CHAPTER 3
AFFECTED ENVIRONMENT

In Chapter 3, the affected environment descriptions of the Hanford Site and Idaho National Laboratory are presented to provide the context for understanding the environmental consequences described in Chapter 4. As such, they serve as a baseline from which any environmental changes that may be brought about by implementing the proposed actions and alternatives can be identified and evaluated; the baseline conditions are the existing conditions. The affected environment is described for the following impact areas: land resources, infrastructure, noise and vibration, air quality, geology and soils, water resources, ecological resources, cultural and paleontological resources, socioeconomics, existing human health risk, environmental justice, waste management, and spent nuclear fuel.

3.1 APPROACH TO DEFINING THE AFFECTED ENVIRONMENT

This chapter describes the environment at both the Hanford Site (Hanford) and Idaho National Laboratory (INL) that could be affected through actions evaluated in this *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)*. For each resource area, this environmental impact statement (EIS) describes first the existing environment of each site as a whole and then that of each site's areas within which the proposed actions would take place.

The U.S. Department of Energy (DOE) evaluated the environmental impacts of the proposed actions within defined regions of influence (ROIs). These ROIs are specific to the resource area evaluated; encompass geographic areas within which any meaningful impact is expected to occur; and can include the areas within which the proposed actions would take place, the sites as a whole, or nearby or distant offsite areas. For example, impacts on historic resources were evaluated at specific facility locations within each site, whereas human health risks to the general public from exposure to airborne radioactive contaminant emissions were assessed for an area within an 80-kilometer (50-mile) radius of the facility locations. Economic effects such as job and income changes were evaluated within a socioeconomic ROI that includes the counties in which each site is located and nearby counties in which a substantial portion of the site's workforce resides. Brief descriptions of the ROIs for each resource area are given in Table 3–1.

Baseline conditions for each environmental resource area were determined from information provided in previous EISs and environmental studies, other government reports and databases, and relevant laws and regulations. The *Hanford Site National Environmental Policy Act (NEPA) Characterization (Hanford NEPA Characterization Report)* (Duncan 2007); *Hanford Site Environmental Report for Calendar Year 2010 (Including Some Early 2011 Information) (Hanford Site Environmental Report)* (Poston, Duncan, and Dirkes 2011); *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* (DOE 2002a); and *Idaho National Laboratory Site Environmental Report, Calendar Year 2008* (DOE 2009a) were important sources of information on the affected environment at Hanford and INL.

3.2 HANFORD SITE

American Indians used the area along the Columbia River in eastern Washington, including the area occupied by Hanford, for thousands of years for fishing, hunting, and gathering. Following the expedition of Lewis and Clark, which reached the Hanford area in 1805, use of the land began to change as fur traders and settlers populated the area. By the beginning of the twentieth century, much of the area was used for farming and grazing (DOE 1999a:4-1, 4-3). The Hanford Engineer Works was established in 1943 as one of the three original Manhattan Project sites. Hanford occupies approximately 151,775 hectares (375,040 acres) in Washington State, just north of Richland (Duncan 2007:4.1).

Table 3–1. General Regions of Influence for the Affected Environment

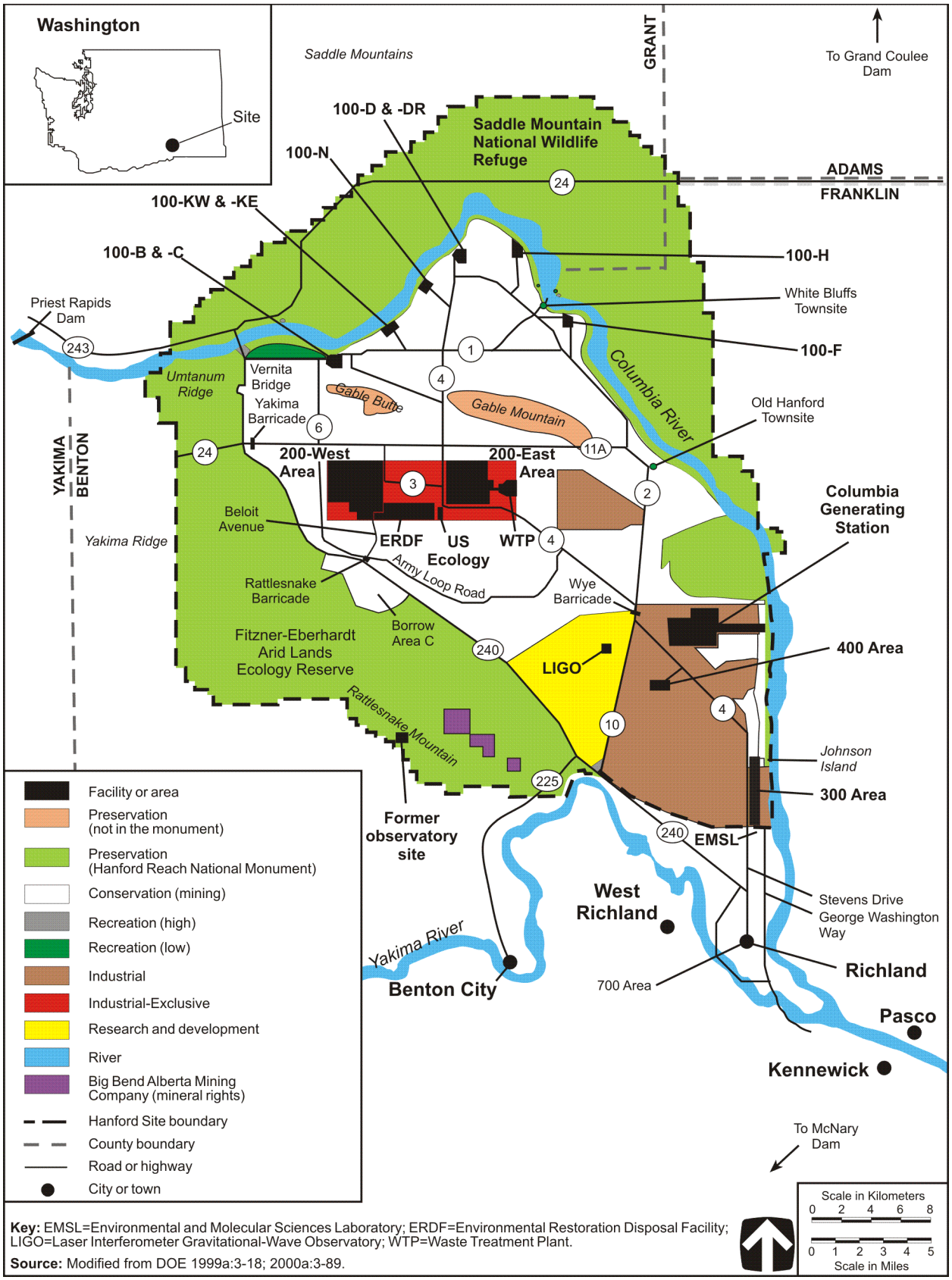
Environmental Resource Area	Region of Influence
Land resources	The proposed-action areas,[a] the site, and areas immediately adjacent to the site
Infrastructure	The proposed-action areas, the site, and local areas supporting the site
Noise and vibration	The proposed-action areas, the site, nearby offsite areas, and access routes to the site
Air quality	The proposed-action areas, the site, and nearby offsite areas within local air quality control regions
Geology and soils	The proposed-action areas, the site, and nearby offsite areas
Water resources	The proposed-action areas, the site, and adjacent surface-water bodies and groundwater
Ecological resources	The proposed-action areas, the site, and nearby offsite areas
Cultural and paleontological resources	The proposed-action areas and the site
Socioeconomics	The counties where at least 90 percent of site employees reside
Existing human health risk	The proposed-action areas, the site, offsite areas within 80 kilometers of the site, and the transportation corridors
Environmental justice	Offsite areas within 80 kilometers of the site and along the transportation corridors between the sites
Waste management	Site waste management facilities

[a] Proposed-action areas are the 200 Areas, 400 Area, and Borrow Area C for the Hanford Site and the Materials and Fuel Complex and Idaho Nuclear Technology and Engineering Center for Idaho National Laboratory.

Note: To convert kilometers to miles, multiply by 0.6214.

The site extends over parts of Adams, Benton, Franklin, and Grant Counties (see Figure 3–1). In the past, Hanford was a U.S. Government defense materials production site that included nuclear reactor operation; uranium and plutonium processing; the storage and processing of spent nuclear fuel (SNF); and the management of radioactive, hazardous, and dangerous wastes. The current mission at Hanford includes managing waste products, cleaning up the site, researching new ideas and technologies for waste disposal and cleanup, and reducing the size of the site (Poston, Duncan, and Dirkes 2011:v, E-3). Present Hanford programs are diversified and include the management of radioactive waste; cleanup of waste sites, soil, and groundwater related to past releases; stabilization and storage of SNF; research into renewable energy and waste disposal technologies; cleanup of contamination; and stabilization and storage of plutonium.

Hanford is owned and used primarily by DOE, but portions of it are owned, leased, or administered by other Government agencies. Public access to the site is limited to travel on the Route 4 and Route 10 access roads as far as the Wye Barricade, State Routes 24 and 240, and the Columbia River. By restriction of access, the public is shielded from portions of the site formerly used for the production of nuclear materials and currently used for waste storage and disposal. Only about 6 percent of the land area has been disturbed and is actively used, leaving mostly vacant land with widely scattered facilities (Neitzel 2005:4.144). Figure 3–1 shows the generalized land use at Hanford as developed in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement (Hanford Comprehensive Land-Use Plan EIS)* (DOE 1999a) and modified by the designation of the Hanford Reach National Monument (65 FR 37253).



Key: EMSL=Environmental and Molecular Sciences Laboratory; ERDF=Environmental Restoration Disposal Facility; LIGO=Laser Interferometer Gravitational-Wave Observatory; WTP=Waste Treatment Plant.

Source: Modified from DOE 1999a:3-18; 2000a:3-89.

Figure 3–1. Generalized Land Use at the Hanford Site and Vicinity

Hanford includes extensive production, service, and research and development (R&D) areas. Onsite programmatic and general purpose facilities, many of which are inactive, occupy approximately 800,000 square meters (8.6 million square feet) of space. Fifty-one percent (409,000 square meters [4.4 million square feet]) is general purpose space, accommodating offices, laboratories, shops, warehouses, and other support facilities. The remaining 392,000 square meters (4.2 million square feet) of space are committed to programmatic facilities, including processing; evaporation; filtration; and waste recovery, treatment, and storage facilities, as well as R&D laboratories. While more than half of the general purpose and programmatic facilities are more than 30 years old, several new facilities, including the Waste Treatment Plant (WTP) and the privately owned Laser Interferometer Gravitational-Wave Observatory (LIGO), are being or have been constructed. Facilities designed to perform previous missions are being evaluated for reuse in the cleanup mission. The existing facilities are grouped into the numbered operational areas discussed in the following paragraphs (DOE 1996a:3-20, 3-21; Duncan 2007:4.1, 4.3).

The 100 Areas, which cover about 1,100 hectares (2,720 acres), are in the northern part of the site on the southern shore of the Columbia River. Within these areas are eight retired plutonium production reactors and the dual-purpose N Reactor, all of which have been permanently shut down since 1991. Waste sites throughout the 100 Areas are currently undergoing remediation, consisting of the excavation of contaminated soils and structural materials. Additionally, SNF currently stored in indoor basins in the 100 Areas is being moved to the 200 Areas. Contaminated groundwater in the 100 Areas is being treated via both ex situ and in situ methods.

The 200 Areas, which include the 200-East and 200-West Areas, are in the center of Hanford. Together, they cover about 5,100 hectares (12,602 acres) and are, respectively, about 11 and 8 kilometers (6.8 and 5 miles) south and 12 and 20 kilometers (7.5 and 12.4 miles) west of the Columbia River. Historically, these areas were devoted to nuclear fuel processing; plutonium processing, fabrication, and storage; and waste management and disposal. The WTP is currently under construction within the 200-East Area. This plant includes a number of facilities that will pretreat and separate waste recovered from the 200 Area tank farms into high-level radioactive waste (HLW) and low-activity waste (LAW) streams, vitrify the HLW stream, and vitrify or similarly immobilize the LAW stream. In addition to 18 underground tank farms, the 200 Areas contain a number of low-level radioactive waste burial grounds (LLBGs). DOE constructed the Environmental Restoration Disposal Facility (ERDF) in the southeast portion of the 200-West Area for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup waste. A commercial low-level radioactive waste (LLW) disposal site (the US Ecology Commercial LLW Disposal Site) occupies 40 hectares (100 acres) just southwest of the 200-East Area. The land is leased by the State of Washington from the Federal Government and subleased to US Ecology, Inc. Facilities to be constructed under the Tank Closure alternatives analyzed in this *TC & WM EIS* are proposed to be located in the 200 Areas.

The 300 Area is in the southern part of the site, just north of the city of Richland, and covers 150 hectares (370 acres). From the early 1940s, most R&D activities were conducted in the 300 Area. It was also the location of nuclear fuel fabrication. A few of the facilities continue to support nuclear and nonnuclear R&D activities for the Pacific Northwest National Laboratory. Many of the facilities in the 300 Area are being deactivated. Waste sites in the 300 Area are currently undergoing remediation, consisting of the excavation of contaminated soils and structural materials. The 300 Area is undergoing accelerated remediation of waste sites and inactive buildings to support future non-DOE uses.

The 400 Area, located 8 kilometers (5 miles) northwest of the 300 Area, is the site of the Fast Flux Test Facility (FFTF) and the Fuels and Materials Examination Facility (FMEF). The latter facility, located to the west of FFTF, was constructed in the late 1970s and early 1980s to perform fuel fabrication and development and postirradiation examination of breeder reactor fuels. FMEF never operated and is currently in a layup condition suitable for a future mission. Designed and built as a liquid-metal

(sodium)-cooled reactor, FFTF was intended as the Nation's lead reactor for development and testing of materials and equipment for DOE's liquid-metal fast-breeder reactor programs. It operated for about 10 years (1982 to 1992) as a national research test facility, during which time it also produced a wide variety of medical isotopes and made hydrogen-3 (tritium) for the U.S. fusion research program. FFTF was ordered shut down in 1995, but the shutdown process was deferred in 1997 on receipt of DOE direction for the facility to come to a standby condition. Later, in the "Record of Decision for the *Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility*" (66 FR 7877), DOE announced that FFTF would be permanently deactivated. Completion of final decontamination and decommissioning of the facility is addressed in this *TC & WM EIS*.

The 600 Area is the designation for Hanford lands that are not part of any other designation. Thus, it includes all of Hanford not occupied by the 100, 200, 300, and 400 Areas (Duncan 2007:4.133).

Other areas at Hanford include the land occupied by the facilities of Energy Northwest (formerly known as the Washington Public Power Supply System) and an area currently leased by Washington State and used for disposal of hazardous substances. Energy Northwest operates the Columbia Generating Station on land leased from DOE that is located approximately 4 kilometers (2.5 miles) northeast of the 400 Area. The original lease called for the operation of three nuclear power plants; however, construction of two of the plants has been stopped and other industrial options are now being considered. Other facilities include the Volpentest Hazardous Materials Management and Emergency Response Training and Education Center, which is used to train hazardous materials response personnel. It is located in the southeastern portion of the site and covers about 32 hectares (80 acres). The Hanford Patrol Training Academy, a regional law enforcement training facility, provides classrooms, library resources, practice shoot houses, an exercise gym, and an obstacle course. LIGO, a national research facility built by the National Science Foundation for scientific research, is designed to detect cosmic gravitational waves. The facility consists of two optical tube arms, each 4 kilometers (2.5 miles) long and arrayed in an "L" shape, and is extremely sensitive to vibrations (DOE 1999a:4-8, 4-9). The 700 Area is the administrative center in downtown Richland and consists of Government-owned buildings (e.g., the Federal Building) (DOE 2000a:4-90).

In addition, there are DOE-leased facilities and DOE-contractor-owned or -leased facilities that support Hanford operations. These facilities are on private or Port of Benton land south of the 300 Area (DOE 1996a:3-21).

DOE has transferred the Richland North Area—formerly the 1100 Area, an area that served as a procurement, central warehousing, vehicle maintenance, transportation, and distribution center for Hanford—and the smaller 3000 Area to the Port of Benton for use in economic development and diversification (DOE 2000a:3-91).

3.2.1 Land Resources

Land resource areas include land use and visual resources. Land use is defined in terms of the kinds of anthropogenic activities (e.g., agriculture, residential, industrial) for which land is developed (EPA 2006). Natural resource and other environmental characteristic attributes make a site more suitable for some land uses than for others. Changes in land use may have beneficial or adverse effects on other resources—ecological, cultural, geologic, and atmospheric. Visual resources are natural and manmade features that give a particular landscape its character and aesthetic quality. Landscape character is determined by the visual elements of form, line, color, and texture. All four elements are present in every landscape.

3.2.1.1 Land Use

3.2.1.1.1 General Site Description

The Tri-Cities area southeast of Hanford includes residential, commercial, and industrial land uses. This area, which encompasses the cities of Richland, Kennewick, and Pasco, is the population center closest to Hanford. Additional cities near the southern boundary of Hanford include Benton City, Prosser, and West Richland. Agriculture is a major land use in the remaining areas surrounding Hanford. In 2007, wheat was the largest crop in terms of area planted in Adams, Benton, Franklin, and Grant Counties. Alfalfa, potatoes, corn, vegetables, and fruit are some of the other crops grown in these counties (USDA 2009).

In 1977, DOE designated Hanford as a National Environmental Research Park, an outdoor laboratory for ecological research to study the environmental effects of energy development. The Hanford National Environmental Research Park is a shrub-steppe habitat that contains a wide range of semiarid land ecosystems and offers the opportunity to examine linkages between terrestrial, subsurface, and aquatic environments (DOE 2000a:3-91; Vaughan and Rickard 1977:1, 2). An integral part of the Hanford Reach National Monument is the Fitzner-Eberhardt Arid Lands Ecology Reserve, which includes 31,080 hectares (76,800 acres) of primarily shrub-steppe vegetation to the west of State Route 240 (see Figure 3–1). This area was originally set aside in 1967 for ecological research and educational purposes (O'Connor and Rickard 2003:vi, 1).

Hanford Site Land Use Designations

Preservation – An area managed for the preservation of archaeological, cultural, ecological, and natural resources. No new consumptive uses are allowed within this area. Public access is limited.

Conservation (Mining) – An area reserved for the management and protection of archaeological, cultural, ecological, and natural resources, but where limited and managed mining (e.g., quarrying for governmental purposes) could occur as a permitted special use. Public access is limited.

Recreation (High) – An area allocated for high-intensity, visitor-serving activities and facilities (commercial and governmental), such as golf courses, recreational-vehicle parks, boat-launching facilities, tribal fishing facilities, destination resorts, cultural centers, and museums.

Recreation (Low) – An area allocated for low-intensity, visitor-serving activities and facilities, such as improved recreational trails, primitive boat-launching facilities, and permitted campgrounds.

Industrial – An area suitable and desirable for activities such as reactor operations, rail and barge transport, mining, manufacturing, food processing, assembly, warehouse, and distribution operations.

Industrial-Exclusive – An area suitable and desirable for treatment, storage, and disposal of hazardous, dangerous, radioactive, and nonradioactive wastes.

Research and Development – An area designated for conducting (1) basic or applied research that requires the use of a large-scale or isolated facility, or (2) smaller- scale, time-limited research conducted in the field or within facilities that consume limited resources.

Source: DOE 1999a:3, 4.

Land use designations based on the Hanford Comprehensive Land-Use Plan include Preservation, Conservation (Mining), Recreation, Industrial, Industrial-Exclusive, and Research and Development (see Figure 3–1). Approximately 6 percent of the site has been disturbed and is occupied by DOE facilities (Neitzel 2005:4.144). Hanford contains a variety of widely dispersed facilities, including retired reactors, R&D facilities, and various deactivated production and processing plants. Preservation and Conservation (Mining) are the predominant land uses at Hanford. Borrow Area C (also known as quarry No. 2) located south of State Route 240, falls within the Conservation (Mining) land use designation. The 200 Areas are classified as Industrial-Exclusive. Industrial areas include an area to the east of the 200 Areas and most of the southeast corner of the site, including the 400 Area.

Important areas within the Preservation land use designation include the Hanford Reach National Monument, which incorporates a portion of the Columbia River corridor, as well as the Fitzner-Eberhardt Arid Lands Ecology Reserve to the south and west and portions of Hanford north of the Columbia River (65 FR 37253). Other special status lands in the vicinity of Hanford include the McNary National Wildlife Refuge, which is administered by the U.S. Fish and Wildlife Service (USFWS), as well as the

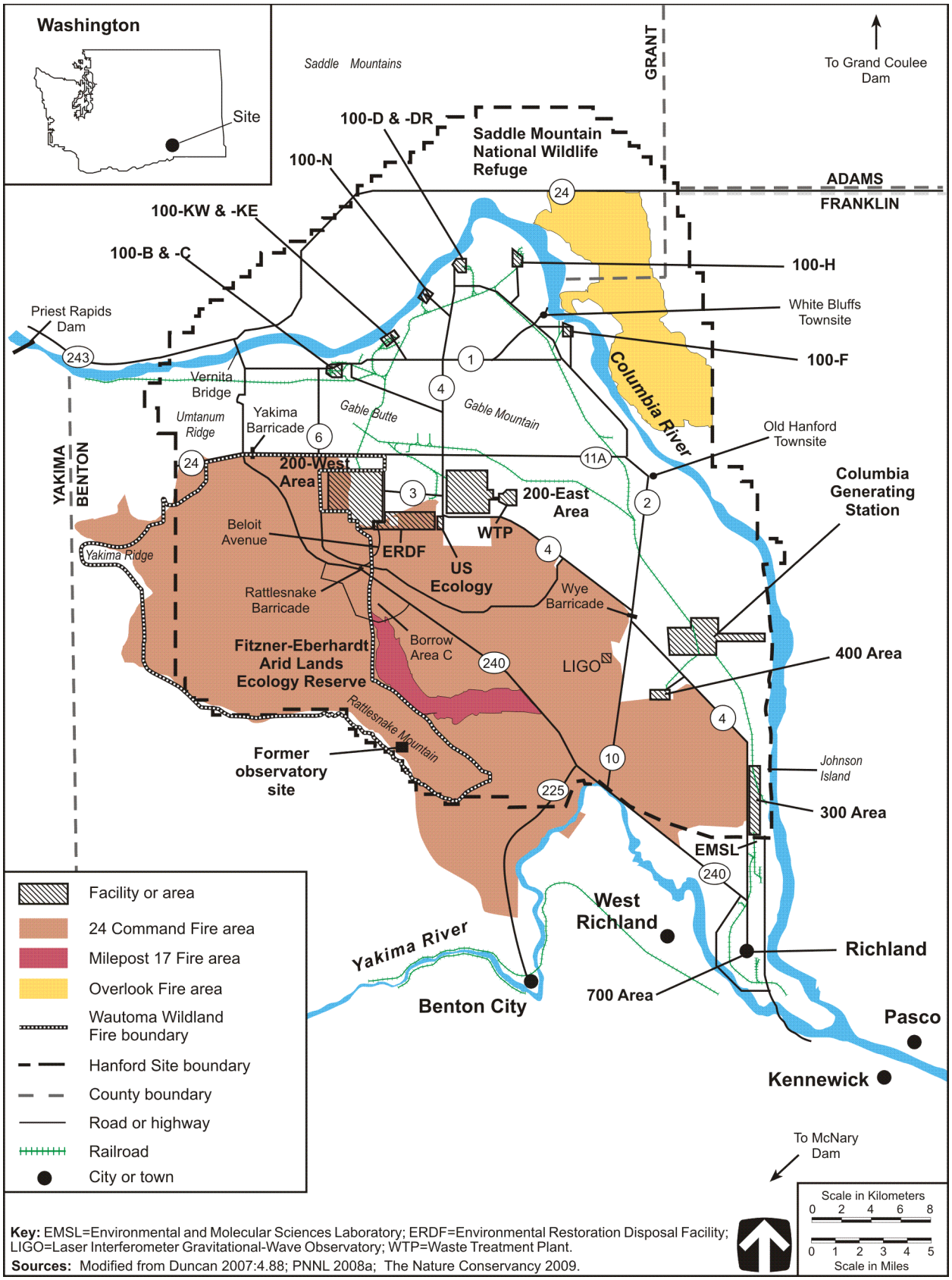
Columbia River Islands Area of Critical Environmental Concern and McCoy Canyon, both of which are administered by the U.S. Bureau of Land Management (BLM) (DOE 2000a:3-91).

The Columbia River, which is adjacent to and runs through Hanford (see Figure 3–1), is used for numerous purposes, including public boating, waterskiing, fishing, hunting, transportation, irrigation, and municipal water supply. Public access is allowed to certain islands, while other areas are considered sensitive because they include unique habitats and cultural resources. The area known as the Hanford Reach includes the 0.4-kilometer (0.25-mile) strip of public land on either side of the last free-flowing, nontidal segment of the Columbia River in the United States. On June 9, 2000, under the authority of the Antiquities Act of 1906 (16 U.S.C. 431 et seq.), the President issued a proclamation that established the Hanford Reach National Monument (65 FR 37253) on approximately 78,900 hectares (195,000 acres). This proclamation recognizes the unique character and biological diversity of the area, as well as its geologic, paleontological, historic, and archaeological significance. USFWS manages the monument under existing agreements with DOE. DOE manages land within the monument that is not subject to existing agreements; however, DOE consults with the Secretary of the Interior when developing any management plans affecting these lands. In the future, when appropriate cleanup has been completed, USFWS and DOE will extend management agreements to lands in the monument not currently managed by USFWS.

On June 27, 2000, a fire known as the 24 Command Fire was started by a fatal motor vehicle accident on State Route 24 about 3.2 kilometers (2 miles) west of the State Route 240 intersection. As a result of high winds, high temperatures, and low humidity, the fire spread rapidly and eventually consumed 66,322 hectares (163,884 acres) of Federal, state, and private lands. A total of 56,246 hectares (138,986 acres) within Hanford burned, including lands within the Hanford Reach National Monument, most of the Fitzner-Eberhardt Arid Lands Ecology Reserve, and areas near former production sites (see Figure 3–2). The fire was declared controlled on July 2, 2000. Fire suppression impacts included bulldozing 66 kilometers (41 miles) of fire lines, widening dirt roads, and cutting fences (DOI 2000:iii, iv). Vegetation loss due to the firefighting activities exposed the soil to erosion by subsequent wind and rain.

More recently, several major fires burned portions of Hanford in 2007. On July 13, 2007, three lightning-caused wildfires merged and became known as the Overlook Fire; this fire covered 8,527 hectares (21,071 acres) on the east side of the Columbia River on Hanford Reach National Monument lands (see Figure 3–2). The Overlook Fire burned native shrublands and grasslands in areas on the Wahluke Slope. On August 13, 2007, the Milepost 17 Fire started along State Route 240 and burned about 1,905 hectares (4,708 acres) in a crescent-shaped area on the Fitzner-Eberhardt Arid Lands Ecology Reserve. The Wautoma Fire started on August 16, 2007, on private lands and burned across the Fitzner-Eberhardt Arid Lands Ecology Reserve onto central Hanford. These two fires burned approximately 31,161 hectares (77,000 acres) of Federal and private lands. About 26,709 hectares (66,000 acres) burned on the Fitzner-Eberhardt Arid Lands Ecology Reserve, including the northern slope of Rattlesnake Mountain, and approximately 3,116 hectares (7,700 acres) burned on the central portion of Hanford, including land adjacent to the 200-West Area (PNNL 2008a).

DOE developed the *Hanford Comprehensive Land-Use Plan EIS* to provide the framework for future use of the site's lands and resources (DOE 1999a). Preparation of the plan was consistent with the National Defense Authorization Act (P.L. 104-201), which required the development of a future-use plan for at least the next 50 years. Preparation of the plan involved a number of cooperating agencies and consulting tribal governments, including BLM; the U.S. Bureau of Reclamation; USFWS; the City of Richland; Benton, Franklin, and Grant Counties; the Nez Perce Tribe; and the Confederated Tribes of the Umatilla Indian Reservation. The *Hanford Comprehensive Land-Use Plan EIS* consists of four basic elements: a



Key: EMSL=Environmental and Molecular Sciences Laboratory; ERDF=Environmental Restoration Disposal Facility; LIGO=Laser Interferometer Gravitational-Wave Observatory; WTP=Waste Treatment Plant.

Sources: Modified from Duncan 2007:4.88; PNNL 2008a; The Nature Conservancy 2009.

Figure 3–2. Extent of Area Burned During Recent Fires at the Hanford Site

map depicting land uses for the site; description of the purpose, intent, and principal uses of each land use designation; a set of policies governing land use actions; and implementing procedures. Figure 3–1 reflects land use designations developed in the plan. DOE has issued the *Supplement Analysis, Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 2008a) to review information and update the status of activities since the original plan was issued in 1999. An amended Record of Decision (ROD) (73 FR 55824) was issued to clarify and confirm DOE's commitments to the Hanford Comprehensive Land-Use Plan process.

As noted earlier, Hanford lies within Adams, Benton, Franklin, and Grant Counties, each of which developed a comprehensive land use plan in response to Washington's Growth Management Act (RCW 36.70A). This act requires state and local governments to manage Washington's growth by identifying and protecting critical areas and natural resource lands, designating urban growth areas, preparing comprehensive plans, and implementing them through capital investments and development regulations (Washington State 2007). The counties have no jurisdiction over Federal lands.

The *Adams County Comprehensive Plan* (ACPC 2005) does not specifically mention Hanford; however, the small area of the site within the southwestern portion of the county is classified as General Agriculture. That portion of Hanford lying within Benton County is designated as the Hanford Region within the *Benton County Comprehensive Land Use Plan*; however, a subarea plan has not been completed for this area (BCPC 2009). The *Franklin County Growth Management Comprehensive Plan* (Franklin County 2008) identifies Hanford as Federal land and labels it as the Hanford Reach National Monument on its Comprehensive Land Use Plan map. That portion of Hanford lying within Grant County is known as the Wahluke Slope. Within the *Grant County Comprehensive Plan/Environmental Impact Statement*, this area is identified as Hanford Federal Reserve (GCDCD 1999; GCGIS 2002). A subarea plan has yet to be developed for this tract.

Under separate treaties signed in 1855 (see Chapter 8, Section 8.1.7), much of the land in what is now referred to as "eastern Washington, eastern Oregon, and Idaho" was ceded to the United States by a number of regional American Indian tribes. The land area includes land occupied by Hanford. Under these treaties, the tribes retained the right to fish in usual and accustomed places. Tribal fishing rights are recognized on rivers within the ceded lands, including the Columbia River, which flows through Hanford.

In addition to fishing rights, the tribes retained under the treaties the privilege to hunt, gather roots and berries, and pasture horses and cattle on open and unclaimed lands. It is the position of DOE that Hanford, like other ceded lands that were settled or used for specific purposes, is not open and unclaimed land. While reserving all rights to assert their respective positions regarding treaty rights, the tribes are participants in DOE's land use planning process, and DOE considers tribal concerns in that process.

3.2.1.1.2 200 Areas Description

The *Hanford Comprehensive Land-Use Plan EIS* and subsequent supplement analysis (DOE 1999a:3-5, 3-18, 3-53; 2008a) and RODs (64 FR 61615, 73 FR 55824) designated a 5,064-hectare (12,513-acre) area within the Central Plateau of Hanford as Industrial-Exclusive (see Figure 3–1). This area, which includes the 200-East and 200-West Areas, encompasses the location of activities proposed under the various Tank Closure alternatives evaluated in this *TC & WM EIS*. The Industrial-Exclusive designation preserves DOE control of continuing remediation activities and use of the existing compatible infrastructure required to support activities such as dangerous radioactive and mixed waste treatment, storage, and disposal (TSD). Further, under this designation, DOE continues its Federal waste disposal mission, and the Northwest Interstate Compact on Low-Level Radioactive Waste Management allows for continued use of the US Ecology Commercial LLW Disposal Site for the disposal of commercial radioactive waste (Ecology 2011). The Industrial-Exclusive designation also allows for the expansion of existing facilities or the development of new compatible facilities in support of ongoing missions. Research supporting

dangerous radioactive and mixed waste TSD facilities is also encouraged, and new uses of radioactive materials, such as food irradiation, could be developed within this land use designation.

3.2.1.1.3 400 Area Description

Under the *Hanford Comprehensive Land-Use Plan EIS* and subsequent supplement analysis (DOE 1999a:3-5, 3-18; 2008a) and RODs (64 FR 61615; 73 FR 55824), land in the 400 Area is designated for industrial use, including reactor operations, manufacturing, warehousing, and related activities. The 400 Area occupies 61 hectares (150 acres) and is 7 kilometers (4.3 miles) to the west of the nearest site boundary. The Property Protected Area, within which FFTF and associated facilities are located, is 18 hectares (44.5 acres) in size.

3.2.1.1.4 Borrow Area C Description

Prior to April 1999, McGee Ranch (in the northwest corner of Hanford north of Route 24 and south of the Columbia River) was identified as the primary suitable source of silt, loam, and basalt rock borrow material. Based on public and tribal input received by DOE during the *Hanford Comprehensive Land-Use Plan EIS* process and as recorded in its RODs (64 FR 61615; 73 FR 55824), DOE decided to protect a wildlife corridor through the McGee Ranch and consolidate the many planned borrow areas at Hanford into one location, identified as Borrow Area C (see Figure 3–1), to keep a primary source of geologic materials available for Hanford remediation activities. Borrow Area C is a large polygonal area 926.3 hectares (2,289 acres) in size bordering State Route 240 on the south. Although the area is contiguous with the Fitzner-Eberhardt Arid Lands Ecology Reserve, it is designated for Conservation (Mining) in the *Hanford Comprehensive Land-Use Plan EIS*. Such areas are typically reserved for management and protection of cultural, ecological, and natural resources; however, they may also be used in limited, managed mining activities (DOE 1999a:3-4, 3-18). Borrow Area C is largely undeveloped, consistent with its land use classification; however, a road was built in 2006 to access a portion of the site that will be used to generate borrow material for environmental remediation activities.

3.2.1.2 Visual Resources

3.2.1.2.1 General Site Description

Hanford lies in the Pasco Basin of the Columbia Plateau northwest of the city of Richland, where the Yakima and Columbia Rivers join. The land in the vicinity of Hanford ranges from generally flat to gently rolling. Rattlesnake Mountain, rising to 1,060 meters (3,480 feet) above mean sea level, forms the southwestern boundary of the site. Gable Mountain and Gable Butte are the highest landforms within the site, rising to a height of 329 meters (1,081 feet) and 238 meters (782 feet), respectively. The Columbia River flows through the northern part of the site, and, turning south, forms part of the eastern site boundary. White Bluffs, steep whitish-brown bluffs adjacent to the river, are a striking feature of the landscape (DOE 2000a:3-93).

Typical of the regional shrub-steppe desert, the site is dominated by widely spaced, low-brush grasslands. A large area of nonvegetated, stabilized sand dunes extends along the east boundary, and nonvegetated blowouts are scattered throughout the site. Hanford is characterized by mostly undeveloped land, with widely spaced clusters of industrial buildings along the southern and western banks of the Columbia River and at several interior locations (DOE 2000a:3-93).

Hanford facilities can be seen from elevated locations such as Gable Mountain, Gable Butte, Rattlesnake Mountain, and other parts of the Rattlesnake Hills along the western perimeter. Site facilities also are visible from State Routes 240 and 24 and the Columbia River. Because of terrain features, distances involved, the size of Hanford, and the size of individual structures, not all facilities are visible from the highways or the Columbia River (DOE and Ecology 1996:4-60).

DOE and its leaseholders operate and maintain buildings and equipment on Gable Mountain and Rattlesnake Mountain that also affect the view from these elevated natural features. The tallest structures, the six communication towers (height 30 meters [100 feet]) are located on Rattlesnake Mountain. Numerous other structures and related activities on these mountains (e.g., communication towers and equipment/structures, research and monitoring equipment/structures, an observatory, fire breaks, access roads) are currently visible from the surrounding area, including State Route 240. In March 2008, the DOE Richland Operations Office (DOE-RL) announced it would not renew existing permits, licenses, and easements on Rattlesnake Mountain and that structures would be removed, returning the land to natural conditions. In 2009, the Rattlesnake Mountain Observatory was removed and communications operations were consolidated. Additionally, excess facilities, infrastructure, and debris were removed (Poston, Duncan, and Dirkes 2010:1.4, 2011:1.4).

State Route 240 provides public access through the southwestern portion of Hanford. Views along this highway include the lands of the Fitzner-Eberhardt Arid Lands Ecology Reserve in the foreground to the west, with the prominent peak of Rattlesnake Mountain and the extended ridgelines of Rattlesnake Hills in the background. Views to the east feature rather flat terrain, with the structures of the 200-West Area visible in the central area and Gable Butte and Gable Mountain in the background. From the highway, the Saddle Mountains can be seen in the distance to the north, and steam plumes from the Energy Northwest reactor cooling towers are often visible in the distance to the east. The views along State Route 240 are expansive due to the flat terrain and the predominantly short, treeless vegetation cover.

The 24 Command Fire burned 66,322 hectares (163,884 acres) of Federal, state, and private lands, including 56,246 hectares (138,986 acres) within Hanford (see Figure 3–2), while firefighting activities resulted in the construction of 66 kilometers (41 miles) of bulldozed fire lines, widened dirt roads, and cut fences (DOI 2000:iii, iv). Thus, both the fire and the activities required to control it resulted in dramatic changes to the visual character of affected portions of the site. Visual resources were also affected by duststorms resulting from exposed soil. The most recent large fires to burn across Hanford were the Overlook, Milepost 17, and Wautoma Fires (PNNL 2008a). The Overlook Fire blackened 8,527 hectares (21,071 acres) on the east side of the Columbia River on Hanford Reach National Monument land. The Milepost 17 and Wautoma Fires burned 31,161 hectares (77,000 acres) of Federal and private lands. These two fires left large areas blackened across the southwestern portion of Hanford, including the slope of Rattlesnake Mountain, which is visible from Richland and other areas in the region. Alterations to the visual character of Hanford resulting from these fires will change over time since the landscape will tend to recover as rains promote the growth of vegetation, fire lines are rehabilitated, and fences are repaired. Because of the slow regeneration of sagebrush, however, it will be years before the visual character of the area will mirror prefire conditions.

The landscape adjacent to Hanford consists primarily of rural rangeland and farms. The city of Richland, part of the Tri-Cities area, is the only adjoining urban area. Viewpoints affected by DOE facilities are primarily associated with the public access roadways, including State Routes 24 and 240, Horn Rapids Road, Route 4 South, and Stevens Drive; the Columbia River bluffs; and the northern edge of the city of Richland. The Energy Northwest nuclear reactor and DOE facilities are brightly lit at night and are highly visible from many areas. Developed areas are consistent with a BLM Visual Resource Management (VRM) Class IV rating, and for the remainder of Hanford VRM ratings range from Class II to Class III (BLM 1986:6, 7). Management activities within Class II and III areas may be seen but should not dominate the view; those in Class IV areas dominate the view and typically are the focus of viewer attention.

3.2.1.2.2 200 Areas Description

The tallest structure within the 200 Areas is the meteorological tower, with a height of 124 meters (408 feet) (Duncan 2007:4.8). Additionally, a number of stacks are around 61 meters (200 feet) in height. Travelers can see some site facilities in the 200-West Area on an 11-kilometer (7-mile) segment of State Route 240 south of the Yakima Barricade (near the junction of State Routes 240 and 24). At the closest approach, these structures are about 3.2 kilometers (2 miles) distant. However, not all facilities are visible, as many (e.g., storage tanks) are situated below ground, and undeveloped areas are present within and adjacent to the 200 Areas. It is within some of these undeveloped areas that a number of proposed project facilities would be located (see Chapter 4, Figures 4–1 and 4–2).

