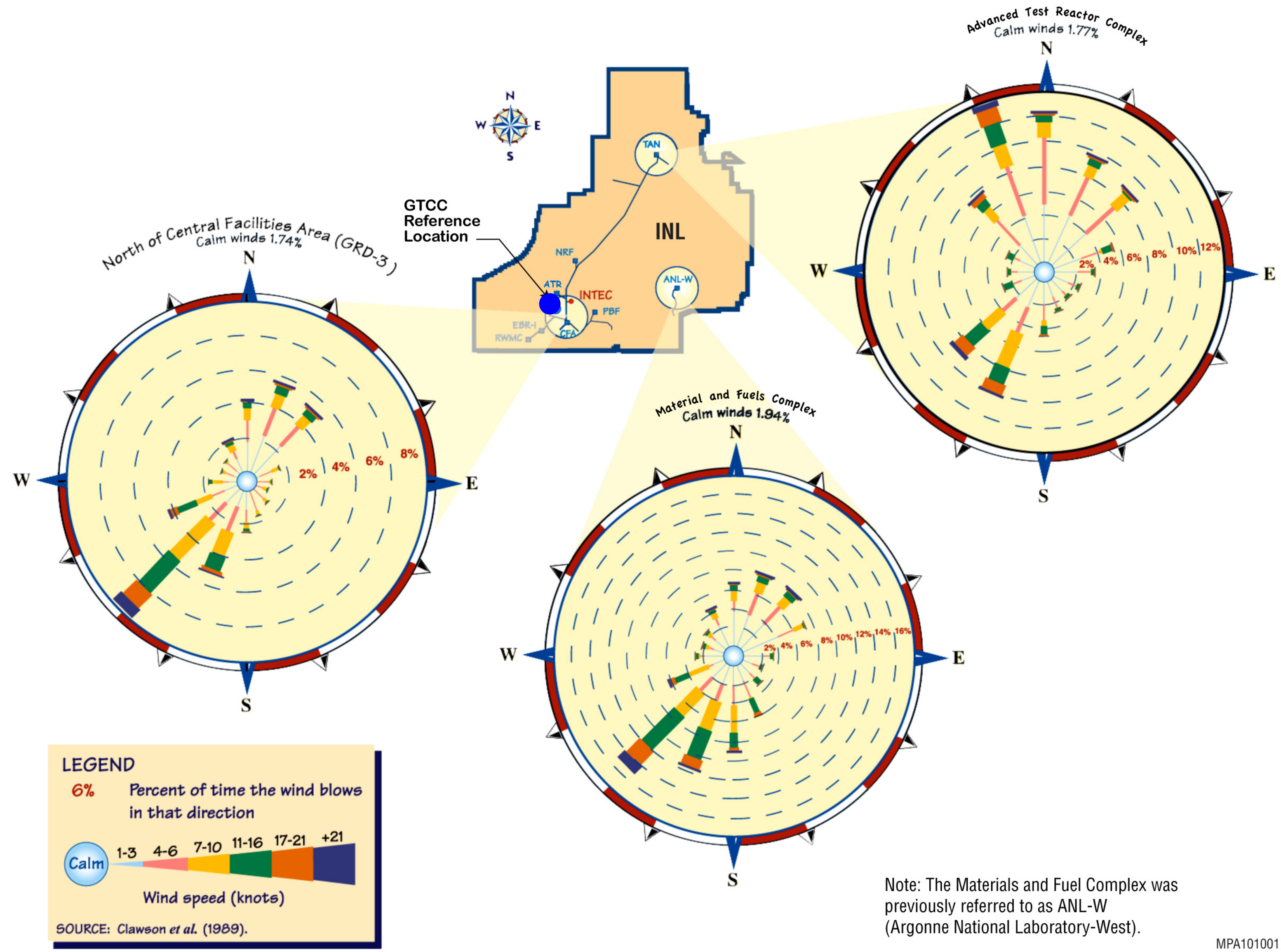


FIGURE 7.1.1-1 Wind Roses at Meteorological Stations on the INL Site (Source: DOE 2002)

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)

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)

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.

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

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 $\mu g/m^3$	120 $\mu g/m^3$ (80%)	Bingham Co. (2003)
	Annual	50 $\mu g/m^3$	37 $\mu g/m^3$ (74%)	Bingham Co. (2003)
$PM_{2.5}$	24-hour	35 $\mu g/m^3$	59 $\mu g/m^3$ (169%)	Idaho Falls, Bonneville Co. (2004)
	Annual	15.0 $\mu g/m^3$	10.1 $\mu g/m^3$ (67%)	Idaho Falls, Bonneville Co. (2004)
Lead[h]	Calendar quarter	1.5 $\mu g/m^3$	0.03 $\mu g/m^3$ (2.0%)	Kellogg, Shoshone Co. (2002)[f]
	Rolling 3-month	0.15 $\mu g/m^3$	–	–
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.)

[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).

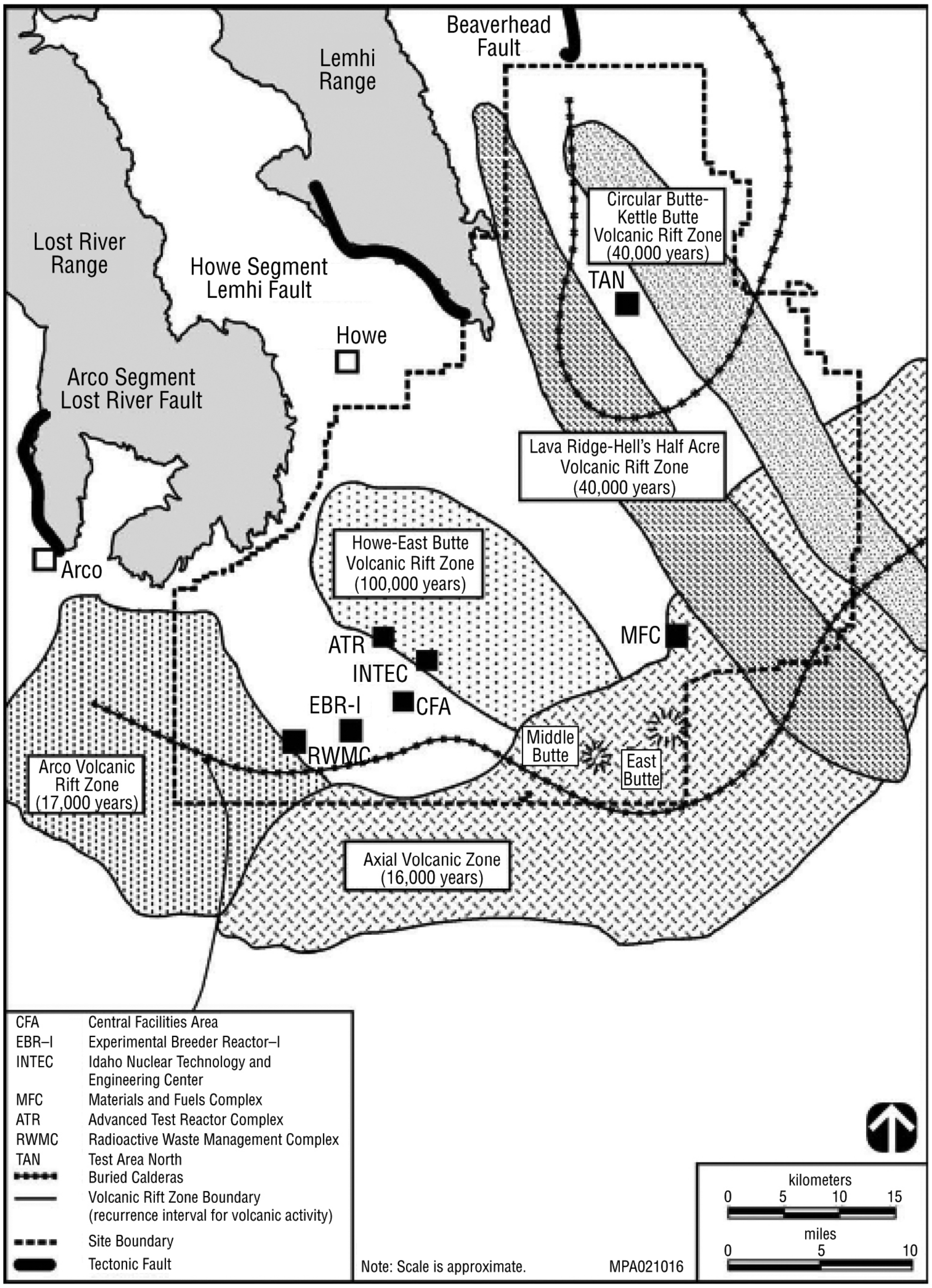


FIGURE 7.1.2-1 Location of INL on the Eastern Snake River Plain (Source: DOE 2005)

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).

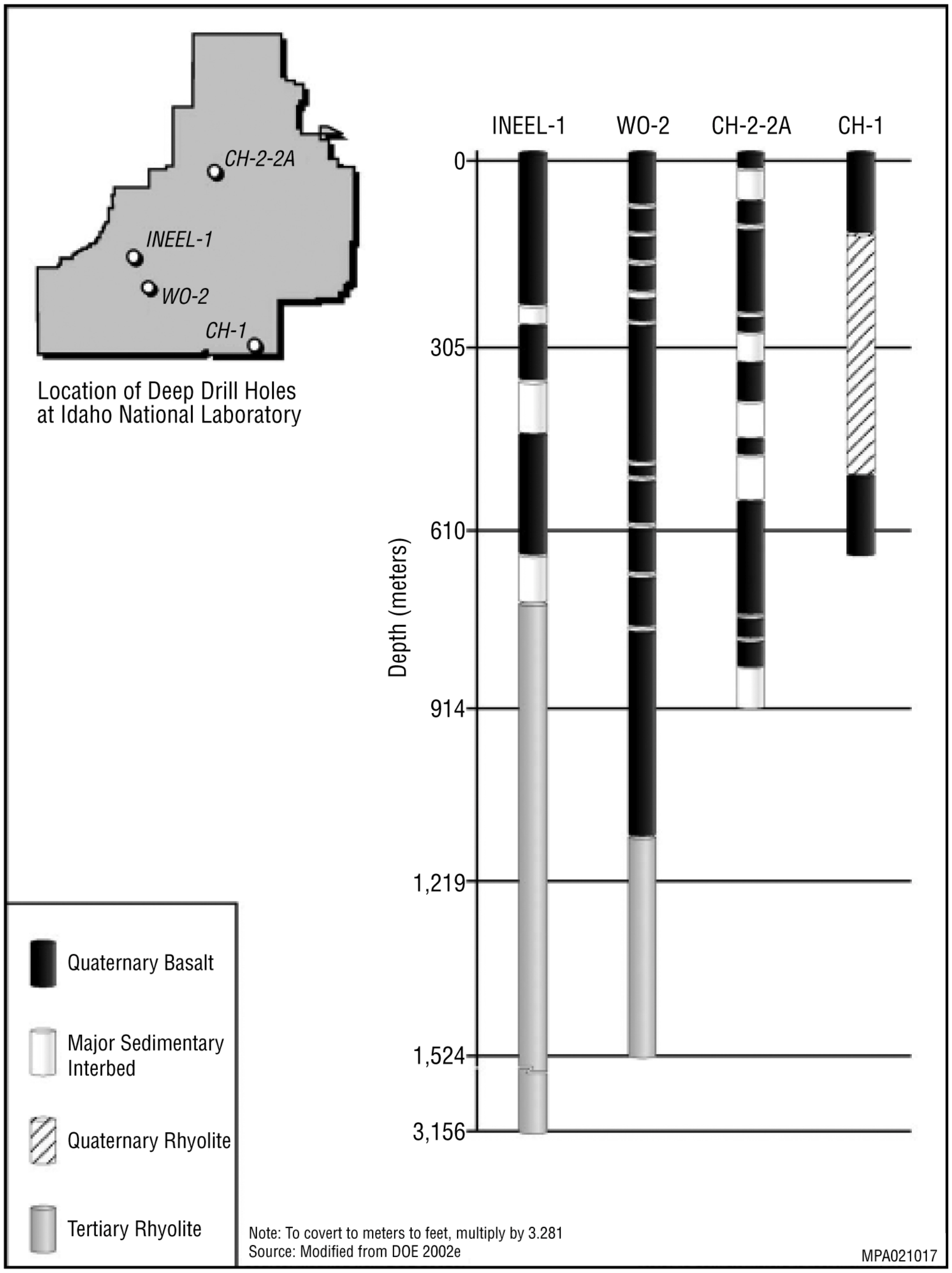
7.1.2.1.3 Site Geology and Stratigraphy. INL is underlain by about 1 to 2 km (0.6 to 1.2 mi) of Quaternary age basaltic lava flows interbedded with poorly consolidated sedimentary materials. Interbedded sediments consist of materials deposited by streams (silts, sands, and gravels), lakes (clays, silts, 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)