Aboveground structures throughout the 200 Areas are visible from elevated locations such as Gable Mountain, Gable Butte, and Rattlesnake Mountain. They are not visible from the Columbia River. Because the 200-East and 200-West Areas are highly developed industrial areas, they have a VRM Class IV rating. Natural features of visual interest within the vicinity of the 200 Areas include Gable Butte, 6.9 kilometers (4.3 miles) to the northwest; Gable Mountain, 8 kilometers (5 miles) to the northeast; Rattlesnake Mountain, 14 kilometers (8.7 miles) to the south; and the Columbia River, as close as 10 kilometers (6.2 miles) to the northwest.

3.2.1.2.3 400 Area Description

FMEF, the tallest building in the 400 Area, is 30 meters (100 feet) in height and can be seen from State Route 240; however, FFTF is also a prominent feature. Developed areas within the 400 Area are consistent with a VRM Class IV rating. Natural features of visual interest within a 40-kilometer (25-mile) radius include the Columbia River, 6.8 kilometers (4.2 miles) to the east; Rattlesnake Mountain, 18 kilometers (11 miles) to the west-southwest; Gable Mountain, 19 kilometers (12 miles) to the north-northwest; and Gable Butte, 27 kilometers (17 miles) to the northwest (DOE 2000a:3-94).

3.2.1.2.4 Borrow Area C Description

Borrow Area C, except for a roadway completed in 2006, is an undeveloped area on the south side of State Route 240 (see Figure 3–1). It is generally indistinguishable from the Fitzner-Eberhardt Arid Lands Ecology Reserve, which surrounds it on three sides. Since the 24 Command Fire burned the area in 2000, the original vegetation of the area has changed substantially and it now appears as grassland with little shrub component. A large portion of Borrow Area C surface was burned by the recent 2007 Wautoma Fire. Due to the presence of the road across a portion of the site, Borrow Area C is consistent with a BLM VRM Class II rating. It is readily visible from State Route 240, located immediately adjacent to the area, and Rattlesnake Mountain, about 6.4 kilometers (4 miles) to the south. It is also visible in the distance from Gable Mountain, 12.9 kilometers (8 miles) to the northeast, and Gable Butte, 11.3 kilometers (7 miles) to the north.

3.2.2 Infrastructure

As used in this *TC & WM EIS*, infrastructure encompasses the condition, capacity, and usage of ground transportation and utilities (electricity, fuel, and water) at Hanford and in the site vicinity. In addition to the descriptions provided below, a summary of sitewide infrastructure characteristics is presented as Table 3–2. Further information on transportation infrastructure is presented in Section 3.2.9.4, and waste management infrastructure is addressed in Section 3.2.12.

Table 3–2. Hanford Sitewide Infrastructure Characteristics

Resource	Site Usage[a]	Site Capacity
Transportation		
Roads (kilometers)	607[b]	N/A
Railroads (kilometers)	183	N/A
Electricity		
Energy (megawatt-hours per year)	172,585	1,743,240
Peak load (megawatts)	24[c]	199[d]
Fuel		
Natural gas (cubic meters per year)	977,840	N/A
Fuel oil (liters per year)	2,954,000	(e)
Diesel fuel (liters per year)	1,191,900	(e)
Gasoline (liters per year)	150,300	(e)
Propane (liters per year)	551,400	(e)
Water (liters per year)	816,560,000	18,500,000,000[f]

[a] All values are for fiscal year 2006.

[b] Includes asphalt-paved roads only.

[c] Estimated from average sitewide electrical energy usage, assuming peak load is 120 percent of average demand.

[d] Reflects the capacity of the primary substations serving the 100, 200, 300, and 400 Areas but not necessarily the availability of electric power from the Bonneville Power Administration, which can vary (Uecker 2007).

[e] Limited only by the ability to ship resources to the site.

[f] Capacity of the Hanford Export Water System.

Note: To convert cubic meters to cubic feet, multiply by 35.315; kilometers to miles, by 0.6214; liters to gallons, by 0.26417.

Key: N/A=not applicable.

Source: Duncan 2007:4.150, 4.152; Ferns 2003a, 2003b; Fluor Hanford 2006a:Attachments 1 and 2; Uecker 2007.

3.2.2.1 Ground Transportation

3.2.2.1.1 General Site Description

The DOE-maintained road network within Hanford consists of 607 kilometers (377 miles) of asphalt-paved road and provides access to the various work centers (see Figure 3–1). Primary access roads on the site are Routes 1, 2, 3, 4, 6, 10, and 11A and Beloit Avenue. Public access to the 200 Areas and interior locations of Hanford is restricted by guarded gates at the Wye Barricade (at the intersection of Routes 10 and 4), the Yakima Barricade (at the intersection of State Route 240 and Route 11A), and the Rattlesnake Barricade (south of the 200-West Area) (Duncan 2007:4.152).

The Hanford rail system originally consisted of about 209 kilometers (130 miles) of track. It connected to the Union Pacific commercial track at the Richland Junction and to the now-abandoned commercial right-of-way (Chicago, Milwaukee, St. Paul, and Pacific Railroad) near Vernita Bridge in the northwest section of the site (see Figure 3–2). Prior to 1990, annual sitewide railcar movements numbered about 1,400, transporting materials such as coal, fuel, hazardous process chemicals, and radioactive materials and equipment. Coal deliveries ceased with the replacement of site coal-fired steam plants by oil and natural gas package boilers. In October 1998, 26 kilometers (16 miles) of track were transferred to the Port of Benton and are currently operated and maintained by the Tri-City and Olympia Railroad Company. Included were those track segments constituting the Hanford southern rail connection

(from Horn Rapids Road to Columbia Center) and those serving the Richland North Area (Duncan 2007:4.150).

3.2.2.1.2 200 Areas Description

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 Route 4 North off Route 11A for vehicles entering the site at the Yakima Barricade. The 200-West Area is accessed from State Route 240 by Beloit Avenue. A network of both improved and semi-improved roads provide access to individual facilities within the 200-East and 200-West Areas and to the WTP site. Inactive rail spurs traverse portions of both the 200-East and 200-West Areas (see Figure 3–2).

3.2.2.1.3 400 Area Description

The 400 Area access road can be reached directly via a roadway off Route 4. An inactive rail spur to the 400 Area originates northeast of the site from the vicinity of the Energy Northwest Columbia Generating Station.

3.2.2.1.4 Borrow Area C Description

Borrow Area C is accessible via a two-lane, 2.0-kilometer-long (1.25-mile-long) asphalt-paved roadway. Completed in 2006, the roadway extends southeast into the interior of Borrow Area C from the intersection of Beloit Avenue and State Route 240 and south of the Rattlesnake Barricade.

3.2.2.2 Electricity

3.2.2.2.1 General Site Description

Electric power for Hanford is purchased wholesale from the Bonneville Power Administration, which provided nearly 90 percent of the electricity consumed on the site in 2006 (Duncan 2007:4.157). Hanford is a Priority Firm customer, and the Bonneville Power Administration is contractually obligated to provide as much power as Hanford requires. Being a Priority Firm customer ensures that, in the event of severe regional power shortages, Hanford (along with other Priority Firm customers) would be the last level of Bonneville Power Administration service to be shut off (Fluor Hanford 2005a:45, 46). Power for the 700 Area and the Richland North Area is provided by the City of Richland (DOE 1999a:4-112). The Richland Energy Services Department and the Benton and Franklin County public utility districts provide electricity to the Tri-Cities and surrounding areas and also purchase nearly all their electric power from the Bonneville Power Administration (Duncan 2007:4.156). Because the transmission line capacity across the site was developed when the nine 100 Area reactors were operating, historically there has been surplus capacity on the Hanford electrical transmission system (Ferns 2003a). In 2006, the sitewide average electric load demand was approximately 19.7 megawatts (172,585 megawatt-hours) for 8,760 hours (see Table 3–2).

Power to the electrical system that serves the 100 and 200 Areas is provided from two sources, the Bonneville Power Administration Midway substation at the northwestern site boundary and a transmission line from the Bonneville Power Administration Ashe substation near Energy Northwest's Columbia Generating Station. The 100/200 Area electrical system consists of about 80 kilometers (50 miles) of 230-kilovolt transmission lines, six primary substations, about 217 kilometers (135 miles) of 13.8-kilovolt distribution lines, and 124 secondary substations. The 100/200 Area transmission and distribution systems, like the Bonneville Power Administration source lines, have redundant routings to ensure electrical service to individual areas and designated facilities within those areas (DOE 1990:3-1, 3-2; 1999b:3-47). The 100/200 Area system had been upgraded in the 1980s with an installed usable electric load capacity of 244 megavolt-amperes (about 195 megawatts) and had a peak

load demand of 54.7 megawatts at that time (DOE 1990:3-1–3-3; ICF KH Engineers Hanford 1995:4, 5). Presently, the 100 Areas are served by one primary substation (151-KW substation) that has a usable load capacity of 50 megavolt-amperes (about 40 megawatts) (Uecker 2007). Total electrical energy consumption in the 100 Areas was 23,440 megawatt-hours in fiscal year 2006, reflecting an average electric load demand of 2.7 megawatts (Fluor Hanford 2006a:Attachment 2).

3.2.2.2.2 200 Areas Description

The main 251-W substation that serves the 200 Areas has a current usable load capacity of 33 megavolt-amperes (about 26 megawatts) (Uecker 2007). The 251-W substation also serves as the electrical dispatch center for the 100, 200, and 300 Areas (DOE 1990:3-1–3-2; ICF KH Engineers Hanford 1995:4, 5).

In late 2001, DOE completed construction of a new 62.5-megavolt-ampere-capacity (about 50-megawatt) substation to support future WTP operations. The substation is supplied by 230-kilovolt transmission lines and can receive power directly from the Columbia Generating Station or the Priest Rapids Dam (DOE 2001a).

In fiscal year 2006, total electrical energy consumption was 53,915 megawatt-hours in the 200-East Area and 43,888 megawatt-hours in the 200-West Area, for a 200 Area total of 97,803 megawatt-hours (Fluor Hanford 2006a:Attachment 2). This consumption reflects an average electric load demand of about 11.2 megawatts for activities in the 200 Areas.

3.2.2.2.3 400 Area Description

For the 300 and 400 Areas, electric power is supplied via two separate 115-kilovolt Bonneville Power Administration transmission lines. The first originates from the Bonneville Power Administration Benton switch station south of the Columbia Generation Station; the second, from the Bonneville Power Administration White Bluffs substation in the southeast portion of Hanford (DOE 1990:3-6). The primary 300 Area substation (351 substation) currently has a usable electric load capacity of 20 megavolt-amperes (about 16 megawatts) (Uecker 2007). Total electrical energy consumption in the 300 Area was 18,117 megawatt-hours in fiscal year 2006, reflecting an average electric load demand of 2.1 megawatts (Fluor Hanford 2006a:Attachment 2).

There is one 13.8-kilovolt tie line from the 300 Area to the 400 Area emergency power system that also provides alternate power for maintenance outages. Redundancy in the distribution lines to designated facilities ensures continuity of service and the rerouting of power for the maintenance of system components. There are two substations in the 400 Area: Building 451A (FFTF substation), which serves the FFTF reactor complex, and Building 451B (FMEF substation), serving FMEF and associated buildings (DOE 1990:3-8, 3-9; 1999b:3-47; Fluor Hanford 2005a:16). The FFTF substation has a usable load capacity of 50 megavolt-amperes (about 40 megawatts); the FMEF substation, a usable capacity of 33.3 megavolt-amperes (about 27 megawatts) (Uecker 2007).

Electrical energy usage for FFTF averaged approximately 55,000 megawatt-hours annually during standby, reflecting an average electric power demand of about 6 megawatts (Fluor Hanford 2005a:46). The total electrical energy consumption for the 400 Area as a whole during fiscal year 2006 was 20,385 megawatt-hours, reflecting an average electric load demand of 2.3 megawatts (Fluor Hanford 2006a:Attachment 2).

3.2.2.2.4 Borrow Area C Description

No electric power distribution lines serve Borrow Area C at present. Overhead electrical distribution lines could be extended to the site from the vicinity of Beloit Avenue and State Route 240 to support borrow area operations as needed.

3.2.2.3 Fuel

3.2.2.3.1 General Site Description

Both fuel oil and natural gas are used as energy sources at Hanford facilities. A commercial vendor supplies fuel oil to the site, including the 200 Areas. The primary fuel for the 300 Area is natural gas, which is supplied by the Cascade Natural Gas Corporation (Duncan 2007:4.157; Ferns 2003a).

Liquefied petroleum gas (propane) is the primary facility fuel source in the 100 Areas. In addition, diesel fuel, gasoline, and propane are consumed to operate vehicles and other equipment at Hanford (Fluor Hanford 2006a:Attachment 1:4, Attachment 2).

Individual package boilers supply heat and process steam to specific facilities in the 200-East, 200-West, and 300 Areas. Oil-fired package boilers produce steam in the 200 Areas, while natural-gas-fired package boilers produce steam in the 300 Area. A new underground natural gas line was installed from south of Richland to the 300 Area to supply natural gas to the new package boilers (DOE 1999a:4-112).

Hanford sitewide fuel oil consumption, reflecting demands in the 200 Areas, was 2,954,000 liters (780,400 gallons) in fiscal year 2006. Total natural gas consumption by 300 Area facilities was about 977,840 cubic meters (34,530,000 cubic feet) during the same time period (see Table 3–2). Total diesel fuel consumption was 1,191,880 liters (314,860 gallons); total gasoline consumption, 150,300 liters (39,700 gallons); and total propane consumption, 551,400 liters (145,670 gallons). Fuel consumption by nonfleet vehicles and equipment was substantially lower in fiscal year 2006 than in previous years due to the slowdown in WTP construction (Fluor Hanford 2006a:Attachment 1:4, Attachment 2).

3.2.2.3.2 200 Areas Description

As indicated above, individual package boilers supply heat and process steam to facilities in the 200-East and 200-West Areas. When complete and operational, a dedicated fuel-oil-fired central utilities plant will supply heat and process steam to the WTP complex within the 200-East Area.

3.2.2.3.3 400 Area Description

At FFTF, fuel oil was required to operate the emergency fire pumps, emergency diesel generators, and the sodium preheaters in the main heat transport system dump heat exchangers. Fuel oil usage during operations averaged 76,000 liters (20,000 gallons) annually (Fluor Hanford 2005a:46). No fuel oil consumption was recorded for the 400 Area in fiscal year 2006 (Fluor Hanford 2006a:Attachment 2).

3.2.2.3.4 Borrow Area C Description

There is no liquid fuel storage or consumption in Borrow Area C.

3.2.2.4 Water

3.2.2.4.1 General Site Description

The Hanford water system includes numerous buildings, pumps, valve houses, reservoirs, and wells, in addition to a distribution piping system that delivers water to all areas of the site. The Export Water System, the largest system at Hanford, delivers water from the Columbia River to the 100 and 200 Areas and parts of the 600 Area (DOE 1999a:4-112). The Hanford water system is further divided into nine DOE-owned, contractor-operated, regulated drinking water systems. Only one of the nine systems (the 400 Area system) uses groundwater from the unconfined aquifer instead of water from the Columbia River. The 400 Area used emergency backup well 499-SO-8 (P-14) as a source of drinking water for the first 6 months of 2010. Primary supply well 499-S1-8J (P-16) supplied the system for the remaining 6 months. Backup well 499-S0-7 (P-15) did not supply water to the 400 Area during 2010 (Poston, Duncan, and Dirkes 2011:8.53–8.55).

In the 300 Area, the water system distributes water supplied by the City of Richland. The Richland water supply system provides drinking water to the 300 Area, the Richland North Area, and the Volpentest Hazardous Materials Management and Emergency Response Training and Education Center (Poston, Duncan, and Dirkes 2011:8.53). This system obtains about 82 percent of its water directly from the Columbia River, while the remainder is split between a well field in north Richland (recharged from the river) and groundwater wells. In 2006, the city of Richland's total water use was approximately 20.1 billion liters (5.3 billion gallons). The city of Pasco water system draws from the Columbia River and used about 15.3 billion liters (4.0 billion gallons) in 2006. While the Kennewick water system partly depends on the Columbia River for its supply, two groundwater wells serve as the sole source of water between November and March. The total water usage by the city of Kennewick was 13.4 billion liters (3.5 billion gallons) in 2006. A significant number of Kennewick's residents (about 22,000 residential customers) also draw irrigation water from the Kennewick Irrigation District, which has the Yakima River as its source (Duncan 2007:4.155).

3.2.2.4.2 200 Areas Description

Water for the 200-East and 200-West Areas is filtered and chlorinated at the 283-W Water Treatment Plant (Ferns 2003b; Fluor Hanford 2006a:Attachment 1:8). Construction of an additional 4.8 kilometers (3 miles) of pipeline was completed by DOE in late 2001 to deliver water to the WTP site for drinking, fire protection, and future WTP operations (DOE 2001a). The total raw water capacity of the Export Water System is currently rated at approximately 35,200 liters (9,300 gallons) per minute, or about 18.5 billion liters (4.89 billion gallons) per year. However, the potable water capacity of the treatment plant is about 5,680 liters (1,500 gallons) per minute, or about 2.98 billion liters (0.788 billion gallons) per year, which is limited by the plant's chlorination capacity (Ferns 2003b). The original Export Water System was designed to supply raw water to the 100-B, 100-D, 100-F, and 100-H Area reactor operations in addition to the 200 Areas. Since reactor shutdown, it has been reconfigured to mainly furnish water to the 200 Areas and has undergone further modification. Prior to 1990, the system had a daily average pumping demand of about 72 million liters (19 million gallons) per day, with the 200 Areas consuming over 22,700 million liters (6 billion gallons) annually (DOE 1990:5-3, 5-9). Hanford sitewide water production and usage totaled approximately 816.6 million liters (215.7 million gallons) in fiscal year 2006, including groundwater withdrawals in the 400 Area. Of this total, the amount of water produced and used in the 200 Areas was 303.1 million liters (80.1 million gallons) (Fluor Hanford 2006a:Attachment 1:8).

3.2.2.4.3 400 Area Description

In the 400 Area, the primary and two backup groundwater supply wells each have a production capacity of 833 liters (220 gallons) per minute (DOE 2000a:3-113). Groundwater is chlorinated at the well as it is

pumped into one of three 1,140-cubic-meter (300,000-gallon) storage tanks. Approximately 4,540 liters (1,200 gallons) of sodium hypochlorite were consumed annually in water treatment (Fluor Hanford 2005a:46). Annual groundwater withdrawals during operations averaged about 197 million liters (52 million gallons) (DOE 2000a:3-113; Fluor Hanford 2005a:46). Groundwater production and usage in the 400 Area was measured at approximately 116 million liters (30.6 million gallons) in fiscal year 2006 (Fluor Hanford 2006a:Attachment 1:8).

3.2.2.4.4 Borrow Area C Description

No utility systems serve Borrow Area C at present. Development plans call for a new waterline to be extended down Beloit Avenue from the 200-West Area distribution system to provide water in support of future borrow area operations.

3.2.3 Noise and Vibration

Noise is unwanted sound that interferes or interacts negatively with the human or natural environment. Noise may disrupt normal activities or diminish the quality of the environment. Noise sources, existing noise levels at Hanford, and noise standards are described in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a:3-29–3-31, F-31, F-32) and in the *Hanford NEPA Characterization Report* (Duncan 2007:4.161–4.165).

3.2.3.1 General Site Description

Background noise levels at Hanford were measured during two surveys in 1996 and 2007. Data from a survey of 15 sites at Hanford found that background noise levels (measured as the 24-hour equivalent sound level) ranged from 30 to 60.5 decibels A-weighted (dBA) (a unit of measurement that accounts for the frequency response of the human ear). A second survey of 5 isolated areas concluded that background sound levels in undeveloped areas could best be described as a mean 24-hour equivalent sound level of 24 to 36 dBA. Wind was identified as the primary contributor to background sound levels at Hanford (Duncan 2007: 4.162, 4.164).

Major noise sources within Hanford include various facilities, equipment, and machines (e.g., cooling systems, transformers, engines, pumps, boilers, steam vents, paging systems, construction and material handling equipment, vehicles). However, most Hanford industrial facilities are far enough from the site boundary that noise levels from these sources at the boundary are either unmeasurable or barely distinguishable from background noise levels. It can reasonably be assumed that Hanford is currently in compliance with state noise regulations (DOE 1996a: 3-29, 3-31; Neitzel 2005:4.149–4.153).

The primary source of noise at the site and nearby residences is traffic. The potential impact of traffic noise resulting from activities at Hanford was evaluated for a draft EIS addressing the siting of the proposed New Production Reactor (Duncan 2007:4.164). Estimates were made of baseline traffic noise along two major access routes: State Route 24, from Hanford west to Yakima, and State Route 240, south of the site and west of Richland, where it handles maximum traffic volume. About 9 percent of the employees at Hanford commute by vanpool or bus. Modeled traffic noise levels (equivalent sound level [1 hour]) at 15 meters (50 feet) from State Route 24 for both peak and offpeak periods were 62 dBA. Traffic noise levels from State Route 240 for both peak and offpeak periods were 70 dBA. These traffic noise levels were projections based on employment levels about 30 percent higher than actual levels at Hanford in 1997. Existing traffic noise levels may be different due to changes in site employment and ridesharing activities (DOE 1999b:3-8; Duncan 2007:4.161–4.165).

Washington State has established noise standards for different source and receiving areas. Hanford belongs to source area Class C (industrial). The maximum allowable noise level for residential,

commercial, and industrial areas is 50 to 70 dBA (WAC 173-60). For industrial areas impacting a residential area, the limit is 60 dBA during daylight hours and 50 dBA at night. U.S. Environmental Protection Agency (EPA) guidelines for environmental noise protection include a day-night average sound level of no more than 55 dBA to protect the public from the effects of broadband environmental noise in typically quiet outdoor residential areas (EPA 1974:29). Land use compatibility guidelines adopted by the Federal Aviation Administration and the Federal Interagency Committee on Urban Noise indicate that yearly day-night average sound levels less than 65 dBA are compatible with residential land uses (14 CFR 150). These guidelines further indicate that noise levels up to 75 dBA are compatible with residential uses if suitable noise reduction features are incorporated into structures. It is expected that, for most residences near Hanford, the day-night average sound level is less than 65 dBA and thus compatible with residential land use, although noise levels may be higher for some residences along major roadways. Truck traffic, especially on State Routes 240 and 10; excavation activity at various projects at Hanford, such as the WTP and the Integrated Disposal Facility (IDF) in the 200-East Area (IDF-East); and roadwork on State Route 240 have resulted in ground vibration sufficient to interfere with operation of the LIGO (Raab 1996; SAIC 2006a).

3.2.3.2 200 Areas Description

No distinguishing noise characteristics in the 200 Areas have been identified. The 200 Areas are far enough away from the nearest site boundary (10 kilometers [6.2 miles]) that industrial noises emanating from those areas are either unmeasurable or barely distinguishable from background levels at the site boundary. The 200-West Area is about 2.3 kilometers (1.4 miles) from the closest part of the Hanford Reach National Monument.

3.2.3.3 400 Area Description

No distinguishing noise characteristics in the 400 Area have been identified. The 400 Area is far enough away from the site boundary (6.9 kilometers [4.3 miles]) that industry-related noise levels at that boundary are unmeasurable or barely distinguishable from background levels. The 400 Area is about 6.9 kilometers (4.3 miles) from the closest part of the Hanford Reach National Monument.

3.2.3.4 Borrow Area C Description

There are currently no quarry activities in Borrow Area C that would produce audible noise in the area of the Hanford Reach National Monument immediately adjacent to the quarry (SAIC 2006b). The major noise source in this area is traffic along State Route 240.

3.2.4 Air Quality

Air pollution refers to the direct or indirect introduction of any substance into the air that could endanger human health; harm living resources, ecosystems, or material property (e.g., buildings); or impair or interfere with the comfortable enjoyment of life or other legitimate uses of the environment. Air pollutants are transported, dispersed, and concentrated by meteorological and topographical conditions. Air quality is affected by air pollutant emission characteristics, meteorology, and topography. This section primarily discusses criteria and toxic air pollutants. Radioactive air pollutants are discussed further in Section 3.2.10.

3.2.4.1 General Site Description

The climate at Hanford and the surrounding region is characterized as that of a semiarid steppe. The humidity is low, and winters are mild. According to data collected from 1946 through 2004, the average monthly temperatures at the Hanford Meteorological Station (located between the 200-East and 200-West Areas) range from a low of –0.7 degrees Celsius (°C) (31 degrees Fahrenheit [°F]) in January to a high of 24.7 °C (76 °F) in July. Annual average relative humidity is 55 percent. While the average

annual precipitation is 17 centimeters (6.8 inches), most precipitation occurs during the late autumn and winter, with more than half of the annual amount occurring from November through February. The monthly average windspeeds are lower during the winter, averaging 2.7 to 3.1 meters per second (6 to 7 miles per hour); during the summer they average 3.6 to 4.0 meters per second (8 to 9 miles per hour). Prevailing winds are from the northwest (Duncan 2007:4.5–4.13). Figures 3–3 and 3–4 show wind roses for the Hanford Meteorological Station at the 200 Area for the 9-meter (30-foot) and 61-meter (200-foot) elevations, respectively, for the period 1997 through 2006. Figures 3–5 and 3–6 show wind roses for the meteorological station at the 400 Area for the 9-meter (30-foot) and 61-meter (200-foot) elevations, respectively, for the period 1997 through 2006.

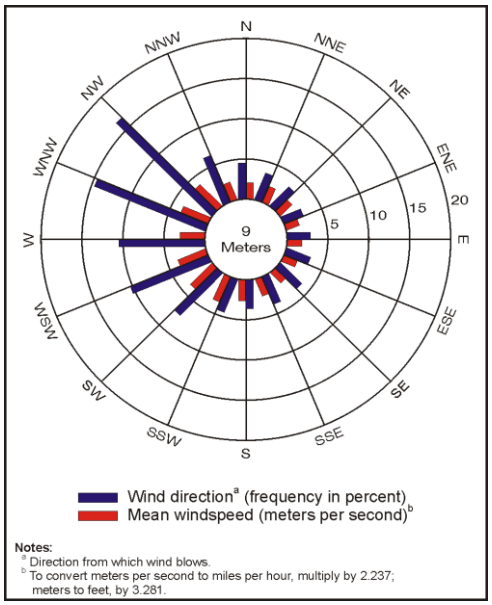


Figure 3–3. Wind Rose for the Hanford Meteorological Station at the 200 Area, 1997–2006 (9-Meter Elevation)

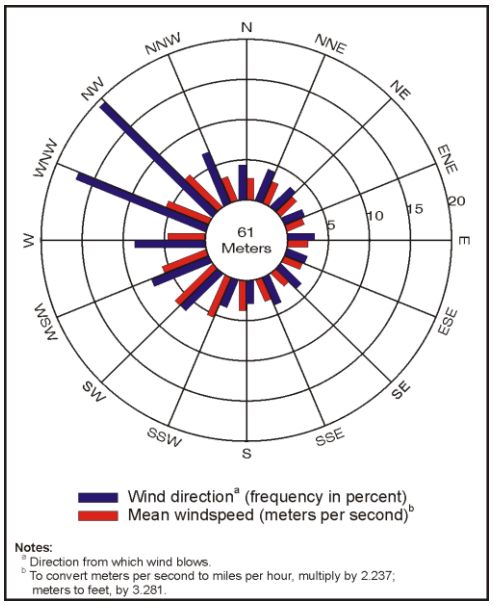


Figure 3–4. Wind Rose for the Hanford Meteorological Station at the 200 Area, 1997–2006 (61-Meter Elevation)

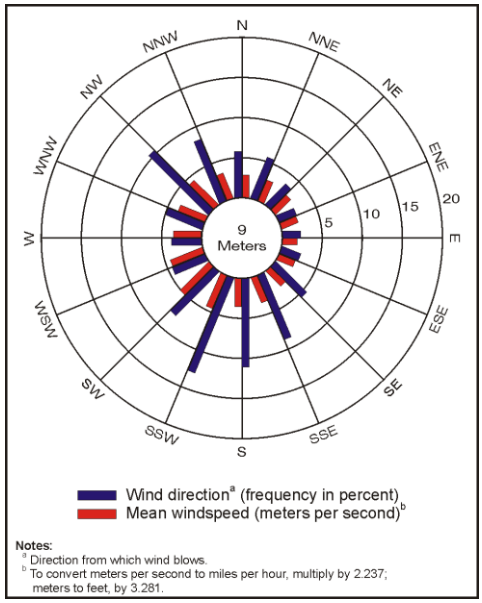


Figure 3–5. Wind Rose for the Fast Flux Test Facility Meteorological Station at the 400 Area, 1997–2006 (9-Meter Elevation)

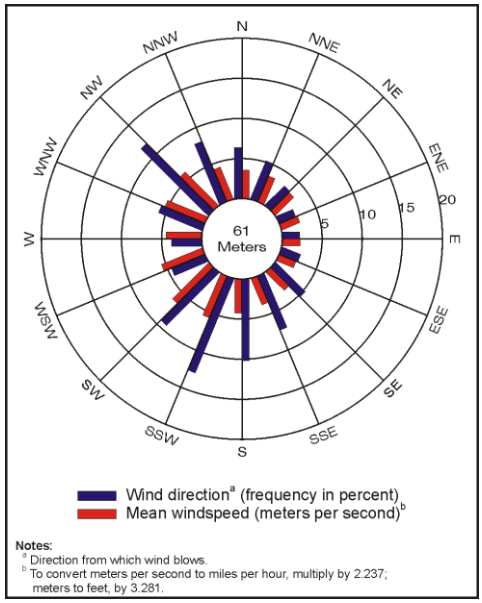


Figure 3–6. Wind Rose for the Fast Flux Test Facility Meteorological Station at the 400 Area, 1997–2006 (61-Meter Elevation)

Tornadoes are infrequent and generally small in the northwestern portion of the United States. In the 10 counties closest to Hanford (Benton, Franklin, Grant, Adams, Yakima, Klickitat, Kittitas, and Walla Walla Counties in Washington, and Umatilla and Morrow Counties in Oregon), only 28 tornadoes have been recorded for the period from 1950 through 2006. The average occurrence of thunderstorms in the vicinity of the Hanford Meteorological Station is 10 per year, with about 1.9 percent considered severe (Duncan 2007:4.13, 4:14).

Most of Hanford is within the South-Central Washington Intrastate Air Quality Control Region No. 230, but a small portion of the site is in the Eastern Washington-Northern Idaho Interstate Air Quality Control Region No. 62. None of the areas within Hanford and its surrounding counties are designated as nonattainment areas with respect to National Ambient Air Quality Standards (NAAQS) for criteria air pollutants (40 CFR 81.348). Particulate matter (PM) concentrations can reach relatively high levels in eastern Washington State because of extreme natural events such as duststorms and large brush fires. Duststorms are treated as uncontrollable natural events under EPA policy (Nichols 1996). Accordingly, the air quality impact of such storms can be disregarded in determining whether an area is in nonattainment for atmospheric particulates. However, states are required to develop and implement a natural-events action plan (Duncan 2007:4.19). Applicable NAAQS and Washington State ambient air quality standards are presented in Table 3–3.

The primary sources of criteria and toxic air pollutants at Hanford include emissions from power generation and chemical processing (Duncan 2007:4.19). Other sources include vehicular emissions and construction, environmental remediation, and waste management activities (Wisness 2000). The tank farms in the 200 Areas produced reportable quantities of ammonia emissions in 2010 (Poston, Duncan, and Dirkes 2011:8.10). Modeled ambient air pollutant concentrations at the site boundary attributable to existing sources at Hanford are presented in Table 3–3.

These ambient air pollution concentrations are based on dispersion modeling using year 2005 emissions for Hanford, which are presented in Table 3–4. Only those pollutants that would be emitted under any of the alternatives evaluated in this *TC & WM EIS* are presented. Emissions from carbon tetrachloride vapor extraction work in the 200-West Area are included among the toxic pollutant emissions shown. Emissions from tank vents other than ammonia and criteria pollutants are included among the composite toxic air pollutants. These emissions include 1,3-butadiene, 2-hexanone, 2-pentanone, acetone, acetonitrile, benzene, heptane, hexane, methyl amyl ketone, nonane, octane, phosphoric acid tributyl ester, and toluene (DOE and Ecology 1996:G-36–G-38). The concentrations at the site were calculated from 2000–2004 meteorological data using the AERMOD [American Meteorological Society/U.S. Environmental Protection Agency Regulatory Model] dispersion model.

Background concentrations of criteria pollutants are well below ambient standards. As shown in Table 3–3, these modeled concentrations from Hanford sources represent a small percentage of the ambient air quality standards. Hanford emissions should not result in air pollutant concentrations that violate the ambient air quality standards for criteria pollutants. Detailed information on emissions of other pollutants at Hanford is discussed in the *Hanford Site Environmental Report* (Poston, Duncan, and Dirkes 2011:8.10–8.12).

The principal sources of radioactive emissions at Hanford are facilities in the 100, 200, 300, 400, and 600 Areas. Source emissions in the 600 Area are reported with those from the 200-West Area due to the proximity of the emitting facility to the 200-West Area. Emission sources are discussed in the *Hanford Site Environmental Report* (Poston, Duncan, and Dirkes 2011:8.10). Radioactive airborne emissions in 2010 are summarized in Table 3–5. Emissions data are provided as a baseline and are the basis for the human health baseline information discussed in Section 3.2.10, but are not used in the modeling for this *TC & WM EIS*.

Table 3–3. Modeled Nonradioactive Ambient Air Pollutant Concentrations from Hanford Site Sources and Ambient Air Quality Standards

Pollutant	Averaging Period	Most Stringent Standard or Guideline[a] (micrograms per cubic meter)	Maximum Hanford Concentration[b] (micrograms per cubic meter)
Criteria Pollutants			
Carbon monoxide	8 hours 1 hour	10,000[c] 40,000[c]	39.5 162
Nitrogen dioxide	Annual 1 hour	100[c] 188[d]	0.237 13.2
Ozone	8 hours 1 hour	147[d] 235[f]	(e) (e)
PM_{10}	Annual 24 hours	50[f, g] 150[c]	0.134 0.926
$PM_{2.5}$	Annual 24 hours	15[d] 35[d]	0.113[h] 1.09[h]
Sulfur dioxide	Annual 24 hours 3 hours 1 hour 1 hour 1 hour	50[f] 260[f] 1,300[c] 1,000[f] 660[f, i] 197[d]	0.00577 0.52 2.01 5.0 5.0 2.19
Other Regulated Pollutants			
Total suspended particulates	Annual 24 hours	60[f] 150[f]	0.134[h] 0.926[h]
Ammonia	24 hours	70.8[j]	1.91

[a] The more stringent of the Federal and state standards is presented if both exist for the averaging period. The National Ambient Air Quality Standards (40 CFR 50), other than those for ozone, particulate matter, and lead, and those standards based on annual averages, are not to be exceeded more than once per year. The annual arithmetic mean $PM_{2.5}$ standard is attained when the weighted annual arithmetic mean concentration (3-year average) does not exceed the standard value. The 24-hour $PM_{2.5}$ standard is met when the 98th percentile over 3 years of 24-hour average concentrations is less than or equal to the standard value. The 24-hour PM_{10} standard is met when the standard value is not exceeded more than once per year over a 3-year period. The annual arithmetic mean PM_{10} standard is attained when the weighted annual arithmetic mean concentration (3-year average) is less than or equal to the standard value. The 1-hour nitrogen dioxide standard is met when the 3-year average 98th percentile of the daily maximum 1-hour average does not exceed the standard value. The Federal 1-hour sulfur dioxide standard is met when the 3-year average 99th percentile of the daily maximum 1-hour average does not exceed the standard value.

[b] Site contributions based on a 2005 emissions inventory, including emissions from the 200 Areas.

[c] Federal and state standard.

[d] Federal standard.

[e] Not directly emitted or monitored by the site.

[f] State standard.

[g] The U.S. Environmental Protection Agency recently revoked the annual PM_{10} standard.

[h] Assumed to be the same as the concentration of PM_{10} because there are no specific emissions data for total suspended particulates or $PM_{2.5}$.

[i] Not to be exceeded more than twice in any 7 consecutive days.

[j] State acceptable source impact level.

Note: The National Ambient Air Quality Standards include standards for lead. Lead emissions identified at the site are small (less than 1 kilogram per year) and were not modeled. The State of Washington also has ambient standards for fluorides. No emissions of fluorides have been reported at Hanford. To convert cubic meters to cubic feet, multiply by 35.315; kilograms to pounds, by 2.2046.

Key: PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers.

Source: 40 CFR 50; 71 FR 61144; Johnson 2006; Poston et al. 2006:10.12; WAC 173-460, 173-470, 173-474, 173-475, 173-481, 173-490.

Table 3–4. Nonradioactive Constituents Emitted to the Atmosphere at the Hanford Site, 2005

Constituent	Emissions (kilograms)
Carbon monoxide	14,000
Nitrogen oxides	12,000
Particulate matter PM_{10} $PM_{2.5}$	6,500 2,800 1,000
Sulfur oxides	3,000
Lead	0.47
Volatile organic compounds[a]	14,000[b]
Ammonia	12,000[c]
Other toxic air pollutants	6,600[d]

[a] Produced from burning fossil fuels for steam generation and electrical generators and calculated from estimates of emissions from the 200-East and 200-West Area tank farms; evaporation losses from fuel dispensing; and emissions from operation of the 242-A Evaporator and the 200 Area Effluent Treatment Facility, Central Waste Complex, T Plant complex, and Waste Receiving and Processing Facility.

[b] Estimate does not include emissions from certain laboratory operations and mobile sources.

[c] Calculated estimates of releases from the 200-East and 200-West Area tank farms, operation of the 242-A Evaporator, and the 200 Area Effluent Treatment Facility.

[d] A composite of calculated estimates of toxic air pollutants, excluding ammonia.

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers.

Source: Poston et al. 2006:10.12.

Table 3–5. Radionuclides Discharged to the Atmosphere at the Hanford Site, 2010

Radionuclide	Release Location					
	100 Areas	200-East Area	200-West Area	300 Area	400 Area	Total
	(curies)					
Hydrogen-3 (tritium) (as elemental tritium)	NM	NM	NM	7.3×10^{1}	NM	7.3×10^{1}
Hydrogen-3 (tritium) (as tritiated water vapor)	NM	NM	NM	2.8×10^{2}	1.8×10^{-3}	2.8×10^{2}
Krypton-85	NM	NM	NM	4.4×10^{-1}	NM	4.4×10^{-1}
Strontium-90	1.0×10^{-4}[a]	1.6×10^{-4}[a]	2.8×10^{-5}[a]	5.5×10^{-6}[a]	NM	2.9×10^{-4}
Iodine-129	NM	1.7×10^{-3}	NM	NM	NM	1.7×10^{-3}
Xenon-131m	NM	NM	NM	1.0×10^{-8}	NM	1.0×10^{-8}
Xenon-133	NM	NM	NM	3.0×10^{-9}	NM	3.0×10^{-9}
Cesium-137	2.5×10^{-5}	1.5×10^{-5}	1.8×10^{-5}	4.1×10^{-9}	4.1×10^{-7}[b]	5.8×10^{-5}
Radon-220	NM	NM	NM	9.0×10^{1}	NM	9.0×10^{1}
Radon-222	NM	NM	NM	1.4×10^{-8}	NM	1.4×10^{-8}
Plutonium-238	3.0×10^{-6}	2.0×10^{-9}	3.9×10^{-8}	4.4×10^{-7}	NM	3.5×10^{-6}
Plutonium-239 and -240	5.1×10^{-5}	1.7×10^{-6}	3.5×10^{-5}	5.8×10^{-7}	9.1×10^{-15}	8.8×10^{-5}

Table 3–5. Radionuclides Discharged to the Atmosphere at the Hanford Site, 2010 *(continued)*

Radionuclide	Release Location					
	100 Areas	200-East Area	200-West Area	300 Area	400 Area	Total
	(curies)					
Plutonium-241	1.2×10^{-4}	ND	1.5×10^{-5}	4.3×10^{-7}	NM	1.4×10^{-4}
Americium-241	1.7×10^{-5}	1.4×10^{-7}	3.1×10^{-6}	7.4×10^{-9}	NM	2.0×10^{-5}
Americium-243	NM	NM	NM	1.4×10^{-7}	NM	1.4×10^{-7}
Total releases	**3.2×10^{-4}**	**1.9×10^{-3}**	**9.9×10^{-5}**	**4.4×10^{2}**	**1.8×10^{-3}**	**4.4×10^{2}**

[a] This value includes gross beta release data, treated as strontium-90 in dose calculations.