1 

2 **FIGURE 7.1.2-2 Lithologic Logs of Deep Drill Holes at INL**
3 **(Source: DOE 2005)**
4
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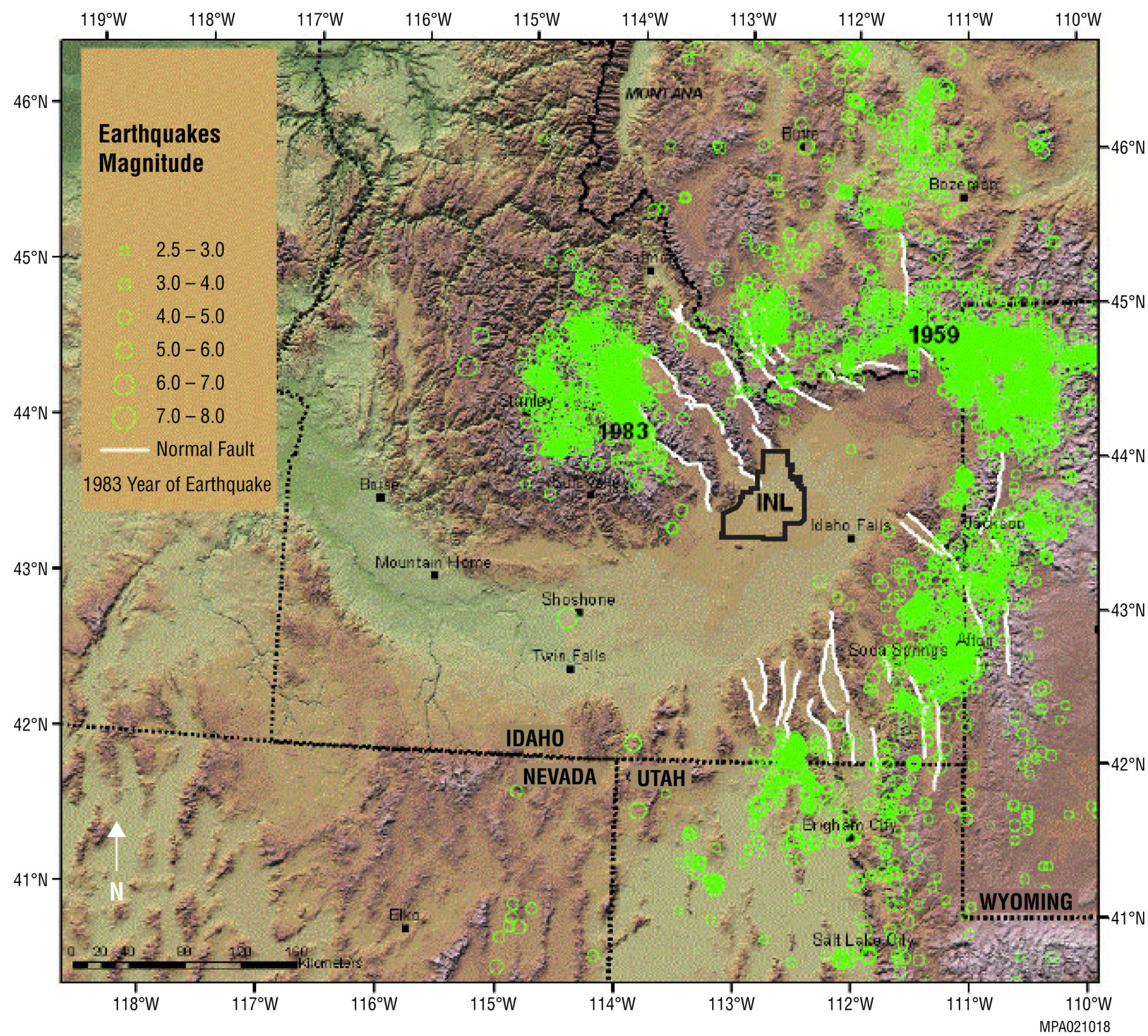

FIGURE 7.1.2-3 Map of Earthquakes with Magnitudes of 2.5 or Greater Occurring from 1872 to 2004 near INL (The Hebgen Lake and Borah Peak earthquakes are indicated as "1959" and "1983" on the map, respectively.) (Source: Payne 2006)

(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

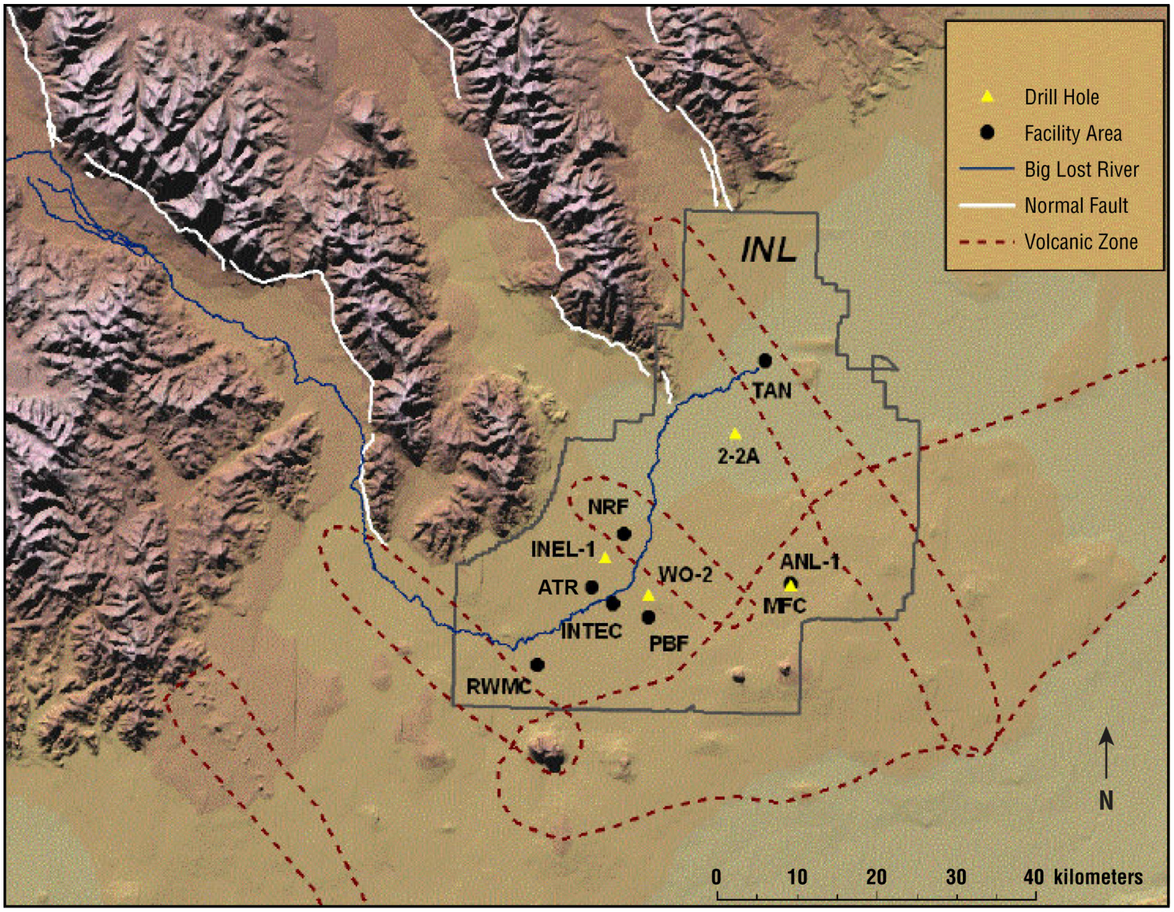

FIGURE 7.1.2-4 Locations of Normal Faults, Volcanic Rift Zones, Deep Drill Holes, and INL Facility Areas (Source: Payne 2006)

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.

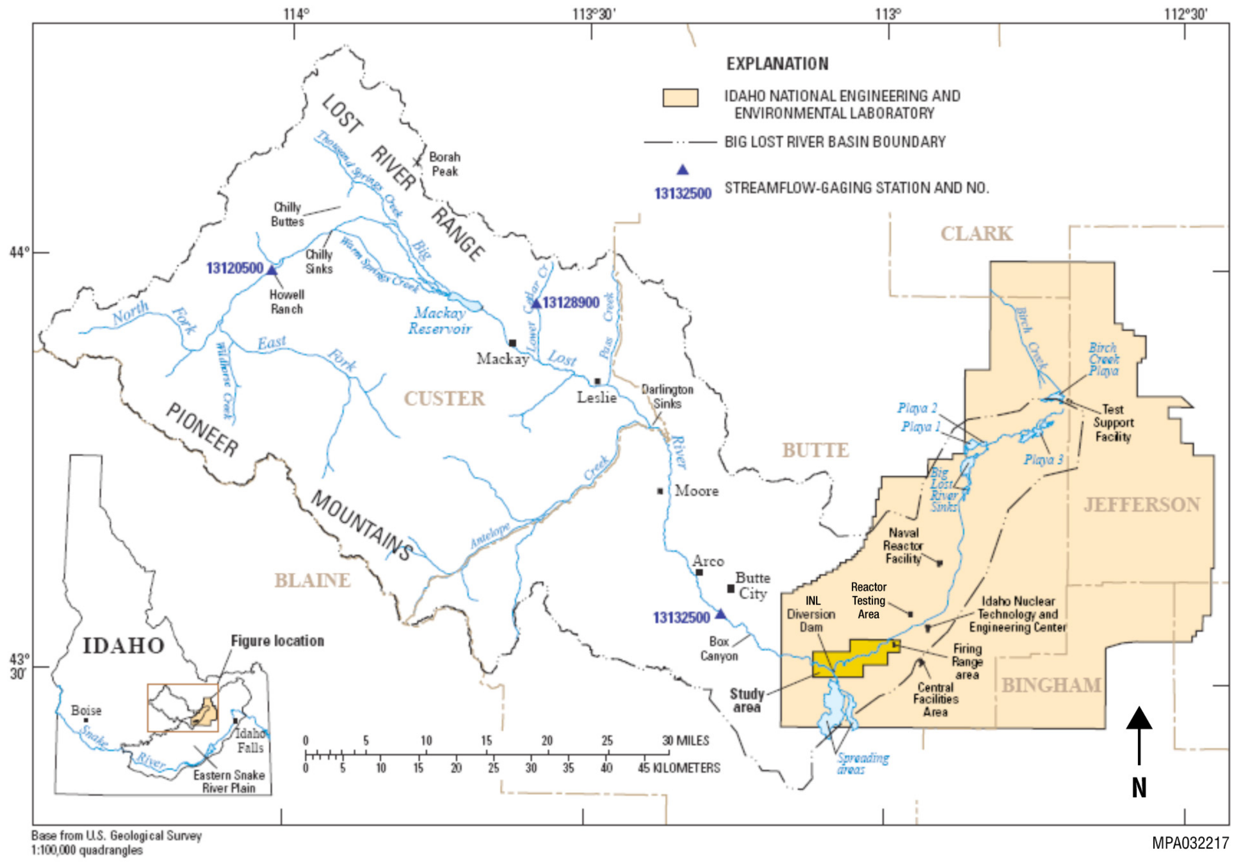

FIGURE 7.1.3-1 Location of the Big Lost River Basin and INL (Source: Berenbrock et al. 2007)

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

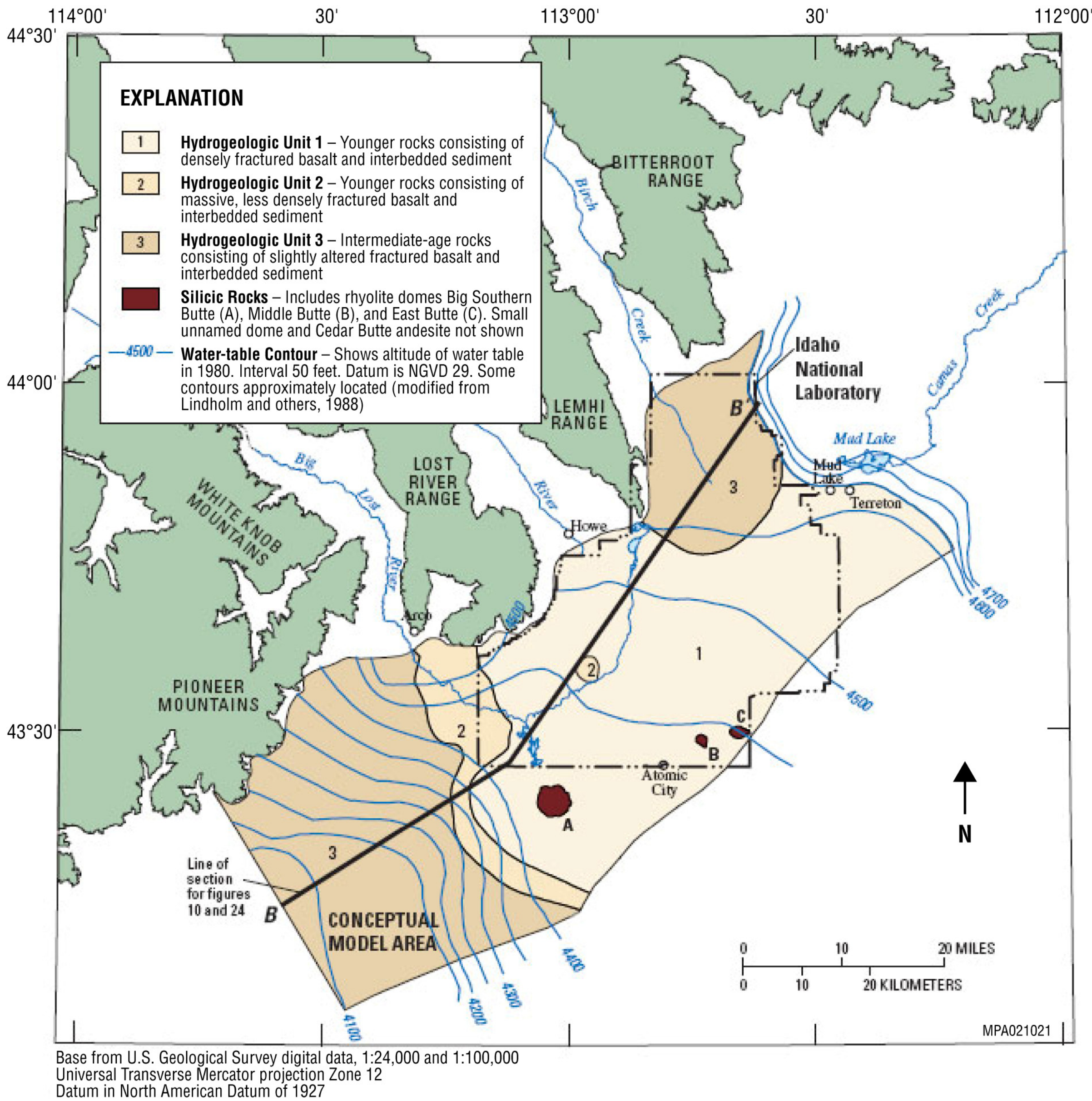

FIGURE 7.1.3-2 Water Table Contours for 1980 (hydrogeologic units at the water table also shown) (Source: Ackerman et al. 2006)