[b] This value is derived entirely from data on gross beta emissions from 400 Area stacks.

Key: ND=not detected; NM=not measured.

Source: Poston, Duncan, and Dirkes 2011:8.11.

The nearest Prevention of Significant Deterioration (PSD) Class I areas to Hanford are Mount Rainier National Park, 160 kilometers (100 miles) to the west; Goat Rocks Wilderness Area, about 145 kilometers (90 miles) to the west; Mount Adams Wilderness Area, about 153 kilometers (95 miles) to the southwest; and Alpine Lakes Wilderness Area, about 177 kilometers (110 miles) to the northwest (40 CFR 81.434; Ecology 2005; Duncan 2007:4.19). A Class I area is one in which very little increase in pollution is allowed owing to the pristine nature of the area. Hanford and its vicinity are classified as a Class II area, in which more-moderate increases in pollution are allowed. The PUREX [Plutonium-Uranium Extraction] and Uranium Trioxide Plants were issued a PSD permit for nitrogen oxide emissions in 1980. These facilities were permanently shut down in the late 1980s and deactivated in the 1990s. None of the currently operating Hanford facilities have nonradioactive emissions of sufficient magnitude to warrant consideration under PSD regulations (Duncan 2007:4.17). DOE has applied for and received a PSD permit for the WTP, which includes the Pretreatment Facility, HLW Vitrification Facility, LAW Vitrification Facility, six steam-generating boilers, two diesel fire pumps, and three emergency diesel generators (Ecology 2001, 2005; Hibbard 2003). New emission sources may require a PSD increment consumption analysis if they have significant emissions and air quality impacts. The PSD increments are shown in Table 3–6.

Table 3–6. Prevention of Significant Deterioration Increments for the Hanford Site

Emission	Class I Areas	Class II Areas
	(micrograms per cubic meter)	
Sulfur Dioxide		
Annual	2	20
24-hour	5	91
3-hour	25	512
PM_{10}		
Annual	4	17
24-hour	8	30
Nitrogen Dioxide		
Annual	2.5	25

Note: To convert cubic meters to cubic feet, multiply by 35.315.

Key: PM_{10}=particulate matter with an aerodynamic diameter less than or equal to 10 micrometers.

Source: 40 CFR 52.21.

A sitewide air operating permit for Hanford (permit No. 00-05-006) became effective in July 2001 and was renewed in December 2006 (Duncan 2007:6.23) in accordance with Title V of the Clean Air Act and Amendments of 1990, the Federal and state programs under "State Operating Permit Programs" (40 CFR 70), and the *Washington Administrative Code (WAC)* (WAC 173-401). The Hanford Site Air Operating Permit (Ecology 2001, 2006) includes a compilation of requirements for both radioactive emissions covered by the existing state license and nonradioactive emissions. It entails emission and reporting requirements for various sources in the 200 Areas, including oil-fired boilers, large internal-combustion engines, tank exhausters, waste retrieval systems, rotary-mode core sampling systems, tank sluicing, emergency fire pump generators, the 200 Area Effluent Treatment Facility (ETF), tank waste retrieval, tank farm ventilation systems, storage of vented waste containers at the Central Waste Complex (CWC), the Waste Receiving and Processing Facility (WRAP), IDF-East, the Bulk Vitrification Facilities, the WTP, the WTP's Concrete Batch Plant, the T Plant complex, and the Plutonium Finishing Plant. The requirements include a limitation of 0.05 percent sulfur distillate fuel oil for larger boilers in the 200 Areas. The primary effects of the permit are to consolidate approval orders and applicable requirements into one permit, require the permitted party to conduct periodic monitoring to show continuous compliance with permit conditions and applicable requirements, and require biannual reporting and annual certification of continuous compliance. A final PSD permit for the WTP was issued by the Washington State Department of Ecology (Ecology) in November 2003. That permit applies to two HLW melters, two LAW melters, and six boilers and requires the use of ultralow-sulfur (maximum 0.003 percent sulfur) fuel in the boilers, diesel fire pump, and diesel generators (Ecology 2005, 2006; Hibbard 2003). The revised application for this permit indicates that concentrations of the pollutants for which the PSD analysis was required (nitrogen dioxide and PM) would be below significant levels for Class II areas and nearby Class I areas when the required best-available control technology was applied. The maximum contributions to ambient air concentrations from these sources are shown in Table 3–7 (Ecology 2005; Su-Coker and Curn 2003).

Table 3–7. Maximum Waste Treatment Plant Contributions to Ambient Air Concentrations as Analyzed for the Revised Prevention of Significant Deterioration Permit Application

Emission	Class I Areas	Class II Areas
	(micrograms per cubic meter)	
PM_{10}		
Annual	0.0008	0.11
24-hour	0.058	1.93
Nitrogen Dioxide		
Annual	0.00505	0.61

Key: PM_{10}=particulate matter with an aerodynamic diameter less than or equal to 10 micrometers.
Source: Ecology 2005; Su-Coker and Curn 2003.

As determined in 2004 monitoring conducted off site by the Benton County Clean Air Authority, the maximum and annual average concentrations of PM with an aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$) or 10 micrometers (PM_{10}) were below EPA and Washington State standards (Duncan 2007:4.19). Ambient air quality at Hanford is discussed in more detail in the *Hanford Site Environmental Report* (Poston, Duncan, and Dirkes 2011:8.13–8.24). The air operating permit indicates that toxic air pollutants from tank farm activities in the 200 Areas have been demonstrated to be below the acceptable source impact levels and are required to remain below these levels (Ecology 2001, 2006).

Routine monitoring of most nonradioactive pollutants is not conducted at the site. Monitoring of nitrogen oxides and total suspended particulates at Hanford has been discontinued as a result of the phasing out of those programs that required the monitoring. Carbon monoxide, sulfur dioxide, and nitrogen dioxide

have been monitored periodically in communities and commercial areas southeast of Hanford (Duncan 2007:4.19). In 1995, moreover, air samples of semivolatile organic compounds were collected on the site and at an offsite location, and results are discussed in the site's annual environmental report. All concentrations of these compounds were below the applicable risk-based concentrations (Dirkes and Hanf 1996:95–108). Continuous monitoring of PM_{10} and $PM_{2.5}$ was initiated at the Hanford Meteorological Station and the 300 Area in 2001. Values reported for PM_{10} exceeded the 24-hour standard value only once during 2005 on a windy day. The PM monitors involved in this effort are not used to determine compliance with ambient standards (Poston et al. 2006:10.26, 10.27). Ambient monitoring of ammonia and other toxic pollutants is not routinely conducted at Hanford.

Continuous monitoring is performed for radioactive airborne emissions from Hanford activities that have the potential to exceed 1 percent of the 10-millirem-per-year standard for offsite doses specified in the "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (40 CFR 61, Subpart H) and in the state "Ambient Air Quality Standards and Emission Limits for Radionuclides," subsection "Ambient Standard" (WAC 173-480-040). These emissions are primarily from ventilation stacks in the 100, 200, 300, 400, and 600 Areas. Radioactivity in the ambient air is routinely monitored in the area near Hanford. The radiological monitoring network includes downwind air samplers near the sites and facilities and in distant offsite communities. Monitoring in 2010 consistently detected concentrations of uranium-234 and -238 at most of the locations in the 100 Areas, in the 200-East Area, in the 200-West Area, and within the 300 Area. Occasional detection of other radionuclides varied by area: americium-241 and cesium-137 at the 100 Areas and plutonium-239 and -240 at the 100 Areas and the 200-West Area. Average concentrations in near-facility air samples are compared with those in distant communities in the *Hanford Site Environmental Report* (Poston, Duncan, and Dirkes 2011:8.9, 8.10, 8.16, 8.17).

Radionuclides are also regulated under the Washington State "Radiation Protection Standards" (WAC 246-221), which limit the maximum total effective dose equivalent for any member of the public to 100 millirem per year.

3.2.4.2 200 Areas Description

Prevailing winds in the 200 Areas are from the west-northwest to northwest (Duncan 2007:4.8, 4.9). The 200 Areas emit various nonradioactive air pollutants. The sources of criteria and toxic air pollutant emissions in the 200 Areas include generators; tank farm exhausters; evaporators; boilers; vehicles; and construction, environmental remediation, and waste management activities (Hebdon 2003; Johnson 2006; Wisness 2000). The tank farms in the 200 Areas produced reportable ammonia emissions in 2010 (Poston, Duncan, and Dirkes 2011:8.10). Year 2005 emissions for the 200 Areas are included in the sitewide emissions presented in Table 3–4. Emissions from carbon tetrachloride vapor extraction work in the 200-West Area are included in the toxic pollutant emissions shown. Emissions from tank vents other than ammonia and criteria pollutants are included in the composite toxic air pollutants. These emissions include 1,3-butadiene, 2-hexanone, 2-pentanone, acetone, acetonitrile, benzene, heptane, hexane, methyl amyl ketone, nonane, octane, phosphoric acid tributyl ester, and toluene (DOE and Ecology 1996:G-36–G-38).

The primary sources of radioactive emissions to the air from the 200 Areas are the storage and treatment of radioactive waste. In 2010, emissions from the 200 Areas originated from the PUREX Plant, Waste Encapsulation and Storage Facility, Plutonium Finishing Plant, T Plant, underground storage tanks, WRAP, and waste evaporators (Poston, Duncan, and Dirkes 2011:8.10). Radioactive airborne emissions from the 200 Areas in 2010 are summarized in Table 3–5.

The Hanford Site Air Operating Permit (Ecology 2006) includes emission and reporting requirements for various sources in the 200 Areas, including oil-fired boilers, large internal-combustion engines, tank exhausters, waste retrieval systems, rotary-mode core sampling systems, tank sluicing, emergency fire pump generators, the 200 Area ETF, tank waste retrieval, tank farm ventilation systems, storage of vented waste containers at the CWC, and WRAP.

3.2.4.3 400 Area Description

Prevailing winds in the 400 Area are from the south-southwest, with a secondary maximum from the northwest (Duncan 2007:4.9). The 400 Area emits no nonradioactive air pollutants of regulatory concern. Operations and support activities at FFTF and the Maintenance and Storage Facility release small quantities of radioactive material to the environment (Poston, Duncan, and Dirkes 2011:8.10, 8.11).

3.2.4.4 Borrow Area C Description

Prevailing winds in the area around Borrow Area C are likely from the west-northwest to northwest, although farther to the west, under the influence of Yakima Ridge, they are from the west-southwest (Duncan 2007:4.9). There are currently no quarry activities in Borrow Area C that would produce emissions of air pollutants.

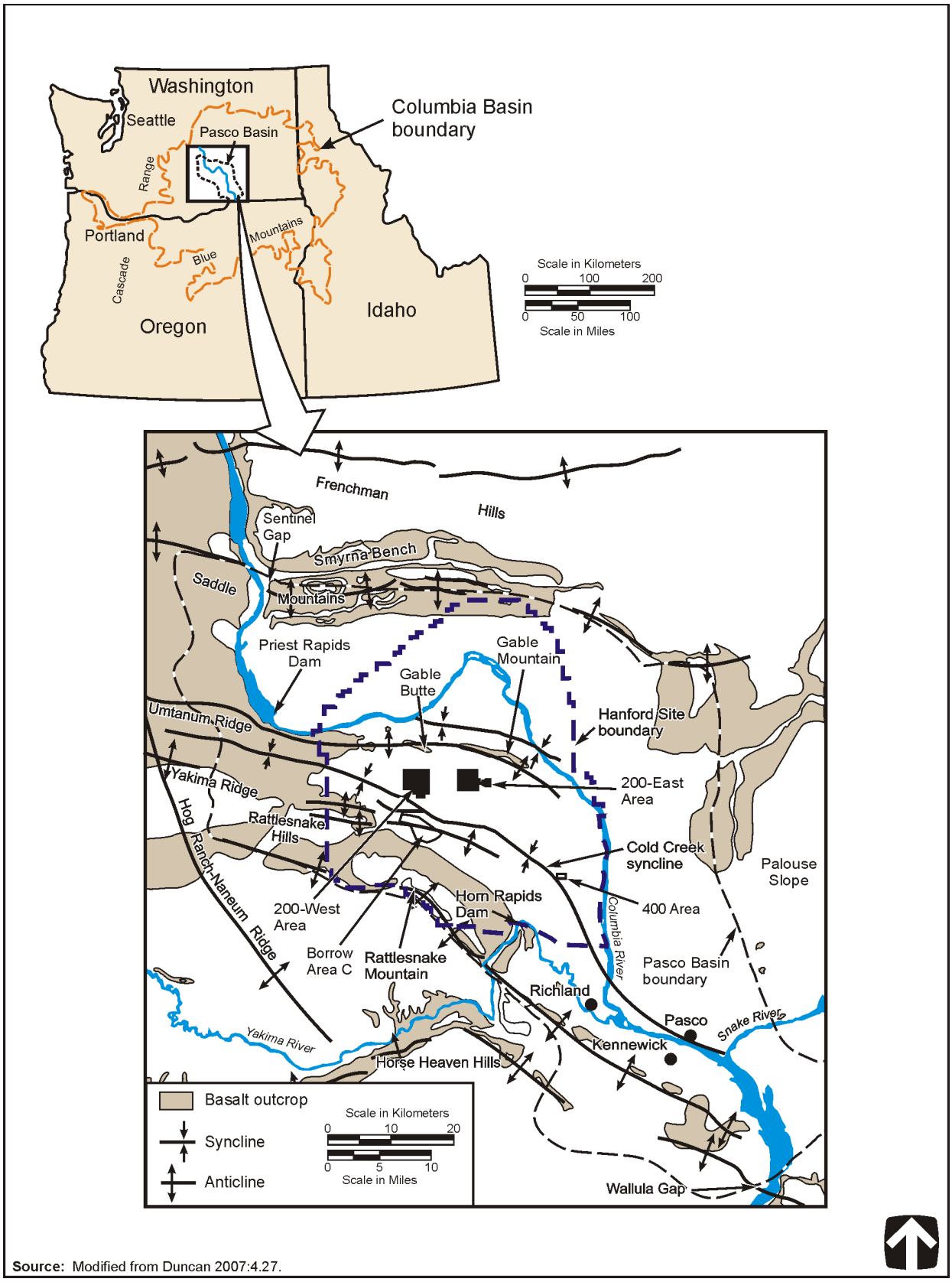
3.2.5 Geology and Soils

The geologic and soil resources of Hanford and the vicinity are described below with respect to regional physiography and geologic structure; site stratigraphy; rock and mineral resources; geologic hazards, including regional seismicity; and soil attributes. The geologic and soil characteristics of the 200 Areas, 400 Area, and Borrow Area C are specifically described.

3.2.5.1 General Site Description

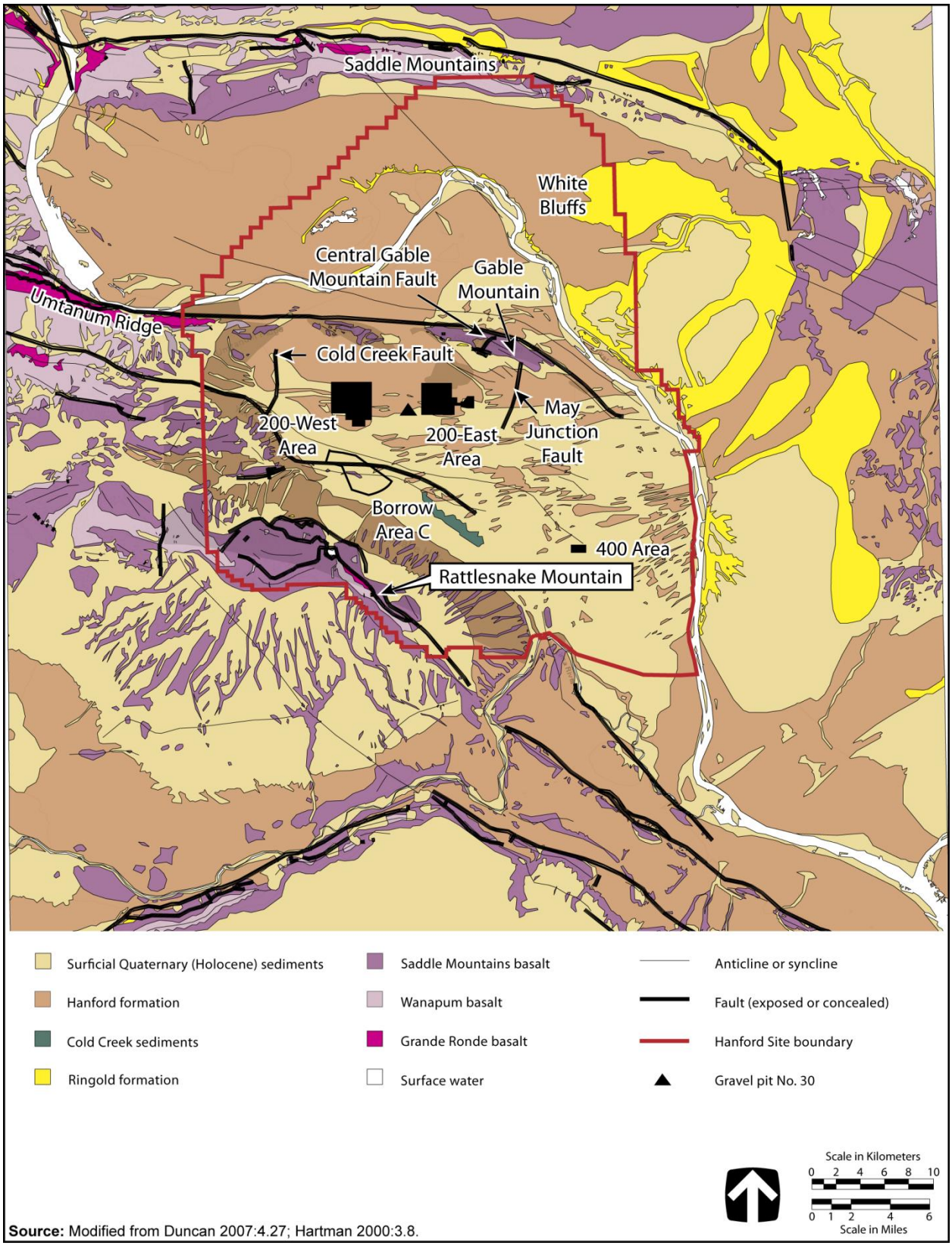
3.2.5.1.1 Physiography and Structural Geology

Hanford lies within the Columbia Basin, which comprises the northern part of the Columbia Plateau physiographic province and the Columbia River flood-basalt geologic province (Duncan 2007:4.25; Reidel et al. 1994:1, 2). Thus, the extent of the Columbia Basin is generally defined as that area underlain by the Columbia River Basalt Group. Within this region, Hanford lies within the Pasco Basin, a structural and topographic depression of generally lower-relief plains and anticlinal ridges (Duncan 2007:4.25, 4.26). Elevations across the central portion of the basin and Hanford range from about 119 meters (390 feet) above mean sea level at the Columbia River to 229 meters (750 feet) above mean sea level across the 200 Areas. The Pasco Basin is bounded on the north by the Saddle Mountains; on the west by Hog Ranch–Naneum Ridge and the eastern extension of Umtanum and Yakima Ridges; on the south by Rattlesnake Mountain and the Rattlesnake Hills; and on the east by the Palouse Slope. Two east-west trending ridges, Gable Butte and Gable Mountain, lie in the central portion of Hanford between the 100 and 200 Areas. These features reflect the eastern extension of Umtanum Ridge into Hanford. Rattlesnake Mountain, the highest of the Rattlesnake Hills, reaches an elevation of 1,060 meters (3,480 feet) above mean sea level, the highest elevation in the area. A geologic fault is typically present on the north side of the folded ridges where the strata fractured as the ridges were folded (see Figures 3–7 and 3–8) (DOE 1999a:4.12, 4.13; Duncan 2007:4.25, 4.26, 4.29, 4.159).



Source: Modified from Duncan 2007:4.27.

Figure 3–7. Physiographic Setting and General Structural Geology of the Pasco Basin and Hanford Site



Source: Modified from Duncan 2007:4.27; Hartman 2000:3.8.

Figure 3–8. Surface Geology and Structural Features of the Pasco Basin and Hanford Site

Several geologic processes, acting over millions of years, have shaped the surface topography of the Columbia Basin and specifically formed the rocks, sediments, and soils found across Hanford. The area was covered with numerous basaltic lava flows (now represented by the Columbia River Basalt Group) between 6 million and 17 million years ago. This was followed by tectonic forces that folded the basalt. In this landscape, the ancestral Columbia River meandered across the area, leaving behind layers of sediment called the Ringold Formation. Beginning as early as 1.8 million years ago and extending through much of the Pleistocene epoch (i.e., until 15,000 years ago), the region was inundated by a series of Ice Age floods that deposited sediments that are informally referred to as the "Hanford formation." During the freezes and thaws that occurred in the Ice Age, an ice dam across the Clark Fork River and glacial Lake Missoula in Montana formed and failed many times, each time releasing a wall of water that surged southwest through the Columbia Basin, inundating the area that is now Hanford. The most recent major glacial flood cycle is thought to have occurred between 15,000 and 30,000 years ago. Fine-grained deposits associated with the last floods commonly contain Mount St. Helens volcanic ash, dated approximately 15,000 years ago (Duncan 2007:4.25, 4.29, 4.30, 4.33, 4.35).

Current interpretations suggest that as many as 40 individual flooding events occurred during the most recent glacial cycle, as ice dams holding back glacial Lake Missoula repeatedly formed and burst. In addition to flood episodes from Lake Missoula, there was also at least one flood from glacial Lake Bonneville in Utah, and possibly floods from other ice-dammed lakes in northern Washington and Idaho. Temporary lakes were created when flood waters were dammed, resulting in the formation of the short-lived glacial Lake Lewis behind Wallula Gap. Evidence for these temporary lakes includes high-water marks inferred from ice-rafted boulders and sediments along the basin margins at elevations between 370 and 385 meters (1,214 to 1,261 feet) above sea level, far above the present Pasco Basin bottom. As the water moved across eastern Washington, it eroded the basalt, forming channels of barren rocky land referred to as the "scablands." At other localities, away from the main flood channels, the water deposited bars of gravel and sand. Branching flood channels, giant current ripples, ice-rafted erratics (i.e., rocks and boulders remaining after the melting of the ice), and giant flood bars are among the landforms created by the floods and readily seen at Hanford (Duncan 2007:4.33; USGS 2002).

Since the end of the Pleistocene epoch, winds have locally reworked the flood sediments, depositing dune sands in the lower elevations and loess (windblown fine sand and silt) around the margins of the Pasco Basin. Anchoring vegetation has stabilized many sand dunes. Active dunes exist north of the 300 Area in the Hanford Reach National Monument. Some dunes were temporarily reactivated by the removal of vegetation resulting from the 24 Command Fire of June–July 2000 (Duncan 2007:4.25, 4.34).

Structurally, Hanford is near the junction of the Yakima Fold Belt and the Palouse Slope. The underlying basalt of the Palouse Slope dips gently toward the central Columbia Basin and exhibits mild structural deformation. A wedge of Columbia River basalt underlies the Palouse Slope (see Figure 3–7) and thins gradually toward the east and north. The Yakima Fold Belt consists of all the generally east-west-trending, long, narrow ridges (anticlines) and intervening valleys (synclines) that arose as tectonic forces buckled and folded the basalt and associated sediments in the western Columbia Basin. The fold belt was growing during the eruption of the Columbia River basalts and continued to grow into the Pleistocene epoch and probably into the present from north-south compression. A fault is typically present on the north side of the ridges where the rock broke as it was folded (Duncan 2007:4.25-4.27, 4.30, 4.35, 4.36).

Mapped faults in the Hanford area include reverse or thrust faults on the north side of the Saddle Mountains on the northern Hanford boundary and in association with Rattlesnake Mountain and the Rattlesnake Hills in the southwestern portion of the site (part of the Rattlesnake-Wallula alignment, which passes along the southwest boundary of Hanford) (see Figure 3–8) (Duncan 2007:4.35, 4.37). Other faults include the Cold Creek Fault, on the west end of the Cold Creek syncline, and the May Junction Fault, located nearly 4.8 kilometers (3 miles) east of the 200-East Area. Moreover, a potential

for Quaternary-age (Holocene) faulting has been identified on the Gable Butte–Gable Mountain Segment of the Umtanum Ridge–Gable Mountain anticline—specifically, on Gable Mountain where the Central Gable Mountain Fault has offset sediments 13,000 years old (Reidel et al. 1994:12-14).

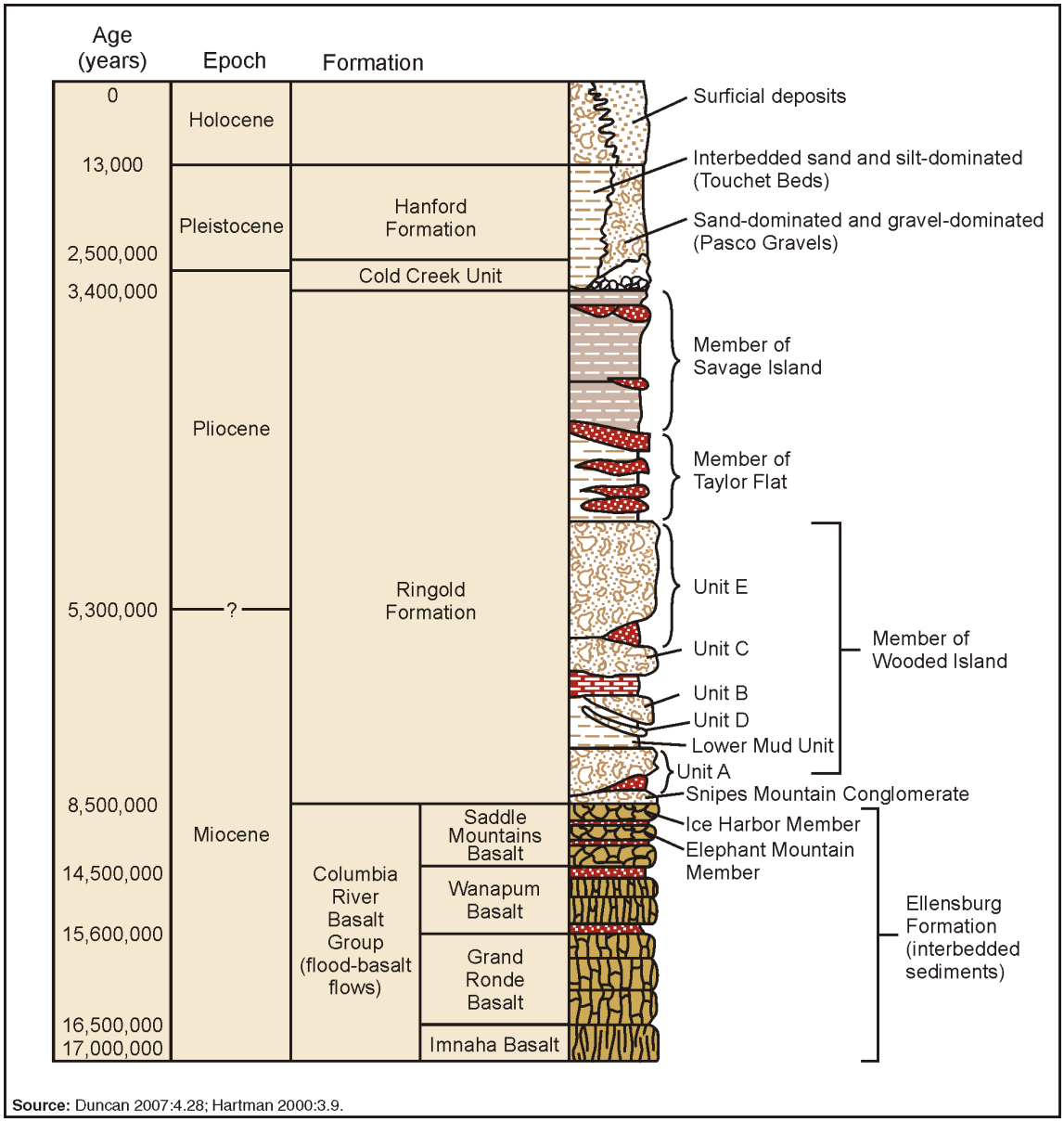
3.2.5.1.2 Stratigraphy

The unconsolidated sediments and rocks beneath Hanford consist of Miocene-age (5 million to 24 million years old) and younger strata that overlie older Cenozoic sedimentary and volcanic basement rocks (DOE 1999a:4-12, 4-16; Duncan 2007:4.26, 4.28). The major geologic units immediately underlying Hanford are, in ascending order, (1) the Columbia River Basalt Group and interbedded Ellensburg Formation and (2) the Ringold Formation, Cold Creek Unit, and Hanford formation, collectively known as the suprabasalt sediments. The surficial occurrence and distribution of these units is shown in Figure 3–8. Figure 3–9 presents a stratigraphic profile of Hanford.

The Columbia River Basalt Group consists of sequences of Miocene-age continental flood basalts that cover an extensive area across Washington, Oregon, and Idaho. These basalts erupted over a period ranging from approximately 6 million to 17 million years ago. Columbia River basalt flows erupted from north-northwest trending fissures or linear vent systems mostly in north-central and northeastern Oregon, eastern Washington, and western Idaho. Beneath Hanford is a minimum of 50 basalt flows with a combined thickness greater than 3,000 meters (9,800 feet). Basalt outcrops are exposed on ridges at Gable Mountain, Gable Butte, and the Saddle Mountains in the northern part of Hanford, and on Rattlesnake Hills and Yakima Ridge on the western and southwestern edges of the site (see Figure 3–7). Basalt flows at Hanford have eroded to various degrees in localized areas. Interbedded with, and in some places overlying the Columbia River Basalt Group, are the volcaniclastic (volcanic-sedimentary) and fluvial (stream-deposited) sedimentary materials of the Ellensburg Formation. In the western Columbia Basin, the Ellensburg Formation is mostly volcaniclastic sediment; in the central and eastern basin, fluvial mainstream and overbank sediments of the ancestral Clearwater-Salmon and Columbia Rivers form the dominant lithologies (Duncan 2007:4.29; Reidel et al. 1994:2-4).

The Ringold Formation consists of a mix of variably cemented gravel, sand, silt, and clay deposited by the ancestral Columbia River system (Duncan 2007:4.31; Hartman 2000:32). Ringold Formation deposits represent an eastward shift of the Columbia River across Hanford. The Columbia River first flowed across the west side of Hanford (where Dry Creek is now), crossing through Rattlesnake Hills. The river eventually shifted to a course that took it through Gable Mountain–Gable Butte Gap (Gable Gap) and south across the present 200-East Area (Hartman 2000:3.2). In summary, about 8.5 million years ago, the river meandered across a gravelly braided plain, depositing the extensive gravel and interbedded sand of the oldest Ringold sediments, Unit A, Member of Wooded Island (see Figure 3–9). Between 5 and 7 million years ago, the Columbia River abandoned the Yakima River water gap (near present-day Benton City) and began to exit the Pasco Basin through Wallula Gap. Around 6.7 million years ago, the Columbia River became a sandy alluvial system, depositing extensive lake and stream overbank sediments known as the Ringold Formation Lower Mud Unit. The Lower Mud Unit was covered by another extensive sequence of mainstream gravels and sands in the central Pasco Basin and fine-grained overbank deposits near the 100 Areas. The most extensive of the coarse sediments, Unit E, Member of Wooded Island, underlies much of the 200 Areas. The Columbia River sediments became more sand-dominated about 5 million years ago when over 90 meters (295 feet) of interbedded fluvial sand and overbank deposits accumulated at Hanford. These deposits are collectively called the Member of Taylor Flat. The fluvial sands of the Member of Taylor Flat dominate the lower cliffs of the White Bluffs but have been subsequently eroded from most of Hanford. The last Ringold unit (Member of Savage Island) was deposited between 3.4 and 4.8 million years ago in the form of lake deposits. A series of three successive lakes are recognized along the White Bluffs and elsewhere along the margin of the Pasco Basin. Then, regional uplift associated with the Cascade Mountains marked a change from sedimental disposition to removal and caused the river to cut through its own earlier deposits (the Ringold

Formation), exposing the White Bluffs (Duncan 2007:4.31). The Ringold Formation at Hanford is as much as 185 meters (607 feet) thick and attains a thickness of about 285 meters (935 feet) along White Bluffs (see Figure 3–8) (Neitzel 2005:4.32; Reidel et al. 1994:3).



Source: Duncan 2007:4.28; Hartman 2000:3.9.

Figure 3–9. Stratigraphic Column of the Hanford Site

The Plio-Pleistocene Cold Creek Unit includes all alluvial and eolian (wind-deposited) sediments, as well as a series of extensively weathered, carbonate-rich, buried soil profiles called paleosols. These sediments and paleosols overlie the Ringold Formation and underlie the Hanford formation in the vicinity of the 200-West Area, and may extend over most of the central Pasco Basin. The Cold Creek Unit, which is also locally prevalent in the subsurface within the Cold Creek syncline, includes deposits referred to in older Hanford literature as the "Plio-Pleistocene Unit" and "pre-Missoula gravels," as well as the 200-West Area's "early Palouse soils" and "caliche layer" (DOE 2002b:3-1, 3-2). Because the Plio-Pleistocene Cold Creek Unit was formed when the Ringold Formation was eroding and relatively little was being deposited, the distribution of the unit depends in part on erosion and weathering of the underlying Ringold Formation and postdepositional erosion by the Ice Age floods. As such, the

Cold Creek Unit is discontinuous, with a thickness ranging from 0 to 20 meters (0 to 66 feet) (Neitzel 2005:4.32). Cold Creek Unit paleosols and small-stream drainages were developing in the 200-West Area while the Columbia River was still eroding the 200-East Area. The paleosols and side-stream sediments, which are referred to as the "Lower Cold Creek Unit," are consequently more numerous and heavily cemented, forming layers known as caliches or hardpans in the 200-West Area. Eolian and minor fine-grained stream sediments were deposited on the Lower Cold Creek Unit, resulting in a wide variety of sediments that are referred to as the "Upper Cold Creek Unit." The thickness and type of sediment are highly variable due to several localized environments. Because of their fine-grained or cemented nature, the Upper and Lower Cold Creek Units play important roles in the movement of water and contaminants through the vadose zone. Cold Creek Unit gravels of mixed lithologies in a sand matrix reflect deposition by the Columbia River as it flowed through Gable Gap. These mainstream gravel deposits, which are informally called the pre-Missoula gravels, immediately overlie the Ringold Formation. They are often difficult to differentiate from similar gravel deposits in the Ringold Formation and Hanford formation (Duncan 2007:4.32, 4.33; Hartman 2000:3.3).

The gravel, sand, and silt deposits composing the strata informally called the Hanford formation are products of Ice Age floods that inundated the Pasco Basin and Hanford during the Pleistocene epoch as previously described in this section. The Hanford formation sediments were left after the floodwater receded and now blanket low-lying areas over most of Hanford. Associated deposits occur in three distinct assemblages, dominated by coarse sand and gravel, sand, and interbedded sand and silt (Duncan 2007:4.33). The sediments range up to boulder size, with the lithofacies (sediment types) grading or interfingering with one another in both the horizontal and vertical directions (DOE 2002b:3-9). The gravel-dominated flood deposits are generally confined to tracts within or adjacent to flood channels and reflect higher-energy depositional environments. A major depositional feature called the Cold Creek bar underlies the 200 Areas at Hanford and was deposited just south of one such channel. Gravel-dominated flood sediments deposited on the north side of the bar grade into sand-dominated sediments on the south side. Gravel- and sand-dominated sediments compose most of the vadose zone beneath Hanford. Coarse- to fine-sand deposits represent a transitional depositional environment between the fluvial gravel-dominated deposits and the interbedded sands and silts. The interbedded sand- and silt-dominated sediments were deposited in low-energy slackwater areas around the margins of the Pasco Basin, and they are rarely encountered during Hanford operations. They specifically consist of rhythmically bedded silt and sand (referred to as "rhythmite deposits") and have been named the "Touchet Beds" at Hanford (see Figure 3–9) (Duncan 2007:4.33; Hartman 2000:3.3).

Clastic dikes are vertical to subvertical tabular structures that crosscut normal sedimentary layers and are usually filled with multiple layers of unconsolidated sediments. They are common in Hanford vadose zone sediments (Duncan 2007:4.34). (See Appendix N, Section N.5.5, for additional information on clastic dikes.)

Surficial Quaternary-age (Holocene) deposits (gravel, sand, and silt), with a total thickness of generally less than 5 meters (16 feet), span much of Hanford. Eolian deposits of fine-grained sand and silt also occur, particularly in the southern part of the 200-East Area and in the 200-West Area (Hartman 2000:3.4). An extensive, stabilized field of sand dunes extends from the southern boundary of the 200-East Area to the south across the 300 Area and east to the Columbia River. An active dune field is located just north of Energy Northwest in Hanford Reach National Monument (DOE 1999a:4-22; Duncan 2007:4.33).

3.2.5.1.3 Rock and Mineral Resources

Geologic resources, including relatively large volumes of gravel, sand, and silt, are available from the suprabasalt sediments and associated soils on Hanford. Basalt is also plentiful. As discussed in the *Environmental Assessment, Use of Existing Borrow Areas, Hanford Site, Richland, Washington*

(DOE 2001b), a number of active gravel and sand pits and two rock quarries at Hanford have been identified for use as a continuing source of borrow materials for new facility construction and the maintenance of existing facilities and transportation corridors, as well as fill and capping material for remediation and other sites. Specifically addressed in the environmental assessment was the provision of an additional 7.6 million cubic meters (10 million cubic yards) of materials over a 10-year period (beginning in fiscal year 2001), including 692,000 cubic meters (905,000 cubic yards) to support WTP project activities.

Of the two designated quarries on the site, Borrow Area C, located due south of the 200-West Area and just south of State Route 240, is described as having large volumes of basalt and sand (DOE 1999a:D-7; 2001b:2-2, 3-1–3-4). Borrow Area C is a 926.3-hectare (2,289-acre) area that would be operated to provide necessary rock riprap (basalt), aggregate (gravel and sand), and soil (silt and loam) to support facility construction and tank closure activities as described in this *TC & WM EIS* (DOE 2003a:5-3, 6-15, 6-21, 6-46, 6-73). This borrow site would be developed using modern open-pit excavation techniques, with excavations averaging 4.6 meters (15 feet) in depth and provision for cut-slope maintenance, haul roads, and stockpile and buffer areas. It is estimated that Borrow Area C could yield 42.6 million cubic meters (55.7 million cubic yards) of borrow material (SAIC 2006b). The other quarry, gravel pit No. 30, located between the 200-East and 200-West Areas, is an approximately 54-hectare (134-acre) borrow site containing a large quantity of aggregate suitable for multiple uses (DOE 2001b:3-4, A-3). Aggregate reserves at pit No. 30 are estimated at 15.3 million cubic meters (20 million cubic yards) of material (DOE 1999a:D-4). This pit continues to provide aggregate (sand and gravel) for onsite concrete batch plants in support of the construction of new facilities, including those at the WTP adjacent to the 200-East Area.

As for other geologic resources on the site, placer gold was historically extracted along the Columbia River on and near Hanford, and small volumes of natural gas were produced from wells developed on Rattlesnake Mountain from about 1929 to 1941 (DOE 1999a:4-18).