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

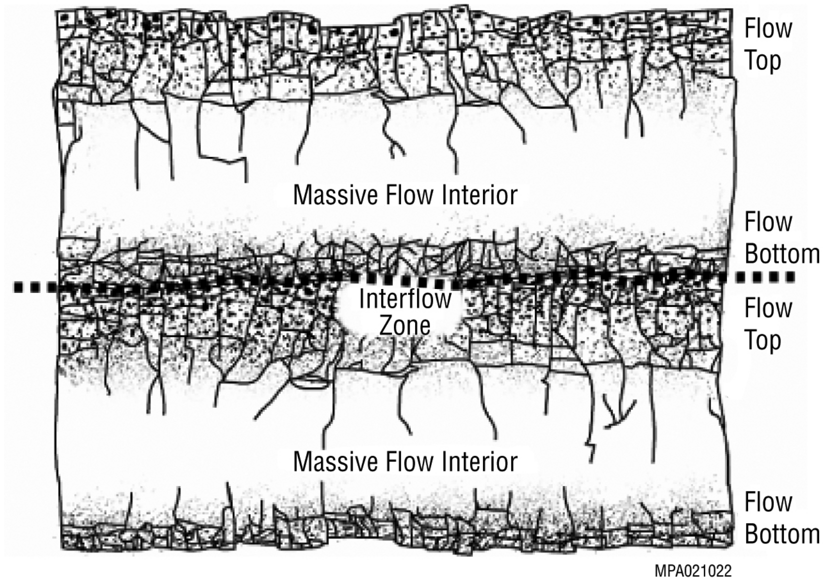

FIGURE 7.1.3-3 Diagram Showing Permeable Interflow Zone (Source: Wood et al. 2007)

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

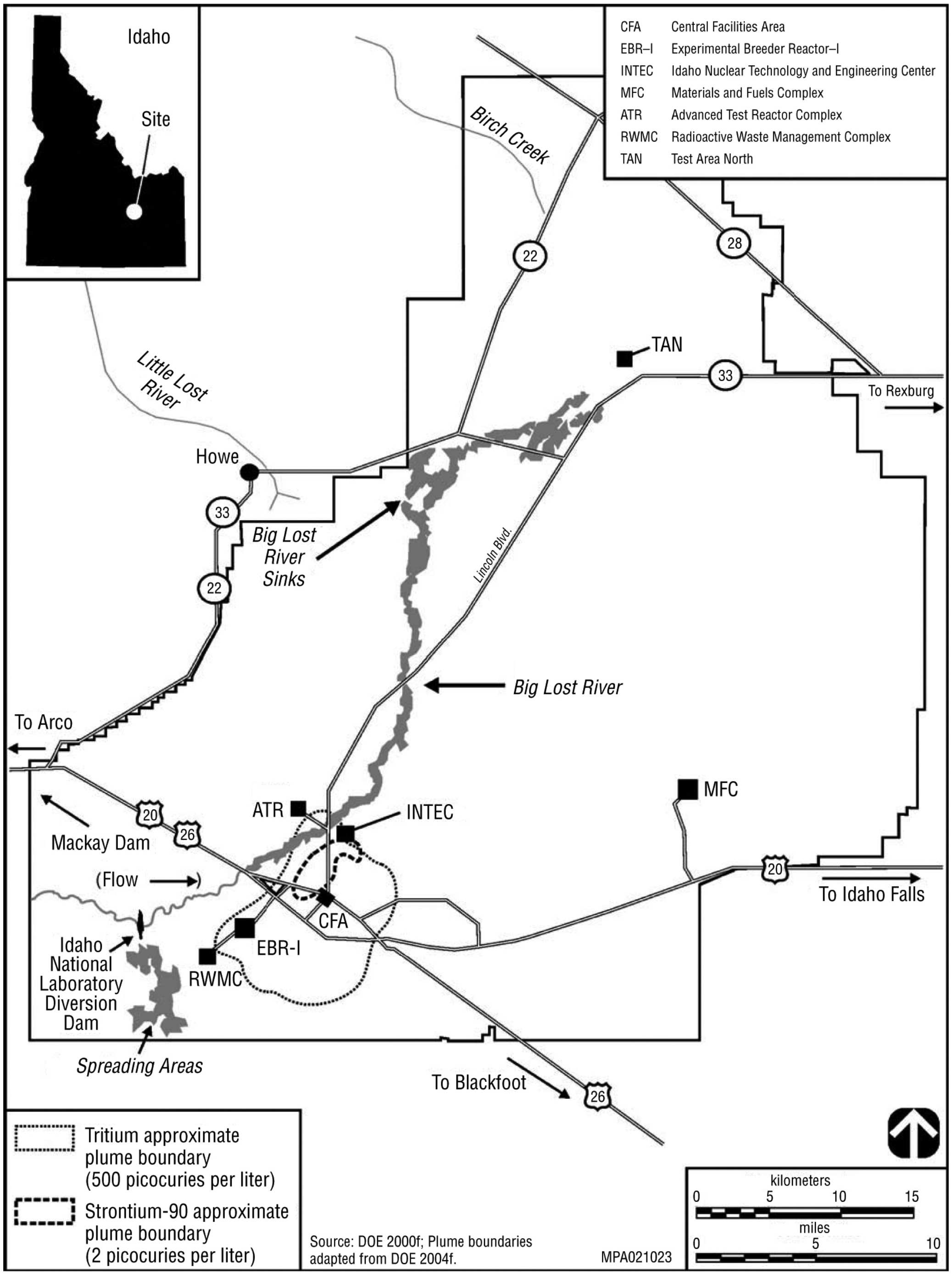

FIGURE 7.1.3-4 Extent of Tritium and Strontium-90 Plumes within the Snake River Plain Aquifer (Source: DOE 2005)

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.

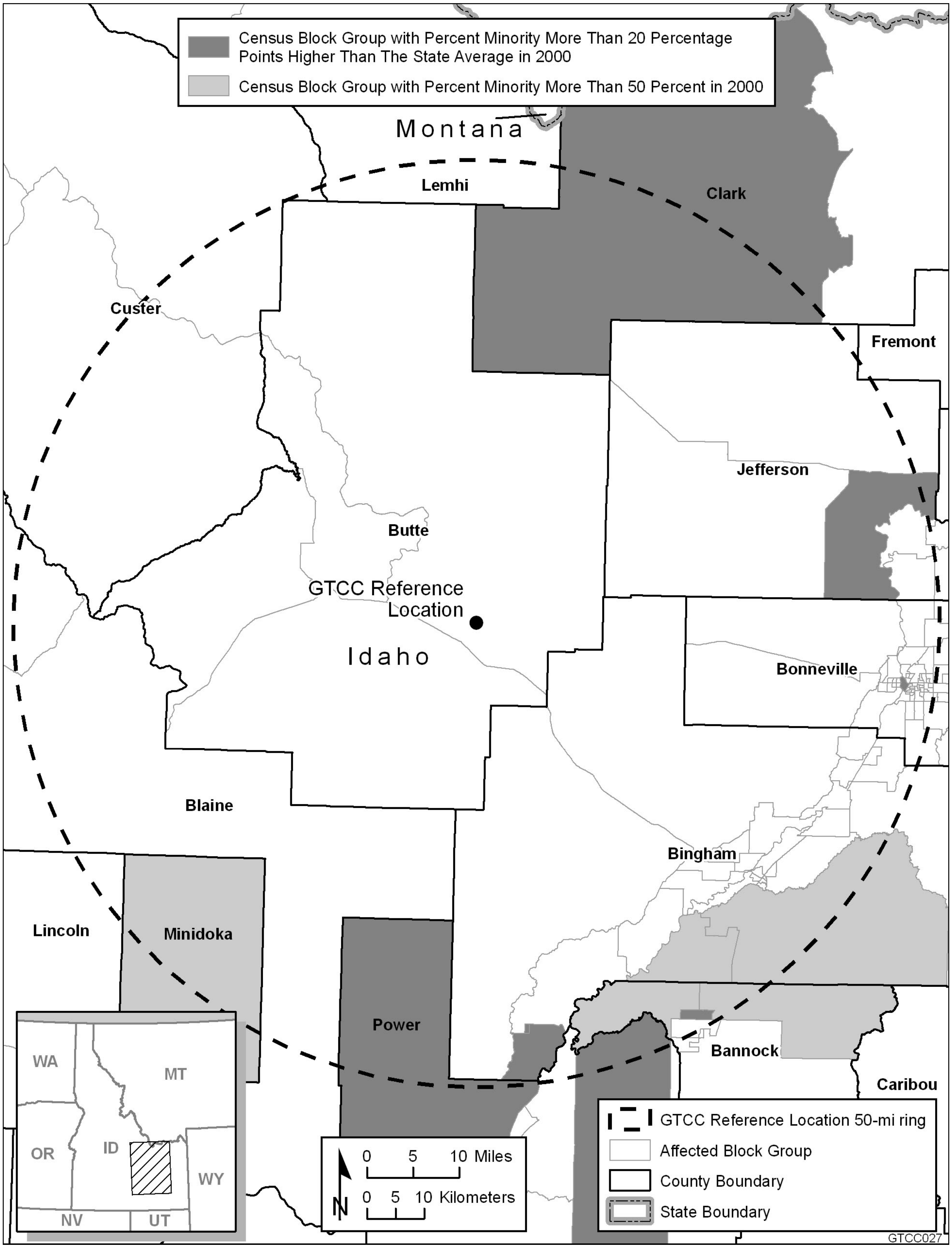

FIGURE 7.1.7-1 Minority Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at INL (Source: U.S. Bureau of the Census 2008b)

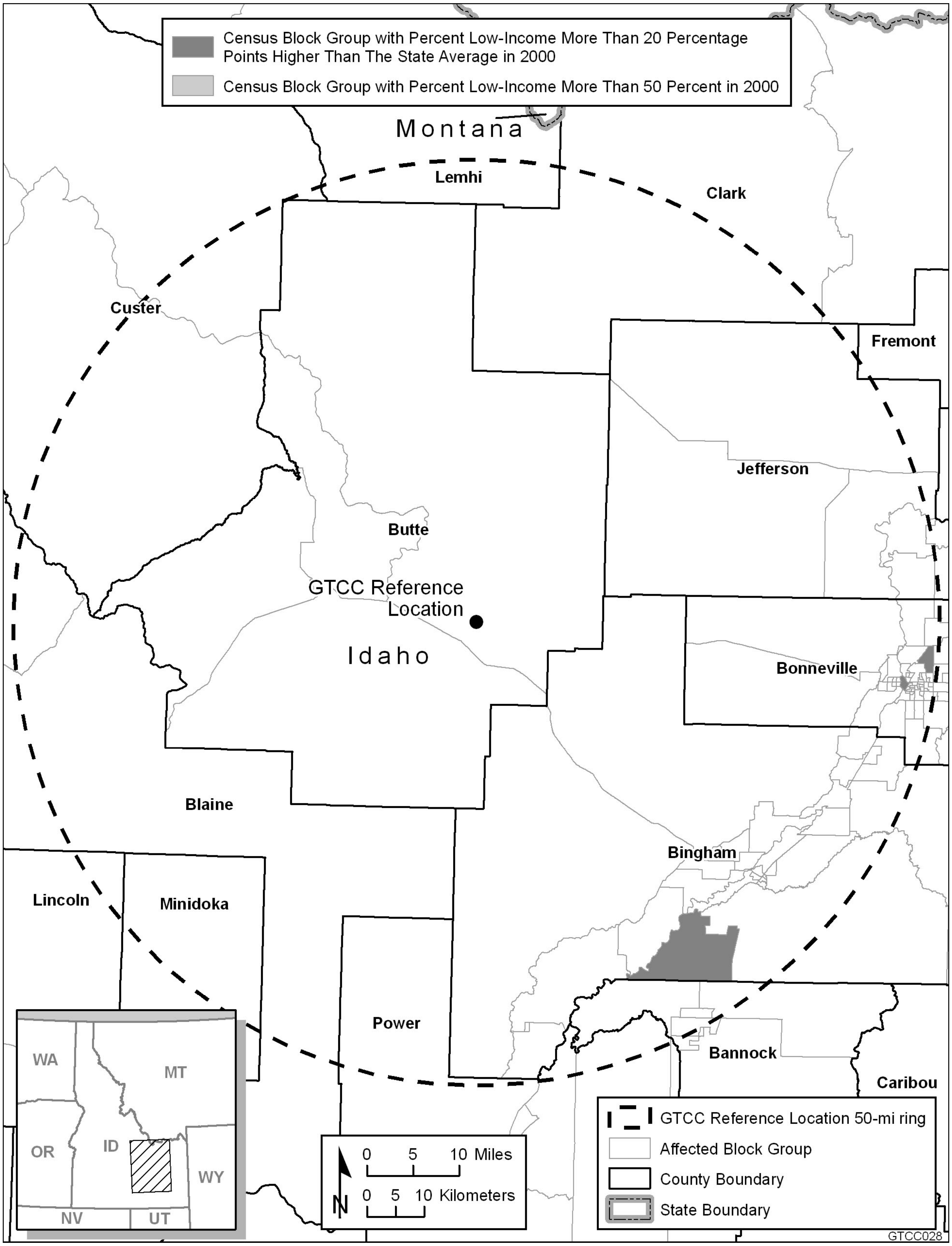

FIGURE 7.1.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at INL (Source: U.S. Bureau of the Census 2008b)

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

Pollutant	Total Emissions (tons/yr)[a]	Operation Emissions (tons/yr)					
		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.