3.2.5.1.4 Seismicity and Geologic Hazards

The seismicity of the Columbia Plateau, as determined by the rate of earthquakes per area and the magnitude of these events, is lower than that of other regions in the Pacific Northwest. Nevertheless, Hanford has been affected by earthquakes within and beyond the Columbia Plateau. The largest known earthquake in the Columbia Plateau occurred in 1936 near Milton Freewater, Oregon. This moderate earthquake had a magnitude of 5.75 and a maximum Modified Mercalli Intensity (MMI) of VII, and it featured a number of aftershocks (Duncan 2007:4.43). Appendix F, Table F–7, summarizes and compares the parameters cited in this *TC & WM EIS* to describe earthquakes and their effects. Other moderate-to-major earthquakes with magnitudes greater than 5 or MMIs of VI have occurred along the boundaries of the Columbia Plateau northwest of Hanford and extending into the northern Cascade Range. A strong-to-major earthquake of uncertain location occurred in north-central Washington in 1872. This event had an estimated magnitude of 7.4 and an estimated maximum MMI ranging from VIII to IX (Duncan 2007:4.43; USGS 2003). Evidence of landslides near Lake Chelan, Washington, suggests a location near there. A more recent study of this event indicates a magnitude of 6.8, a maximum MMI of VIII, and a location at the south end of Lake Chelan (Duncan 2007:4.43). Nevertheless, it was reportedly felt over a wide area from British Columbia, Canada, to Oregon and from the Pacific Ocean to Montana. Near Lake Chelan, huge landslides, massive fissures in the ground, and a 9-meter-high (30-foot-high) geyser were reported. Shaking-intensity maps produced for the event indicate that MMI VI shaking extended southeast across the Columbia Plateau and beyond Hanford (USGS 2003).

Major earthquakes have also occurred east of the Columbia Plateau in the Rocky Mountains. These include the 1959 Hebgen Lake earthquake in western Montana, which had a magnitude of 7.5 and an MMI of X, and the 1983 Borah Peak earthquake in central Idaho, which had a magnitude of 7.3 and an

MMI of IX. A number of strong-to-major earthquakes (magnitude 6 to greater than 7) have occurred in western Washington in and around the Puget Sound area in association with the subducting Juan de Fuca tectonic plate. Most recently, a magnitude-6.8 earthquake (termed the "Nisqually earthquake") occurred on February 28, 2001, near Olympia, Washington. It produced ground shaking that reached an MMI of VIII. This event was similar to other events recorded in 1949 and 1965 (Duncan 2007:4.42, 4.43).

The two largest earthquakes near Hanford occurred in 1918 and 1973; each had an approximate magnitude of 4.4 and an MMI of V. They occurred in the central portion of the Columbia Plateau north of Hanford near Othello, Washington (Duncan 2007:4.43). The epicenter of the December 20, 1973, event was instrumentally located approximately 49 kilometers (30 miles) northeast of the 200 Areas. This earthquake occurred at a rather shallow depth of about 1 kilometer (0.6 miles) (USGS 2010a). Earthquakes in eastern Washington generally originate at shallow depths, most at depths of less than 6 kilometers (3.7 miles). The Saddle Mountains region in which the December 20, 1973, earthquake occurred is one of the most active earthquake areas in eastern Washington; earthquakes there tend to occur in clusters or "swarms" (i.e., the earthquakes are concentrated in an area and occur in a series over a short period of time) (Noson, Qamar, and Thorsen 1988). Earthquake swarms have also occurred in several locations within Hanford. Deeper earthquakes in the central Columbia Plateau occur up to depths of about 30 kilometers (18.6 miles). These deeper earthquakes are less clustered and generally occur as isolated events. Survey data indicate that the shallow earthquake swarms are occurring in the Columbia River Basalts and the deeper earthquakes in deeper, crustal layers (Duncan 2007:4.43, 4.45). A total of 126 small earthquakes (generally ranging in magnitude from 2.5 to 4.3) have been recorded within a radius of 100 kilometers (62 miles) of the Central Plateau of Hanford (200 Areas) since the December 1973 earthquake. The closest of these was a magnitude-3.3 event on November 13, 1994; it had an epicenter about 4 kilometers (2.5 miles) north of the 200 Areas (USGS 2010a).

As part of the operating license review for Energy Northwest, the U.S. Nuclear Regulatory Commission (NRC) concluded that four Hanford earthquake sources should be considered for seismic design: the Rattlesnake-Wallula alignment, Gable Mountain, a "floating" earthquake in the tectonic province, and a swarm area. The NRC estimated a maximum earthquake magnitude of 6.5 for the Rattlesnake-Wallula alignment and 5.0 for Gable Mountain. The floating-earthquake design criterion was developed from the largest event located in the Columbia Plateau, the magnitude-5.75 Milton-Freewater earthquake. The maximum-swarm earthquake for the purposes of seismic design was a magnitude-4.0 event based on the December 1973 earthquake (Duncan 2007:4.45, 4.46).

Earthquake-produced ground motion is expressed in units of percent *g* (force of acceleration relative to that of the Earth's gravity). Two differing measures of this motion are peak horizontal (ground) acceleration and response spectral acceleration. Seismic hazard metrics and maps developed by the U.S. Geological Survey (USGS) and adapted for use in the *International Building Code* depict maximum considered earthquake ground motions of 0.2- and 1.0-second spectral accelerations based on a 2 percent probability of exceedance in 50 years. This corresponds to an annual probability (chance) of occurrence of about 1 in 2,500. Appendix F, Section F.5.2, of this *TC & WM EIS* provides a more detailed explanation of these map parameters and their use. For the 200 Areas, the calculated maximum considered earthquake ground motion is approximately 0.41 *g* for a 0.2-second spectral acceleration and 0.15 *g* for a 1.0-second spectral acceleration. The calculated peak ground acceleration for the given probability of exceedance at the site is approximately 0.18 *g* (USGS 2008). For comparison, the aforementioned 2001 Nisqually earthquake produced peak horizontal (ground) accelerations ranging from 0.0016 to 0.0055 *g*, as measured across Hanford (Duncan 2007:4.43). The USGS earthquake ground motion values are cited to provide the reader with a general understanding of seismic hazard. However, for the design of moderate- or high-hazard nuclear facilities, DOE prescribes seismic criteria that are more rigorous and thus provide a greater margin of safety than the values cited here (see Appendix F, Section F.5.2).

Probabilistic seismic hazard analyses are used to determine ground motions expected from multiple earthquake sources, which are then used to design or evaluate facilities at Hanford. On the basis of the most recent site-specific seismic analyses, it is estimated that an earthquake producing a horizontal (ground) acceleration of 0.10 *g* at Hanford would be experienced on average every 500 years (annual probability of occurrence of 1 in 500). An earthquake producing a peak horizontal (ground) acceleration of 0.2 *g* is calculated to have an annual probability of occurrence of 1 in 2,500, which is in approximate agreement with the national seismic hazard maps produced by USGS (Duncan 2007:4.46). As stated in DOE Order 420.1B, Change 1, DOE requires nuclear and nonnuclear facilities to be designed, constructed, and operated so that the public, workers, and environment are protected from adverse impacts of natural phenomena hazards, including earthquakes. A site-specific ground response model developed for the WTP being constructed at Hanford stipulated increased ground motions for the design basis of this facility by up to 40 percent to be more conservative (Duncan 2007:4.46).

Several major volcanoes are in the Cascade Range west of Hanford, including Mount Adams and Mount St. Helens, 165 kilometers (102 miles) and 220 kilometers (137 miles), respectively, from the site. Ashfalls from at least three Cascade volcanoes have blanketed the central Columbia Plateau since the late Pleistocene epoch. Generally, ashfall layers have not exceeded more than a few centimeters (less than 1.5 inches) in thickness, except for the Mount Mazama (Crater Lake, Oregon) eruption, when as much as 10 centimeters (3.9 inches) of ash fell over eastern Washington (Barghusen and Feit 1995:2.2–2.14).

Slope failure is also a potential concern at Hanford, although only the slopes of Gable Mountain and White Bluffs are steep enough to warrant landslide concern. White Bluffs, east of the Columbia River, poses the greatest concern. This risk is in part attributable to the largely unconsolidated and uncemented nature of the Ringold sediments composing much of the bluffs, the discharge of irrigation water atop the bluffs and subsequent percolation thereof through the sediments, and the general dip of the sediments toward the Columbia River (DOE 1999a:4-18, 4-21; Duncan 2007:4.39, 4.40).

3.2.5.1.5 Soils

Fifteen different soil types occur at Hanford. These soils vary from sand to silty and sandy loam. The dominant soil types are Quincy (Rupert) sand, Burbank loamy sand, Ephrata sandy loam, and Warden silt loam (Duncan 2007:4.39, 4.40). No soils at Hanford are currently classified as prime or unique farmland soils because there are no current soil surveys, and the only prime or unique farmland soils in the region are irrigated (DOE 1999a:4-23, 4-24). The parent material for the predominant soil types at Hanford includes Hanford formation and Holocene-age surficial deposits, as discussed Section 3.2.5.1.2. Quincy (Rupert) sand is the most widespread soil type at Hanford and makes up much of the southeast and east-central portions of the site. However, it is also found across portions of the 200-East Area and the majority of the western portion of the 200-West Area. It developed from sandy alluvial deposits mantled by windblown sand. The soils are deep to moderately deep—51 to 76 centimeters (20 to 30 inches). Burbank loamy sand occurs mainly north of the 200 Areas and south of the Columbia River, along with Ephrata sandy loam. The Burbank soil is moderately deep overall, but grades to a gravelly subsoil. The surface soil may be up to 76 centimeters (30 inches) thick, with the subsoil containing up to 80 percent gravel. While this soil intermingles with Quincy (Rupert) sand and Ephrata sandy loam in the 200-East Area, it composes the balance (eastern portion) of the 200-West Area. Warden silt loam occurs in a broad band in the south and southwestern portions of the site, running from the south boundary of the site and downslope of Rattlesnake Mountain (DOE 1999a:4-23–4-27; Duncan 2007:4.40–4.42).

3.2.5.2 200 Areas Description

The Central Gable Mountain Fault is the nearest potentially active fault to the 200 Areas; it is 4 kilometers (2.5 miles) northeast of the 200-East Area (see Figure 3–8). The geology of the 200-West Area is notably different from that of the 200-East Area, despite the fact that they are separated by a distance of only 6.4 kilometers (4 miles). The 200-West Area has one of the most complete suprabasalt stratigraphic sections on Hanford, including the Cold Creek Unit, with a stratigraphic thickness of up to 168 meters (550 feet) (Hartman 2000:3.11).

The Hanford formation is the main geologic unit at the surface for both the 200-East Area and 200-West Area. The Hanford formation is thickest in the vicinity of the 200-East Area, where it is over 100 meters (330 feet) thick. Gravel-dominated sediments make up most of the Hanford formation in the northern part of the 200-East Area and across the 200-West Area. Also in the northern part of the 200-East Area, the Hanford formation generally rests directly on basalt, and an erosional window through the Elephant Mountain Member is suspected near the northeast corner of the 200-East Area. Regardless, gravel-dominated Hanford sediments were deposited by high-energy water in or immediately adjacent to the main cataclysmic flood channels. The sand-dominated sediments are most common in the central to southern parts of the 200 Areas and were deposited adjacent to the main flood channels during the waning stages of flooding. Finer rhythmite deposits (also called Touchet Beds) are primarily found south and west of the 200 Areas (Duncan 2007:4.38, 4.39).

The Cold Creek Unit in the 200-East Area may be represented by the mainstream pre-Missoula gravels. Beneath some of the 200-East Area tank farms, two suspected Cold Creek Unit sediment types have been encountered between the Hanford formation and underlying Columbia River Basalt that include fine-grained silt up to 10 meters (33 feet) thick and sandy gravel to gravelly sand. Beneath the 200-West Area, the Cold Creek Unit overlies the tilted and eroded Ringold Formation where both the lower and upper portions of the unit have been identified. The Lower Cold Creek Unit mainly consists of basaltic to quartzitic gravels, sands, silt, and clay that are cemented with one or more layers of calcium carbonate and other assemblages. The Upper Cold Creek Unit primarily consists of a distinctive silt-rich interval representing eolian deposits in the 200-West Area. Locally, interbedded layers of fine sand and silt, more characteristic of stream deposits, are found with the eolian deposits. The silt-dominated deposits can be correlated across most of the 200-West Area (Duncan 2007:4.38, 4.39).

Sediments of the Ringold Formation are generally not present across much of the northern part of the 200-East Area, while some units are present in the southern part. The Lower Mud Unit is present under much of Hanford and is a nearly continuous feature beneath the 200-West Area and the southern half of the 200-East Area. The Lower Mud Unit consists primarily of lake bed silt and clay deposits, with at least one well-developed paleosol at the top of the sequence in the 200-West Area. Where present, the Lower Mud Unit forms the base of the unconfined aquifer at Hanford and acts as an aquitard, separating groundwater in the underlying Ringold Unit A from the unconfined aquifer (Duncan 2007:4.31, 4.38).

Unit E of the Member of Wooded Island is by far the thickest of the Ringold Formation units present beneath the 200 Areas and consists of well-rounded gravel in a sand and silt matrix. Erosion by the Columbia River during Cold Creek Unit deposition and flooding during Hanford formation deposition have removed Unit E from most of the northeastern part of the 200-East Area. The Ringold Formation Member of Taylor Flat consists of a sequence of fluvial sands and overbank deposits. Erosional remnants of the Member of Taylor Flat are found beneath parts of the 200-West Area, but it has been eroded from beneath all of the 200-East Area (Duncan 2007:4.38). As described in Section 3.2.5.1.5, the predominant soil types across the 200 Areas developed from the surficial sediments are Quincy (Rupert) sand and Burbank loamy sand.

3.2.5.3 400 Area Description

The nearest potentially active fault to the 400 Area (Central Gable Mountain Fault) is 19 kilometers (12 miles) away (see Figure 3–8). Surficial stratigraphy in the 400 Area consists of sand-dominated sediments of the Hanford formation, which attain a thickness of about 37 to 55 meters (120 to 180 feet) beneath the area. These glaciofluvial sediments are specifically composed of poorly graded, fine-to-medium, dense sands that are locally silty and gravelly. The sands grade downward to dense gravelly sands. Reworked gravelly sands and the sandy gravel of the Ringold Formation immediately underlie the Hanford formation sediments, which transition into silty sand, silts, and clays. Ringold Formation sediments extend to a depth of 181 meters (594 feet) beneath the 400 Area, where they contact the Elephant Mountain Member of the Saddle Mountain Basalt Formation. Eolian deposits overlie the Hanford formation sediments across the 400 Area. These deposits consist of 1.5 to 4.6 meters (5 to 15 feet) of fine-to-medium sand dunes that have been stabilized by sagebrush and grasses (WHC 1992:30–33). The predominant soil type in the 400 Area is Quincy (Rupert) sand (DOE 1999a:4.25; Duncan 2007:4.40).

3.2.5.4 Borrow Area C Description

The surficial geology of Borrow Area C is mainly dominated by the gravelly, sandy, and silty Quaternary-age sediments that cover much of the southern half of Hanford. The deposits also include even younger alluvium deposited by the Cold Creek drainage that traverses Borrow Area C. Pockets of older Hanford formation sediments and of Saddle Mountain Basalt also occur at the surface, and at depth, across the area (see Figure 3–8). This assemblage of fine- to coarse-grained sediments and basalt provides a wide range of borrow materials for multiple uses as described in Section 3.2.5.1.3. Mapped soils across Borrow Area C mainly include the Hezel sand interlaced with Esquatzel silt loam. Hezel sand is similar to Quincy (Rupert) sand. Hezel sand soils developed in wind-blown sands that mantled lake-laid sediment. Esquatzel silt loam is a deep soil that formed in recent alluvium derived from loess and lake sediment (Duncan 2007:4.40–4.42).

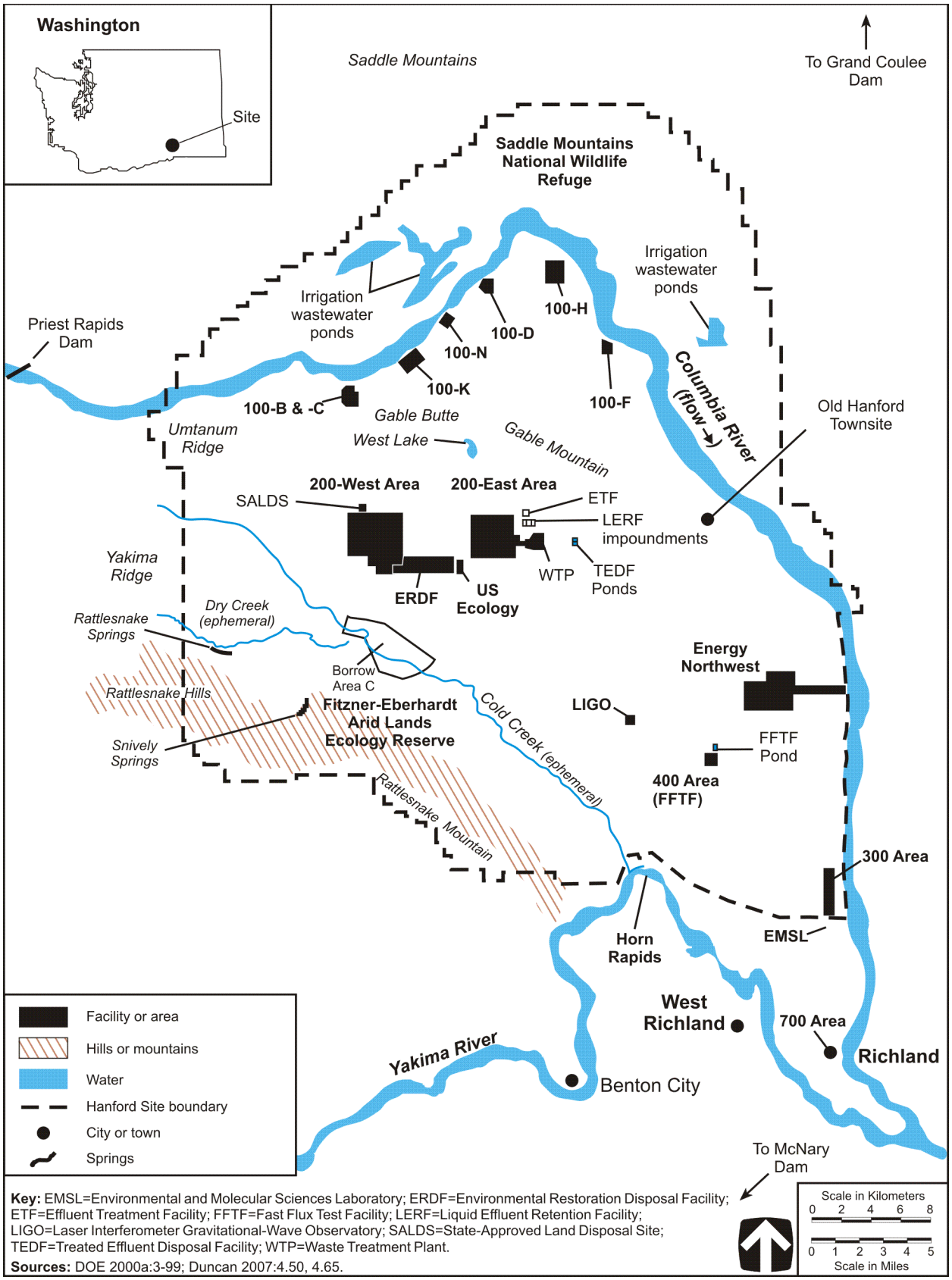
3.2.6 Water Resources

Water resources include all forms of surface water and groundwater, as well as the content of the so-called vadose zone. Surface water is defined as all water bodies that occur above the ground surface, including rivers, streams, lakes, and ponds, and other features. The vadose zone is the unsaturated or partially saturated region between the ground surface and the groundwater-saturated zone (the top of the water table). Groundwater refers to water within the saturated zone—i.e., water that, as at Hanford, typically originates as natural recharge from rain and snowmelt or artificially as recharge from activities such as irrigation, industrial processing, and wastewater disposal, and water destined to return to the surface through discharge to springs and seepage into rivers and streams, evaporation from shallow water table areas, or human activity involving wells or excavations.

3.2.6.1 Surface Water

3.2.6.1.1 General Site Description

Major surface-water features at Hanford include the Columbia River; Columbia riverbank seepage; springs; and ponds, including those constructed for effluent management (see Figure 3–10). In addition, the Yakima River flows along a short section of the southern boundary of the site. The Columbia River is the second-largest river in the contiguous United States in terms of total flow and the dominant surface-water feature on the site. Flow of the Columbia River is regulated by several dams, seven upstream and four downstream from the site. The nearest dam upstream from Hanford is the Priest Rapids Dam, and the nearest one downstream is the McNary Dam (Duncan 2007:4.49).



Key: EMSL=Environmental and Molecular Sciences Laboratory; ERDF=Environmental Restoration Disposal Facility; ETF=Effluent Treatment Facility; FFTF=Fast Flux Test Facility; LERF=Liquid Effluent Retention Facility; LIGO=Laser Interferometer Gravitational-Wave Observatory; SALDS=State-Approved Land Disposal Site; TEDF=Treated Effluent Disposal Facility; WTP=Waste Treatment Plant.

Sources: DOE 2000a:3-99; Duncan 2007:4.50, 4.65.

Figure 3–10. Major Surface-Water Features on the Hanford Site

The 82-kilometer (51-mile) Hanford Reach, which is the last free-flowing, nontidal section of the river in the United States, extends from the Priest Rapids Dam to the upstream edge of Lake Wallula behind the McNary Dam. Because the flows are regulated, flow rates in the Hanford Reach can vary considerably. Columbia River flow rates near the Priest Rapids Dam during the 90-year period from 1917 to 2007 averaged nearly 3,330 cubic meters (117,600 cubic feet) per second; however, daily average flows during this period ranged from 570 to 19,500 cubic meters (20,100 to 689,000 cubic feet) per second (Duncan 2007:4.49, 4.51). In 2010, the Columbia River had below-normal flows; the average daily flow rate downstream of Priest Rapids Dam was 2,670 cubic meters (94,200 cubic feet) per second. Columbia River flows typically peak from April through June during spring runoff from snowmelt and are lowest from September through October. As a result of daily fluctuations in discharges from the Priest Rapids Dam, the depth of the river varies widely over a short time period, with stage changes of up to 3 meters (10 feet) during a 24-hour period along the Hanford Reach. The width of the river varies from approximately 300 to 1,000 meters (980 to 3,300 feet) along the Hanford Reach. This variation also occurs with changes in flow rate, which cause repeated wetting and drying of an area along the shoreline (Duncan 2007:4.51; Poston, Duncan, and Dirkes 2011:8.27–8.29).

Primary uses of the Columbia River include hydroelectric power generation, irrigation of crops in the Columbia Basin, and materials transport by barge. The Hanford Reach is the upstream navigable limit of barge traffic. Barges are used to transport reactor vessels from decommissioned nuclear vessels to Hanford for disposal. The Columbia River is also used extensively for recreation, including fishing, hunting, boating, sailboarding, water skiing, diving, and swimming. In addition to its use as a water supply source for Hanford, the river is a source of drinking water for several communities (Duncan 2007:4.52).

Ecology has designated that segment of the Columbia River extending from the Grand Coulee Dam to the Washington Oregon border, and encompassing the Hanford Reach, for the following uses: salmon and trout spawning and rearing; primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting, commerce, and navigation; boating; and aesthetic values (WAC 173-201A).

No federally designated wild and scenic rivers exist in the Hanford vicinity. In 1996, the National Park Service proposed designation of the Hanford Reach as a “recreational river” under the National Wild and Scenic Rivers System as part of broader resource conservation initiatives (DOE 1999a:4-5). The Hanford Reach was proclaimed a national monument in 2000 (see Section 3.2.1.1.1). Creation of the national monument did not convey with it full protection of the river’s eligibility as a wild and scenic river. Section 404 of the Omnibus Parks and Public Lands Management Act of 1996 (P.L. 104-333) amended the original study legislation (P.L. 100-605) to mandate that no Federal agency may construct any dam, channel, or navigation project. Under the Wild and Scenic Rivers Act and U.S. Department of the Interior practices, USFWS manages the river as if it were a wild and scenic river and will take no actions that would change its status. This protection only partially extends to other Federal agencies. Those agencies are obliged to take all reasonable care to protect the river’s free flow and “outstandingly remarkable resources” as defined by the Wild and Scenic Rivers Act, but they are not obliged to forego projects if no reasonable alternative exists (USFWS 2008:3-2012).

DOE continues to assert a federally reserved water withdrawal right for the Columbia River (DOE 1999a:4-49, 4-50). In fiscal year 2006, total sitewide water consumption was about 817 million liters (215.7 million gallons). Ten of the 11 DOE-owned, contractor-operated water treatment and distribution systems, as well as the City of Richland system that serves the 300 Area, use water pumped from the Columbia River. The 400 Area continued to use a groundwater supply well in 2009 (see Section 3.2.2.4).

Rattlesnake Springs and Snively Springs are in the western portion of the site and flow into intermittent streams that infiltrate rapidly into the surface sediments (see Figure 3–10). Water discharged from Rattlesnake Springs flows down Dry Creek, a tributary to Cold Creek, for about 3 kilometers (1.9 miles) before infiltrating into the ground. An alkaline spring has been documented at the east end of Umtanum Ridge. Several springs are also found on the slopes of Rattlesnake Mountain along the western and southwestern edges of the site. The seepage of groundwater into the Columbia River was documented along the Hanford Reach long before Hanford operations began. This seepage occurs both below the river surface and on the exposed riverbank. Seepage flows are rather small and intermittent, influenced primarily by changes in the river level. Contaminants originating at Hanford have been documented in some of these discharges along the Hanford Reach (DOE 1999a:4-29–4-32; Duncan 2007:4.55, 4:56).

Other naturally occurring surface-water features at Hanford include West Lake and, in three clusters, approximately 20 vernal ponds or pools. The clusters are located on the eastern end of Umtanum Ridge, in the central part of Gable Butte, and at the eastern end of Gable Mountain. The ponds appear to form during the wetter winter periods in shallow depressions underlain by a layer of basalt (DOE 1999a:4-31, 4-32; Duncan 2007:4.64).

West Lake is a natural pond located north of the 200 Areas that is sustained by limited groundwater discharge in a topographic depression. Historically, the lake benefited from an artificially elevated water table beneath much of Hanford attributable to waste management activities in the 200 Areas. With the cessation of production activities at Hanford, the amount of water discharged to the ground in the 200 Area plateau has substantially decreased. Accordingly, over the past 10 years, West Lake has decreased in size to the point that it currently consists of a group of small isolated pools and mudflats. Artificial ponds primarily associated with waste management activities also exist on the site. These include two Treated Effluent Disposal Facility (TEDF) disposal ponds, three Liquid Effluent Retention Facility (LERF) impoundments adjacent to the 200-East Area, and the FFTF Ponds in the 400 Area that are used by FFTF and other facilities (see Figure 3–10) (Duncan 2007:4.50, 4.64; Poston, Duncan, and Dirkes 2011:6.23, 6.24, 8.40). In addition, there are irrigation ponds and wetlands in the northwest portion of the site and north of the Columbia River (Duncan 2007:4.50, 4.73).

Hanford has one EPA-issued National Pollutant Discharge Elimination System (NPDES) Permit—No. WA-002591-7. This permit covers two active outfalls in the 100-K Area. CH2M HILL Plateau Remediation Company is the holder of this permit. The outfall for the 300 Area TEDF was removed from the permit during 2009 because the facility was shut down (Poston, Duncan, and Dirkes 2011:5.25, D.2). CH2M HILL Plateau Remediation Company held an NPDES Construction General Permit in early 2010 that began on June 3, 2009. This permit established the terms and conditions under which stormwater discharges associated with construction activity were authorized. CH2M HILL Plateau Remediation Company filed a notice of termination for its coverage under this permit on March 18, 2010. Discharges from the TEDF Ponds, ETF, and LERF in the 200-East Area; the FFTF Ponds; the 100-N Area sewage lagoon; and consolidated industrial activities are covered by state waste discharge permits issued by Ecology. Ecology-issued NPDES general permits for mining activities are also in place, including a General Sand and Gravel permit for operation of the Concrete Batch Plant and for gravel pit No. 30, located between the 200-East and 200-West Areas. There were four permit violations during 2010. Numerous sanitary waste discharges to the ground from sanitary systems serving facility personnel in the 100 and 200 Areas are permitted by the Washington State Department of Health. Sanitary waste discharges from the 400 Area are conveyed to Energy Northwest's treatment facility. Sanitary waste from the 300 Area and from other facilities in and north of Richland discharges to the City of Richland wastewater treatment facility. Wastewater from the Environmental Molecular Sciences Laboratory, located in the Richland North Area, also discharges to the city's wastewater treatment facility under pretreatment permit No. CR-IU005. This permit was most recently reissued in 2001 (Poston, Duncan, and Dirkes 2011:5.25, 5.26, D.2).

During 2010, Columbia River samples were collected and analyzed to compile data on radiological, chemical, and physical water quality parameters. Water samples were collected from fixed monitoring stations at the Priest Rapids Dam and Richland, Washington, and from cross-river transects and nearshore locations. Samples were also collected upstream from Hanford facilities at the Priest Rapids Dam and the Vernita Bridge to provide background data from locations unaffected by site operations, as well as from other locations to identify any increase in contaminant concentrations attributable to such operations. During the 2010 study, tritium, uranium-234 and -238, and naturally occurring beryllium-7 and potassium-40 were consistently measured in river water at levels greater than their reported minimum detectable concentrations. Concentrations of all other radionuclides were typically below the minimum detectable concentrations. Most of these radionuclides derive from worldwide fallout from historical nuclear weapons testing and effluent from Hanford facilities. Tritium and uranium occur naturally in the environment, in addition to being present in Hanford effluent. Nevertheless, all radioactive contaminant concentrations measured in the Columbia River in 2010 were lower than applicable DOE-derived concentration guides for ingested water (DOE Order 458.1, Change 2) and Washington State ambient surface-water-quality criteria. During 2010, there was no indication of any deterioration of Columbia River water or sediment quality resulting from operations at Hanford (Poston, Duncan, and Dirkes 2011:xv, 8.32, 8.37, C.9–C.12).

DOE also conducts sampling of groundwater seeps (also referred to as "riverbank springs") along the Columbia River nearshore during periods of low flow. Water samples were collected from eight shoreline spring areas in 2010. The majority of samples were analyzed for gamma-emitting radionuclides, gross alpha and gross beta concentrations, and tritium. Samples from selected springs were analyzed for strontium-90; technetium-99; and uranium-234, -235, and -238. Most samples were also analyzed for metals and anions, and selected samples for volatile organic compounds as well. Contaminants of Hanford origin continued to be detected in water from shoreline springs entering the Columbia River in 2010; included were gross alpha; gross beta; tritium; strontium-90; technetium-99; and uranium-234, -235, and -238. Concentrations of radionuclides in shoreline springwater have varied over the years with changes in the degree of river water and groundwater mixing (i.e., the bank storage effect). All radioactive contaminant concentrations measured in riverbank springs in 2010 were lower than the applicable DOE-derived concentration guides, although other exceedances were observed. Gross alpha activity exceeded the ambient surface-water quality and EPA maximum contaminant level (MCL) of 8.2 picocuries per liter in riverbank springwater at the 300 Area, with a maximum value of 86 ± 11 picocuries per liter. Total uranium levels exceeded the EPA primary drinking water standard of 30 micrograms per liter (equivalent to 27 picocuries per liter) in 300 Area springwater, with a maximum total uranium concentration of 107 ± 10.6 micrograms per liter (71 ± 10 picocuries per liter). This chemical toxicity standard, which became effective December 8, 2003, is deemed more protective of human health than the radiation dose standard (65 FR 76708). Elevated uranium concentrations exist in the unconfined aquifer beneath the 300 Area as a result of past Hanford operations. The gross alpha and gross beta concentrations observed in 300 Area riverbank springwater parallel those of uranium and are likely associated with its presence. In 2010, the maximum observed tritium concentration was 37,000 ± 7,200 picocuries per liter at the Old Hanford Townsite riverbank spring as compared with the ambient surface-water-quality criterion of 20,000 picocuries per liter (Poston, Duncan, and Dirkes 2011:8.46–8.50, D.6).

Concentrations of almost all nonradioactive contaminants measured in riverbank springs on the Hanford shoreline from 2005 through 2010 were below the applicable Washington State ambient surface-water-quality criteria. The only exception was chromium, whose concentrations in springwater in the 100-B, -K, -N, -D, -H, and -F Areas were above state ambient surface-water acute-toxicity levels. Volatile organic compounds were near or below detection limits for most samples (Poston, Duncan, and Dirkes 2011:8.50).

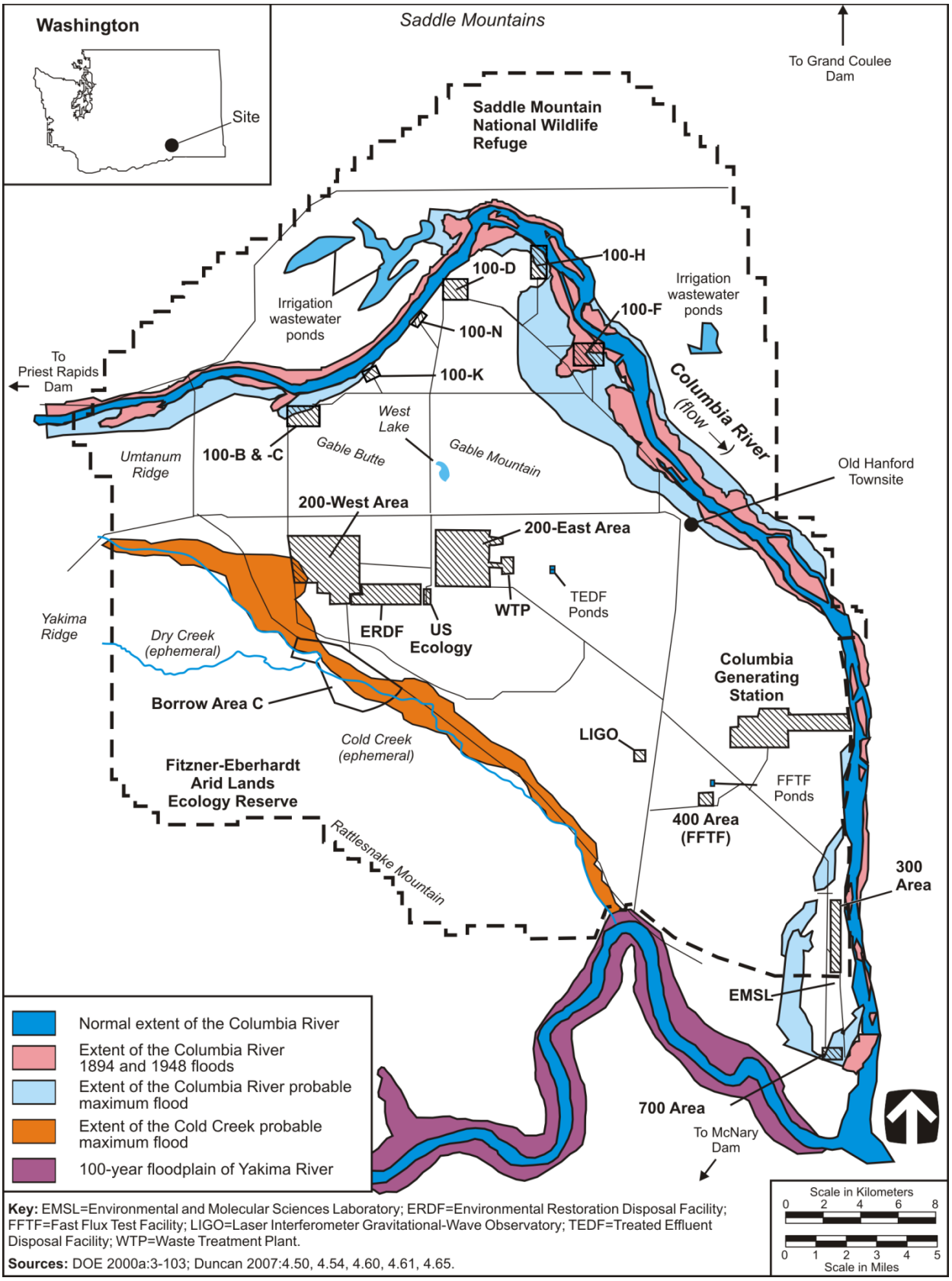
West Lake and the FFTF Ponds were sampled periodically during 2010 for water quality. The ponds remained inaccessible to the public and, therefore, did not constitute a direct offsite environmental impact during 2010. However, they were accessible to migratory waterfowl and deer, creating a potential biological pathway for the dispersion of contaminants, and they are near facilities undergoing remediation. Grab samples were collected quarterly from the FFTF Ponds (water) and from West Lake (water and sediment). All water samples were analyzed for tritium. Water samples from the FFTF Ponds were also analyzed for gross alpha and gross beta concentrations, as well as gamma-emitting radionuclides. All radionuclide concentrations in onsite pond water samples were lower than applicable values in the DOE-derived concentration guides (DOE Order 458.1, Change 2) and the Washington State ambient surface-water-quality criteria. The median tritium concentration in FFTF Pond water during 2010 was 33 percent of the Washington State ambient surface-water-quality criterion of 20,000 picocuries per liter. The sources of contaminants in the pond water are groundwater contaminant plumes from the 200 Areas that have migrated to water supply wells near the 400 Area. Tritium concentrations in West Lake water during 2010 were similar to those observed in the past. All results for 2010 were below the laboratory-reported detection limits (Poston, Duncan, and Dirkes 2011:8.40–8.42).

Flooding of the site has occurred along the Columbia River, but the likelihood of a recurrence of large-scale flooding has been greatly reduced by the upstream construction of several flood control/water storage dams. Major floods are typically due to melting of the winter snowpack combined with above-normal precipitation. No maps of flood-prone areas have been produced by the Federal Emergency Management Agency, as these maps are produced only for areas that could be developed and are not under Federal control. However, analyses have been completed to determine the potential for the probable maximum flood. This is determined through hydrologic factors such as precipitation within the drainage basin, snowmelt, and tributary conditions. The probable maximum flood for the Columbia River below the Priest Rapids Dam has been calculated at 40,000 cubic meters (1.4 million cubic feet) per second, which is greater than the 500-year flood (DOE 1999a:4-34; Duncan 2007:4.58). The extents of the 1894 and 1948 floods and of the probable maximum flood are shown in Figure 3–11.

In addition, potential dam failures on the Columbia River have been evaluated by the U.S. Army Corps of Engineers. A number of hypothetical scenarios were evaluated, including the destruction of 25 percent and 50 percent of the center section of Grand Coulee Dam by explosives. The 50 percent breach scenario, which was believed to represent the largest realistically conceivable flow resulting from either a natural or manmade breach, would result in a discharge rate of 600,000 cubic meters (21 million cubic feet) per second. In addition to the areas of Hanford that would be inundated by the probable maximum flood, as illustrated in Figure 3–11, the remainder of the 100 Areas, the 300 Area, and nearly all of the city of Richland, Washington, would be flooded. However, the 200 Areas and the 400 Area would be above the resulting flood level (Duncan 2007:4.62).

3.2.6.1.2 200 Areas Description

The 200 Areas are located in the Central Plateau of Hanford approximately 10 kilometers (6.2 miles) southeast of the Columbia River. Neither the 200-East nor 200-West Area lies within the probable maximum flood area of the Columbia or Yakima River (see Figure 3–11). However, the southwest corner of the 200-West Area is within the probable maximum flood area of Cold Creek. This portion of the 200-West Area is largely undeveloped, and the 200-West Area tank farms are east of the delineated probable maximum flood area boundary.



Key: EMSL=Environmental and Molecular Sciences Laboratory; ERDF=Environmental Restoration Disposal Facility; FFTF=Fast Flux Test Facility; LIGO=Laser Interferometer Gravitational-Wave Observatory; TEDF=Treated Effluent Disposal Facility; WTP=Waste Treatment Plant.

Sources: DOE 2000a:3-103; Duncan 2007:4.50, 4.54, 4.60, 4.61, 4.65.

Figure 3–11. Floodplains on the Hanford Site

West Lake, located north of the 200-East Area, is a natural feature recharged from groundwater. The lake has not received direct effluent discharges from Hanford facilities; rather, its existence is attributable to intersection of the elevated water table with the land surface in the topographically low area. West Lake water levels fluctuate with water table elevation, which is influenced by wastewater discharge in the 200 Areas. The water level and size of the lake have been decreasing over the past several years because of reduced wastewater discharge (Duncan 2007:4.64). The 200 Area TEDF consists of two disposal ponds from which wastewater percolates into the subsurface. These ponds, each 2 hectares (5 acres) in size, receive industrial wastewater under Ecology-issued State Waste Discharge Permit No. ST-4502, issued in accordance with WAC 173-216. The 200 Area TEDF received 1,170 million liters (310 million gallons) of unregulated effluent for disposal in 2010. The major source of this effluent was uncontaminated cooling water and steam condensate from the 242-A Evaporator with a variety of other uncontaminated waste streams from other Hanford facilities. Sanitary wastewater in the 200 Areas is primarily treated in a series of onsite sewage systems (Poston, Duncan, and Dirkes 2011:6.24, 6.25, D.2).

Water for the 200 Areas is provided by the 283-W Water Treatment Plant (see Section 3.2.2.4.2). The water source for this filtration and chlorination plant is the Columbia River.

3.2.6.1.3 400 Area Description

The 400 Area is 6.3 kilometers (3.9 miles) from the west bank of the Columbia River. No specific flooding analyses have been completed for the 400 Area, but analyses have been completed for the site as a whole. According to the sitewide data, the elevation of the ground surface in the 400 Area is higher than that of the probable maximum flood of the Columbia River. It is also higher than the elevations of the maximum historical floods of 1894 and 1948 (see Figure 3–11) (DOE 2000a:3-105).

The only surface-water bodies in the vicinity of the 400 Area are the FFTF Ponds (i.e., the 4608 B/C ponds) located just north of the 400 Area (DOE 1999a:4-31; Duncan 2007:4.50; Poston, Duncan, and Dirkes 2011:8.28). The ponds receive nonradioactive industrial process wastewater discharge collected by the process sewer system from four 400 Area facilities, including FFTF, FMEF, the Maintenance and Storage Facility, and the water pumphouse. The pond system consists of two cells that measure 15 by 30 meters (50 by 100 feet) and have 1.2-meter (4-foot) walls. Most of the wastewater discharged to the pond system was cooling-tower blowdown from eight FFTF auxiliary cooling towers and three FMEF cooling towers. Individual effluent streams were collected at a central drain line that runs to the pond, and the effluent was monitored before discharge. Approximately 76 million liters (20 million gallons) per year of process wastewater were historically discharged to the FFTF Ponds. Discharged wastewater rapidly percolates into the ground, leaving the ponds dry under normal conditions (DOE 2000a:3-105, 3-106). Discharges to the ponds continue to be regulated under State Waste Discharge Permit No. ST-4501, and the effluent is periodically sampled and analyzed for permit compliance. During 2010, grab samples for selected radionuclides were collected from the FFTF Ponds and analyzed quarterly. In general, average levels of gross beta and tritium have declined in recent years; however, both did increase in 2010. The average tritium concentration in the FFTF Pond water during 2010 was 33 percent of the Washington State ambient surface-water-quality criterion of 20,000 picocuries per liter. The sources of contaminants in the pond water are groundwater contaminant plumes from the 200 Areas that have migrated to wells within the 400 Area that supply water to facility operations (Poston, Duncan, and Dirkes 2011:8.41, 8.42, D.2).

About 3.8 million liters (1 million gallons) of sanitary wastewater also were discharged annually from 400 Area facilities to the Energy Northwest system for treatment. Moreover, liquid LLW from equipment washing was generated during standby operations at a maximum rate of about 3,785 liters (1,000 gallons) per year. It was collected in tanks and transported to the 200 Area ETF for treatment and disposal (DOE 2000a:3–106).

Waste management activities and facilities are discussed in greater detail in Section 3.2.12.

3.2.6.1.4 Borrow Area C Description

No perennial surface-water features, including streams and ponds, have been documented within the boundaries of Borrow Area C. However, portions of the area lie within the probable maximum flood zone associated with Cold Creek (see Figure 3–11). This ephemeral stream may only contain water after large precipitation or snowmelt events before the water rapidly infiltrates into the subsurface (Duncan 2007:4.49).

3.2.6.2 Vadose Zone

3.2.6.2.1 General Site Description

Unconsolidated sands and gravels of the Hanford formation make up most of the vadose zone. In some areas, however, such as most of the 200-West Area and in some of the 100 Areas, the sediments of the Ringold Formation make up the lower part of the vadose zone. The Cold Creek Unit also composes part of the vadose zone in the western portion of the site. Where sediments are present, the thickness of the vadose zone ranges from less than 1 meter (3.3 feet) at the Columbia River to more than 100 meters (328 feet) near the center of Hanford (Duncan 2007:4.66).

Moisture movement through the vadose zone is important at Hanford because it is the driving force for migration of most contaminants to the groundwater. Radioactive and hazardous wastes in the soil column from past intentional liquid waste disposals, unplanned leaks, solid waste burial grounds, and underground tanks are potential sources of continuing and future vadose zone and groundwater contamination. Contaminants may continue to move downward for long periods (tens to hundreds of years, depending on recharge rates) after termination of liquid waste disposal. Except for the State-Approved Land Disposal Site (SALDS), the 200 Area TEDF, and septic drain fields, substantial artificial recharge to the vadose zone ended in the mid-1990s. Currently, the major source of recharge is natural precipitation. Natural infiltration in the vadose zone causes preexisting water to be displaced downward by newly infiltrated water. The amount of recharge at any particular site highly depends on the soil type and the presence of vegetation. Usually vegetation reduces the amount of infiltration through the biological process of transpiration (Duncan 2007:4.66).

The stratigraphy of the vadose zone influences the movement of liquid through the soil column. Where conditions are favorable, liquid effluent may be spread laterally or local perched water zones may develop. Perched water zones form where downward-moving moisture accumulates on top of low-permeability soil lenses or highly cemented horizons. Preferential flow may also occur along discontinuities such as clastic dikes and fractures. Clastic dikes are a common geologic feature in the suprabasalt sediments at Hanford (see Section 3.2.5.1.2). Their most important feature is their potential to either enhance or inhibit vertical and lateral movement of contaminants in the subsurface, depending on the textural relationships of the strata involved (Duncan 2007:4.66).

Hanford has more than 800 past-practice liquid disposal facilities. Radiochemical- and hazardous-chemical-bearing liquid wastes were discharged to the vadose zone through reverse (injection) wells, French drains, ponds, cribs, and trenches (ditches). From 1944 through the late 1980s, 1.5 billion to 1.7 billion cubic meters (396 billion to 449 billion gallons) of effluent were disposed of in the soils. Most effluent was released in the 200 Areas. The major groundwater contaminant plumes emanating from the 200 Areas are tritium and nitrate. The major sources for both were discharges resulting from the chemical processing of irradiated nuclear fuel rods. Also of concern are technetium-99 and iodine-129, which, like tritium and nitrate, are mobile in the vadose zone and groundwater. The major sources of technetium-99 and iodine-129 were discharges to liquid disposal facilities. Vadose zone sources for these contaminants remain beneath many past-practice disposal facilities. However, other than physical sampling and laboratory analysis, there are no currently available monitoring techniques for tritium, nitrate, technetium-99, and iodine-129 in the vadose zone (Duncan 2007:4.67).

Approximately 280 unplanned releases in the 200 Areas also contributed contaminants to the vadose zone. Many of these were from underground tanks. In addition, approximately 50 active and inactive septic tanks and drain fields and numerous radioactive and nonradioactive landfills and dumps have impacted the vadose zone (Duncan 2007:4.67).

In the 200 Areas, 149 single-shell tanks (SSTs) and 28 double-shell tanks (DSTs) have been used to store HLW and mixed waste. The waste resulted from uranium and plutonium recovery processes and, to a lesser extent, from strontium and cesium recovery processes (Duncan 2007:4.67). Sixty-seven of the SSTs are known or suspected to have leaked liquid waste to the vadose zone between the 1950s and the present, although it is likely that some of the tanks have not actually leaked. Nevertheless, estimates of the total leak loss range from less than 2,840 million liters (750 million gallons) to as much as 3,970 million liters (1,050 million gallons). The three largest tank leaks were 435,000 liters (115,000 gallons), 37,900 to 1,049,000 liters (10,000 to 277,000 gallons), and 265,000 liters (70,000 gallons) (Hanlon 2003:B-13–B-16). The average tank leak was between 41,600 and 60,565 liters (11,000 and 16,000 gallons) (Duncan 2007:4.67). However, these estimates were compiled in the late 1980s and early 1990s from information sources of varying quality. While leak volumes for some tanks are well documented, including tank 241-T-106, which from liquid-level measurements is known to have leaked 435,000 liters (115,000 gallons) of waste, documentation of past leaks for 19 of the 67 tanks that are known or suspected "leakers" is less certain (Hanlon 2003:B-13–B-16). Much effort has been expended to improve SST leak volume estimates using information gathered from extensive tank farm vadose zone investigations. This effort has included an extensive program of field drilling, sampling, and soil analysis in multiple SST farms, as well as directed fundamental research and extensive review of historical process records and gamma logging data (DOE 2003b:6-19–6-22).

In addition to removing pumpable liquids from the SSTs, interim measures have been taken to reduce the movement of tank farm contaminants in the vadose zone. Infiltration of water has been identified as the primary means by which contaminants are displaced beneath the farms. Surface-water controls have been constructed to reduce surface-water run-on from major meteorological events and from breaks in waterlines. Also, waterlines that were determined to be unnecessary have been isolated, cut, and capped. Waterlines that were found to be necessary for continued operations are being leak tested, and any lines found to be leaking will be replaced (Duncan 2007:4.67, 4.68).

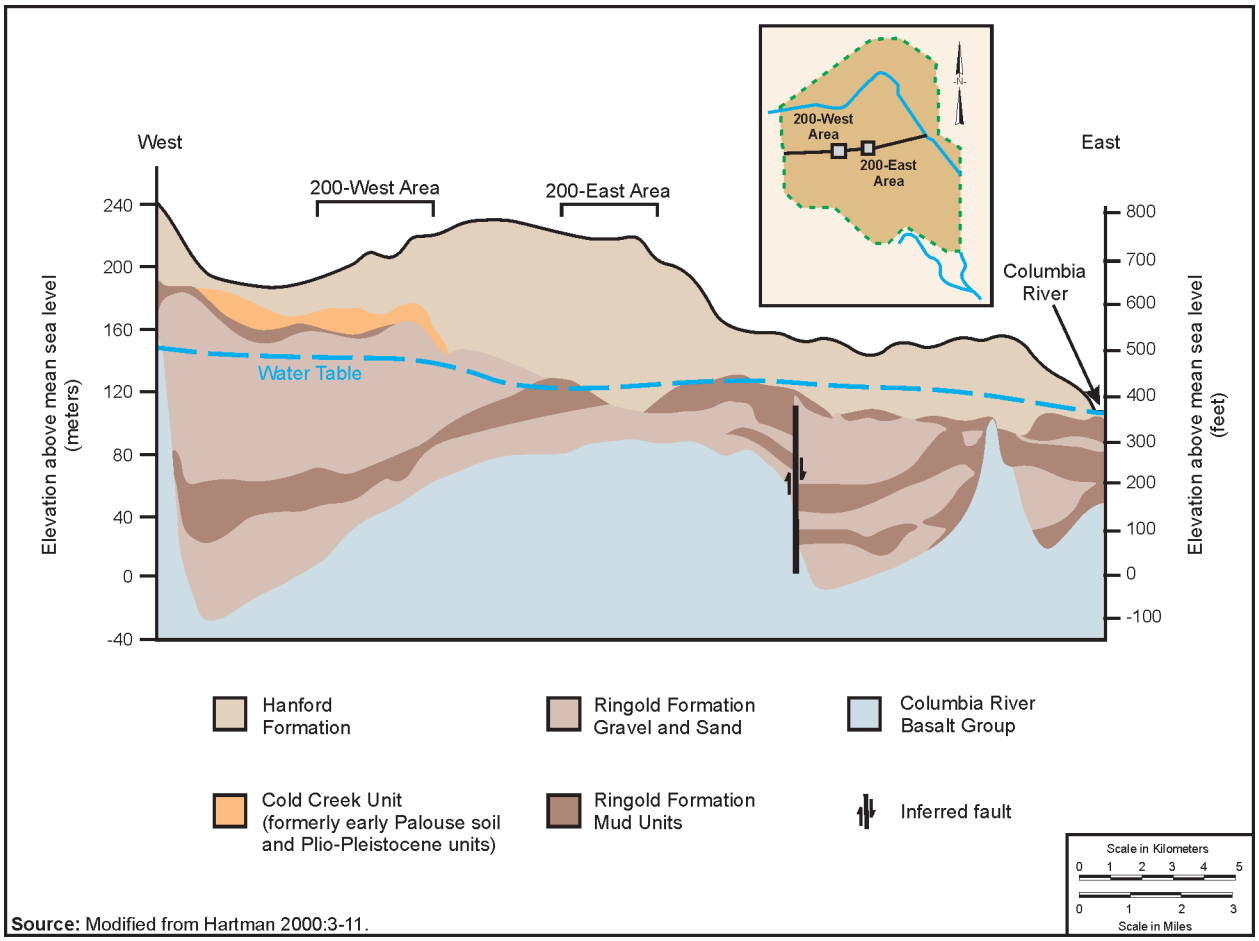
Other sources of vadose zone contamination include reactor cooling-water releases from cracked retention basins and direct discharges of cooling water to trenches (ditches) from the 100-KE, -KW, and -N Reactors. The released cooling waters contained fission and neutron activation products and some chemicals and actinides. Of greatest concern are the impacts of tritium, strontium-90, nitrate, and chromium migrating through the vadose zone to groundwater and, ultimately, to the Columbia River. Leakage from fuel storage basins in the 100-K Area also contributed potentially large inventories of fission products, transuranics, and carbon-14 to the soil column. Thus, both past-practice sites and fuel storage basin leakage are potential sources of vadose zone contaminants in the 100 Areas (Duncan 2007:4.68). DOE, with the concurrence of Ecology and EPA, issued the *Hanford Site Groundwater Strategy: Protection, Monitoring, and Remediation* in February 2004 (DOE 2004a). The document focuses on three key areas: groundwater protection, groundwater monitoring, and remediation of contaminated groundwater. All three of these strategic areas are implemented through the Soil and Groundwater Remediation Project. Activities performed by the project include an ongoing monitoring and assessment program to determine the distribution and movement of existing radioactive and chemical contamination in the soil and groundwater beneath Hanford. Information on these remediation efforts is detailed in the annual site environmental report (Poston, Duncan, and Dirkes 2011:8.6, 8.60, 8.62).

Several compilations of vadose zone contamination have been formulated through the years. A series of reports have been issued in recent years by the Hanford Tank Farm Vadose Zone Project that estimate the curies of gamma-emitting radionuclides and the volumes of contaminated soil associated within each

SST farm. The results were compiled from the baseline spectral gamma logging project and are summarized in 12 spectral gamma logging tank farm reports issued by MACTEC-Environmental Remediation Services between 1996 and 2000 (DOE 2003b:6-20, 6-21; Duncan 2007:4.68).

3.2.6.2.2 200 Areas Description

The thickness of the vadose zone across the 200 Areas ranges from approximately 50 meters (164 feet) in the 200-West Area to approximately 100 meters (328 feet) beneath portions of the 200-East Area (Hartman 2000:4.9, 4.16), as illustrated in Figure 3–12. The geologic and groundwater environments of the 200 Areas are further described in Sections 3.2.5.2 and 3.2.6.3.2, respectively.



Source: Modified from Hartman 2000:3-11.

Figure 3–12. Hydrogeologic Cross Section Through the 200 Areas

3.2.6.2.3 400 Area Description

The thickness of the vadose zone in the 400 Area is approximately 50 meters (164 feet). The geologic and groundwater environments of the 400 Area are further described in Sections 3.2.5.3 and 3.2.6.3.3, respectively.

3.2.6.2.4 Borrow Area C Description

The thickness of the vadose zone across Borrow Area C, estimated to average approximately 50 meters (164 feet), similar to that of the 200-West Area, particularly in areas where basalt does not occur at or near the surface. Accordingly, thinning of the vadose zone is expected to the west and south across the area.

3.2.6.3 Groundwater

3.2.6.3.1 General Site Description

Groundwater under Hanford occurs in confined and unconfined aquifer systems. The hydrostratigraphic (water-bearing) units composing these systems are illustrated in the cross section shown as Figure 3–12.

The unconfined aquifer system, also referred to as the "suprabasalt aquifer system" or Hanford/Ringold aquifer system, lies within the sands and gravels of the Hanford formation and, to a greater degree, the sediments of the Ringold Formation. Portions of the suprabasalt aquifer system are locally confined because major sand and gravel units of the Ringold Formation (e.g., Units A, B, C, D, and E) (see Figure 3–9) are separated by fine-grained (e.g., silt- and clay-dominated) units. In some places, the fine-grained units act as aquitards that locally confine groundwater in deeper permeable sediments. Nevertheless, groundwater generally flows eastward across the site from recharge areas in the higher elevations on the western site boundary and discharges primarily to the Columbia River (see Figure 3–13). The Yakima River is also considered a source of recharge. Since the beginning of Hanford operations in 1943, the water table has risen about 9.1 meters (30 feet) under disposal ponds near the 200-East Area and as much as 27 meters (89 feet) in the 200-West Area. This has caused groundwater mounding with radial and northward flow components in the 200 Areas, although groundwater elevations have declined since 1984 with decreased wastewater disposal.

However, a groundwater mound beneath the 200-West Area still exists, as do small groundwater mounds near the 200 Area TEDF and the SALDS (Duncan 2007:4.68–4.71; Hartman 2000:3.4, 3.5). The 200 Area TEDF is a collection and disposal system for pretreated non–Resource Conservation and Recovery Act (RCRA) (42 U.S.C. 6901 et seq.)–permitted waste streams that began operations in April 1995. Effluent is conveyed to the facility through 18 kilometers (11 miles) of buried pipelines connecting three pumping stations, one disposal sample station (Building 6653), and two 2-hectare (5-acre) disposal ponds east of the 200-East Area.

Discharges from the 200 Area TEDF are regulated by State Waste Discharge Permit No. ST 4502 (see Section 3.2.6.1.2). The TEDF has a capacity of 12,900 liters (3,400 gallons) per minute. In 2010, the 200 Area TEDF disposed of 1,170 million liters (310 million gallons) of wastewater to the subsurface. The major sources of this effluent were uncontaminated cooling water and steam condensate from the 242-A Evaporator, as well as a variety of other uncontaminated waste streams received from other Hanford facilities. The SALDS (also known as the 616-A Crib), located north of the 200-West Area, is the ultimate discharge point for liquid waste treated in the 200-East Area ETF, which first passes through the LERF impoundments. The 200-East Area ETF treats liquid effluent to remove toxic metals, radionuclides, and ammonia, and to destroy organic compounds. It began operations in December 1995. The treated effluent is stored in tanks, sampled, and analyzed prior to being discharged to the SALDS. The disposal site is an underground drain field located just north of the 200-West Area. The treatment process constitutes the best-available technology; it includes pH adjustment, filtration, ultraviolet light and peroxide destruction of organic compounds, reverse osmosis to remove dissolved solids, and ion exchange to remove the last traces of contaminants. Discharges are regulated by State Waste Discharge Permit No. ST 4500. The ETF has a maximum treatment capacity of 570 liters (150 gallons) per minute of effluent. In 2010, the volume of wastewater treated and disposed of was approximately 69.7 million liters (18.4 million gallons). This was primarily CERCLA-regulated wastewater (groundwater from the 200-UP-1 and 200-ZP-1 Operable Units in the 200-West Area) (Poston, Duncan, and Dirkes 2011:6.23–6.25, D.2).

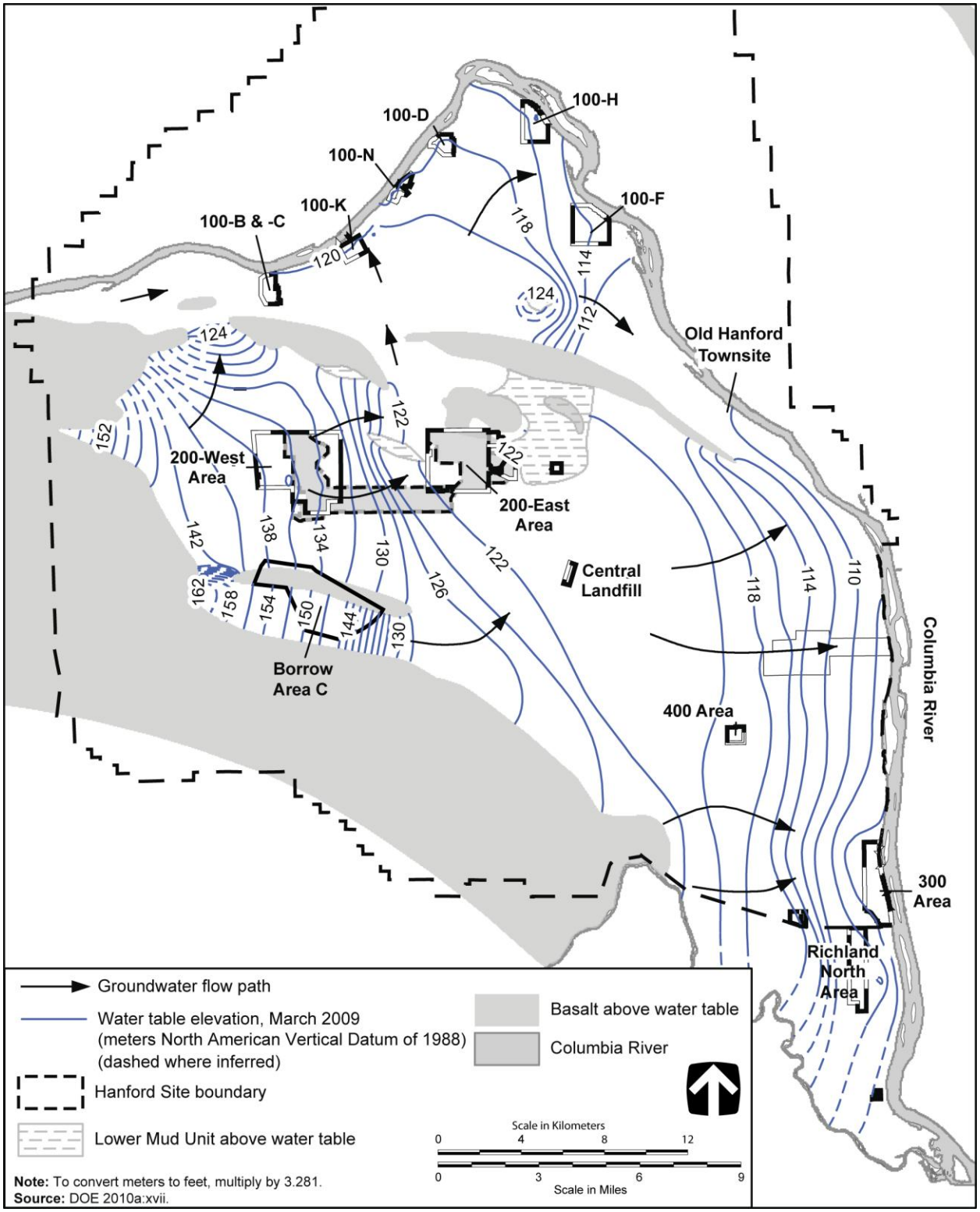


Figure 3–13. Water Table Elevations and Inferred Groundwater Flow for the Unconfined Aquifer System

The generally more consolidated and partially cemented sands and gravels within the Ringold Formation are 10 to 100 times less permeable than the sediments of the overlying Hanford formation, which results in significantly lower hydraulic conductivities. Before wastewater disposal operations at Hanford, the uppermost aquifer was mainly within the Ringold Formation, and the water table extended into the Hanford formation at only a few locations. However, wastewater discharges raised the water table elevation across the site. 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 increased the groundwater velocity because of both the greater volume of groundwater and the higher permeability of the newly saturated Hanford sediments (Duncan 2007:4.71, 4.72).

The saturated thickness of the unconfined aquifer system is greater than 180 meters (590 feet) in areas near the Central Landfill and in areas west of the 200-West Area and north of Gable Butte near the 100-B, -C, and -K Areas, but the aquifer pinches out along the flanks of the basalt ridges. Perched water table conditions have been encountered in sediment above the unconfined aquifer system in the 200-West Area. Depth to the water table across the site ranges from less than 1 meter (3.3 feet) along the Columbia River to more than 100 meters (328 feet) near the center of the site (see Figure 3–12). Daily river-level fluctuations may result in changes in the water table of up to 3 meters (10 feet) near the Columbia River during periods of high-river stage. 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 meters of the shoreline (Duncan 2007:4.69).

The confined aquifer system at Hanford consists of a sequence of basalt-confined aquifers within the Columbia River Basalt Group. Individual aquifers consist of the relatively permeable sedimentary interbeds and the more porous tops and bottoms of basalt flows that compose the group (see Figure 3–9). Saturated but fairly impermeable, dense interior sections of the basalt flows have horizontal hydraulic conductivities (i.e., ability of the rock to transmit water) that are about five orders of magnitude lower than some of the confined aquifers that lie between these basalt flows. The upper basalt-confined aquifer is believed to be recharged from upland areas along the margins of the Pasco Basin as a result of the infiltration of precipitation and surface water where the basalt and interbeds are exposed at or near the ground surface. Hydraulic head information indicates that groundwater in the basalt-confined aquifers generally flows toward the Columbia River and, in some places, toward areas of enhanced vertical interflow with the unconfined aquifer system. Limited water chemistry data indicate that interaquifer flow has taken place in an area near the Gable Mountain anticlinal structure north of the 200-East Area (Duncan 2007:4.69; Hartman 2000:3.4, 3.5). Recharge may also occur through the Hanford/Ringold aquifer system in areas where the hydraulic gradient is downward and from deeper basalt aquifers where an upward gradient is present. The Yakima River may also be a source of recharge. The Columbia River is a discharge area for this aquifer system in the southern portion of the site, but not the northern portion. Discharge also occurs to the overlying Hanford/Ringold aquifer system in areas where the hydraulic gradient is upward. Discharge to overlying or underlying aquifers in the vicinity of the Gable Butte/Gable Mountain structural area may occur through erosional windows in the basalt (DOE 2010a:8.0-5).

Tritium and carbon-14 measurements indicate that groundwater residence or recharge time (the length of time that groundwater has been in the subsurface) is up to thousands of years for the unconfined aquifer and more than 10,000 years for groundwater in the shallow confined aquifer. Chlorine-36 and noble gas isotope data suggest groundwater ages greater than 100,000 years in the deeper confined systems. These rather long residence times are consistent with semiarid-site recharge conditions. However, groundwater travel time from the 200-East Area to the Columbia River has been shown to be much faster, in the range of 10 to 30 years. This is because of the large volumes of recharge from wastewater disposed of in the

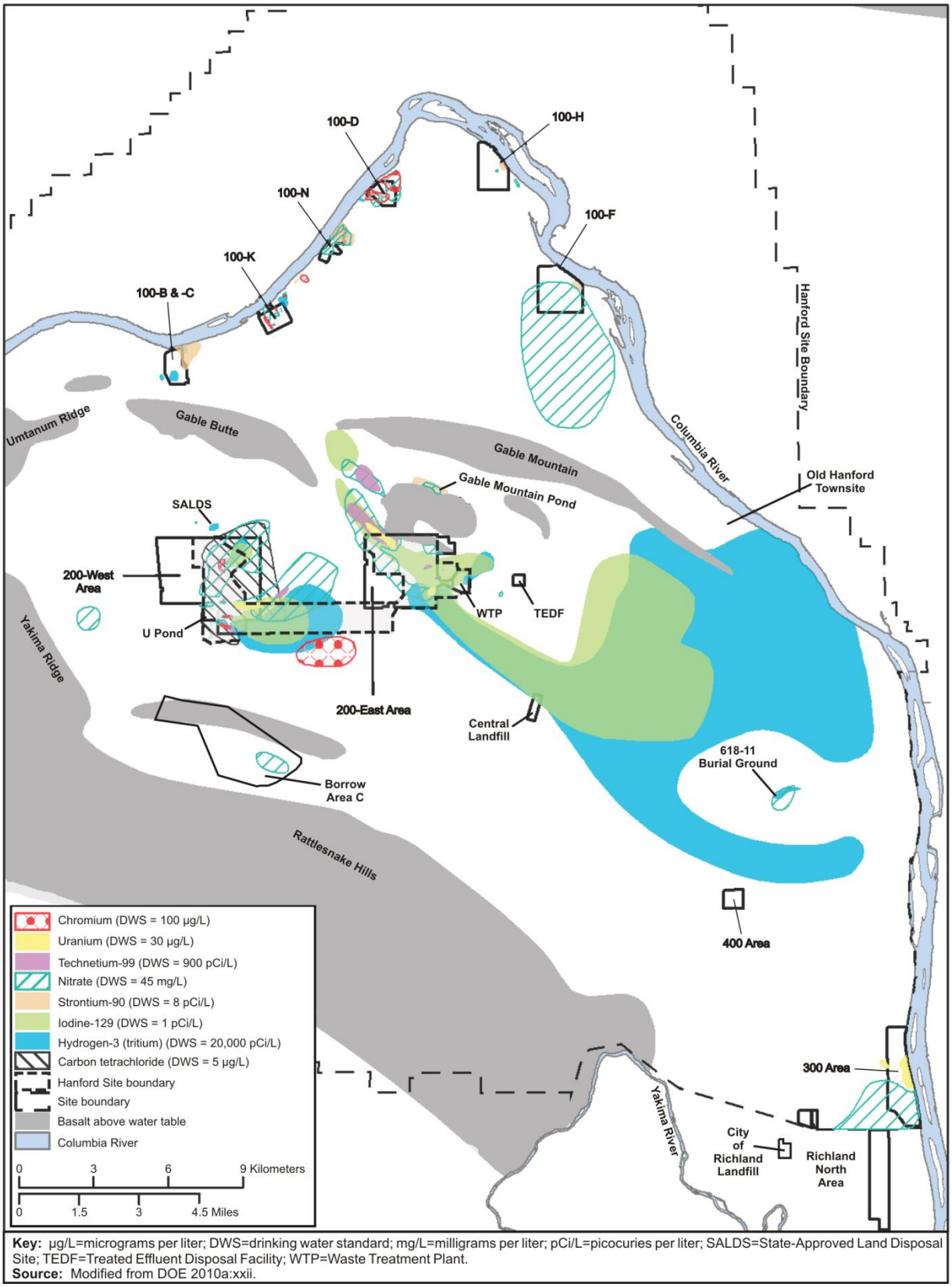
200 Areas between 1944 and the mid-1990s and the rather high permeability of Hanford formation sediments, which are below the water table between the 200 Areas and the Columbia River. Residence times in this portion of the aquifer are expected to increase because of the reduction in wastewater recharge in the 200 Areas. Travel time from the 200-West Area is greater because of the lower permeability of Ringold Formation sediments. Plume monitoring indicates that groundwater from the 200-West Area has moved about 6 kilometers (3.7 miles) during the past 50 years (Duncan 2007:4.72).

Water use in the Pasco Basin, which includes Hanford, is primarily via surface-water diversion; groundwater accounts for less than 10 percent of water use (DOE 1999a:4-49). While most of the water used by Hanford is surface water withdrawn from the Columbia River, some groundwater is used. One of the principal users of groundwater was FFTF in the 400 Area, which used about 697,000 liters (184,000 gallons) per day when it operated (DOE 2000a:3-109). The 400 Area continued to use groundwater supply wells for drinking water in 2010 (see Section 3.2.2.4.1).

Groundwater quality beneath large portions of Hanford has been affected by past liquid waste discharges, primarily to ponds, cribs, and trenches (ditches) and from spills, injection wells, and leaks from waste storage tanks. Additional contaminants from spills, leaking waste tanks, and burial grounds (landfills) have also impacted groundwater in some areas. Contaminant concentrations in the existing groundwater plumes are expected to decline through radioactive decay, chemical degradation, and dispersion. However, contaminants also exist within the vadose zone beneath waste sites (see Section 3.2.6.2), as well as in waste storage and disposal facilities. These contaminants could continue to move downward into the unconfined aquifer system. Some contaminants, such as tritium, move with the groundwater, while movement of other contaminants (e.g., strontium, cesium, plutonium) is slower because they react with or are sorbed on the surface of minerals within the aquifer or the vadose zone (Duncan 2007:4.73, 4.74). Groundwater contamination is monitored and is being actively remediated in several areas through pump-and-treat operations. The unconfined aquifer system contains radioactive and nonradioactive contaminants at levels that exceed water quality criteria and standards. During reporting period 2009 (i.e., October 1, 2008, through December 31, 2009), 922 wells and 326 aquifer tubes were sampled for radioactive and/or chemical constituents. Overall, tritium, nitrate, and iodine-129 continue to be the most widespread groundwater contaminants associated with past Hanford operations (DOE 2010a:1.0-3, 1.0-4).

Figure 3–14 depicts the distribution of major radionuclides and hazardous chemicals in the unconfined aquifer system, including those concentrations above applicable MCL or drinking water standards, during reporting period 2009. The figure depicts groundwater quality on a regional scale. Discussion of additional, smaller-scale contaminant plumes can be found in Appendices L, N, and O. The figure also depicts the locations of former waste management sites (e.g., Gable Mountain Pond, U Pond, B Pond, effluent disposal cribs) and burial grounds. Also shown are locations of active waste management and treatment facilities such as the SALDS, the 200 Area TEDF, and the ERDF.

The areas of the tritium and iodine-129 plumes are the largest areas in which contaminant concentrations exceed drinking water standards. These dominant plumes have sources in the 200-East Area and extend toward the east and southeast. Less-extensive tritium and iodine-129 plumes are also present in the 200-West Area. Technetium-99 exceeds standards in plumes within both the 200-East and 200-West Areas. One technetium-99 plume has moved to the northwest beyond the 200-East Area. Uranium is less mobile than tritium, iodine-129, or technetium-99; isolated plumes are found in the 200-East, 200-West, and 300 Areas. Strontium-90 exceeds standards in the 100 Areas, the 200-East Area, and beneath the former Gable Mountain Pond. Other radionuclides, including cesium-137, cobalt-60, and plutonium, are even less mobile in the subsurface and exceed drinking water standards in only a few wells in the 200-East Area (DOE 2010a:xx).



Key: µg/L=micrograms per liter; DWS=drinking water standard; mg/L=milligrams per liter; pCi/L=picocuries per liter; SALDS=State-Approved Land Disposal Site; TEDF=Treated Effluent Disposal Facility; WTP=Waste Treatment Plant.
Source: Modified from DOE 2010a:xxii.

Figure 3–14. Distribution of Major Radionuclides and Hazardous Chemicals in the Unconfined Aquifer System During Reporting Period 2009

Nitrate is a widespread nonradioactive contaminant in Hanford groundwater, with plumes originating from the 100 and 200 Areas and from offsite industry and agriculture. Carbon tetrachloride, the most widespread organic contaminant on Hanford, forms a large plume beneath the 200-West Area. Other organic contaminants include chloroform, found in the 200-West Area, and trichloroethene. Trichloroethene plumes that approach or exceed the drinking water standard are found in the 100-K and 100-F Areas. Chromium contamination underlies portions of 100-B, -C, -D, -F, -H, and -K Areas; the 600 Area; and the 200-West Area in exceedance of standards (DOE 2010a:xx, xxi). Information on groundwater monitoring and chemical analysis is further summarized in the annual site environmental report, and detailed results are provided in the Hanford annual groundwater monitoring report (DOE 2010a; Hartman, Rediker, and Richie 2009; Poston, Duncan, and Dirkes 2011). Vertical gradients between the basalt-confined aquifer and the unconfined aquifer systems are upward on most of Hanford. Downward gradients are measured in the west portion of Hanford, near B Pond, and north and east of the Columbia River (DOE 2010a:xiii). No aquifers have been designated sole-source aquifers in the Columbia Plateau (EPA 2009).

3.2.6.3.2 200 Areas Description

Along the southern edge of the 200-East Area and in the 200-West Area, the water table occurs almost entirely in the upper gravel layers (Unit E) of the Ringold Formation, while in most of the 200-East Area, it occurs primarily in the Hanford formation and in the lower gravel layers (Unit A) of the Ringold Formation. The upper Ringold strata across most of the 200-East Area were eroded by the ancestral Columbia River and, in some places, by the Missoula floods that subsequently deposited Hanford gravels and sand on what was left of the Ringold Formation. Because the Hanford formation and Cold Creek Unit sand and gravel deposits are much more permeable than the Ringold gravels, the water table is rather flat in the 200-East Area, but groundwater flow velocities are higher. On the north side of the 200-East Area, there is evidence of erosion channels that may allow interaquifer flow between the unconfined and uppermost basalt-confined aquifer systems (Duncan 2007:4.75).

The subsurface hydrology of the 200 Areas has been strongly influenced by the discharge of large quantities of wastewater to the ground for more than 50 years. Those discharges have caused elevated water levels across much of Hanford, resulting in a groundwater mound beneath the former B Pond east of the 200-East Area and a larger groundwater mound beneath the former U Pond in the 200-West Area. Water table changes beneath the 200-West Area have been greatest because of the lower transmissivity of the aquifer in this area. In recent years, discharges of water to the ground have been greatly reduced, and corresponding decreases in the water table elevation have been measured. The decline in part of the 200-West Area has been more than 8 meters (26 feet). Water levels are expected to continue to decrease as the unconfined groundwater system reaches equilibrium with the new level of artificial recharge (Duncan 2007:4.75, 4.81). Currently, the water table elevation is about 11 meters (36 feet) above the estimated water table elevation prior to the start of Hanford operations. Computer simulations show that when equilibrium conditions are established in the aquifer after site closure, the water table may still be 5 to 7 meters (16 to 23 feet) higher than the pre-Hanford water table because of modeling uncertainties, artificial recharge from offsite irrigation, or differences in current Columbia River conditions as compared with pre-Hanford times, such as dam construction (DOE 2010a:2.0-2, 2.0-3).

Across the 200-East Area, the depth to the water table varies from approximately 65 meters (213 feet) to 100 meters (328 feet), and the thickness of the saturated zone above the top of the basalt varies from 0 meters in the north to about 80 meters (262 feet) in the south. The depth to the water table in the 200-West Area varies from about 50 meters (164 feet) to greater than 100 meters (328 feet). Beneath the 200-West Area, the saturated thickness of the unconfined aquifer varies from about 65 meters (213 feet) to greater than 150 meters (492 feet) (Hartman 2000:4.9, 4.16).

Groundwater beneath the 200-West Area generally flows from west to east across most of the area, but is locally influenced by the 200-ZP-1 groundwater pump-and-treat remediation system. The decline in liquid effluent discharges to the soil in the 200-West Area and the resulting decline in the water table have changed the flow direction in the northern part of the area about 35 degrees over the past decade from a north-northeast to a more eastward direction. Flow in the central part of the 200-West Area (the south part of the 200-ZP-1 Operable Unit) is strongly influenced by the operation of the 200-ZP-1 groundwater pump-and-treat remediation system. This system extracts water from the vicinity of the 216-Z cribs and trenches (ditches), treats it to remove carbon tetrachloride and other volatile organic compounds, then reinjects the water into the aquifer west of the area (DOE 2010a:7.0-2, 7.0-3).