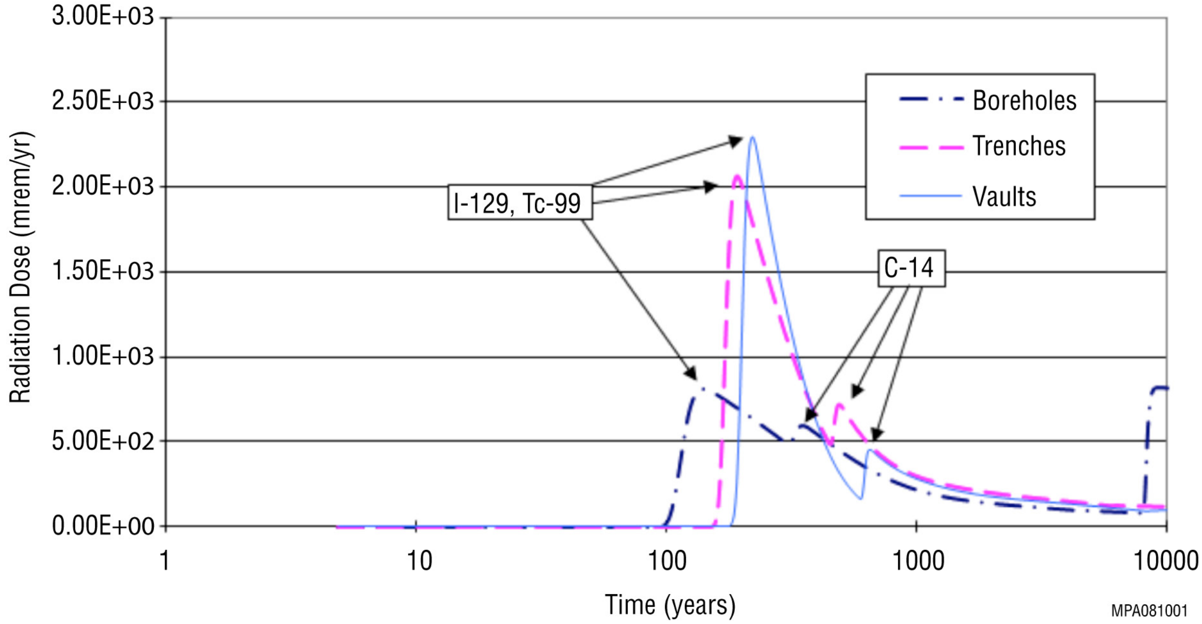

FIGURE 7.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal for the Three Land Disposal Methods at INL

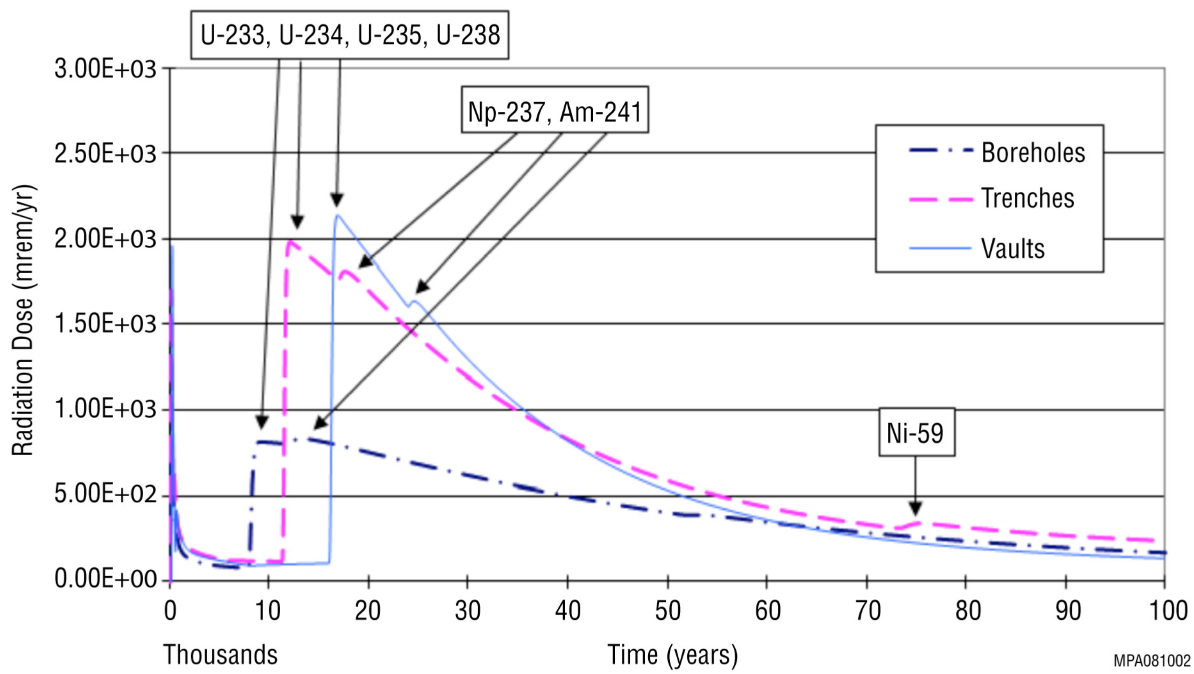

FIGURE 7.2.4-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Three Land Disposal Methods at INL

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[e]	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).

[e] 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.

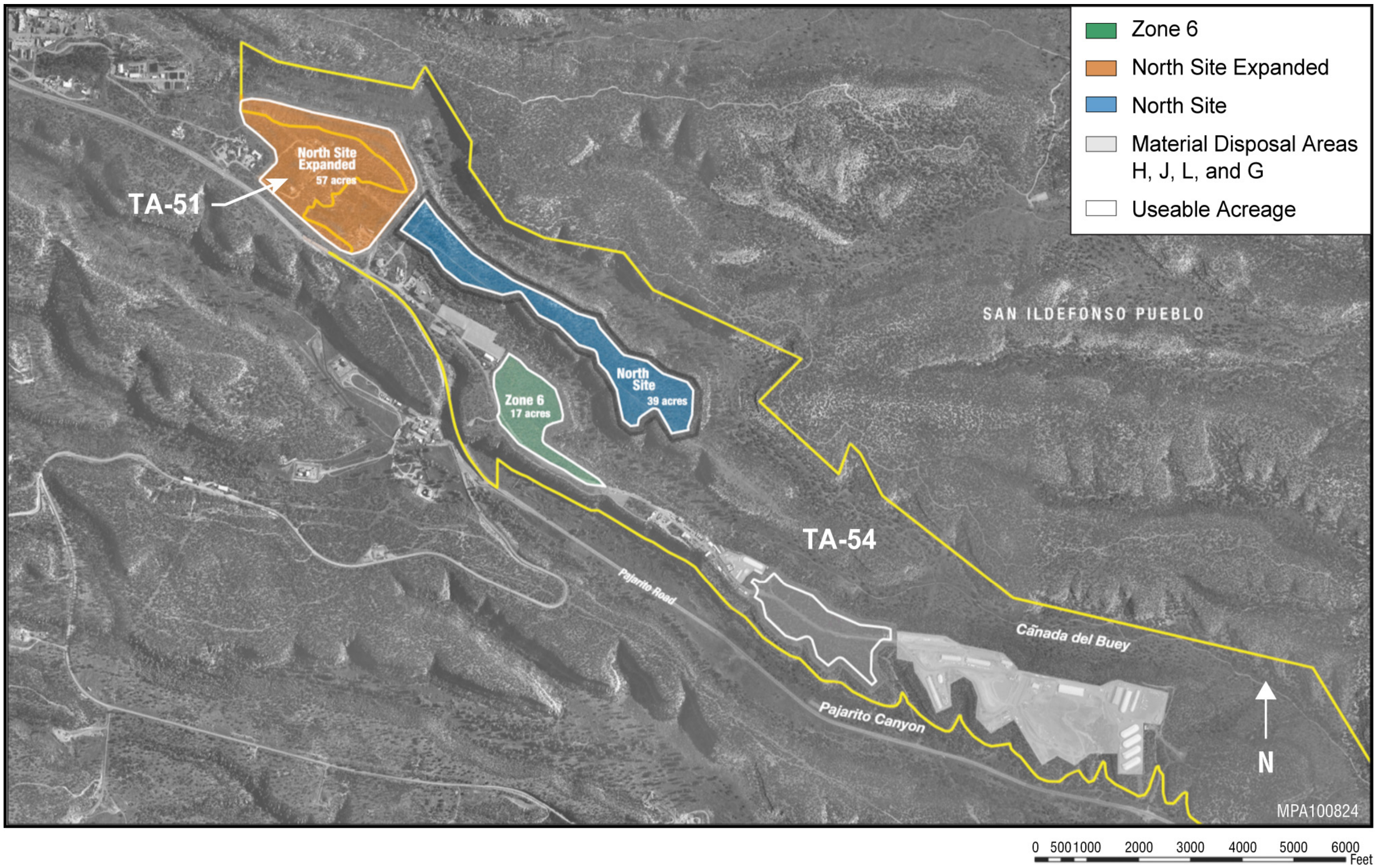


FIGURE 8.1-1 GTCC Reference Locations at LANL: North Site, North Site Expanded, and Zone 6

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

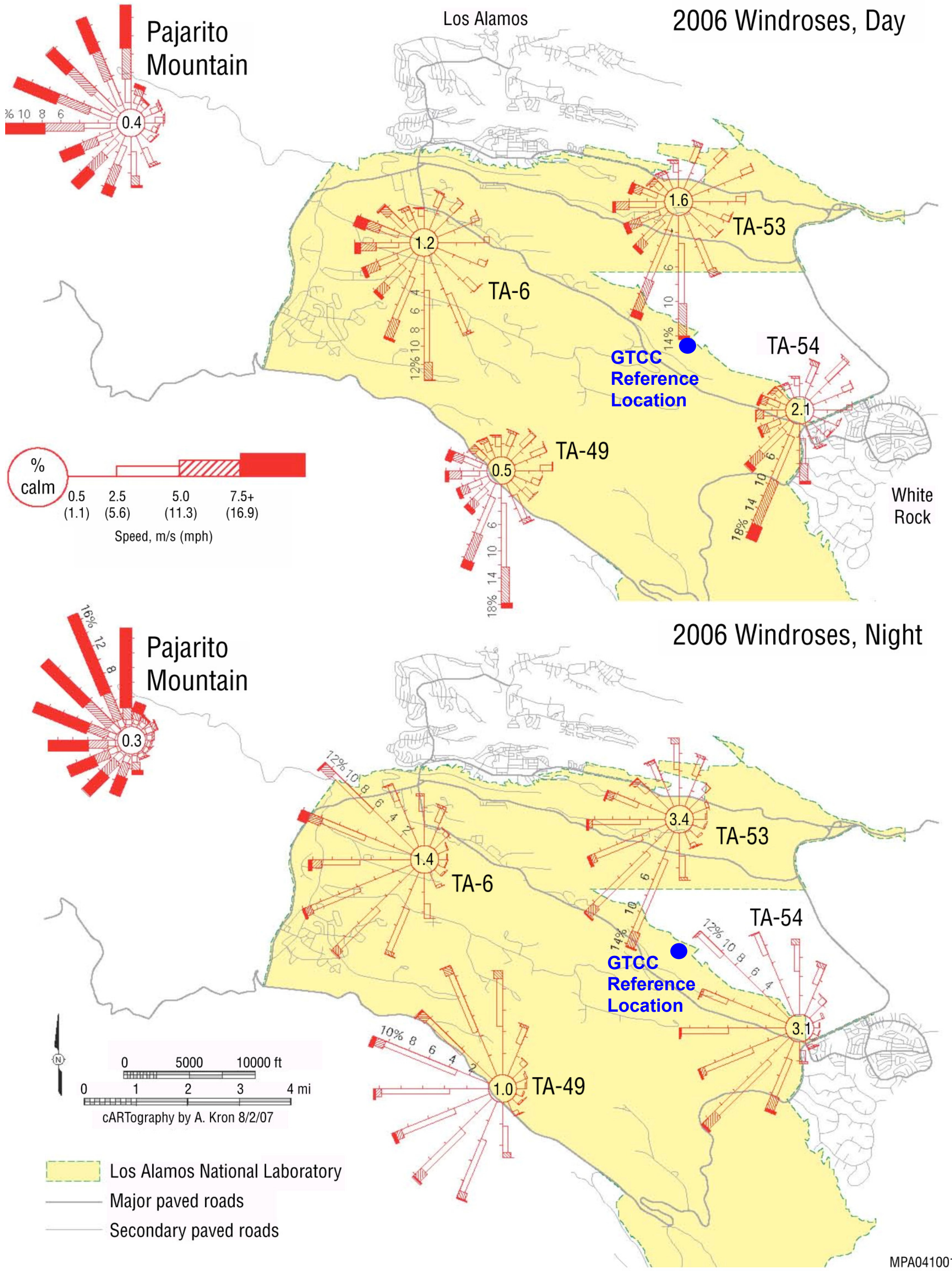


FIGURE 8.1.1-1 Daytime and Nighttime Wind Roses at and around the LANL Site in 2006 (Source: LANL 2007)

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.)