Groundwater flow in the central portion of Hanford, which encompasses the 200-East Area, is significantly affected by the presence of a buried flood channel that lies in a northwest-to-southeast orientation. The water table in this area is very flat due to the high permeability of the Hanford formation. Groundwater flow in this region is significantly affected by the presence of the low-permeability sediment of the Ringold Formation (i.e., the Lower Mud Unit) at the water table east and northeast of the 200-East Area, as well as basalt above the water table (see Figure 3–13). These features constitute barriers to groundwater flow. The extent of the basalt units above the water table continues to increase slowly due to the declining water table, resulting in an even greater effect on groundwater flow in this area. Because of the very low hydraulic gradient in the 200-East Area and vicinity, as well as uncertainty in the water-level elevation data, determining precisely the direction of groundwater flow is problematic. What is observable is that water enters the 200-East Area and vicinity from the west and southwest, as well as from beneath the mud units to the east and from the underlying aquifers (i.e., the upper basalt-confined aquifer system), where the confining units have been removed or thinned by erosion. The flow of water divides into two flow paths, one moving to the north through Gable Gap and the other southeast toward the central part of the site (see Figure 3–13). While the precise location of the flow divide has not been established, it has been determined through water-level data that groundwater flows north through Gable Gap and southeast between the 200-East Area and the Central Landfill (DOE 2010a:2.0-3).

3.2.6.3.3 400 Area Description

Groundwater flow within the unconfined aquifer across the 400 Area is generally to the east-southeast. The Hanford formation immediately underlying the area consists mainly of sand-dominated sediments. Depth to the water table, located near the contact between the Hanford and Ringold Formations, is estimated at 49 meters (161 feet). Sediments of the Hanford formation dominate groundwater flow in the 400 Area because of their higher permeability than those of the Ringold Formation. The Ringold Formation consists of gravelly sands, sandy gravel, silty sands, fluvial gravels, and overbank and lacustrine silt and clay. The saturated thickness of this aquifer system is about 140 meters (460 feet) (Hartman 2000:4.25; Hartman, Rediker, and Richie 2009:2.11–2.24).

Nitrate has historically been the only significant contaminant attributable to 400 Area operations. Elevated nitrate has been attributed to a former sanitary sewage lagoon located west and upgradient of the FFTF Ponds (Hartman 2000:4.25; WHC 1992:44). The FFTF Ponds are also a known source of nitrate contamination. In 2009, nitrate concentrations were well below the drinking water standard of 45 milligrams per liter in all 400 Area water supply wells. However, nitrate exceeded the standard in well 699-2-7 associated with the FFTF Ponds (DOE 2010a:5.0-7, 5.0-41).

The 400 Area's three water supply wells are completed in the unconfined (Hanford/Ringold) aquifer system. The primary production well (499-S1-8J) was installed in 1985 in the lower unconfined aquifer system after tritium contamination was detected in the original two wells (499-S0-7 and 499-S0-8) near the top of the aquifer (Hartman 2000:4.25). These elevated tritium levels were associated with the groundwater plume from the vicinity of the PUREX Plant in the 200-East Area. Well 499-S1-8J now

serves as the main water supply well for the 400 Area, while 499-S0-7 and 499-S0-8 are backup supply wells. During reporting period 2009, tritium levels were below the drinking water standard (20,000 picocuries per liter); the highest tritium concentration during 2009 was measured in well 499-S0-7 at 6,400 picocuries per liter. Well 699-2-7 associated with the FFTF Ponds had a maximum tritium concentration of 9,800 picocuries per liter (DOE 2010a:5.0-7, 5.0-38, 5.0-41).

3.2.6.3.4 Borrow Area C Description

No groundwater wells have been developed in Borrow Area C to precisely determine groundwater flow and direction and depth to groundwater. Based on regional topography and the direction of flow of Cold Creek, groundwater flow across Borrow Area C is inferred to be generally to the east (see Figure 3–13). Depth to the water table is estimated to average approximately 52 meters (170 feet).

3.2.7 Ecological Resources

Ecological resources include terrestrial resources, wetlands, aquatic resources, and threatened and endangered species. Terrestrial resources are the plant and animal communities most closely associated with the land; for aquatic resources, a water environment. Wetlands are "those areas that are inundated or saturated by groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (33 CFR 328.3). Endangered species are those plants and animals in danger of extinction throughout all or a large portion of their range; threatened species, those species likely to become endangered within the foreseeable future. Other organisms may be designated by USFWS and the state as special status species, such as candidate, species of concern, sensitive, and watch.

3.2.7.1 Terrestrial Resources

3.2.7.1.1 General Site Description

Hanford is within the Columbia Basin Ecoregion, an area that historically included over 6 million hectares (14.8 million acres) of steppe and shrub-steppe vegetation. In the early 1800s, the dominant plant in the Hanford area was big sagebrush underlain by perennial Sandberg's bluegrass and bluebunch wheatgrass. With the advent of settlement, livestock grazing and agricultural production contributed to colonization by nonnative plant species. Although agriculture and livestock production were the primary activities within the region and on Hanford at the beginning of the twentieth century, these activities ceased at the site when the Government acquired it in 1943. Remnants of past agricultural practices are still evident. Now the site encompasses undeveloped land interspersed with the industrial development; only about 6 percent of the site has been developed (Duncan 2007:4.84; Neitzel 2005:4.144).

A variety of both native and nonnative plant species are found across the site. A total of 727 species of vascular plants has been recorded on the site, of which 179 are nonnative species. In addition, 29 soil lichens and 6 moss species have been identified. Prior to the 24 Command Fire in July 2000, studies identified as many as 48 vegetation communities and land use areas on Hanford (see Figure 3–15). However, these may be roughly grouped into shrublands, grasslands, areas containing trees, and riparian areas and wetlands (Duncan 2007:4.85–4.87).

Shrublands occupy the most extensive area on Hanford. Of the numerous types present, sagebrush-dominated communities predominate; other shrub communities vary with changes in soils and elevation. Typical vegetation in shrubland habitat includes big sagebrush, threetip sagebrush, bitterbrush, gray rabbitbrush, winterfat, snow buckwheat, and spiny hopsage. In the recent past, big sagebrush plant communities covered about 80 percent of the mapped land on the site; however, much of this area (28,750 hectares [71,040 acres]) was burned by the 24 Command Fire in 2000 and again by the Milepost 17 and Wautoma Fires in 2007 (Duncan 2007:4.89; PNNL 2008a).

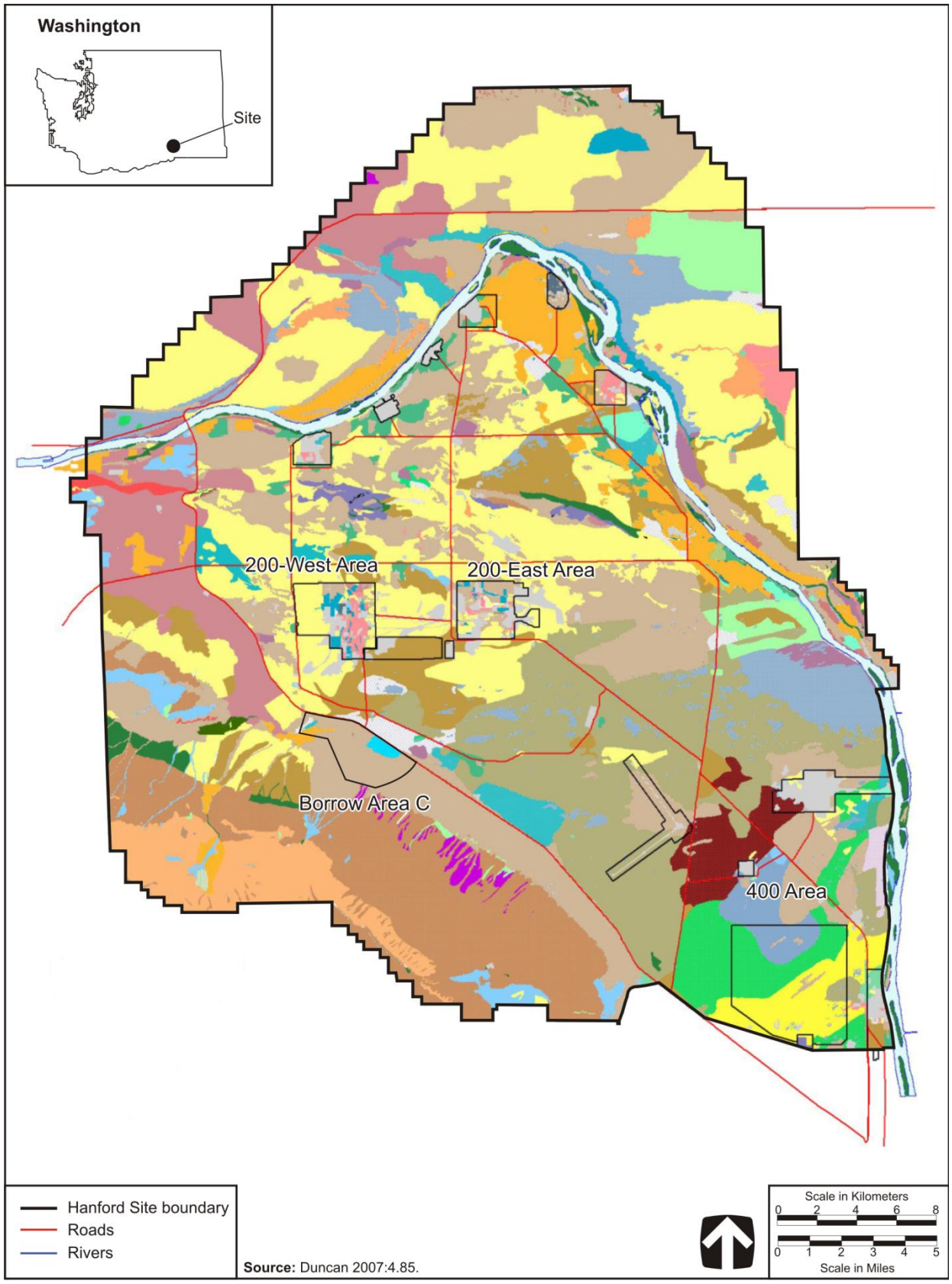


Figure 3–15. Vegetation Communities on the Hanford Site

Legend

- Abandoned Old Agricultural Fields
- Alkali Saltgrass-Cheatgrass
- Big Sagebrush-Bitterbrush/Bunchgrass
- Big Sagebrush-Bitterbrush/Needle-and-Thread Grass
- Big Sagebrush-Bitterbrush/Sandberg's Bluegrass
- Big Sagebrush-Rigid Sagebrush/Bunchgrass
- Big Sagebrush-Rock Buckwheat/Bunchgrass
- Big Sagebrush-Spiny Hopsage/Bunchgrass
- Big Sagebrush-Spiny Hopsage/Sandberg's Bluegrass – Cheatgrass
- Big Sagebrush/Bluebunch Wheatgrass
- Big Sagebrush/Bunchgrass
- Big Sagebrush/Needle-and-Thread Grass
- Big Sagebrush/Sand Dropseed
- Big Sagebrush/Sandberg's Bluegrass – Cheatgrass
- Bitterbrush/Bunchgrass
- Bitterbrush/Indian Ricegrass
- Bitterbrush/Needle-and-Thread Grass
- Black Greasewood/Alkali Saltgrass
- Bluebunch Wheatgrass – Needle-and-Thread Grass
- Bluebunch Wheatgrass-Sandberg's Bluegrass
- Bunchgrass – Cheatgrass
- Crested Wheatgrass
- Disturbed
- Gray Rabbitbrush-Snow Buckwheat/Bunchgrass
- Gray Rabbitbrush/Bunchgrass
- Gray Rabbitbrush/Cheatgrass
- Gray Rabbitbrush/Needle-and-Thread Grass
- Gray Rabbitbrush/Sand Dropseed
- Gray Rabbitbrush/Sandberg's Bluegrass – Cheatgrass
- Needle-and-Thread Grass – Indian Ricegrass
- Needle-and-Thread Grass – Sandberg's Bluegrass
- Nonriverine Wetlands and Associated Deepwater Habitats
- Rabbitbrush/Bunchgrass
- Rigid Sagebrush/Sandberg's Bluegrass
- Riparian
- Riverine Wetlands and Associated Deepwater Habitats
- Sand Dropseed – Sandberg's Bluegrass – Cheatgrass
- Sandberg's Bluegrass – Cheatgrass
- Snow Buckwheat – Bitterbrush/Bunchgrass
- Snow Buckwheat/Bunchgrass
- Snow Buckwheat/Sandberg's Bluegrass – Cheatgrass
- Spiny Hopsage/Sandberg's Bluegrass – Cheatgrass
- Talus
- Threetip Sagebrush/Bunchgrass
- Thymeleaf Buckwheat/Sandberg's Bluegrass
- Vernal Pool
- White Bluffs
- Winterfat/Bunchgrass

Source: Duncan 2007:4.86.

Figure 3–15. Vegetation Communities on the Hanford Site *(continued)*

Washington State considers pristine shrub-steppe habitat as a priority habitat because of its relative scarcity in the state and its importance to several state-listed wildlife species (WDFW 2007). Designation and characterization of priority habitat provide a basis for sound, defensible land management planning and assist in the management of regulated species. Sagebrush communities are also considered a Level III resource under the *Hanford Site Biological Resources Management Plan*. Biological resources are ranked from Level I to Level IV, with Level IV being the most significant in terms of the presence of threatened or endangered species, as well as rare, unique, or vanishing habitat. Impacts on Level III resources should be avoided or minimized; however, when avoidance and minimization are not possible, rectification or mitigation is recommended (DOE 2001c:4.7).

While most grasses occur as understory in shrub-dominated plant communities, there are a number of grassland communities on the site. Common species include Sandberg's bluegrass, needle-and-thread grass, Indian ricegrass, and thickspike wheatgrass. Cheatgrass has replaced many native perennial grass species and is well established in many low-elevation (less than 244 meters [800 feet]) and/or disturbed areas (Duncan 2007:4.90).

Before settlement, Hanford's landscape lacked trees, although the Columbia River nearshore supported a few scattered cottonwoods or willows. Homesteaders planted trees in association with agricultural areas. Shade and ornamental trees were planted around former military installations and industrial areas on the site. Currently, 23 species of trees occur on Hanford. The most common species are black locust, Russian olive, cottonwood, mulberry, sycamore, and poplar. These trees provide nesting habitat and cover for many birds and mammals (Duncan 2007:4.90).

Riparian habitat includes riffles, gravel bars, backwater sloughs, shorelines, islands, and palustrine areas associated with the Columbia River floodplain, as well as site springs. Vegetation occurring along the river shoreline includes water smartweed, pondweed, sedges, reed canary grass, and bulbous bluegrass. Trees include willow, mulberry, and Siberian elm. Other riparian vegetation associated with perennial springs and seeps includes bulrush, spike rush, and cattail. North of the Columbia River, several irrigation return ponds support riparian vegetation. The riparian areas associated with Snively and Rattlesnake Springs were greatly impacted by the 24 Command Fire (Duncan 2007:4.92, 4.93).

Within the Columbia Basin, microbiotic crusts commonly occur in the top 1 to 4 millimeters (0.04 to 0.16 inches) of soil and are composed primarily of algae, lichen, and mosses. Living organisms (primarily green algae) and their byproducts bind individual soil particles together to form these crusts. The functions of microbiotic crusts include soil stability and protection from erosion; fixation of atmospheric nitrogen; nutrient contribution to plants, thereby influencing soil-plant water relations; and increased water infiltration, seedling germination, and plant growth. The ecological roles of microbiotic crusts depend on the cover of various crustal components. Carbon inputs are higher when mosses and lichens are present than when the crust is dominated by cyanobacteria. Nitrogen inputs are higher with greater water infiltration. Soil surface stability is related to cyanobacterial biomass, as well as total moss and lichen cover (Duncan 2007:4.87, 4.88).

Several unique habitats and populations of rare plants on Hanford contribute to its biodiversity. Unique habitats include basalt outcrops, river bluffs, dunes, and islands. The tops of Rattlesnake Mountain, Umtanum Ridge, Gable Butte, and Gable Mountain have rock outcrops and thin rocky soils. Plant communities dominated by thymeleaf buckwheat and Sandberg's bluegrass most often occupy these basalt outcrops. The White Bluffs border the Columbia River along the northern shoreline, presenting a steep environment with sparse and patchy vegetation. Vegetation includes black greasewood, spiny hopsage, Indian ricegrass, and a number of sensitive species. Dune areas, such as those occurring on the eastern part of the site near the Energy Northwest complex, support bitterbrush, scrufpea, and thickspike wheatgrass. Island habitat accounts for about 466 hectares (1,152 acres) on Hanford. Vegetation characterizing the islands includes willow, poplar, Russian olive, mulberry, snow buckwheat, lupine,

mugwort, and yarrow. The Nature Conservancy of Washington has conducted a number of surveys of the site and has identified a total of 127 populations of 30 rare plants (Duncan 2007:4.89, 4.95, 4.96).

Approximately 300 species of terrestrial vertebrates have been observed on Hanford, including 46 of mammals, 258 of birds, 10 of reptiles, and 5 of amphibians. The shrub and grassland habitats of Hanford support many groups of terrestrial wildlife. Mammals include large game animals such as the Rocky Mountain elk and mule deer; predators such as coyote, bobcat, and badger; and herbivores such as deer, harvest mice, ground squirrels, voles, and black-tailed jackrabbits. Forty-one bird species are common to shrub and grassland habitats, including the western meadowlark, horned lark, long-billed curlew, vesper and sage sparrows, loggerhead shrike, northern harrier, and golden eagle. The side-blotched lizard is the most abundant species of lizard on Hanford, while the Great Basin gopher snake, western yellow-bellied racer, and western rattlesnake are the most common snakes. The painted turtle is also a resident on Hanford. The Great Basin spadefoot toad, Woodhouse's toad, Pacific tree frog, tiger salamander, western toad, and bullfrog are the only amphibians found on the site (Duncan 2007:4.83, 4.84, 4.90-4.92; Landeen and Crow 1997:78).

Many species of insects occur throughout all of the habitats found at Hanford. Butterflies, grasshoppers, and darkling beetles are among the most conspicuous of the approximately 1,500 species of insects identified from specimens collected on the site. The actual number of insect species occurring on Hanford may reach as high as 15,500. Recent site surveys performed by The Nature Conservancy identified 43 new taxa and 142 new findings for the state of Washington. The high diversity of insect species on Hanford is believed to reflect the size, complexity, and quality of the shrub-steppe habitat (Duncan 2007:4.92).

Riparian areas provide nesting and foraging habitat and escape cover for many species of birds and mammals. Mammals occurring primarily in riparian areas include rodents, bats, mink, porcupine, raccoon, and mule deer. Birds common to these areas include the American robin, black-billed magpie, song sparrow, and dark-eyed junco. Great blue herons and black-crowned night herons are associated with trees in riparian habitat, and bald eagles have wintered on Hanford since 1960. Hanford is located in the Pacific Flyway and serves as a resting area for neotropical migrant birds, migratory waterfowl, and shorebirds (Duncan 2007:4.93, 4.94).

A number of species are associated with unique habitats found on Hanford. White Bluffs and Umtanum Ridge provide nesting for birds, including the red-tailed hawk, cliff swallow, and rough-winged swallow. Bluff areas also provide habitat for sensitive species (e.g., the peregrine falcon) that otherwise might be subject to impacts of repeated disturbance. Trees that do not normally occur in arid steppe habitat supply nesting, perching, and roosting sites for many birds such as the ferruginous and Swainson's hawks. Dunes are unique in their association with the surrounding shrub-steppe vegetation and afford habitat for mule deer, coyotes, and burrowing owls. The islands of the Columbia River also afford a unique habitat at Hanford for waterfowl and shorebirds, including the Canada goose, California and ring-billed gulls, and Foster's tern. Some islands accommodate colonial nesting species that may range in population size upward of 2,000 individuals (Duncan 2007:4.95, 4.96).

In response to the 24 Command Fire of 2000, which burned 56,246 hectares (138,986 acres) within Hanford, USFWS prepared the *24 Command Fire, Benton County, Washington, June–July 2000, Burned Area Emergency Rehabilitation Plan* (DOI 2000) that assessed resource issues and impacts and provided recommendations. While vegetation resources were substantially reduced on about 85 percent of the fire area, due to the rather fast passage of the fire over any one area, most soils showed little damage and seed bank sources in the soil were not adversely impacted. Although this will aid natural revegetation, recovery of some plant associations (e.g., sagebrush) may require planting and could take years. Potential long-term impacts of the fire include the establishment of noxious weeds and changes in natural plant communities. The 24 Command Fire had immediate direct impacts on wildlife, including loss of

individual animals, especially smaller, less-mobile species and the young of the year, and displacement of more-mobile animals to unaffected areas. However, displacement itself can lead to increased mortality due to road kills; in the case of Rocky Mountain elk, this has occurred. Long-term impacts on wildlife due to loss of food, cover, and breeding habitat are expected as a result of the fire (DOI 2000:94, 95, 99, 100, 119). The Milepost 17 and Wautoma Fires of 2007 burned a large portion of the same area as the 24 Command Fire (see Figure 3–2). The other major fire that occurred in 2007 was the Overlook Fire, which burned 8,527 hectares (21,071 acres) on the north side of the Columbia River. Most of the area burned by the Overlook Fire consisted of native shrub-steppe uplands, but substantial riparian and wetland habitats in the Wahluke Ponds and other low-lying areas were also damaged. Following the fire, a burned-area rehabilitation plan was developed by USFWS, in consultation with tribes and local technical experts, to address short- and long-term rehabilitation needs (USFWS 2009).

3.2.7.1.2 200 Areas Description

Figures 3–16 and 3–17 illustrate vegetation and land cover in and around the 200-East and 200-West Areas following the 24 Command and Wautoma Fires. Most of the 200 Areas were not directly impacted by either fire (see Figure 3–2). Undisturbed portions of the 200 Areas are characterized by the following communities: big sagebrush/bunchgrass-cheatgrass, cheatgrass-bluegrass, crested wheatgrass-bunchgrass-cheatgrass, and gray rabbitbrush/cheatgrass-bluegrass. The former two communities are prominent in the 200-East Area, while the latter two are more common in the 200-West Area. Most of the waste disposal and storage sites are covered by nonnative vegetation or are kept in a vegetation-free condition by the controlled application of approved herbicides because plants could potentially accumulate waste constituents. Where vegetation is present, it aids in stabilizing surface soil, controlling soil moisture, or displacing more-invasive, deep-rooted species like Russian thistle (Duncan 2007:4.98). Due to the disturbed nature of most of the 200 Areas, wildlife use is limited; however, surveys have recorded the badger, coyote, Great Basin pocket mouse, mule deer, long-billed curlew, killdeer, horned lark, Say's phoebe, American robin, American kestrel, western meadowlark, and common raven (Sackschewsky 2003a:3, 2003b:9, 10; Sackschewsky and Downs 2007).

Surveys of areas potentially affected by the proposed Tank Closure alternatives have been completed (Sackschewsky 2003c, 2003d; Sackschewsky and Downs 2007). While large portions of the 200 Areas have been disturbed, sagebrush habitat, considered a priority habitat by the State of Washington and a Level III resource by the *Hanford Site Biological Resources Management Plan* (DOE 2001c), does occur in a number of locations (see Figures 3–16 and 3–17). It is found within the south-central portion of the 200-East Area and much of the area surrounding the WTP. The former area includes the site of IDF-East, while the latter includes the location within which the DSTs could be built, the location of the Supplemental Treatment Technology Site in the 200-East Area (STTS-East), and the area designated for interim canister storage (see Chapter 4, Figure 4–1). Sagebrush habitat is also found within the southeast corner of the 200-West Area, the location of STTS-West (see Chapter 4, Figure 4–2).

3.2.7.1.3 400 Area Description

The 400 Area, which is classified as "disturbed/nonvegetated" (see Figure 3–15), is located within postfire shrub-steppe habitat dominated by cheatgrass and small shrubs, including gray and green rabbitbrush. Owing to past disturbances and human occupancy of the 400 Area, wildlife is not as abundant as in undisturbed areas. However, a number of species are expected to occur. For example, surveys have identified 50 different bird species in habitats surrounding the building complexes, and 19 species actively nest on or near existing buildings. Species likely present include the American robin, barn swallow, European starling, and pigeon (PNNL 2008b).

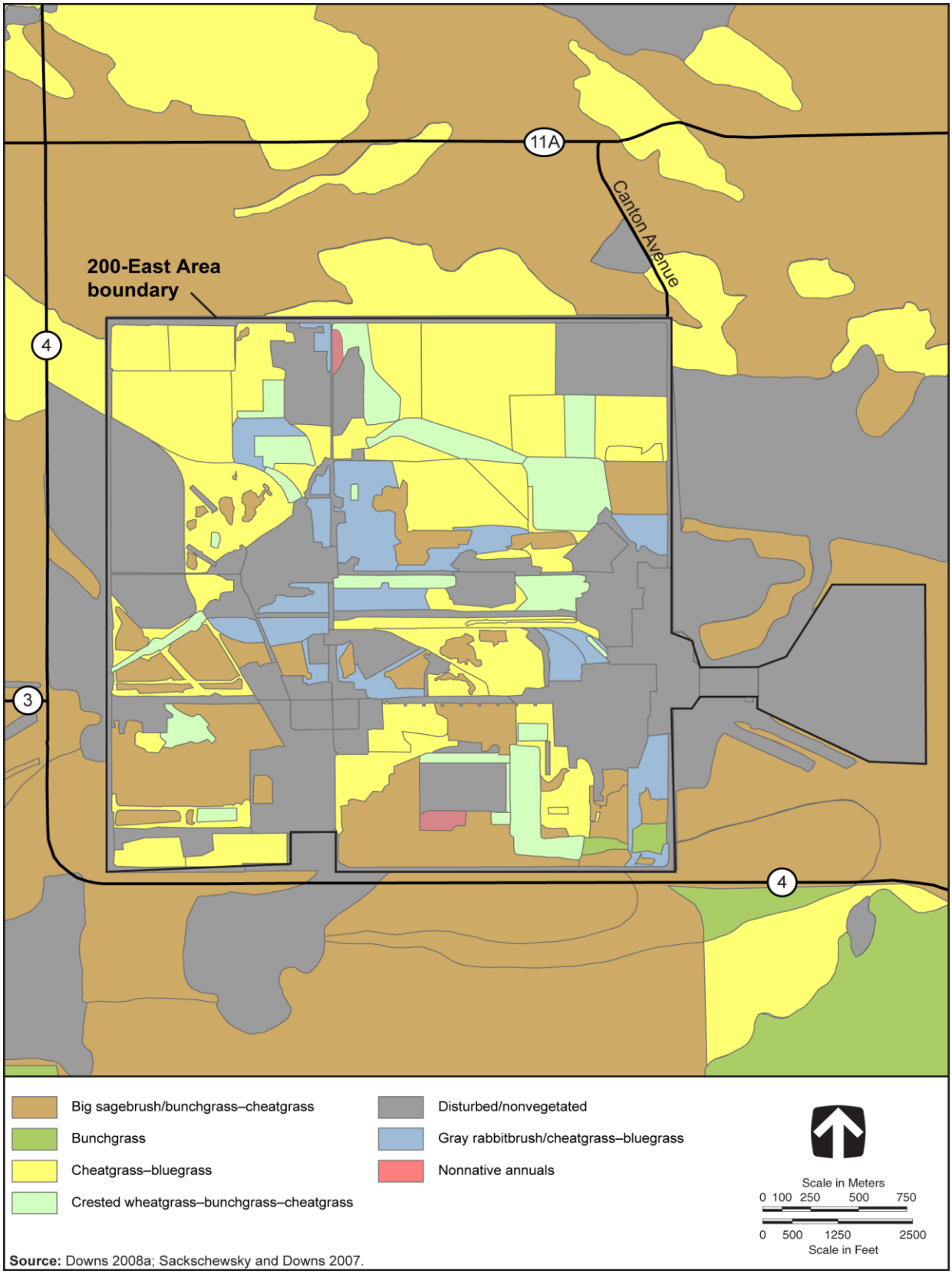
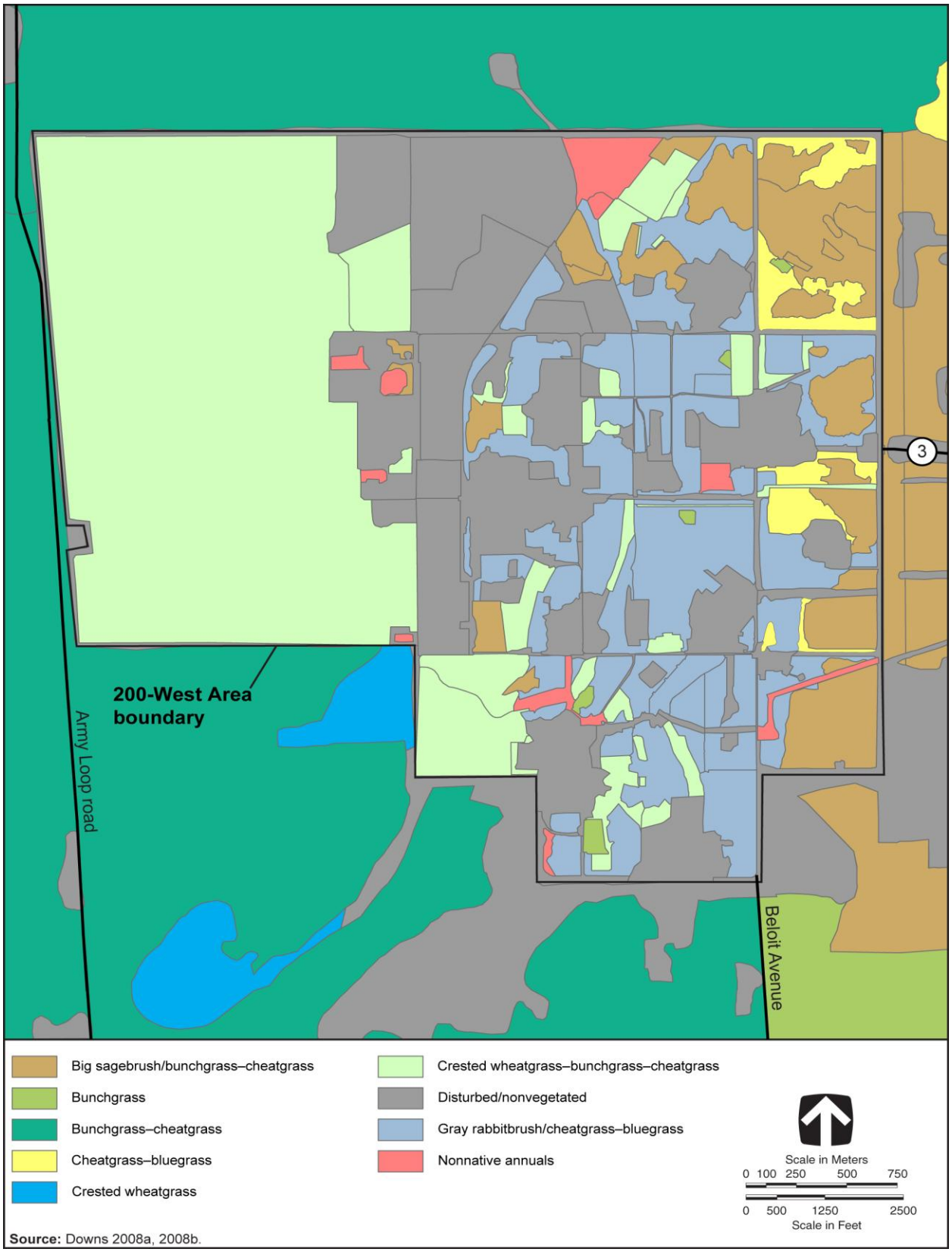


Figure 3–16. Vegetation Communities In and Near the 200-East Area



Source: Downs 2008a, 2008b.

Figure 3–17. Vegetation Communities In and Near the 200-West Area

3.2.7.1.4 Borrow Area C Description

Most of the original vegetation in Borrow Area C was burned in the 24 Command Fire of June 2000. The largest prefire plant community was dominated by Sandberg's bluegrass and cheatgrass, but communities containing other grasses and big sagebrush were also present. Few shrubs remained after the fire, and Sandberg's bluegrass-cheatgrass became the dominant plant community. There is also a rather large, high-quality needle-and-thread grass–Indian ricegrass community, an unusual and relatively pristine community type, in the eastern and western portions of the site (see Figure 3–18). Wildlife inhabiting Borrow Area C include mammals such as the badger, coyote, Rocky Mountain elk, mule deer, and northern pocket gopher; birds such as the horned lark, lark sparrow, rock wren, short-eared owl, and western meadowlark; and reptiles such as the side-blotched lizard (Sackschewsky 2003b:4-7; Sackschewsky and Downs 2007:7-8). A large part of Borrow Area C was burned during the 2007 Wautoma Fire (see Figure 3–2). A biological assessment of the fire has not been made; however, one effect was to maintain the area as grassland.

3.2.7.2 Wetlands

3.2.7.2.1 General Site Description

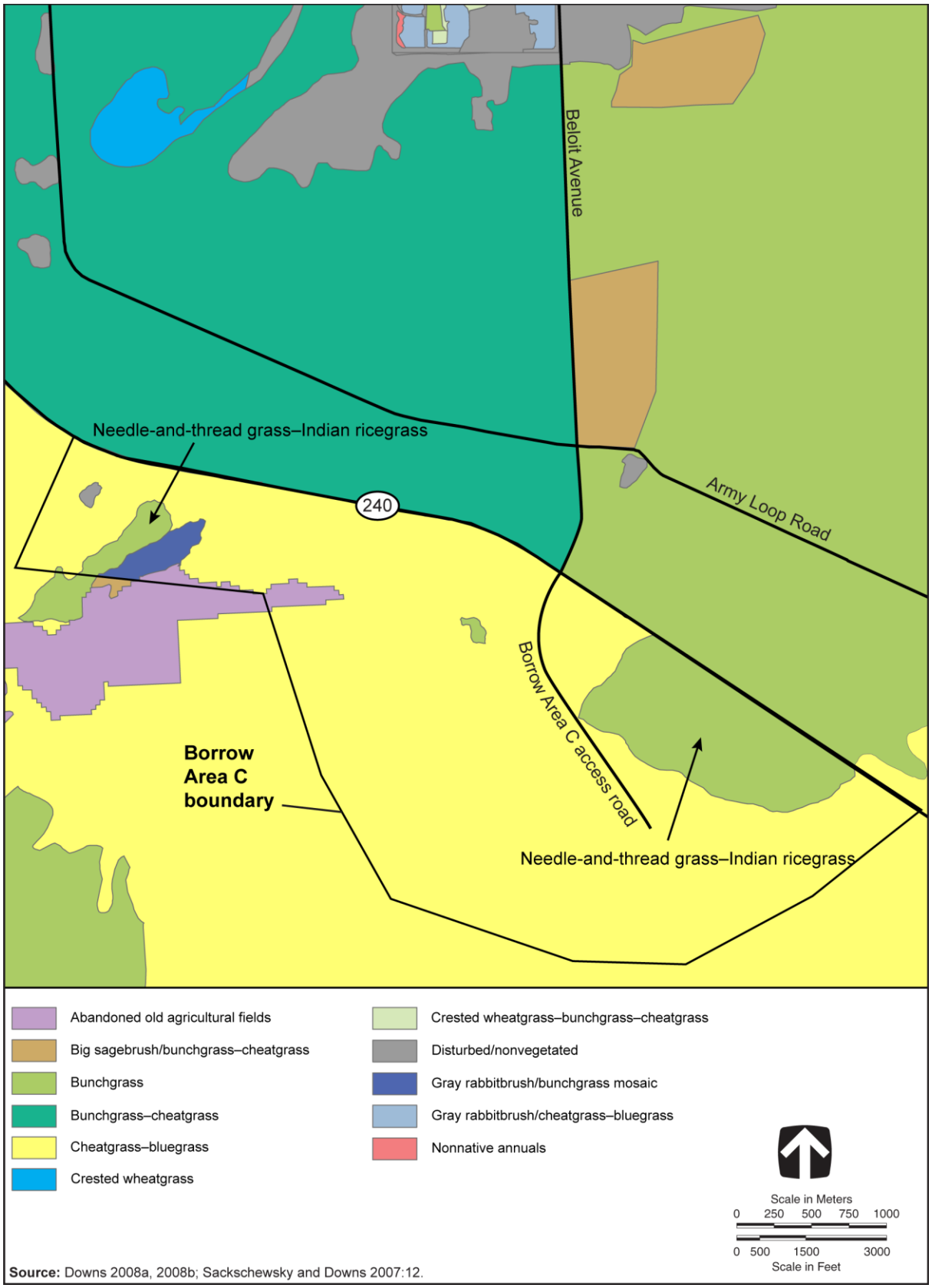
Riparian habitat occurring in association with the Columbia River includes riffles, gravel bars, backwater sloughs, and cobble shorelines. These habitats occur infrequently along the Hanford Reach and have acquired greater significance because of the loss of wetland habitat elsewhere within the region. Vegetation that occurs along the river shoreline includes willow, mulberry, Siberian elm, water smartweed, reed canary grass, sedges, and rushes (Duncan 2007:4.29, 4.93).

Other large wetland areas at Hanford can be found north of the Columbia River within the Saddle Mountain National Wildlife Refuge and the Wahluke Unit. These two areas encompass all the lands extending from the north bank of the Columbia River northward to the site boundary and east of the Columbia River down to Ringold Springs. Wetland habitat in these areas consists of fairly large ponds resulting from irrigation runoff. These ponds have extensive stands of cattails and other emergent aquatic vegetation surrounding the open-water regions. They are extensively used as nesting sites by waterfowl (Duncan 2007:4.93).

Some wetland habitat exists in the riparian zones of some of the larger spring-fed streams on the Fitzner-Eberhardt Arid Lands Ecology Reserve. These zones are not extensive and usually amount to less than 1 hectare (2.5 acres) in size. On the western side of Hanford, Rattlesnake Springs supports a riparian zone of 2.0 kilometers (1.2 miles) in length, which features cattail, peachleaf willow, and other exotic plants. Snively Springs also contains a diverse biotic community similar to that of Rattlesnake Springs (Duncan 2007:4.23). The 24 Command Fire affected approximately 17.8 hectares (44 acres) of willow riparian habitat, including areas around Rattlesnake Springs, Snively Canyon, Benson Springs, and the Yakima River (DOI 2000:108). The Overlook Fire burned substantial riparian and wetland habitat associated with the irrigation ponds and other low-lying areas north of the Columbia River (USFWS 2009).

3.2.7.2.2 200 Areas Description

The only wetland area in the vicinity of the 200 Areas is West Lake. With the cessation of nuclear materials production activities at Hanford, the amount of water discharged to the ground in the 200 Areas substantially decreased. Thus, over the past 10 years, the lake has decreased in size and currently consists of a group of small isolated pools and mudflats. Predominant plants at West Lake include alkali saltgrass, plantain, and salt rattlepod. Bulrush grows along the shoreline; however, the water is too saline to support aquatic macrophytes (i.e., large aquatic plants) (Duncan 2007:4.98, 4.99).



Source: Downs 2008a, 2008b; Sackschewsky and Downs 2007:12.

Figure 3–18. Distribution of Vegetation Communities In and Near Borrow Area C

3.2.7.2.3 400 Area Description

There are no natural wetlands in the 400 Area, although the FFTF Ponds (i.e., 4608 B/C Ponds) are present. Wildlife species observed using the cooling and wastewater ponds include a variety of mammals and waterfowl (DOE 1999b:3-36).

3.2.7.2.4 Borrow Area C Description

There are no wetlands located within Borrow Area C.

3.2.7.3 Aquatic Resources

3.2.7.3.1 General Site Description

The Hanford Reach of the Columbia River flows through the northern portion of the site and forms the eastern site boundary. It is the last free-flowing, nontidal segment of the Columbia River in the United States (Duncan 2007:4.99).

Macrophytes are generally sparse in the Columbia River; however, rushes and sedges occur along the shorelines of the slack-water areas. Where they exist, they provide food and shelter for juvenile fish and spawning areas for some species of warm-water game fish. Phytoplankton (free-floating algae) and periphyton (attached algae) are abundant in the Columbia River and provide food for herbivores such as immature insects, which in turn are consumed by predators. Both zooplankton (small, free-floating aquatic animals) and macrophytes are generally sparse in the river because of the strong currents, rocky bottom, and frequently fluctuating water levels. Benthos, or bottom-dwelling organisms, including insect larvae, clams, snails, and crayfish, are found in the river. These organisms are an important food source for juvenile and adult fish (Duncan 2007:4.100).

The Hanford Reach supports 45 anadromous and resident species of fish. Of these species, spring-run Chinook salmon, sockeye salmon, coho salmon, and steelhead use the river as a migration route to and from upstream spawning areas and are of the greatest economic importance. Additionally, fall-run Chinook salmon and steelhead spawn in the Hanford Reach. Inundation of other mainstream Columbia spawning grounds by dams has increased the importance of the Hanford Reach to fall-run Chinook salmon production in the Columbia and Snake Rivers. American shad is another anadromous species that may spawn in the Hanford Reach (Duncan 2007:4.100, 4.101).

Other fish of importance to sport fishermen are mountain whitefish, white sturgeon, smallmouth bass, crappie, channel catfish, walleye, and yellow perch. Large populations of rough fish are also present, including common carp, redside shiner, suckers, and northern pikeminnow (Duncan 2007:4.101).

The Yakima River borders the southern portion of Hanford. Fish found in the river in the site vicinity include smallmouth bass, salmon, steelhead, and channel catfish. Cold Creek and its tributary, Dry Creek, both ephemeral streams within the Yakima River drainage system, do not support any fish populations (DOE 2000a:3-121; YBFWRB 2008).

There are several springs at Hanford. Rattlesnake Springs, Bobcat Springs, and Snively Springs, located on the Fitzner-Eberhardt Arid Lands Ecology Reserve, form short streams that seep into the ground. None of the springs support any fish populations; however, dense blooms of watercress occur, and aquatic insect populations are higher than they are in mountain streams. Site springs are an important source of water for terrestrial animals (DOE 2000a:3-120; Duncan 2007:4.103).

Three clusters of approximately 20 vernal pools are distributed on the eastern end of Umtanum Ridge, in the central part of Gable Butte, and at the eastern end of Gable Mountain (DOE 1999a:4-31). Vernal pools are seasonally flooded depressions that retain water much longer than the surrounding uplands; nonetheless, the pools are shallow enough to dry up each season. Only plants and animals that are adapted to this cycle of wetting and drying can survive in vernal pools over time. These pools can host freshwater crustaceans and other invertebrates and are of value to terrestrial species.

3.2.7.3.2 200 Areas Description

The LERF and TEDF, located in and adjacent to the 200-East Area, contain five ponds. There are three evaporation ponds associated with the LERF, each of which is about 0.8 hectares (2 acres) in size. The two disposal ponds associated with the TEDF are each about 2 hectares (5 acres) in size. None of these ponds support fish populations. Although the LERF ponds are covered by a floating membrane constructed of very low-density polyethylene (Poston, Duncan, and Dirkes 2011:6.24), the TEDF ponds are not covered and, therefore, are accessible to wildlife. West Lake, which has decreased in size in recent years (see Section 3.2.6.1.2), is the only other water body near the 200 Areas; however, the lake is too saline to support aquatic macrophytes (Duncan 2007:4.98, 4.99).

3.2.7.3.3 400 Area Description

Although no natural aquatic habitat occurs in the 400 Area, the FFTF Ponds (i.e., 4608 B/C Ponds) are present (DOE 1999b:3-36). The 400 Area is 6.8 kilometers (4.2 miles) west of the Columbia River.

3.2.7.3.4 Borrow Area C Description

There are no aquatic resources within Borrow Area C.

3.2.7.4 Threatened and Endangered Species

Endangered species are those plants and animals that are in danger of extinction throughout all or a large portion of their range. Threatened species are those species that are likely to become endangered within the foreseeable future. In addition to threatened and endangered species, USFWS, National Marine Fisheries Services, and the state designate other organisms as candidate, species of concern, sensitive, watch, and review (see Table 3–8). This section addresses special status species for Hanford as a whole, as well as for the proposed facility locations. Informal consultation has been conducted with USFWS, National Oceanic and Atmospheric Administration Fisheries, the Washington State Department of Fish and Wildlife, and the Washington Natural Heritage Program concerning listed species that are potentially present on Hanford (see Appendix C).

3.2.7.4.1 General Site Description

Threatened, endangered, and other federally and state-listed special status species that occur on Hanford are presented in Table 3–8. One federally endangered species and 2 federally threatened species are found on the site. Two species of plants, 1 of birds, and 1 of mammals are listed as Federal candidates, and 4 plants, 1 mollusk, 1 fish, 1 amphibian, 1 reptile, 6 birds, and 1 mammal are designated as Federal species of concern. Neither the candidates nor the species of concern receive legal protection; however, they should be considered during project planning. At the state level, 2 species of plants and 2 of birds are listed as endangered, and 10 plants and 3 birds are listed as threatened. Numerous additional plants and animals have other state special status designations.

Table 3–8. Hanford Site Threatened, Endangered, and Other Special Status Species

Common Name	Scientific Name	Status	
		Federal	State
Plants			
Annual paintbrush	*Castilleja exilis*		Watch
Annual sandwort	*Minuartia pusilla* var. *pusilla*		Review Group 1
Awned halfchaff sedge	*Lipocarpha (=Hemicarpha) aristulata*		Threatened
Basalt milkvetch	*Astragalus conjunctus* var. *rickardii*		Watch
Beaked spike-rush	*Eleocharis rostellata*		Sensitive
Bristly combseed	*Pectocarya setosa*		Watch
Canadian St. John's wort	*Hypericum majus*		Sensitive
Chaffweed	*Anagallis minima Centunculus minimus*		Sensitive
Columbia milkvetch	*Astragalus columbianus*	Species of concern	Sensitive
Columbia River mugwort	*Artemisia lindleyana*		Watch
Columbia yellowcress	*Rorippa columbiae*	Species of concern	Endangered
Coyote tobacco	*Nicotiana attenuata*		Sensitive
Crouching milkvetch	*Astragalus succumbens*		Watch
Desert dodder	*Cuscuta denticulate*		Threatened
Desert evening primrose	*Oenothera caespitosa* ssp. *caespitosa*		Sensitive
Dwarf evening primrose	*Camissonia (=Oenothera) pygmaea*		Sensitive
False pimpernel	*Lindernia dubia* var. *anagallidea*		Watch
Fuzzytongue penstemon	*Penstemon eriantherus whitedii*		Sensitive
Geyer's milkvetch	*Astragalus geyeri*		Threatened
Giant helleborine	*Epipactis gigantea*		Watch
Grand redstem	*Ammannia robusta*		Threatened
Gray cryptantha	*Cryptantha leucophaea*	Species of concern	Sensitive
Great Basin gilia	*Aliciella leptomeria*		Threatened
Hoover's desert parsley	*Lomatium tuberosum*	Species of concern	Sensitive
Kittitas larkspur	*Delphinium multiplex*		Watch
Loeflingia	*Loeflingia squarrosa* var. *squarrosa*		Threatened
Lowland toothcup	*Rotala ramosior*		Threatened
Medick milkvetch	*Astragalus speirocarpus*		Watch
Miner's candle	*Cryptantha scoparia*		Sensitive
Mousetail	*Myosurus clavicaulis*		Sensitive
Piper's daisy	*Erigeron piperianus*		Sensitive
Porcupine sedge	*Carex hystericina*		Watch
Robinson's onion	*Allium robinsonii*		Watch
Rosy balsamroot	*Balsamorhiza rosea*		Watch
Rosy pussypaws	*Cistanthe rosea*		Threatened
Scilla onion	*Allium scilloides*		Watch
Small-flowered evening primrose	*Camissonia* (=*Oenothera*) *minor*		Sensitive

Table 3–8. Hanford Site Threatened, Endangered, and Other Special Status Species *(continued)*

Common Name	Scientific Name	Status	
		Federal	State
Plants *(continued)*			
Small-flowered nama	*Nama densum* var. *parviflorum*		Watch
Smooth cliffbrake	*Pellaea glabella var. simplex*		Watch
Snake River cryptantha	*Cryptantha spiculifera (= C. interrupta)*		Sensitive
Stalked-pod milkvetch	*Astragalus sclerocarpus*		Watch
Suksdorf's monkey flower	*Mimulus suksdorfii*		Sensitive
Thompson's sandwort	*Eremogone franklinii* var. *thompsonii*		Review Group 1
Umtanum desert buckwheat	*Eriogonum codium*	Candidate	Endangered
White Bluffs bladderpod	*Physaria douglasii* ssp. *tuplashensis*	Candidate	Threatened
White eatonella	*Eatonella nivea*		Threatened
Winged combseed	*Pectocarya penicillata*		Watch
Insects			
Columbia River tiger beetle[a]	*Cicindela columbica*		Candidate
Mollusks			
California floater	*Anodonta californiensis*	Species of concern	Candidate
Giant Columbia River limpet	*Fisherola (=Lanz) nuttalli*		Candidate
Giant Columbia River spire snail	*Fluminicola (=Lithoglyphus) columbiana*		Candidate
Fish			
Bull trout[b]	*Salvelinus confluentus*	Threatened	Candidate
Leopard dace[b]	*Rhinichthys flacatus*		Candidate
Mountain sucker[b]	*Catastomus platyrhynchus*		Candidate
River lamprey[b]	*Lampetra ayresi*	Species of concern	Candidate
Spring-run Chinook salmon	*Oncorhynchus tshawytscha*	Endangered[c]	Candidate
Steelhead	*Oncorhynchus mykiss*	Threatened[c, d]	Candidate
Amphibians			
Western toad	*Bufo boreas*	Species of concern	Candidate
Reptiles			
Northern sagebrush lizard	*Sceloporous graciosus*	Species of concern	Candidate
Striped whipsnake	*Masticophis taeniatus*		Candidate
Birds			
American white pelican	*Pelecanus erythrorhynchos*		Endangered
Bald eagle[e]	*Haliaeetus leucocephalus*	Species of concern	Sensitive
Burrowing owl	*Athene cunicularia*	Species of concern	Candidate
Common loon	*Gavia immer*		Sensitive
Ferruginous hawk	*Buteo regalis*	Species of concern	Threatened
Flammulated owl[b]	*Otus flammeolus*		Candidate
Golden eagle	*Aquila chrysaetos*		Candidate
Greater sage grouse	*Centrocercus urophasianus phaios*	Candidate	Threatened

Table 3–8. Hanford Site Threatened, Endangered, and Other Special Status Species *(continued)*

Common Name	Scientific Name	Status	
		Federal	State
Birds *(continued)*			
Lewis's woodpecker[b]	*Melanerpes lewis*		Candidate
Loggerhead shrike	*Lanius ludovicianus*	Species of concern	Candidate
Merlin	*Falco columbarius*		Candidate
Northern goshawk[b]	*Accipter gentilis*	Species of concern	Candidate
Peregrine falcon	*Falco peregrinus*	Species of concern	Sensitive
Sage sparrow	*Amphispiza belli*		Candidate
Sage thrasher	*Oreoscoptes montanus*		Candidate
Sandhill crane	*Grus canadensis*		Endangered
Western grebe	*Aechmophorus occidentalis*		Candidate
Western sage grouse	*Centrocercus urophasianus phaios*		Threatened
Mammals			
Black-tailed jackrabbit	*Lepus californicus*		Candidate
Merriam's shrew	*Sorex merriami*		Candidate
Townsend's ground squirrel	*Spermophilus townsendii*	Species of concern	Candidate
Washington ground squirrel[b]	*Spermophilus washingtoni*	Candidate	Candidate
White-tailed jackrabbit	*Lepus townsendii*		Candidate

[a] Probable but not observed on the Hanford Site.

[b] Reported but seldom seen on the Hanford Site.

[c] Protected as an Evolutionarily Significant Unit for the upper Columbia River.

[d] Protected as an Evolutionarily Significant Unit for the middle Columbia River.

[e] Removed from the list of threatened wildlife in the lower 48 states effective August 8, 2007 (72 FR 37346).

Federal:

Candidate: Current information indicates the probable appropriateness of listing as endangered or threatened.

Endangered: In danger of extinction throughout all or a significant portion of its range.

Species of Concern: Conservation standing is of concern, but status information is still needed (not published in the *Federal Register*).

Threatened: Likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

State:

Candidate: Current information indicates the probable appropriateness of listing as endangered or threatened.

Endangered: In danger of becoming extinct or extirpated from Washington State within the foreseeable future if factors contributing to its decline continue.

Review Group 1: Of potential concern; additional fieldwork is needed before a status can be assigned.

Review Group 2: Of potential concern; unresolved taxonomic questions.

Sensitive: Vulnerable or declining and could become endangered or threatened in Washington State without active management or removal of threats.

Threatened: Likely to become endangered in Washington State within the foreseeable future if factors contributing to its decline or habitat degradation or loss continue.

Watch: More abundant and/or less threatened than previously assumed, but still of interest to the state.

Source: Duncan 2007:4.106, 4.107, 4.109–4.113; USFWS 2007:2-35–2-37; WDFW 2010a; WNHP 2009, 2011.

Of the three fish species listed as threatened and endangered, only the upper Columbia River steelhead spawns in the Hanford Reach, although the extent of spawning is not known. The Upper Columbia River spring-run Chinook salmon do not spawn in the Hanford Reach, but adults pass through the Reach while migrating to spawning grounds, and the juveniles use it as a nursery area until they migrate toward the ocean. The bull trout primarily inhabits smaller streams, usually at higher elevations. The bald eagle is a relatively common winter resident along the Hanford Reach. Although it has occasionally attempted to

nest on Hanford, it has not been successful (Duncan 2007:4.105, 4.108). Although not listed in Table 3−8 as a special status species, the long-billed curlew is a state monitor species, indicating that it is monitored for status and distribution (WDFW 2010b).

Twelve species of plants that occur on Hanford are listed as threatened or endangered in Washington (see Table 3–8). Four of these, chaffweed, awned halfchaff sedge, grand redstem, lowland toothcup, and Columbia yellowcress, are found in areas along the Columbia River. Desert dodder has been found along a dry drainage in Cold Creek Valley and on White Bluffs. Other species associated with White Bluffs include Geyer's milkvetch and White Bluffs bladderpod. White Bluffs bladderpod has been reported nowhere else in the world. Great Basin gilia has been reported near Gable Mountain and at various locations on the Wahluke Slope. Loeflingia and rosy pussypaws have been found in the sandy areas north of Gable Mountain. Umtanum desert buckwheat has been reported growing in thin rocky soils along the crest of Umtanum Ridge and nowhere else in the world. White eatonella has been found locally on steep, sandy slopes near Vernita Bridge (Sackschewsky and Downs 2001:3.15, 3.34, 3.40, 3.45, 3.49, 3.54, 3.72, 3.92, 3.94, 3.101, 3.103).

Four state-listed threatened or endangered birds have been recorded at Hanford. The American white pelican is fairly common along the Hanford Reach, but does not appear to nest or reproduce there. The ferruginous hawk has nested in several areas, including numerous locations in the eastern portion of the site. The greater sage grouse was sighted on the Fitzner-Eberhardt Arid Lands Ecology Reserve in the late 1900s and, in 2003, a dead individual was found near the 100-F Area. Sandhill cranes have been occasionally observed on the Hanford Reach during their spring migration (DOE 1999a:4-59; Duncan 2007:4.105).

USFWS has revised the designation of critical habitat for the bull trout to include the Mainstem Upper Columbia River and Yakima River units (75 FR 63898). The Mainstem Upper Columbia River unit extends upstream from the John Day Dam to the Chief Joseph Dam and includes the Hanford Reach. It provides connectivity between the Mainstem Upper Columbia River habitat unit and 13 additional units. The Yakima River unit includes the entire Yakima River basin, including the portion bordering Hanford to the south. It supports one of the largest populations of bull trout (South Fork Tieton River population above Tieton Dam) in central Washington and provides spawning, rearing, foraging, migratory, connecting, and overwintering habitat.

Although not critical habitat per se, pristine shrub-steppe habitat is considered by Washington State to be a priority habitat. It is so designated because of its relative scarcity in the state and its requirement as nesting/breeding habitat by several federally and state-listed species (WDFW 2007). Designation and characterization of priority habitat provide a basis for sound and defensible land management planning and assist DOE in integrating stewardship activities into site management to protect regulated species.

Up to 9 plant and 10 animal special status species could have been found in the 56,246-hectare (138,986-acre) area that was burned by the 24 Command Fire at Hanford (DOI 2000:v, 121). Direct effects of the fire on protected vegetation included loss of plants and seed stock. Indirect effects included increased competition from invasive plant species, potential loss of soil productivity due to wind erosion, and loss of seed viability; however, indirect effects could also include such benefits as the release of nutrients back into the soil and reduced competition for soil nutrients, soil moisture, and sun. As for wildlife, the 24 Command Fire was determined to have had no effect on any federally listed threatened or endangered species. Potential impacts on state-listed species included direct loss of adults and young, while indirect effects included loss of habitat used as cover and for feeding and raising young. An assessment of the impacts of the 2007 Milepost 17 and Wautoma Fires on threatened and endangered species has not been made.

3.2.7.4.2 200 Areas Description

No federally or state-listed threatened or endangered species have been observed within, or in the immediate vicinity of, the 200 Areas; however, a number of other special status species have been found within areas potentially affected by Tank Closure alternatives (Sackschewsky 2003c, 2003d; Sackschewsky and Downs 2007). Piper's daisy has been observed in the vicinity of the WTP, along the route of the 200-East Area underground transfer line, between the 200-East and 200-West Areas, and within STTS-West. Stalked-pod milkvetch has been found in the vicinity of the WTP and within both STTS-East and -West. Another milkvetch species, crouching milkvetch, was observed within the vicinity of the WTP, within STTS-East, and between the 200-East and 200-West Areas.

Special status animal species that have been observed within areas potentially impacted by Tank Closure alternatives include the sage sparrow, black-tailed jackrabbit, and loggerhead shrike. The sage sparrow has been found within the vicinity of the WTP, within STTS-West, and between the 200-East and 200-West Areas. The black-tailed jackrabbit has been seen along the route of the 200-East Area underground transfer line and between the 200-East and 200-West Areas. The loggerhead shrike was observed within STTS-West and between the 200-East and 200-West Areas. Finally, the long-billed curlew, a state monitor species, was observed along the route of the 200-East Area underground transfer line. Because of the importance of sagebrush habitat, many of these species could be present anywhere such habitat exists (Sackschewsky 2003c, 2003d; Sackschewsky and Downs 2007). In addition to those animals observed within the 200 Areas, the ferruginous hawk, loggerhead shrike, and burrowing owl have been observed nesting in the vicinity, and the block of habitat to the south provides some of Hanford's best sage sparrow habitat (DOE 1999a:4-57, 4-59).

3.2.7.4.3 400 Area Description

No federally or state-listed threatened or endangered plants or animals have been found in the vicinity of the 400 Area (Duncan 2007:106, 107), although a potential exists for the incidental occurrence of some migratory species such as the peregrine falcon. State-listed sensitive plant species have not been found in the 400 Area; however, Piper's daisy does occur in the vicinity. A fire burned the area in the mid-1980s, leaving it dominated by cheatgrass and some small shrubs (DOE 2000a:3-122).

3.2.7.4.4 Borrow C Area Description

Although no federally or state-listed threatened or endangered species occur within Borrow Area C, the area provides extensive habitat for ground-nesting birds, including the long-billed curlew. Two special status plant species have been observed there. Piper's daisy is known to occur in rather high numbers south of the area, and at least one individual has been found along the new access road. Crouching milkvetch and stalked-pod milkvetch have also been observed in Borrow Area C (Sackschewsky 2003b:7; Sackschewsky and Downs 2007:8).

3.2.8 Cultural and Paleontological Resources

Cultural resources are of two primary categories: prehistoric resources, or physical properties reflecting human activities that predate written records; and historic resources, or physical properties that postdate the advent of written records—in the United States, generally considered to be those documented no earlier than 1492. These resources are of special interest and importance to American Indians and include all areas, sites, and materials deemed important for religious or heritage-related reasons, as well as certain natural resources such as plants, which have many uses within various American Indian groups. Paleontological resources are the physical remains, impressions, or traces of plants or animals from a former geologic age that may be sources of information on paleoenvironments and the evolutionary development of plants and animals.

Historic and prehistoric human imprints on the Hanford landscape are well documented, as are local traces of plants and animals from earlier geologic ages, and these cultural and paleontological resources are defined and protected by a series of Federal laws, regulations, and guidelines. The *Hanford Cultural Resources Management Plan* (DOE 2003c) established guidance for identifying, evaluating, recording, curating, and managing such resources. Moreover, cultural resource reviews are typically conducted whenever projects are proposed in previously unsurveyed areas (Neitzel 2005:4.99). Such a review has been conducted in those areas of Hanford that could be developed in connection with the proposed actions analyzed in this *TC & WM EIS* (PNNL 2003, 2007a). Archaeological reconnaissance projects dated from 1926 to 1968 and more-recent National Historic Preservation Act Section 106 and Section 110 surveys conducted between 1987 and 2007 have resulted in formal recording of these resources on archaeological forms and Washington State Historic Property Inventory Forms. DOE archives these records (Duncan 2007:4.6). Additionally, consultation with the Washington State Historic Preservation Office and interested American Indian tribes has been initiated for this EIS (see Appendix C), and a programmatic agreement has been developed among the DOE Richland Operations Office, the Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office regarding the built environment on Hanford (DOE 1996b).

During 1990, the National Park Service formalized the concept of the traditional cultural property (TCP) as a means to identify and protect cultural landscapes, places, and objects that have special cultural significance to American Indians and other ethnic groups. A TCP that is eligible for the National Register of Historic Places (National Register) is associated with the cultural practices or beliefs of a living community that are rooted in that community's history and are important in maintaining the continuing cultural identity of the community.

The Hanford Reach and the greater Hanford Site are central to the practice of the American Indian religion of the region. Native plants and animals are used in ceremonial foods. 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 TCPs within Hanford include, but are not limited to, a wide variety of landscapes such as archaeological sites, cemeteries, trails and pathways, campsites and villages, fisheries, hunting grounds, plant-gathering areas, holy lands, landmarks, and important places of American Indian history and culture (Duncan 2007:4.120).

3.2.8.1 Prehistoric Resources

3.2.8.1.1 General Site Description

More than 8,000 years of prehistoric human activity in the largely arid environment of the middle Columbia River region have left extensive archaeological deposits along the river shores. Well-watered areas inland from the river also show evidence of concentrated human activity, and recent surveys have indicated transient use of arid lowlands for hunting. These cultural sites were occupied continuously or intermittently over substantial timespans. For this reason, a single location may contain evidence of use during both the prehistoric and historic periods, and thus the number of "occupations" could prove substantially greater than the number of identified sites (Neitzel 2005:4.103).

To date, approximately 32,630 hectares (80,640 acres) of Hanford and adjacent areas have been surveyed for archaeological resources. Approximately 1,550 cultural resource sites and isolated finds and 531 buildings and structures have been documented. Forty-nine cultural resource sites are listed in the National Register. Most of these sites are associated with the American Indian landscape and are part of six archaeological districts situated on the shores and islands of the Columbia River. To protect resources, the National Historic Preservation Act (16 U.S.C. 470 et seq.), Section 304, and the

Archaeological Resources Protection Act (16 U.S.C. 470aa et seq.), Section 9, require agencies to withhold from public disclosure information on the location and character of cultural resources (Duncan 2007:4.115).

Prehistoric period sites common to Hanford include remains of numerous pithouse villages, various types of open campsites, spirit quest monuments (rock cairns), hunting camps, game drive complexes, quarries in mountains and rocky bluffs, hunting and kill sites in lowland stabilized dunes, and small temporary camps near perennial sources of water away from the river (Duncan 2007:4.120).

Although development and amateur artifact collectors have disturbed many prehistoric resources throughout the region, restricted public access imposed at Hanford has resulted in less destruction than in many other areas (Duncan 2007:4.120). Destruction from other causes is also slight. A preliminary assessment of possible effects of the 24 Command Fire, for example, determined that a minimum of 190 previously recorded prehistoric and historic archaeological sites could have been affected (DOI 2000:80). These sites range from lithic to can scatters, American Indian hunting sites to ranch buildings, and spirit quest monuments to gas production wells. The assessment found that wooden structures (e.g., a corral) were destroyed, but that other surface and subsurface artifacts such as glass and lithic debris were not severely altered by the fire. Postfire surface visibility, in fact, has been greatly enhanced, presenting opportunities for archaeologists and historians to refine the boundaries of known sites and to locate new sites, though it also increases the potential for looting and vandalism.

3.2.8.1.2 200 Areas Description

A number of cultural resource surveys have been conducted within the 200 Areas (Chatters and Cadoret 1990; PNNL 2003, 2007b). The most important archaeological resource discovered in the 200 Areas is White Bluffs Road, an extensive linear feature that passes diagonally northeast to southwest through the 200-West Area. In the prehistoric period, the road was used as an American Indian trail. White Bluffs Road, which was mapped prior to 1881, originally ran from Fort Colville to White Bluffs Landing on the Columbia River, then southwest to the Yakima River at a point near Sunnyside, Washington, where it connected with routes to The Dalles, Oregon (Chatters and Cadoret 1990:11). White Bluffs Road in its entirety has been determined to be eligible for listing in the National Register. Two intact segments of the road within the 200-West Area are considered contributing elements. These occur in the southwest and northeast parts of the 200-West Area. A 100-meter (328-foot) easement was created to protect these segments of the road from uncontrolled disturbance. The remaining central portion of the road within the 200-West Area has been determined to be noncontributing. The noncontributing segments of White Bluffs Road are those that do not add to the historic significance of the road, but retain evidence (i.e., contiguous traces) of its bearing (Chatters and Cadoret 1990:11, 21; Duncan 2007:4.130).

Additional finds within and adjacent to the 200 Areas that are associated with the prehistoric period include two cryptocrystalline silica flakes (i.e., fragments chipped from a rock core during toolmaking) and a cryptocrystalline silica base of a projectile point that were collected and curated by archaeologists upon discovery. The former were found within the northwestern portion of the 200-West Area 300 meters (984 feet) northwest of White Bluffs Road and may have been associated with its use (Chatters and Cadoret 1990:15, 16). The latter was discovered immediately to the east of the 200-East Area (PNNL 2003). These artifacts have become part of the curated Hanford collection. An additional isolated and incomplete cryptocrystalline silica projectile point was recorded and left in place in the 200 Areas in 2007. Survey results and geologic data indicate that this area has a low potential for the presence of prehistoric subsurface cultural deposits (PNNL 2007b).

3.2.8.1.3 400 Area Description

In 1978, an archaeological reconnaissance survey of the 400 Area was conducted. At that time, the survey indicated that most of the 400 Area, except for 12.1 hectares (30 acres), had already been disturbed by the construction of FFTF. The survey did not disclose any archaeological resources, and other surveys conducted near the project area disclosed no cultural resources. The 400 Area is considered a low-archaeological-sensitivity area (Duncan 2007:4.133; Prendergast 2002).

3.2.8.1.4 Borrow Area C Description

There are no prehistoric archaeological sites recorded within Borrow Area C. Survey results and geologic data on Borrow Area C indicate no-to-low potential for the presence of prehistoric subsurface cultural deposits (PNNL 2007b).

3.2.8.2 Historic Resources

3.2.8.2.1 General Site Description

Lewis and Clark were some of the first European Americans to visit the Hanford region during their 1804–1806 expedition. They were followed by fur trappers, military units, and miners. It was not until the 1860s that merchants set up stores, a freight depot, and the White Bluffs Ferry on the Hanford Reach, and gold miners began to work the gravel bars. Cattle ranches opened in the 1880s, and farmers soon followed. Several small thriving towns, including Hanford, White Bluffs, and Ringold, grew up along the riverbanks in the early twentieth century. Other ferries were established at Wahluke and Richland. These towns, and nearly all other structures, were razed after the U.S. Government acquired the land for the original Hanford Engineer Works (part of the Manhattan Project) in the early 1940s (Neitzel 2005:1.104). Today, the remnants of homesteads, farm fields, ranches, municipal facilities (e.g., Hanford High School, White Bluff Bank), and abandoned military installations can be found throughout Hanford. There are nearly 5,260 hectares (13,000 acres) of abandoned agricultural lands on the site (DOE and Ecology 1996:4-37).

During the years of the Manhattan Project and the Cold War, numerous nuclear reactors and associated processing facilities were constructed at Hanford. The reactor sites cover over 930 hectares (2,300 acres) of land. All of the reactor buildings and major processing facilities still stand, although many ancillary support structures have been removed. Plutonium produced at Hanford was used in the bomb that destroyed Nagasaki, Japan, to help end World War II. The Hanford 105-B Reactor, the world's first full-scale plutonium production reactor, is listed in the National Register and is designated a National Mechanical Engineering Landmark, a National Historic Civil Engineering Landmark, and a National Nuclear Engineering Landmark (DOE and Ecology 1996:4-37; Neitzel 2005:4.109). On August 19, 2008, the B Reactor was designated as a National Historic Landmark (DOE and DOI 2008).

Approximately 650 historic archaeological sites associated with the early-settler cultural landscape have been recorded since 1987. Archaeological resources from this period are scattered over Hanford and include numerous areas with gold-mining features along the Columbia riverbanks, as well as the remains of homesteads, building foundations, agricultural equipment and fields, ranches, and irrigation features. Historic sites from this period include the Hanford Irrigation Ditch; Old Hanford Townsite; Wahluke Ferry; White Bluffs Townsite; Richmond Ferry; Arrowsmith Townsite; White Bluffs Road; and Chicago, Milwaukee, St. Paul, and Pacific Railroad (Neitzel 2005:4.106).

The Manhattan Project and Cold War era landscape includes cultural resources associated with plutonium production, military operations, R&D, waste management, and environmental monitoring activities. Such activities began with the establishment of Hanford (the Hanford Engineer Works) in 1943 and continued until the end of the Cold War in 1990. DOE identified a National Register–eligible Hanford Site

Manhattan Project and Cold War Era Historic District. Approximately 900 buildings and structures were identified as either contributing properties with no individual documentation requirement (not selected for mitigation) or as noncontributing/exempt properties. There are 528 Manhattan Project and Cold War era buildings/structures and complexes eligible for National Register listing as contributing properties within the Historic District. Of that number, 190 have been recommended for individual documentation (Duncan 2007:4.119, 4.124).

3.2.8.2.2 200 Areas Description

Much of the 200 Areas has been altered by Hanford operations. The Hanford Cultural Resources Program conducted a comprehensive archaeological resources survey of the fenced portions of the 200 Areas during 1987 and 1988 (Chatters and Cadoret 1990). The results indicate minimal evidence of American Indian cultural landscape resources and early settler/farming landscape resources. Archaeological surveys conducted since that time have revealed the same pattern (Duncan 2007:4.6.4.2).

As stated previously (see Section 3.2.8.1.2), the White Bluffs Road traverses the 200-West Area. It was originally used as an American Indian trail connecting an important water source, Rattlesnake Springs, with a favorite river crossing on the Columbia River at White Bluffs. White Bluffs Road was an important transportation route during mining, cattle ranching, and settlement eras in the Washington Territory. It played a role in European-American immigration, development, agriculture, and Hanford operations, and thus is of historic importance (Chatters and Cadoret 1990:17; Neitzel 2005:4.113). As noted previously, White Bluffs Road has been determined to be eligible for listing in the National Register (see Section 3.2.8.1.2). The survey conducted during 2000 on White Bluffs Road recorded an additional 54 historic isolated finds and two precontact isolated finds, as well as six dump features (Duncan 2007:4.130).

The only historic artifacts more than 50 years old that were found in the 200-East Area are a hole-in-top can and a flat-topped crimped can. These artifacts were found in the south-central part of the area (Chatters and Cadoret 1990:11, 13, 15, 16; PNNL 2003). An additional site containing cans is located south of the WTP and slightly north of Route 4 South. This site consists of a small military refuse pile of cans and Coke bottles and is likely associated with the National Register–eligible anti-aircraft artillery site located about 400 meters (1,312 feet) south of Route 4 South. This site is considered a noncontributing feature associated with the anti-aircraft artillery site and thus not eligible for listing in the National Register (PNNL 2003).

A historic property inventory has been completed for 72 buildings and structures in the 200 Areas. Of that number, 58 have been deemed eligible for National Register listing as contributing properties within the Hanford Site Manhattan Project and Cold War Era Historic District and thus recommended for mitigation. Included are the 234-5Z Plutonium Finishing Plant, 236-Z Plutonium Reclamation Facility, 242-Z Water Treatment Facility, 231-Z Plutonium Metallurgical Laboratory, 225-B Encapsulation Building, 221-T Canyon (T Plant) Building, 202-A PUREX Building, 202-S REDOX [Reduction-Oxidation] Plant, 212-N Lag Storage Facility, 282-E Pumphouse and Reservoir Building, 283-E Water Filtration Plant, and 284-W Power House and Steam Plant. The 232-Z Waste Incinerator Facility and the 233-S Plutonium Concentration Building are also eligible for the National Register and, along with the 221-T Plant, have been documented to Historic American Engineering Record Standards. The 233-S building was recently demolished. As required by the programmatic agreement with the Advisory Council on Historic Preservation and the Washington State Historic Preservation Office, DOE assessed the contents of the historic buildings and structures within the 200 Areas, and identified and tagged artifacts with interpretive and/or educational value as exhibits within local, state, or national museums (DOE 1996b:8).

An additional feature of historic importance located to the west of the 200-East Area is a small portion of one of the Hanford Atmospheric Dispersion Test Facility arc roads. This portion of the road was determined to be a contributing property within the Manhattan Project and Cold War Era Historic District and was recommended for individual documentation. A Historic Property Inventory Form was completed, and numerous artifacts were identified as having interpretive or educational value in potential exhibits. A selected, representative number of these artifacts were removed and added to the curated Hanford collection (PNNL 2003).

3.2.8.2.3 400 Area Description

Most of the 400 Area has been so altered by construction activities that archaeologists surveying the site during 1978 were able to find only 122 hectares (300 acres) that were undisturbed (Duncan 2007:4.133). In 2002, the Hanford Cultural Resources Laboratory of Pacific Northwest National Laboratory conducted a cultural resource review for deactivation and decommissioning of FFTF within the 400 Area at Hanford (Prendergast 2002). A historic properties survey conducted as part of the review included a literature and records search for the Area of Potential Effect. Five buildings within FFTF were determined to be eligible for National Register listing under criterion A—i.e., they are contributing properties recommended for mitigation within the Hanford Site Manhattan Project and Cold War Era Historic District. The five buildings include the 405 FFTF Reactor Containment Building, the 436 Training Facility, the 4621-W Auxiliary Equipment Facility, the 4703 FFTF Control Building, and the 4710 Operation Support Building. Selection of these five properties followed from the programmatic agreement between DOE, the Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office (DOE 1996b). Both Historic Property Inventory Forms and Expanded Historic Property Inventory Forms were completed for these facilities (Duncan 2007:4.133).

In addition to these 5 buildings, 16 additional buildings within FFTF are eligible for inclusion in the National Register as contributing properties within the Hanford Site Manhattan Project and Cold War Era Historic District, and for these no individual documentation is required. These 16 buildings include the 403 Fuel Storage Facility; 408-A, 408-B, and 408-C Dump Heat Exchangers; 409-A and 409-B Closed Loop Dump Heat Exchangers; 437 Maintenance and Storage Facility; 451-A Substation; 481 and 481-A Pump Houses; 491-E, 491-S, and 491-W Heat Transport Buildings; 4621-E Auxiliary Equipment Building East; 4701-A Guard House; and 4717 Reactor Service Building (Prendergast 2002).

An additional 16 facilities within FFTF are noncontributing properties and thus not eligible for the National Register. They are the 480-A, 480-B, and 480-D Well Pump Houses; Pump 440 90-Day Pad; 432-A Rigging Shed; 482-A Water Storage Tank T-58, 482-B Water Storage Tank T-87, and 482-C Water Storage Tank T-330; 484 Incontainment Chilled Water Building; 4713-A Carpenter Shop; 4713-B Maintenance Shop; 4713-C Warehouse; 4713-D Manipulator Repair Shop; 4716 Rigging Loft; 4721 Turbine Generator; and 4608-B Process Sewer Building (Prendergast 2002).

In December 2002, the Hanford Cultural Resources Laboratory was contracted by DOE-RL, under a Request for Cultural Resources Review, to prepare a curation management plan for the deactivation and decommissioning of FFTF. The purpose of the plan was to ensure the project is in compliance with the requirements of the National Historic Preservation Act of 1966 (as amended) and the programmatic agreement regarding the maintenance, deactivation, alteration, and demolition of the built environment at Hanford (DOE 1996b; Harvey 2002).

The Hanford Cultural Resources Laboratory conducted walkthroughs and prepared written and photographic documentation of the five buildings (405, 436, 4621-W, 4703, and 4710) inside the 400 Area Property Protected Area that were identified as eligible for inclusion in the National Register under criterion A using either a Historic Property Inventory Form or an Expanded Historic Property Inventory Form. Given the possible occurrence of significant artifacts, the Hanford Cultural Resources

Laboratory also conducted walkthroughs of the 16 contributing properties for which no individual documentation was required. In total, 30 artifacts were identified and tagged in 8 of the 21 historic buildings (405, 4703, 436, 403, 4621-E, 4621-W, 4710, and 4701-A) and 1 of the nonhistoric buildings (4732-C). Included were industrial equipment and machinery, photographs and graphs, publications, control room panels, and models. Dimensions of the artifacts were recorded with a view to assessing storage and curation needs. Issues concerning the eventual storage and curation of these artifacts are not yet resolved (Harvey 2002).

A curation management plan was submitted to the State of Washington's Office of Archaeology and Historic Preservation for review and concurrence. In a response dated February 26, 2003, the Deputy State Historic Preservation Officer reported concurrence with the plan's findings and conclusions and support of its recommendations as to interpretation, storage, and curation of the artifacts at FFTF. The Deputy State Historic Preservation Officer did express concern, however, over the levels of contamination at FFTF and in that connection raised the possibility that none of the historic artifacts would be preserved in light of contamination found at FFTF (Griffith 2003).

3.2.8.2.4 Borrow Area C Description

Survey results and geologic data on Borrow Area C indicate no-to-low potential for the presence of historic subsurface cultural deposits. One historic isolated find recorded in 2007 consists of three hole-in-top cans associated with early settler use (PNNL 2007b).

3.2.8.3 American Indian Interests

3.2.8.3.1 General Site Description

In prehistoric and early historic times, American Indians of various tribal affiliations heavily populated the Hanford Reach, and some of their descendants still live in the region. Present-day tribal members retain traditional secular and religious ties to the region, and many have knowledge of the ceremonies and lifeways of their culture. The Washani, or Seven Drums religion, which has ancient roots, is still practiced by many American Indians. Native plant and animal foods, some of which can be found at Hanford, are used in ceremonies performed by tribal members (DOE 2000a:3-125).

Under separate treaties signed in 1855, a number of regional American Indian tribes ceded lands that included the present area of Hanford to the United States. Under the treaties, the tribes reserved the right to fish at usual and accustomed places in common with the citizens of the territory. They also retained the privilege of hunting, gathering roots and berries, and pasturing horses and cattle upon open and unclaimed land. However, it is the position of DOE that Hanford, like other ceded lands that were settled or used for specific purposes, is not open and unoccupied land. All of these tribes are active participants in decisions regarding Hanford and have expressed concerns about hunting, fishing, pasture rights, and access to plant and animal communities and important sites. Tribal concerns have been considered by DOE in the development of this *TC & WM EIS*. For example, American Indian tribal government perspectives on the cleanup at Hanford are provided in Appendix W.

American Indian TCPs within Hanford include, but are not limited to, various archaeological sites, cemeteries, trails and pathways, campsites and villages, fisheries, hunting grounds, plant-gathering areas, holy lands, landmarks, places important in American Indian history, places of persistence and resistance, and "landscapes of the heart" (Duncan 2007:4.120). Culturally important geographic features include Rattlesnake Mountain, Gable Mountain, Gable Butte, Coyote Rapids, and the White Bluffs portion of the Columbia River.