[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).

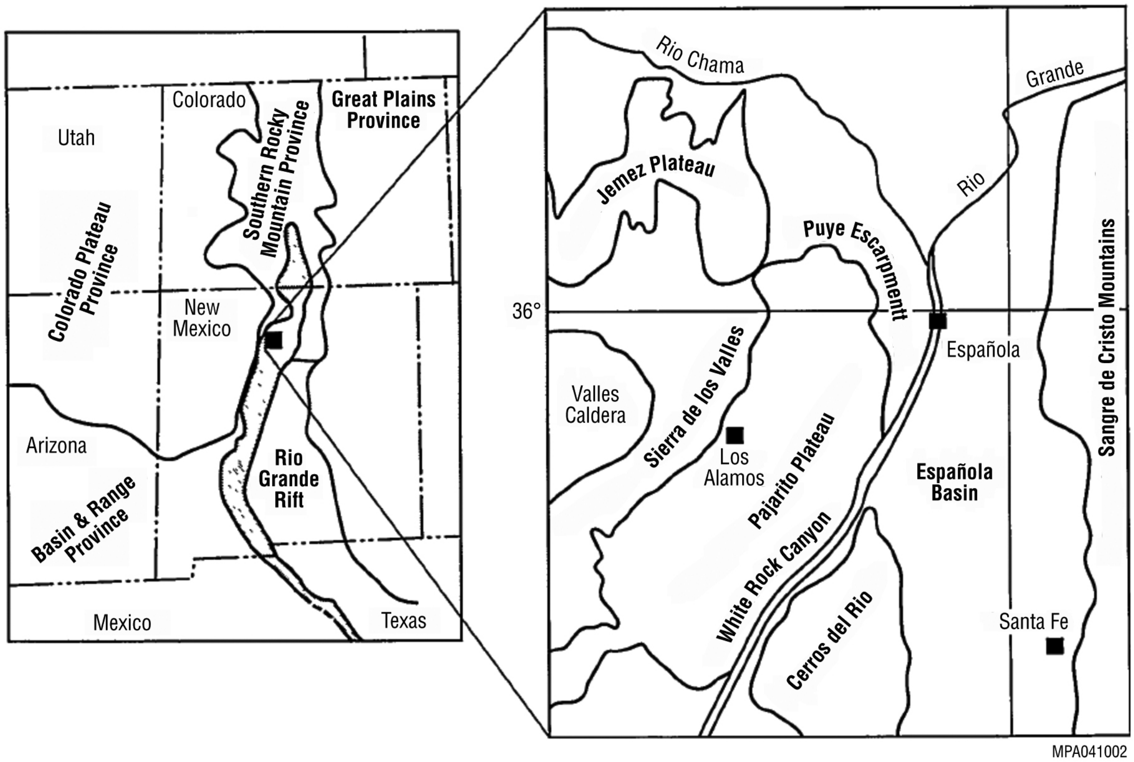
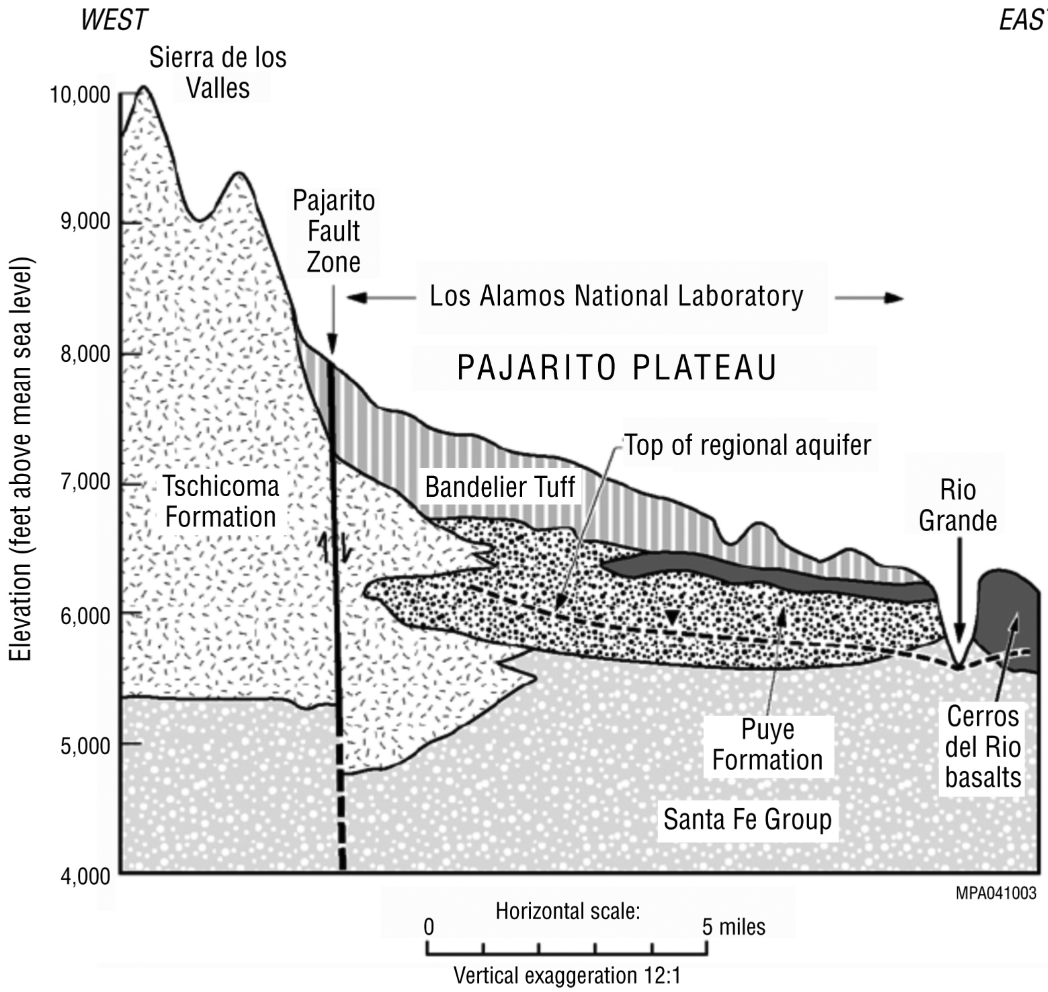


FIGURE 8.1.2-1 Location of LANL in the Southern Rocky Mountain Physiographic Province (Source: Purtymun 1995)

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

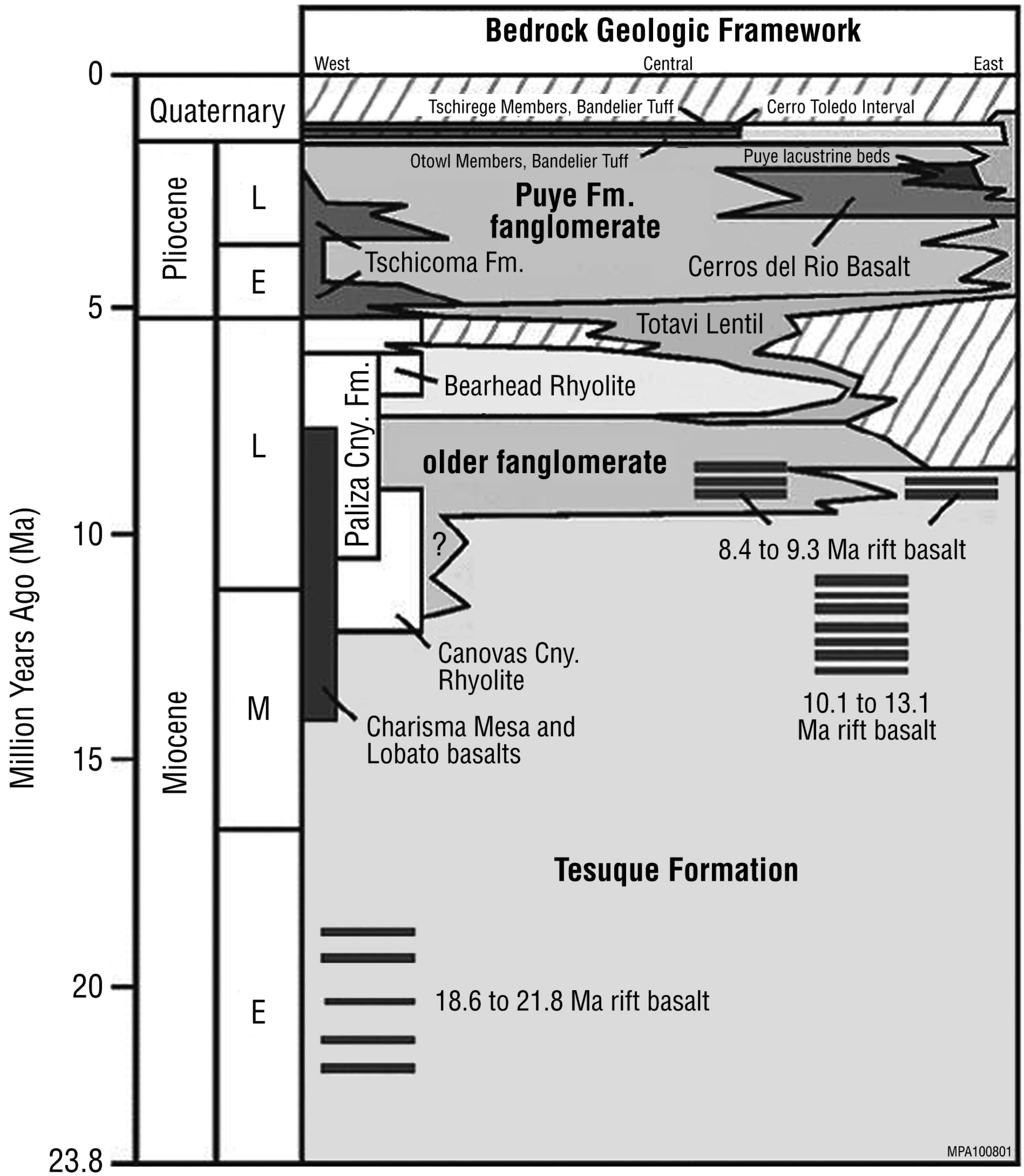


FIGURE 8.1.2-3 Stratigraphic Column for the Pajarito Plateau at LANL (Source: Modified from DOE 2008c)

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

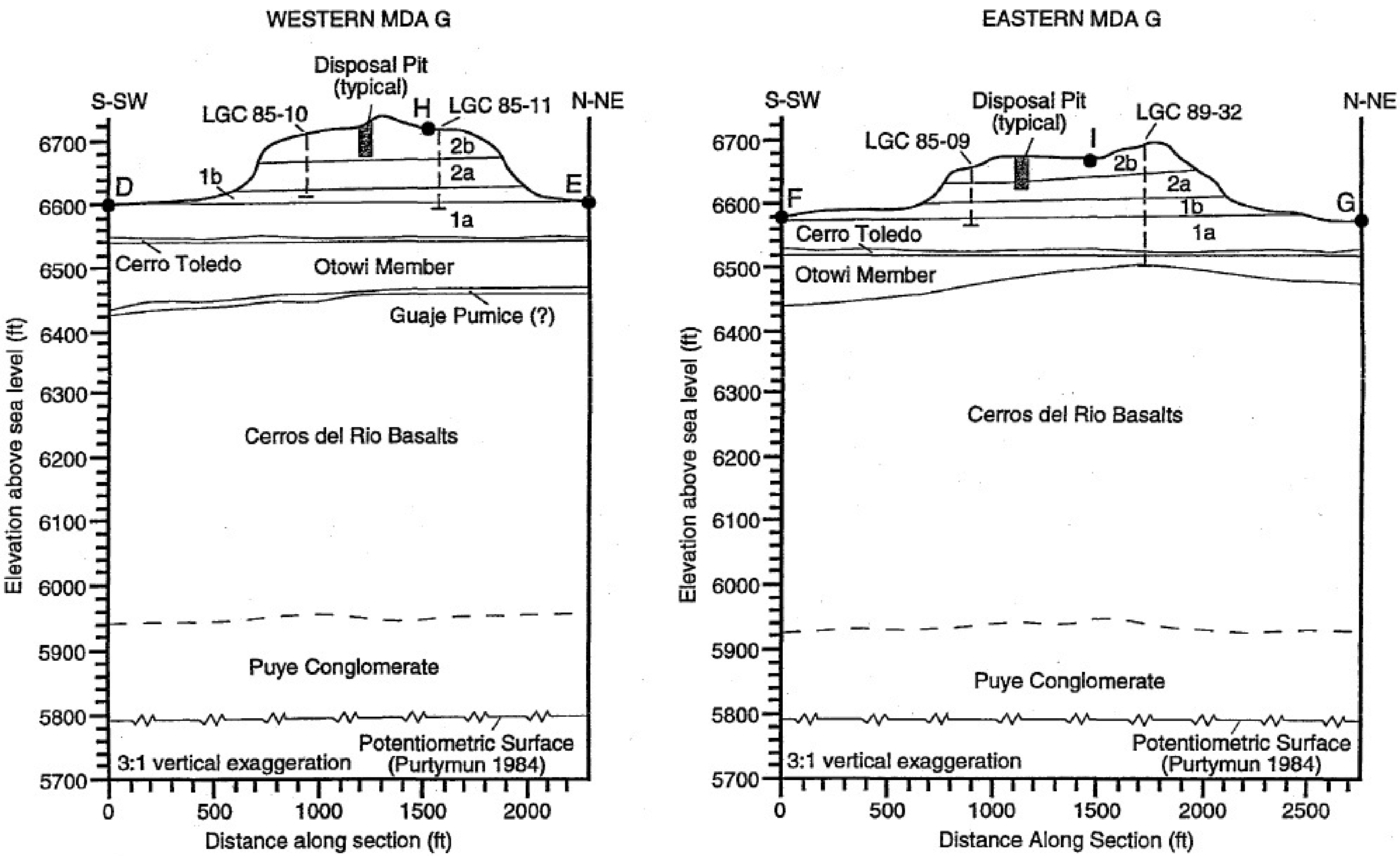


FIGURE 8.1.2-4 Stratigraphy of the Bandelier Tuff at Material Disposal Area G, to the Southeast of the GTCC Reference Location (Source: Krier et al. 1997)

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

[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).

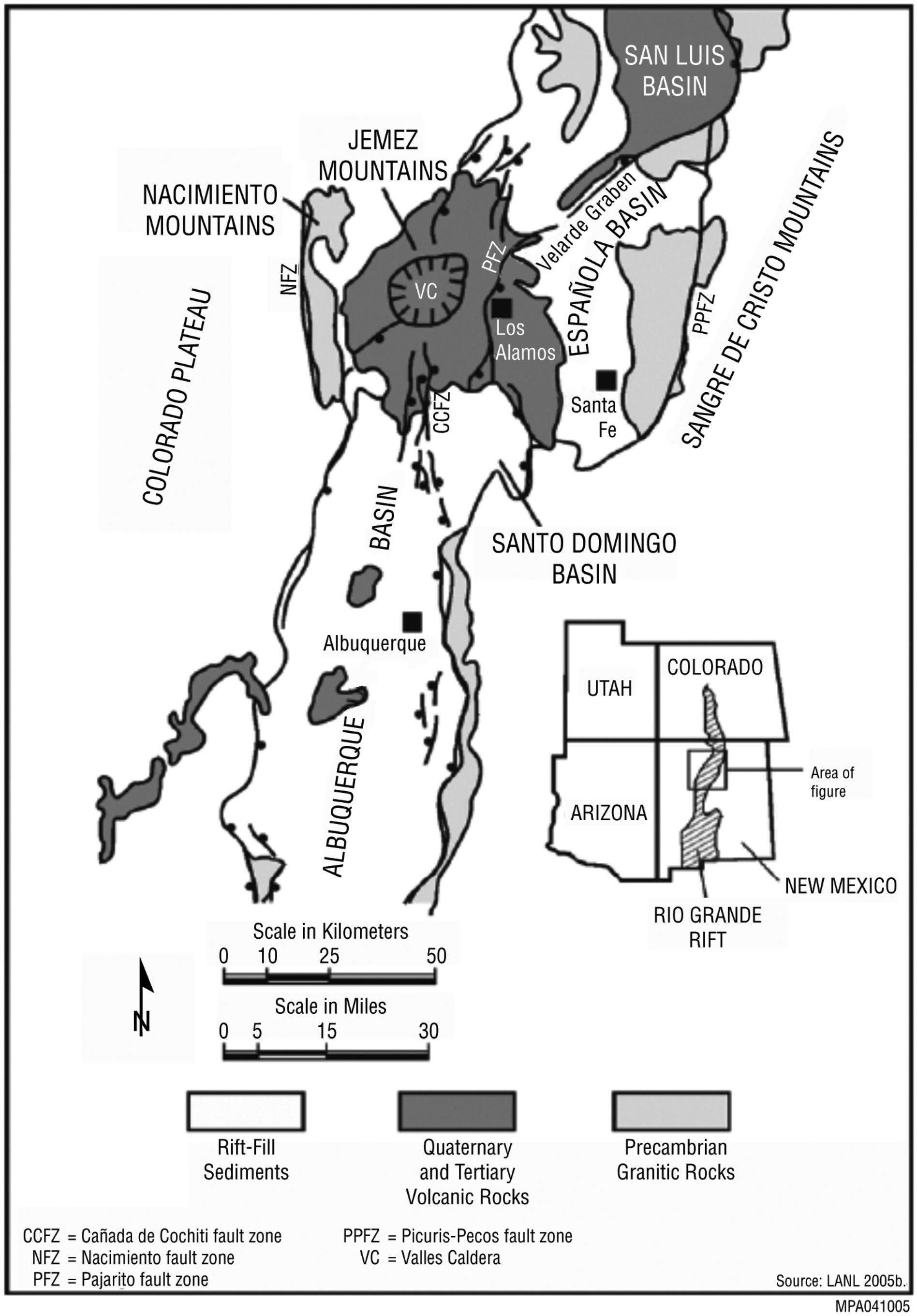
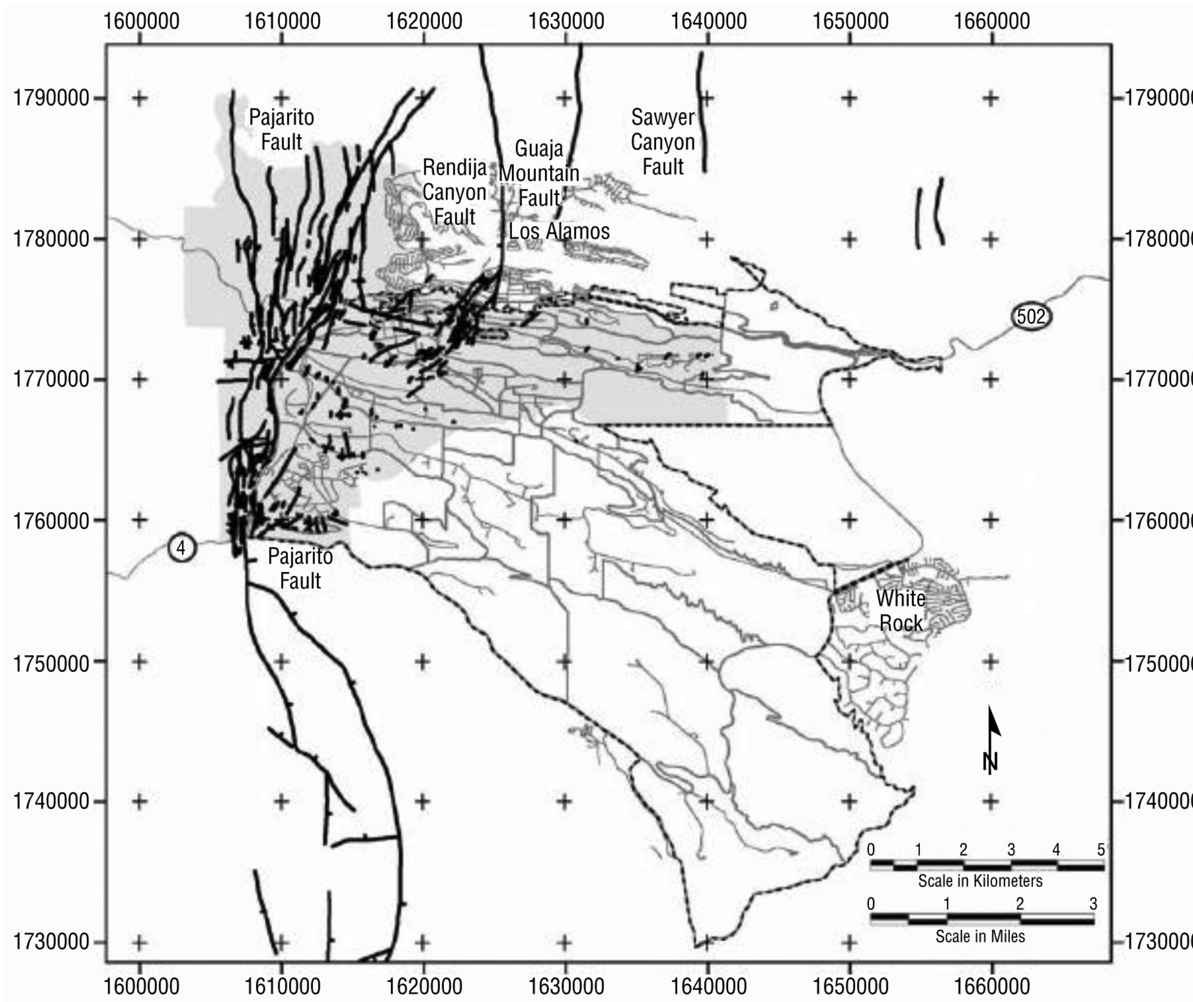


FIGURE 8.1.2-5 Structural Elements of the Rio Grande Rift Zone (Source: DOE 2008c)



Source: LANL 2004e. MPA041006

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.

[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.

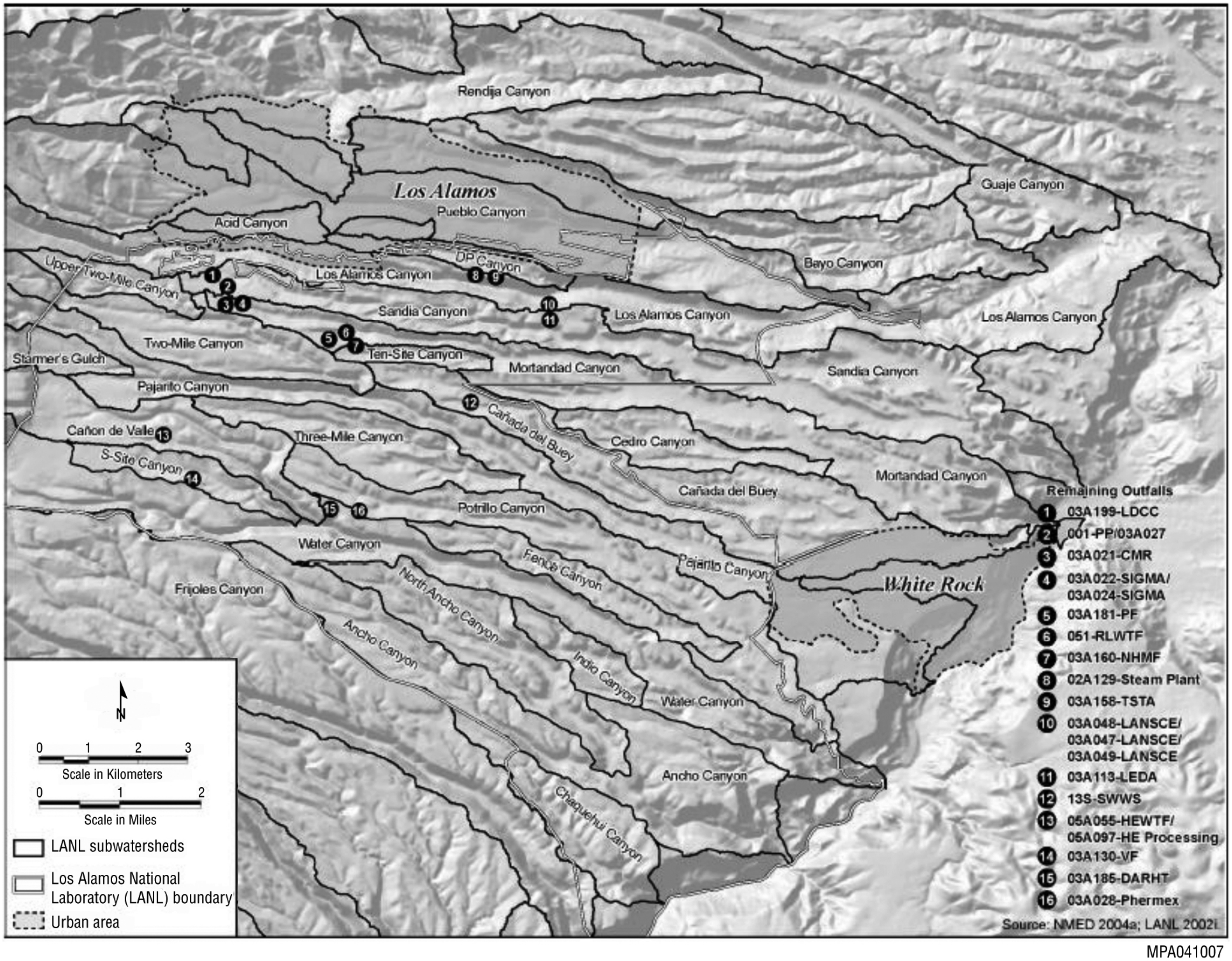


FIGURE 8.1.3-1 Watersheds in the LANL Region (Source: DOE 2008c)

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).

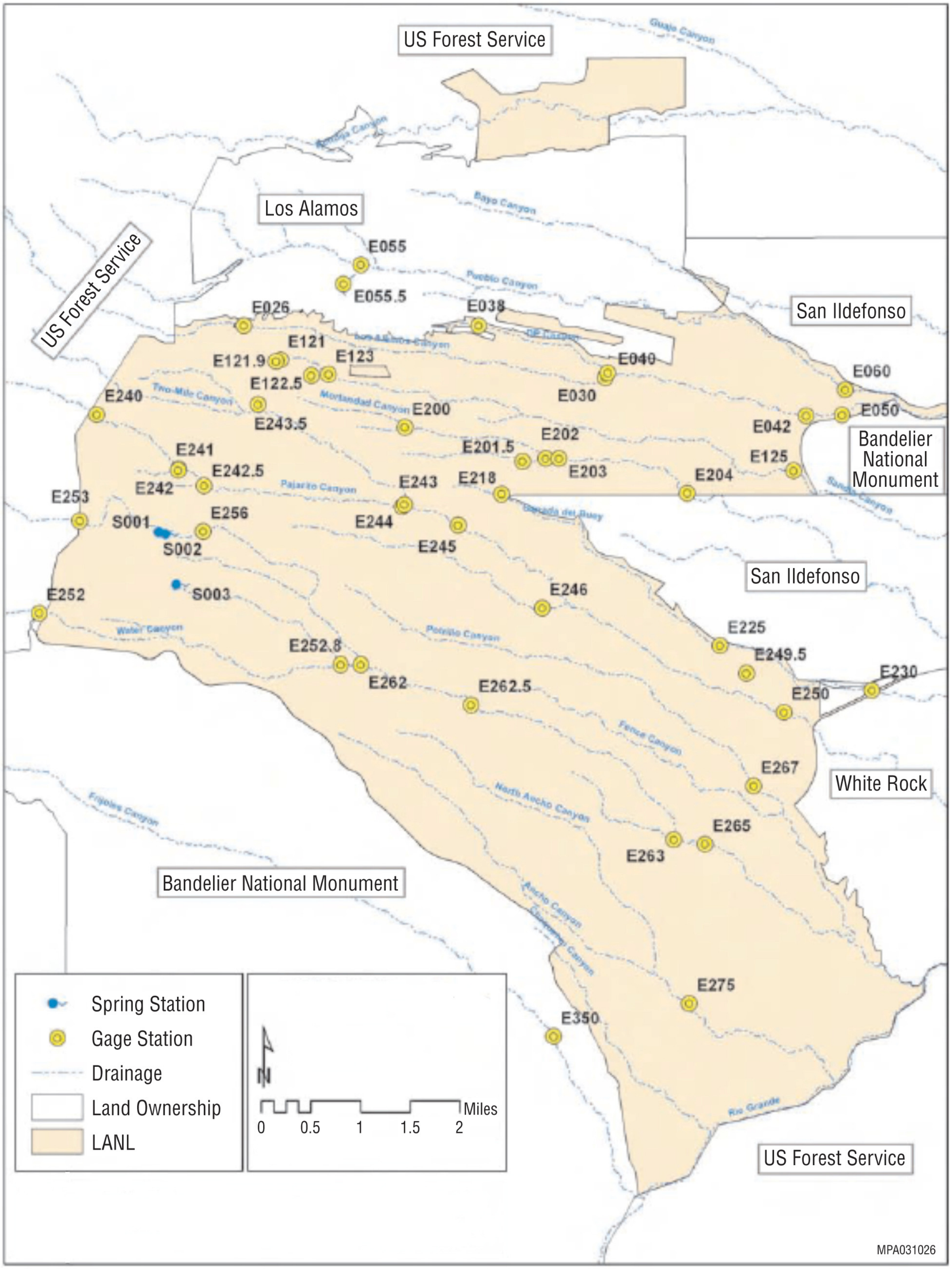


FIGURE 8.1.3-2 LANL Stream Gauging Stations (Source: Romero et al. 2007)

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).

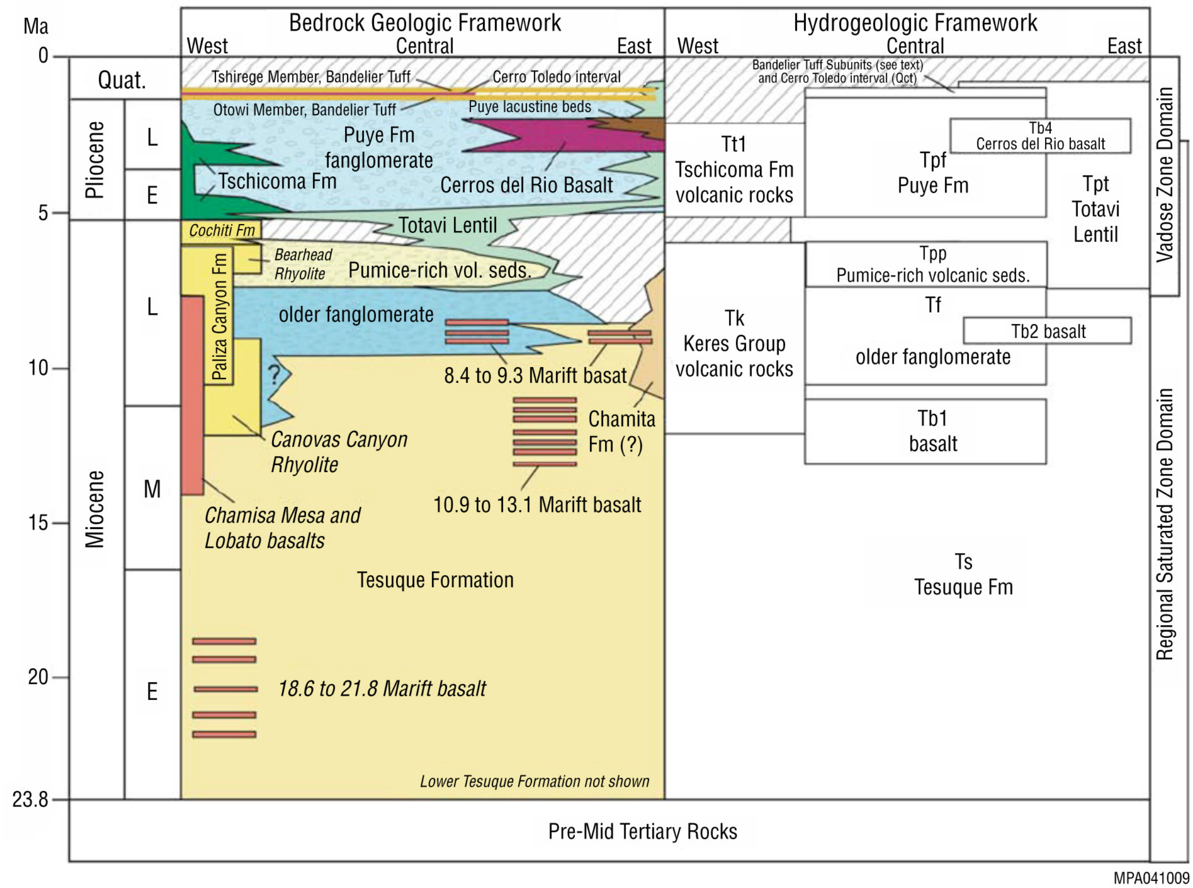


FIGURE 8.1.3-3 Hydrogeologic Units at LANL (Source: Birdsell et al. 2005b)

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)

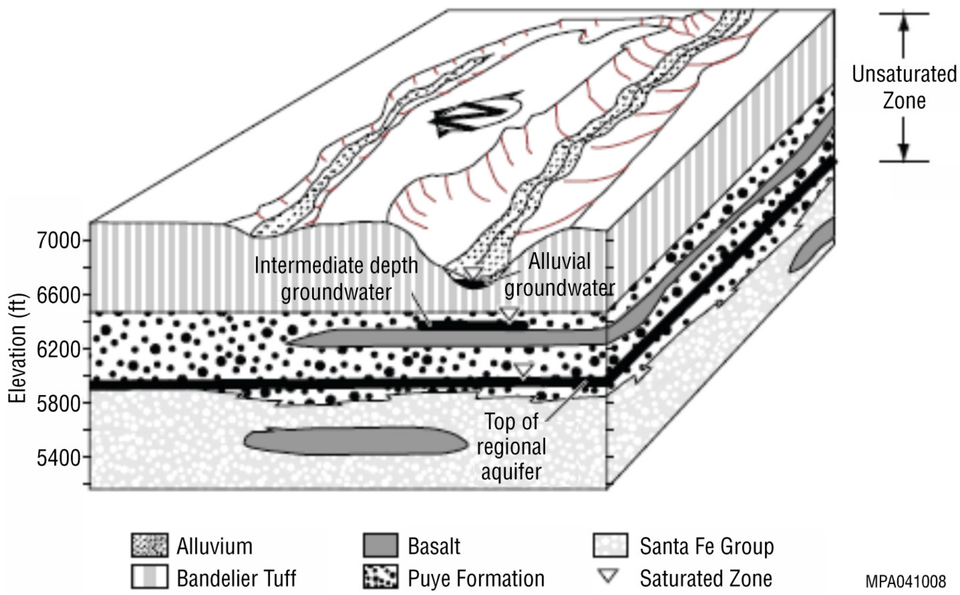


FIGURE 8.1.3-4 Three Modes of Groundwater Occurrence at LANL (Source: DOE 2008c)

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

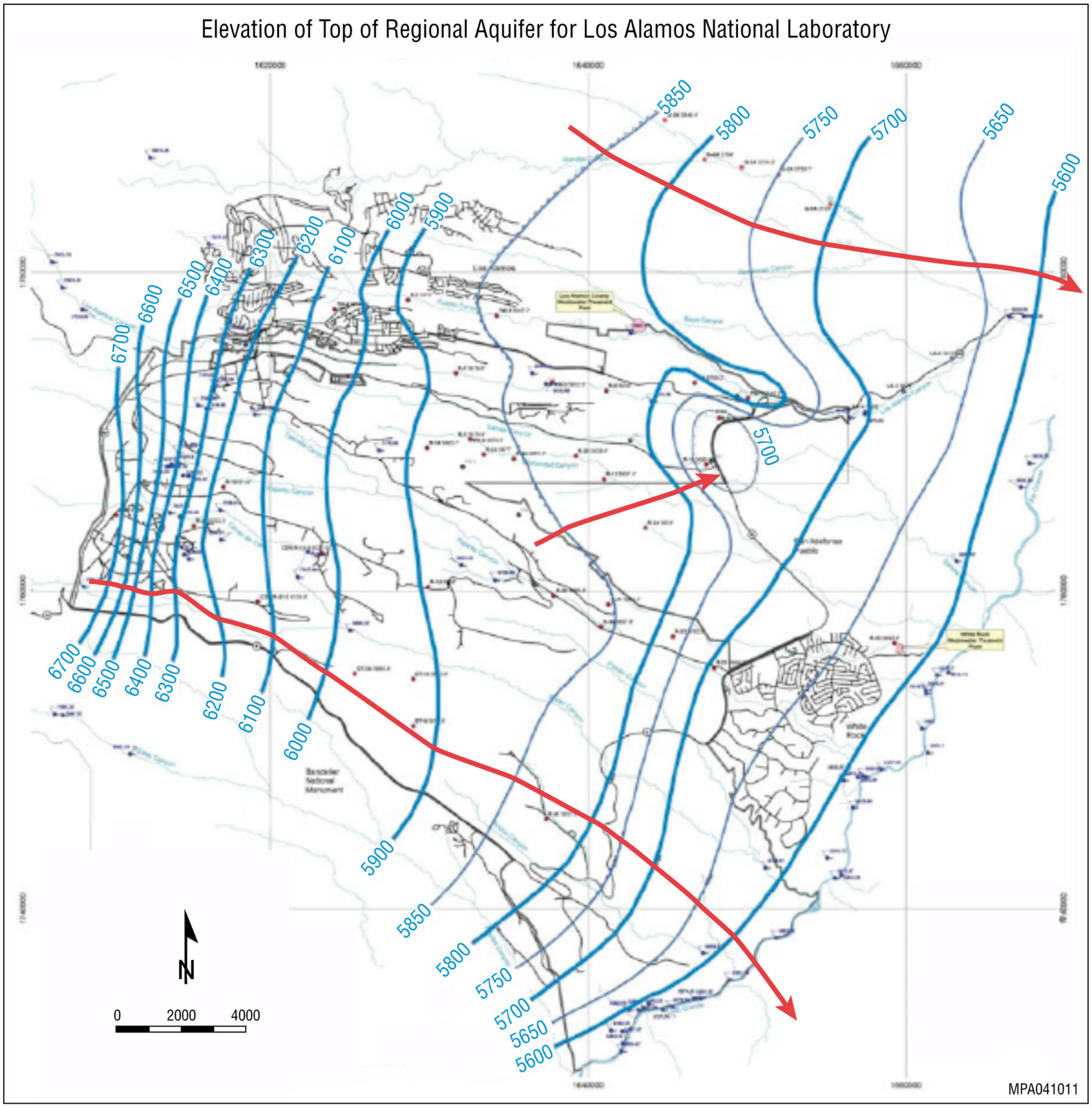


FIGURE 8.1.3-5 Water Table Elevation of LANL Regional Aquifer (Source: Birdsell et al. 2005b)

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.)

[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.)

[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	
Type of Service	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
Fire protection[b]	136	7.2	0	0.0	163	1.1
General	583	30.6	267	6.5	2,519	17.7
	ROI		**New Mexico**			
Type of Service	No.	Level of Service[a]	No.	Level of Service[a]		
Police protection	166	0.3	3,882	2.0		
Fire protection[b]	299	2.1	2,121	1.1		
General	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)

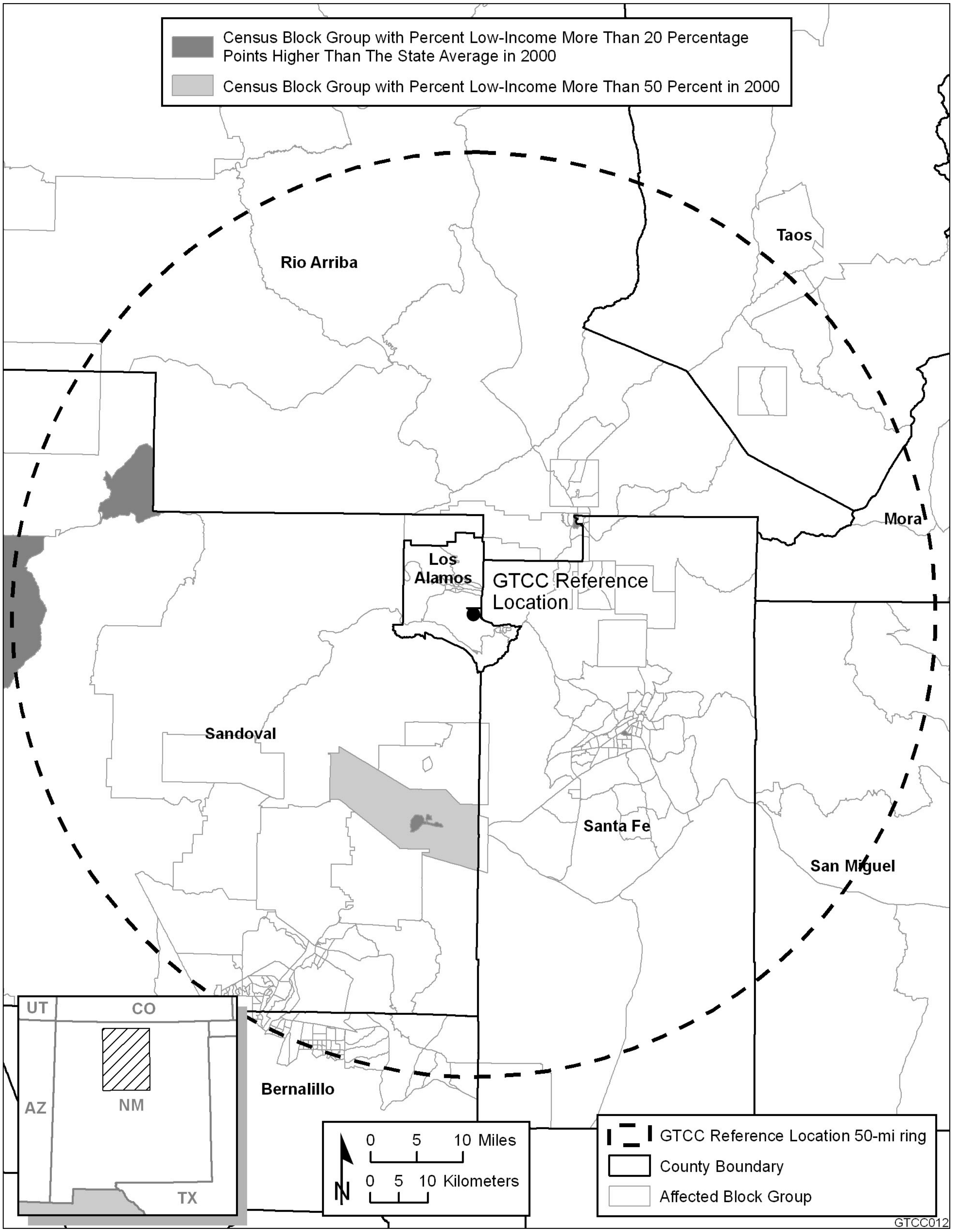

FIGURE 8.1.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at LANL (Source: U.S. Bureau of the Census 2008b)

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.

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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				Peak Annual LCF Risk from Entire Inventory
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	
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.

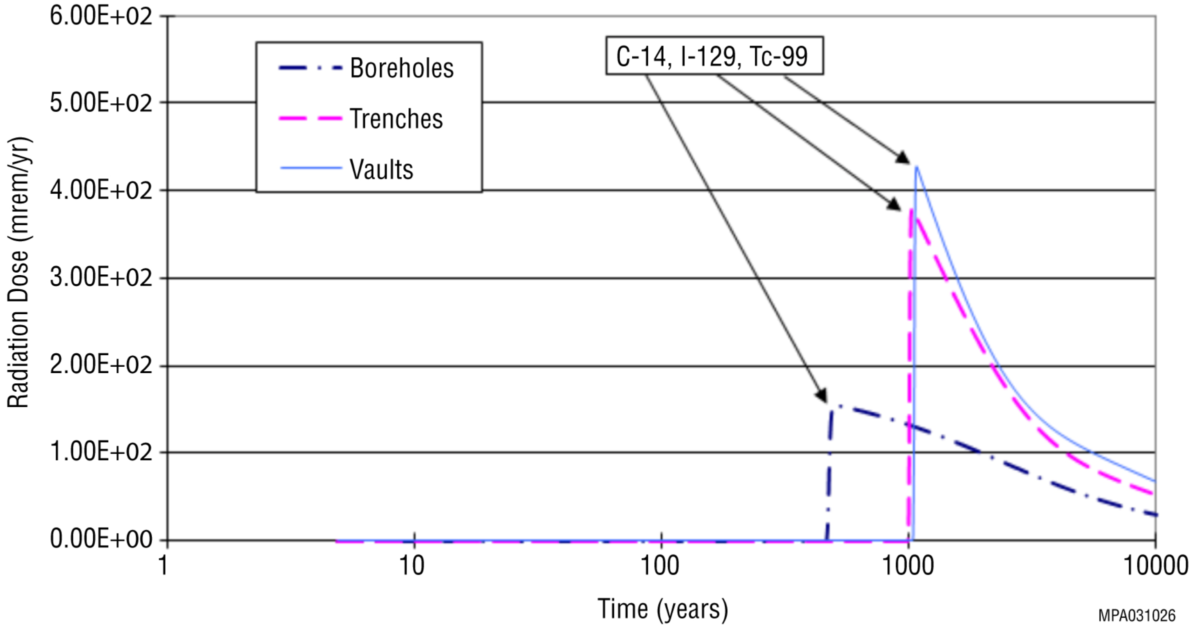

FIGURE 8.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal for the Three Land Disposal Methods at LANL

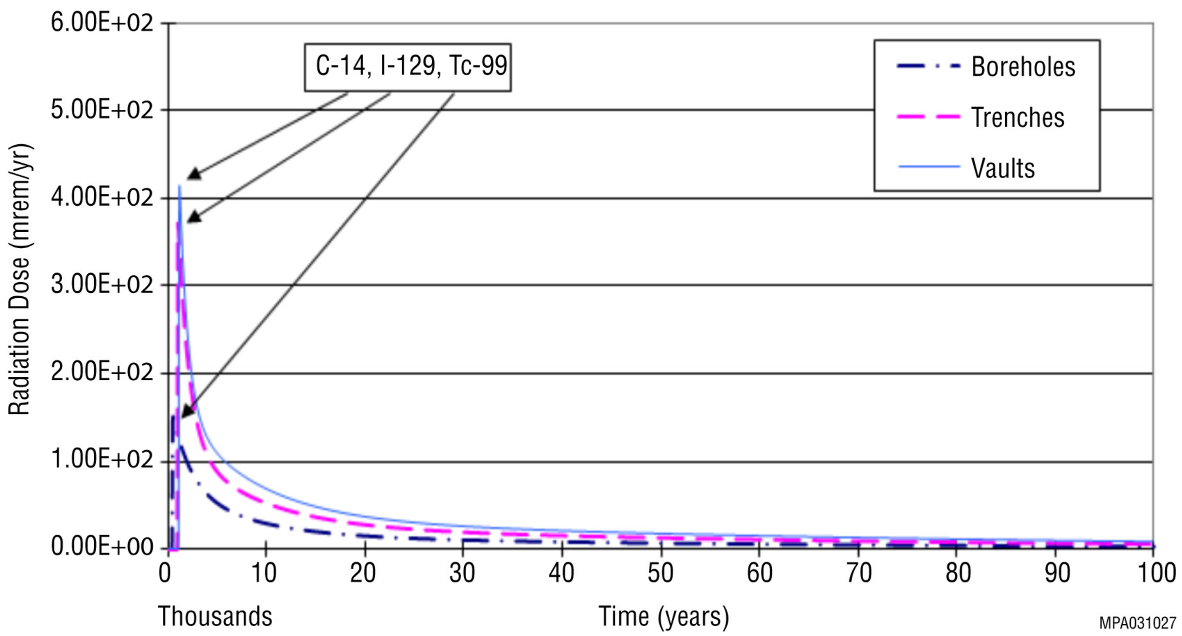

FIGURE 8.2.4-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Three Land Disposal Methods at LANL

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]		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 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.)

Waste	No. of Shipments	Total Distance (km)	Cargo-Related[b] Radiological Impacts: Dose Risk (person-rem): Routine Crew	Routine Public: Off-Link	Routine Public: On-Link	Routine Public: Stops	Routine Public: Total	Accident[e]	Latent Cancer Fatalities[d]: Crew	Latent Cancer Fatalities[d]: Public	Vehicle-Related Impacts[c]: Physical Accident Fatalities
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).

[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 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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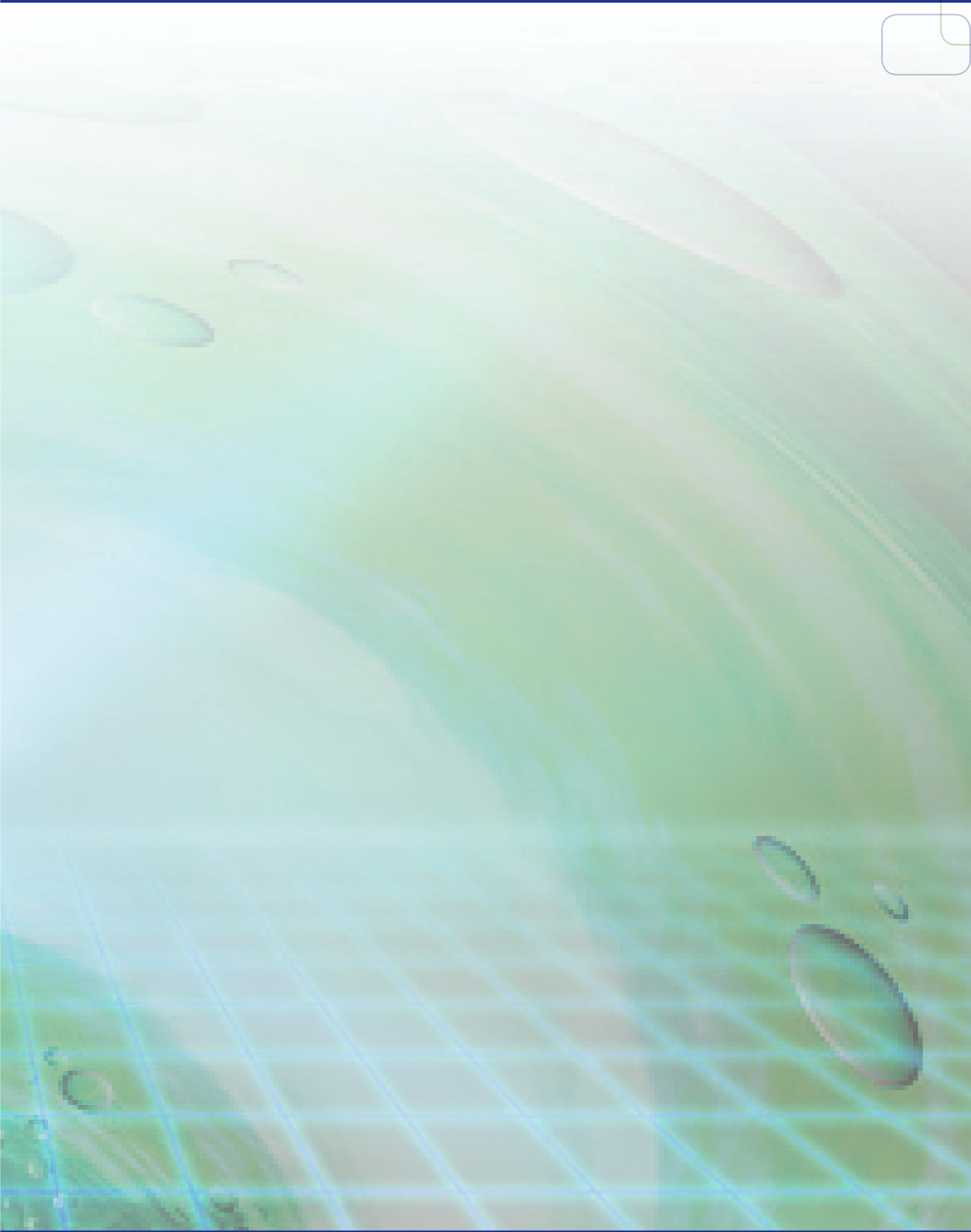

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