3.2.8.3.2 200 Areas Description

As noted above (see Section 3.2.8.1.2), White Bluffs Road, which was originally used as an American Indian trail, traverses the 200-West Area. In addition, two cryptocrystalline silica flakes, a cryptocrystalline silica base of a projectile point, and an incomplete cryptocrystalline silica projectile point were found in or near the 200 Areas (PNNL 2003, 2007b). Many sites used for hunting and religious activities lie just to the north of the 200 Areas on Gable Mountain and Gable Butte. These sites are associated with the Gable Mountain/Gable Butte Cultural District (Duncan 2007:4.130). The area is also visible from Gable Mountain and Gable Butte (PNNL 2007b).

3.2.8.3.3 400 Area Description

The 400 Area is not known to contain any American Indian areas of interest (PNNL 2007b). The area is visible from State Route 240 and from three promontories of cultural and religious significance to area tribes: Rattlesnake Mountain to the southwest, Gable Mountain to the north, and Gable Butte to the northwest.

3.2.8.3.4 Borrow Area C Description

Borrow Area C is not known to contain any American Indian areas of interest, and has no-to-low potential for the presence of prehistoric subsurface cultural deposits. The area is visible from Rattlesnake Mountain (PNNL 2007b).

3.2.8.4 Paleontological Resources

3.2.8.4.1 General Site Description

Remains from the Pliocene and Pleistocene ages have been identified at Hanford. The Upper Ringold Formation dates to the late Pliocene age and contains fish, reptile, amphibian, and mammal fossil remains. Late Pleistocene Touchet Beds have yielded mammoth bones. These beds are composed of fluvial sediments deposited along the ridge slopes that surround Hanford (DOE 2000a:3-126).

3.2.8.4.2 200 Areas Description

No paleontological resources have been identified in the 200 Areas (Schinner 2003).

3.2.8.4.3 400 Area Description

No paleontological resources have been reported in the 400 Area. Late Pleistocene Touchet Beds, which have yielded mammoth bones, are found at distances greater than 5 kilometers (3.1 miles) from the 400 Area (DOE 2000a:3-127).

3.2.8.4.4 Borrow Area C Description

No paleontological resources have been reported in Borrow Area C (PNNL 2007b).

3.2.9 Socioeconomics

This section describes socioeconomic variables associated with community growth and development within the Hanford ROI that could potentially be affected, directly or indirectly, by changes at Hanford. Included are economic characteristics, the region's demography, housing and community services, and local transportation.

Hanford and the communities that support it can be described as a dynamic socioeconomic system. The communities provide the people, goods, and services required by Hanford operations. Hanford, in turn, creates the demand for people, goods, and services and pays for them in the form of wages, salaries, benefits, and payments for goods and services. Effective community support of Hanford's demands depends on the communities' ability to respond to changing environmental, social, economic, and demographic conditions.

The areas in which Hanford employees and their families reside, spend their incomes, and use their benefits, thereby affecting the economic conditions of the region, define the Hanford socioeconomic ROI. This ROI encompasses Benton and Franklin Counties, Washington, which coincides with the statistical boundaries of the Tri-Cities (Richland, Pasco, and Kennewick) Metropolitan Statistical Area. According to employee residence records from April 2007, over 90 percent of DOE contract employees of Hanford live in Benton and Franklin Counties. Approximately 73 percent reside in Richland, Pasco, or Kennewick—more than 36 percent in Richland, 11 percent in Pasco, and 25 percent in Kennewick. Residents of other areas of Benton and Franklin Counties, including West Richland, Benton City, and Prosser, account for about 17 percent of total DOE contractor employment (Duncan 2007).

3.2.9.1 Regional Economic Characteristics

In fiscal year 2006, Hanford employed an average of 9,760 persons, approximately 11 percent of the civilian labor force in the ROI (Duncan 2007). For each full-time person employed at Hanford, approximately 0.75 full-time jobs were added to the local economy (Perteet, Thomas/Lane, and SCM 2001), resulting in creation of an estimated 7,300 additional full-time jobs. This total employment of 17,000 persons (Hanford employment plus indirect employment) was equal to approximately 15 percent of the civilian labor force in the ROI (WSESD 2007).

In 2006, the civilian labor force in the ROI reached 112,000. The annual unemployment average in the regional economic area at that time was 6.3 percent, higher than the annual average of 4.9 percent in Washington State (WSESD 2007).

In general, three major sectors of employment have been the principal driving forces of the economy since the early 1970s: DOE and its contractors operating Hanford, Energy Northwest, and the agricultural community. Three other components can also be readily identified as contributors to the economic base of the Tri-Cities area. The first, loosely termed "other major employers," includes the five major non-Hanford employers in the region; the second is the tourism industry; and the third, the local purchasing power of retired former employees (Duncan 2007).

3.2.9.2 Demographic Characteristics

The demographic profile of the estimated population from the year 2010 is presented in Table 3–9. In that year, the population of the ROI was 253,000. This figure represented an increase from the 2000 census of 32 percent (Census 2011a). Self-designated minority individuals constituted 35 percent of the total population. The largest group of this minority population was Hispanic or Latino.

According to income information from the *2006–2010 American Community Survey 5-Year Estimates* (see Table 3–10), the median annual household income in Benton County, in 2010 dollars, was slightly higher than that for the state of Washington, while Franklin County's was approximately $10,000 lower than that for the state. Also, more than 12 percent of the population in Benton County was below the official poverty level, while almost 20 percent of the population of Franklin County was below that level.

Table 3–9. Demographic Profile of Populations in the Hanford Site Socioeconomic Region of Influence, 2010

Population Group	Benton County		Franklin County		Region of Influence	
	Population	Percentage of Total	Population	Percentage of Total	Population	Percentage of Total
Nonminority						
White non-Hispanic	130,000	74.5	33,800	43.2	164,000	64.8
Minority						
Black or African American[a]	2,220	1.3	1,470	1.9	3,690	1.5
American Indian and Alaska Native[a]	1,570	0.9	531	0.7	2,110	0.8
Asian[a]	4,690	2.7	1,430	1.8	6,130	2.4
Native Hawaiian and Other Pacific Islander[a]	253	0.1	107	0.1	360	0.1
Some other race[a]	15,800	9.0	24,900	31.8	40,700	16.1
Two or more races[a]	6,220	3.6	2,470	3.2	8,690	3.4
White Hispanic	14,000	8.0	13,500	17.2	27,400	10.8
Total minority	**44,700**	**25.5**	**44,400**	**56.8**	**89,100**	**35.2**
Total Hispanic or Latino (of any race)[b]	**32,700**	**18.7**	**40,000**	**51.2**	**72,700**	**28.7**
Total	**175,000**		**78,200**		**253,000**	

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals who identified themselves as Hispanic or Latino, regardless of race.

Note: Total may not equal the sum of the contributions due to rounding.

Source: Census 2011a.

Table 3–10. Income Information for the Hanford Site Region of Influence, 2010

Income Category	Benton County	Franklin County	Washington State
Median household income[a]	$57,400	$47,700	$57,200
Percentage of persons below the poverty level[b]	12.7	19.9	12.1

[a] Census 2011b.

[b] Census 2011c.

3.2.9.3 Housing and Community Services

Table 3–11 presents information on housing availability, public education, and community health-care services in the ROI in 2010. There were 90,300 housing units in the two-county area, of which 83,500 were occupied. The median value of owner-occupied units was $170,000 in Benton County, which was higher than in Franklin County. The vacancy rate was similar in the two counties, Benton (4.3 percent) and Franklin (4.4 percent). In 2009, there were an estimated 11,900 apartments in the Tri-Cities, with approximately 113 available units for rent (WCRER 2009).

Community services include public education and health care (hospitals, hospital beds, and doctors). In the 2009–2010 school year, 11 school districts provided public education in the ROI, with a total enrollment of 49,100 students. During that time, the average Hanford region public school student-to-teacher ratio was 19.9 to 1, while the state public school student-to-teacher ratio was 19.4 to 1 (USDE 2011).

Table 3–11. Housing and Community Services in the Hanford Site Region of Influence, 2010

	Benton County	Franklin County	Region of Influence
Housing			
Total units[a]	66,900	23,400	90,300
Occupied housing units[a]	62,000	21,400	83,500
Vacant units for sale or rent[b]	2,760	983	3,740
Vacancy rate (percent)	4.3	4.4	4.3
Median value[c, d]	$170,000	$147,000	N/A
Public Education[e]			
Total enrollment	32,400	16,700	49,100
Student-to-teacher ratio	20.4	19.1	19.9
Community Health Care[f]			
Hospitals	4	1	5
Hospital beds per 1,000 persons	2.4	1.2	2.1
Physicians per 1,000 persons[g]	2.6	0.9	2.1

[a] Census 2011d.
[b] Census 2011e.
[c] Census 2011f.
[d] Represents median value of all owner-occupied housing units.
[e] USDE 2011.
[f] Census 2011a; WSHA 2011.
[g] AMA 2011; Census 2011a.
Key: N/A=not applicable.

There are five hospitals within the ROI, including Kadlec Medical Center, Kennewick General Hospital, Lourdes Counseling Center–Richland, Prosser Memorial Hospital in Benton County, and Lourdes Medical Center in Franklin County. The bed-to-person ratio in Benton and Franklin County hospitals (using the 2010 population) averaged 2.1 beds to 1,000 people (Census 2011a; WSHA 2011).

A total of 520 physicians serve the ROI. The average physician-to-population ratio (using the 2010 population) is 2.1 physicians to 1,000 people (AMA 2011; Census 2011a). Benton and Franklin Counties are designated by the Federal Government as health professional shortage areas. This designation can be used to access Federal dollars for improved access to health care in underserved areas of Washington State. Franklin County has already been designated as a medically underserved area (WSDOH 2011).

3.2.9.4 Local Transportation

The transportation network in the vicinity of Hanford includes two interstate highways: Interstates 82 and 182. Interstate 82 is 8 kilometers (5 miles) south-southwest of Hanford. Interstate 182, a 24-kilometer-long (15-mile-long) urban connector route 8 kilometers (5 miles) south-southeast of the site, provides an east-west corridor linking Interstate 82 to the Tri-Cities area. Interstate 82 also serves as a primary link between Hanford and Interstates 90 and 84. Interstate 90, north of the site, is the major link to Seattle and Spokane and extends to the East Coast. Interstate 84, south of Hanford in Oregon, is a major corridor leading to Portland, Oregon. State Route 224 (Van Giesen Street), also south of the site, serves as a 16-kilometer (10-mile) link between Interstate 82 and State Route 240. State Route 24 enters the site from the west, continues eastward across the northernmost portion of the site, and intersects

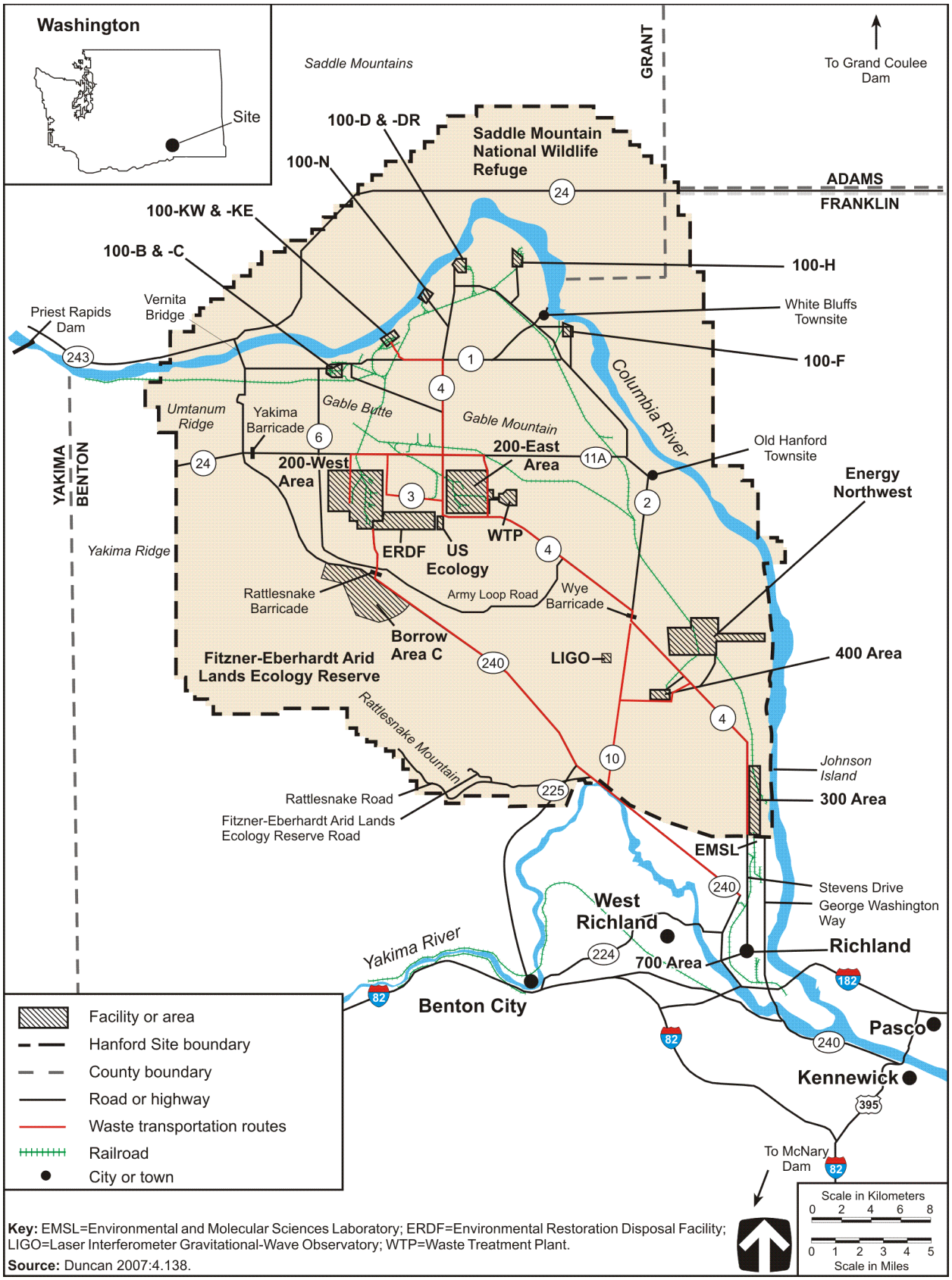
State Route 17 approximately 24 kilometers (15 miles) east of the site boundary. State Route 17 is a north-south route that links Interstate 90 to the Tri-Cities and joins U.S. Route 395 before continuing south through the Tri-Cities. U.S. Route 395 North also provides direct access to Interstate 90. State Routes 240 and 24 traverse Hanford and are maintained by Washington State (Duncan 2007:4.151).

Access to Hanford is via three main routes: Hanford Route 4 South from Stevens Drive or George Washington Way in the city of Richland, Route 10 from State Route 240 near its intersection with State Route 225, or Route 11A from State Route 240 near its intersection with State Route 24 (see Figure 3–19). The primary commute to Hanford requires most employees to travel through the city of Richland by way of State Route 240 (Bypass Highway) or George Washington Way. These two roadways have an average daily traffic volume of between 30,000 and 40,000 vehicles. To help accommodate the high volume of traffic, the Washington State Department of Transportation (WSDOT) completed the expansion of the Bypass Highway from four to six lanes in 2002. Similarly, the City of Richland made major capacity improvements on Stevens Drive north of State Route 240. By the end of 2009, the WSDOT had completed several improvements to State Route 240, including the interchange at U.S. Route 395 and the construction of two new bridges over the Yakima River, thereby substantially alleviating congestion during the daily commute (WSDOT 2011). Hanford's onsite road network is further described in Section 3.2.2.1.

Private vehicles account for 91 percent of the person-trips to Hanford based on a survey of commuters using either the State Route 240 Bypass Highway or George Washington Way. The remaining person-trips are by forms of high-occupancy vehicles (mostly vanpools). Of the 91 percent of person-trips to Hanford by private vehicles, only 3 percent involve carpools; the remaining 88 percent involve single-occupancy vehicles (BFCOG 2006:2-4; Duncan 2007:4.152).

A Washington State law (Washington State 2006) requires urban growth areas containing a state highway segment exceeding a threshold of 100 person-hours of daily delay per mile during the peak period from 6:00 A.M. to 9:00 A.M. on weekdays to implement commute trip reduction programs. The intent is to reduce the time of commutes by workers from their homes to major worksites during that peak period. The WSDOT was required to establish rules for commute trip reduction plans and implementation procedures in 2007. Benton and Franklin Counties have received an exemption. The Benton County plan and ordinance will include the DOE Hanford Reservation. Construction worksites are excluded by law, provided the construction duration is less than 2 years. The ongoing construction of the WTP would not likely be exempt (BFCOG 2006:2-5, 2-6).

The local intercity transit system, Ben Franklin Transit, provides public transit service throughout the Tri-Cities. The company's rideshare/vanpool program includes a fleet of over 300 vans that operate in 14 cities, six counties, and two states, and services major worksites where riders share the cost of operating the vans. Its services also include ride-matching for individuals seeking private vanpools or carpools (BFCOG 2006:2-5, 2-7, 4-26–4-28). Ben Franklin Transit currently has 24 fixed routes, including one between Richland and the Hanford 300 Area. Its vanpools serve eight locations across Hanford and Energy Northwest. In 2011, over 100 vans were commuting to the WTP, and ridership in general has increased since 2005 more than 40 percent (DeJuan 2011). Transit service availability notwithstanding, ridesharing remains an underutilized resource for reducing congestion, particularly along the routes of the Hanford commute in the Tri-Cities area.



Key: EMSL=Environmental and Molecular Sciences Laboratory; ERDF=Environmental Restoration Disposal Facility; LIGO=Laser Interferometer Gravitational-Wave Observatory; WTP=Waste Treatment Plant.

Source: Duncan 2007:4.138.

Figure 3–19. Transportation Routes On and Near the Hanford Site

As stated in Section 3.2.2.1.1, the Hanford rail system originally consisted of approximately 209 kilometers (130 miles) of track connecting to the Union Pacific commercial track at the Richland Junction and to a now-abandoned Chicago, Milwaukee, St. Paul, and Pacific Railroad right-of-way near Vernita Bridge. In October 1998, 26 kilometers (16 miles) of track from Columbia Center to Horn Rapids Road were transferred to the Port of Benton and are currently operated by the Tri-City and Olympia Railroad for the Port of Benton (Duncan 2007:4.150). Along with the rail line, the port received from DOE about 304 hectares (750 acres) of land and numerous buildings encompassing the Richland North Area for economic development purposes. The area is now called the Port of Benton Manufacturing Mall. The Tri-City and Olympia Railroad operates from Kennewick through Richland to the manufacturing mall and also services the city of Richland's Horn Rapids Industrial Site via a spur line built in 1999 (BFCOG 2006:4-34).

The Tri-Cities serve as a regional transportation and distribution center with major land, river, and air connections. The Burlington Northern Santa Fe Railroad main line from Vancouver to Spokane via Pasco is traversed by 45 to 55 through-freight movements daily. The total tonnage reflects the large number of export grain trains that operate via this route to water terminals at Portland, Kalama, and Longview. This line operates at or near its maximum practical capacity. Burlington Northern Santa Fe also operates tracks from the Tri-Cities to Auburn via Yakima, Ellensburg, and Stampede Pass. This line has 6 to 10 freight movements daily. The Union Pacific Railroad also operates a line from Portland to Spokane that enters Walla Walla County south of Wallula Junction, then passes along the east side of the Columbia and Snake Rivers, exiting the county at Lyons Ferry (BFCOG 2006:4-33, 4-34).

Passenger rail service is provided by Amtrak from the Pasco Intermodal Depot. Amtrak operates daily on the Burlington Northern Santa Fe tracks from Vancouver through Pasco to Spokane. Similar service is provided between Seattle and Spokane, where the two trains link to continue toward Chicago (BFCOG 2006:4-34).

The Columbia–Snake River system, with its government locks at each of eight dams, affords 748 kilometers (465 miles) of water transportation from Astoria, Oregon, to Lewiston, Idaho. The system allows the three barge lines serving the region to transport commodities to and from locations throughout the world via the ports of Kalama, Longview, Vancouver, and Portland (the Nation's largest wheat export portal). Over 9 million metric tons of cargo are moved on this water highway every year. Docking facilities at the Ports of Benton, Kennewick, and Pasco play important roles in this regional system. Closer to Hanford, the Port of Benton has over 1,830 meters (6,000 feet) of Columbia River frontage zoned for heavy industrial use at the Richland Technology and Business Campus on the west bank of the Columbia River in North Richland. The dock facilities near the north end of the site are used to unload construction materials and heavy equipment, much of it destined for Hanford, as well as other cargoes bound for North Richland (BFCOG 2006:4-35, 4-37).

Daily air passenger and freight services connect the area with most major cities through the Tri-Cities Airport in Pasco. This modern commercial airport links the Tri-Cities to major hubs. Scheduled air service includes Delta Connection, Horizon Air, United Express, and Allegiant Air (Port of Pasco 2011). Either of two runways is available for use as dictated by crosswinds. The main runway is equipped for precision instrumentation landings and takeoffs. Each runway can accommodate landings and takeoffs by medium-range commercial aircraft (Duncan 2007:4.150, 4.151). The immediate area is also served by Richland Airport, which lies northwest of the Richland central business district and adjacent to the Richland Bypass (State Route 40). Owned by the Port of Benton, this general aviation airport has two paved runways and a localizer instrument system (BFCOG 2006:4-31).

3.2.10 Existing Human Health Risk

Environmental health risks of the activities at Hanford include the effects of acute and chronic exposures to ionizing radiation and hazardous chemicals. Ongoing programs to monitor releases and evaluate their potential health impacts are conducted at Hanford. Additionally, studies have been conducted of the pathways and potential risks of radionuclide and toxic chemical releases during past operations at Hanford. These studies focused on the impacts of the releases in terms of risks of cancer incidence and mortality to site workers, the general public, and the maximally exposed individual (MEI). Results of the current assessments and historic studies indicate little risk of enhanced carcinogenesis; doses from site radionuclide releases tend to be far lower than those from natural background radiation, and chemical exposures are well within stipulated guidelines. Yet in keeping with the goal of optimum protection of vulnerable populations, DOE maintains a comprehensive emergency management program that features hazard-specific plans, procedures, and controls (DOE Order 151.1C).

3.2.10.1 Radiological Exposure and Risk

3.2.10.1.1 General Site Description

Major sources and average levels of exposure to background radiation to individuals in the Hanford vicinity are shown in Table 3–12.[1] The average annual dose from background radiation is approximately 620 millirem. About half of the annual dose is from ubiquitous, natural background sources (311 millirem) that can vary depending on geographic location, individual buildings in the geographic area, and age, but is essentially all from space or naturally occurring sources in Earth. About half of the dose is from medical exposure to radiation (300 millirem), including computed tomography, interventional fluoroscopy, x-rays and conventional fluoroscopy, and nuclear medicine (use of unsealed radionuclides for diagnosis and treatment). Another approximately 14 millirem per year are from consumer products and other sources (nuclear power, security, research, and occupational exposure) (NCRP 2009:12). Average background radiation doses from these sources are expected to remain fairly constant over the period of the proposed actions. Background radiation doses, as identified in Table 3–12, are unrelated to Hanford operations.

Table 3–12. Sources of Radiological Exposure of Individual Doses Unrelated to Hanford Site Operations

Source	Effective Dose Equivalent (millirem per year)[a]
Natural background radiation	311
Medical exposure	300
Consumer, industrial, occupational, and other	14
Total (rounded)	**620**

[a] Averages for the United States.
Source: NCRP 2009:12.

Releases of radionuclides to the environment from Hanford operations provide another source of radiological exposure to individuals in the vicinity of Hanford. Types and quantities of radionuclides released from Hanford operations in 2010 are summarized in Section 3.2.4.1. Estimated doses to the public resulting from these releases are presented in Table 3–13. The estimated dose to an MEI in 2010 was 0.18 millirem; over the last 5 years, the annual dose to the MEI has ranged from 0.045 to 0.18 millirem. The 2010 population dose was 1.1 person-rem; over the last 5 years, the annual dose to the

[1] Average doses from background radiation in the Hanford vicinity are assumed to approximate the average dose to an individual in the U.S. population.

population has ranged from 0.44 to 1.1 person-rem (Poston, Duncan, and Dirkes 2011:8.130–8.132).[2] The population dose from natural background radiation sources was approximately 150,000 person-rem. The doses to the public from Hanford activities fall within the limits established in DOE Order 458.1, Change 2, and are much lower than those due to background radiation.

Table 3–13. Radiation Doses to the Public from Hanford Site Operations, 2010 (Total Effective Dose Equivalent)

Members of the Public	Atmospheric Releases[a]	Liquid Releases[b]	Total[c, d]
Maximally exposed individual (millirem)	0.12	0.056	0.18
Population within 80 kilometers (person-rem)[e]	0.30	0.78	1.1
Average individual within 80 kilometers (millirem)[e]	0.00062	0.0016	0.0023

[a] DOE Order 458.1, Change 2, invokes the Clean Air Act regulations (40 CFR 61, Subpart H), which established a compliance limit of 10 millirem per year to a maximally exposed individual.

[b] Includes exposure pathways from direct consumption and use of water for irrigation. Though not directly applicable to concentrations of radionuclides in surface water or groundwater, an effective dose equivalent limit of 4 millirem per year for the drinking water pathway only is frequently used as a measure of performance. It is inspired by the National Primary Drinking Water Regulations maximum contaminant level for beta and photon activity that would result in an equivalent dose of 4 millirem per year (40 CFR 141.66).

[c] DOE Order 458.1, Change 2, establishes an all-pathways dose limit of 100 millirem per year to an individual member of the public.

[d] Total may not equal the sum of the contributions due to rounding.

[e] The collective population dose is based on the 2000 census population of 486,000. The average individual dose is obtained by dividing the population dose by the number of people in the population.

Note: To convert kilometers to miles, multiply by 0.6214.

Source: Poston, Duncan, and Dirkes 2011:8.130, 8.132.

From a risk coefficient of 600 cancer deaths per 1 million person-rem (0.0006 latent cancer fatalities [LCFs] per person-rem) to the public (see Appendix K, Section K.1.1.6), the risk of an LCF to the MEI due to radionuclide releases from Hanford operations in 2010 was estimated to be 1×10^{-7}. That is, the estimated probability of this person dying of cancer at some time in the future as a result of a radiation dose associated with emissions from 1 year of Hanford operations is about 1 in 10 million. Depending on the type of cancer, it takes a few years to several decades from the time of exposure for a radiation-induced cancer to manifest itself. The hypothetical MEI is a person whose place of residence and lifestyle make it unlikely that any other member of the public would receive a higher radiation dose from Hanford releases. This person is assumed to be exposed to radionuclides in the air and on the ground from Hanford emissions, ingest food grown downwind from Hanford and irrigated with water from the Columbia River downstream from Hanford, ingest fish from the Columbia River, and be exposed to radionuclides in the river and on the shoreline during recreation.

Using the same risk coefficient, the calculated population LCF risk is 7×10^{-4}; this low risk implies no excess LCFs are expected in a population of 486,000 living within 80 kilometers (50 miles) of Hanford from normal operations in 2010. To place this number in perspective, it may be compared with the number of cancer fatalities expected in the same population from all causes. The mortality rate from cancer for the entire U.S. population in 2000 was about 200 deaths per 100,000 people, or 0.2 percent per year (Weir et al. 2003:Figure 1). At that rate, expected fatalities from all cancers in the population living within 80 kilometers (50 miles) of Hanford during would be 972. This figure is much higher than the 7×10^{-4} LCFs calculated to result from Hanford operations in 2010.

[2] Potential impacts on the public were calculated using the GENII computer model. Version 2.09 was used in 2009 for the first time; doses calculated with Version 2.09 were about 2.5 times higher than if they had been calculated with the Version 1.485 used in previous years.

Hanford workers receive the same dose as the general public from background radiation, but they receive an additional dose from working in and near facilities with radioactive materials. The average dose to the individual worker and the cumulative dose to all workers at Hanford from operations in recent years are presented in Table 3–14. Using a risk coefficient of 0.0006 LCFs per person-rem among workers, the calculated number of LCFs among Hanford workers from normal operations exposures in 2009 was 0.08.

Table 3–14. Radiation Doses to Workers from Hanford Site Normal Operations (Total Effective Dose Equivalent)

Occupational Personnel	Onsite Releases and Direct Radiation					
	Standard[a]	**2005**	**2006**	**2007**	**2008**	**2009**
Average radiation worker (millirem)	5,000	89	70	71	45	58
Total of all radiation workers (person-rem)[b]	**None**	**204.1**	**132.9**	**158.0**	**105.9**	**129.3**

[a] No standard is specified for an "average radiation worker"; however, the maximum dose to a worker is limited as follows: The dose limit for an individual worker is 5,000 millirem per year (10 CFR 835). However, the U.S. Department of Energy's (DOE's) goal is to maintain radiological exposure as low as is reasonably achievable. DOE has therefore established the Administrative Control Level of 2,000 millirem per year; the site contractor sets facility administrative control levels below the DOE level, with 500 millirem per year considered a reasonable goal for trained radiation workers and 100 millirem per year for nonradiation workers.

[b] There were 2,294 workers with measurable doses in 2005, 1,911 in 2006, 2,228 in 2007, 2,376 in 2008, and 2,222 in 2009.

Note: Total radiation worker dose presented in the table differs from that calculated from data shown due to rounding.

Source: 10 CFR 835.202; DOE Standard 1098-2008, Change Notice 1; DOE 2008b:3-10; 2009b:3-10; 2010b:3-10; Fluor Hanford 2006b:2.

A number of people work inside the Hanford boundary yet outside access-controlled areas. Considered members of the public, these people are associated with the Columbia Generating Station, operated by Energy Northwest, and with LIGO, operated by the University of California. For these two facilities, a larger dose was determined to be to an individual at LIGO. The calculated radiation dose to a hypothetical receptor at LIGO in 2010 was 0.0054 millirem. This dose, attributed to Hanford stack emissions and assuming full-time occupancy (24 hours per day) of the facility, is well below the 10-millirem-per-year limit for air emissions established by the Clean Air Act (Poston, Duncan, and Dirkes 2011:8.134).

Members of the public may also be exposed to radioactivity through the consumption of wildlife that have access to Hanford. In 2010, the maximum detectable concentration of strontium-90 (12.4 picocuries per gram) was measured in a cottontail rabbit bone sample collected on site at the 100-H Area. Because bone is not normally consumed by humans, it was not considered further (Poston, Duncan, and Dirkes 2011:8.135). In other years, other radionuclides (e.g., cesium-137, uranium isotopes) have been detected in other species such as fish.

There are several non-DOE-related sources of radiological exposure at or near Hanford. These sources include the US Ecology Commercial LLW Disposal Site; the Columbia Generating Station; a nuclear fuel production plant operated by AREVA NP; a commercial LLW treatment facility operated near the site by Perma-Fix Northwest, Inc.; and a commercial decontamination facility operated near the site by PN Services. The radiation dose to a member of the public from these sources in 2010 was conservatively estimated at approximately 0.004 millirem. Therefore, the combined annual dose to a member of the public in 2010 from Hanford area DOE and non-DOE sources was well below any regulatory dose limit (Poston, Duncan, and Dirkes 2011:8.136).

A more detailed presentation of the radioactive environment, including background exposures and radionuclide releases and doses, is presented in the *Hanford Site Environmental Report* (Poston, Duncan, and Dirkes 2011). The concentrations of radioactivity in various environmental media (including air, water, and soil) in the site region (on and off site) are also presented in that report.

3.2.10.1.2 200 Areas Description

External radiation doses on and near Hanford are measured and reported by the site environmental surveillance program. In 2010, the mean annual external dose in the 200 Areas was about 104 millirem—about 33 millirem higher than the historic average of the doses measured at offsite (distant) control locations (Poston, Duncan, and Dirkes 2011:8.122; Poston et al. 2006:10.166). This onsite external dose, which affects workers only, is well below the administrative limit identified in Table 3–14, footnote "a." Columbia River water is used as a source of drinking water by workers in the 200 Areas. Annual average radionuclide concentrations measured in the drinking water during 2010 were below applicable standards (40 CFR 141; Poston, Duncan, and Dirkes 2011:8.136).

3.2.10.1.3 400 Area Description

In 2010, the mean annual external dose in the 400 Area was about 79 millirem, about 5 millirem higher than the average of doses measured at offsite (distant) control locations (Poston, Duncan, and Dirkes 2011:8.122; Poston et al. 2006:10.166). This onsite external dose, which affects workers only, is well below the administrative limit identified in Table 3–14, footnote "a."

Drinking water is obtained from groundwater wells in the 400 Area and is consumed by FFTF workers. Tritium and gross beta were detected in these groundwater wells. The measured concentrations in 2010 suggest a potential annual dose to FFTF workers of approximately 0.2 millirem, well below the EPA limit of 4 millirem per year for public drinking water supplies (Poston, Duncan, and Dirkes 2011:8.136).

3.2.10.2 Chemical Environment

The background chemical environment important to human health consists of the atmosphere, which may contain hazardous chemicals that can be inhaled; drinking water, which may contain hazardous chemicals that can be ingested; and other environmental media, through which people may come in contact with hazardous chemicals (e.g., surface water during swimming, soil through direct contact, food). Hazardous chemicals can cause cancer- and non-cancer-related health effects.

3.2.10.2.1 Carcinogenic Effects

Estimation of carcinogenic health effects focuses on the probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. This probability can be expressed as an incremental or excess individual lifetime cancer risk. The risks from exposure to carcinogenic chemicals are evaluated using chemical-specific unit risk factors published by EPA. The unit risk factor represents the estimated lifetime probability that an individual will develop cancer as a result of exposure to a given concentration of a chemical in air. Assessment of cancer risk from chemical exposures is described in Appendix K, Section K.1.2.6.

3.2.10.2.2 Noncarcinogenic Effects

Noncarcinogenic health effects are expressed in terms of the Hazard Quotient and Hazard Index. The Hazard Quotient is the ratio between the estimated exposure to a toxic chemical and the level of exposure at which adverse health effects can be expected. Hazard Quotients for noncarcinogens are summed to obtain the Hazard Index. If the Hazard Index is less than 1, no adverse health effects are expected.

Adverse public health impacts may result from the inhalation of hazardous chemicals released to the atmosphere during normal Hanford operations. Risks to public health from other possible pathways, such as the ingestion of contaminated drinking water or direct contact with hazardous chemicals, are lower than those from inhalation. Administrative and design controls have been instituted to reduce hazardous chemical releases to the environment and help achieve compliance with permit requirements (e.g., air emission permits, NPDES permits). Moreover, baseline studies have been performed to estimate the highest existing offsite concentrations and the highest concentrations to which members of the public could be exposed, and these studies have been used to develop baseline air emission and other applicable standards for hazardous chemicals (see Section 3.2.4). Hazardous chemical concentrations remain in compliance with applicable guidelines and regulations. Nevertheless, the effectiveness of all controls and mitigation measures is constantly verified through routine monitoring and inspection.

Exposure pathways to Hanford workers during normal operations include the inhalation of contaminants in the workplace atmosphere and direct contact with hazardous materials. The potential for health impacts varies among facilities and workers. DOE policy requires that the workplace be as free as possible from recognized hazards—i.e., conditions likely to cause illness or physical harm. Workers are protected from such hazards through adherence to Occupational Safety and Health Administration and EPA limits on atmospheric and drinking water concentrations of potentially hazardous chemicals. Exposure to hazardous chemicals is also minimized by appropriate training, use of personal protective equipment, monitoring of the workplace environment, limits on the duration of exposure, and engineered and administrative controls. Monitoring and controlling hazardous chemical usage in operational processes help ensure that workplace standards are not exceeded and worker risk is minimized.

3.2.10.3 Health Effects Studies

The question of whether the population around Hanford is subject to elevated cancer incidence or cancer mortality is unresolved. Studies of the health effects of Hanford activities, including studies reported in prior EISs, are summarized below. Included is a summary of the results of the Hanford Environmental Dose Reconstruction (HEDR) Project, even though studies encompassed by that project do not directly address health effects. Existing studies and data suggest that cancer mortality in populations residing near Hanford is not elevated. A survey sponsored by the National Cancer Institute and published in the *Journal of the American Medical Association* (Jablon, Hrubec, and Boice 1991) detected no general increase in the risk of cancer death for people living in 107 counties close to or containing 62 nuclear facilities, including Hanford. Cancer mortality data from Benton, Franklin, and Grant Counties were used in the survey. The survey did not provide an estimate of actual exposures to ionizing radiation or hazardous chemicals, nor did it allow for identification of areas within a given county that might have increased or decreased cancer rates relative to the country as a whole. The authors of the study concluded that, if any excess cancer mortality risk were present in U.S. counties with nuclear facilities, it was too small to be detected using the methods employed.

Sixteen counties are within 80 kilometers (50 miles) of the Hanford boundary—13 counties in Washington and 3 in Oregon. Although the prevailing winds on the 200 Area plateau are from the northwest, in the direction of Franklin County, the prevailing winds at Hanford as a whole are from the south and south-southwest, toward Grant County, Washington. Therefore, Grant County and Franklin County are expected to receive most of the wind-borne contamination from Hanford. Cancer mortality data published by the National Cancer Institute for both white female and white male residents of all U.S. counties from 1970 to 1994 show no elevated cancer rates for white residents of Franklin or Grant County. Cancer mortality rates among white females in the 16 counties ranged from a low of 80.1 per 100,000 person-years[3] in Gilliam County, Oregon, to a high of 149.5 per 100,000 person-years in Lincoln County, Washington. Only Adams, Klickitat, and Lincoln Counties had rates higher than the national rate

[3] In other words, 80.1 deaths per year per 100,000 people.

of 135.9 per 100,000 person-years. Cancer mortality rates among white males in the 16 counties ranged from a low of 161.9 per 100,000 person-years in Gilliam County, Oregon, to a high of 211.8 per 100,000 person-years in Morrow County, Oregon. Morrow County was in fact the only county of the 16 to have a rate higher than the national rate of 209.5 per 100,000 person-years. The data do not include estimates of human exposure to ionizing radiation or hazardous chemicals (DOE 2000a:3-132).

In addition to mortality data, the National Cancer Institute publishes state and county incidence rates for various cancers. Table 3–15 shows the 2003 through 2007 incidence rates for Washington State and the four counties adjacent to Hanford. In the four adjacent counties, the rates for thyroid cancer, leukemia and "all cancers" were lower than the corresponding state incidence rates. In three of the four adjacent counties, the incidence rates for breast cancer were lower than the state average. The Benton County breast cancer incidence rate exceeded the State average, but was lower than rates reported for 11 other counties, all of which are more distant from Hanford. The rates of lung cancer in all four adjacent counties slightly exceeded the state average. However, the highest of these (Franklin County's) was exceeded by the rates for 15 other counties, including 10 on the west side of the Cascade mountain range. The lung cancer rates for the four adjacent counties ranked 16th, 18th, 20th and 21st out of Washington's 39 counties.

Table 3–15. Cancer Incidence Rates[a] for Washington State and Counties Adjacent to the Hanford Site, 2003–2007

Location	All Cancers	Thyroid	Breast	Lung	Leukemia
United States	464.5	10.2	120.6	68.0	12.3
Washington State	479.1	10.3	130.3	66.3	13.9
Benton County	469.7	8.8	137.1	69.3	11.2
Franklin County	441.1	(b)	102.2	70.7	11.5
Grant County	433.2	8.0	103.5	69.4	12.3
Yakima County	436.8	7.6	116.4	68.0	13.2

[a] Cases per 100,000 people per year.

[b] Data has been suppressed by the National Cancer Institute to ensure confidentiality and stability of rate estimates when annual average count is three or fewer cases.

Source: NCI 2010.

Two studies of birth defects in Benton and Franklin Counties were published in 1988 (Sever et al. 1988a, 1988b). The studies focused on congenital malformations among infants born from 1968 to 1980. Results showed a statistically significant association between preconception exposure of the parents to ionizing radiation and neural tube defects in their infants. However, no such association could be observed in regard to other defects in the infants.

The HEDR Project, conducted in the 1980s and 1990s, focused on dose estimation rather than health effects. It featured investigation of the amounts and types of radioactive materials Hanford released from 1944 through 1972, movement of materials through the environment, and exposure of and doses to people. Of primary concern were radioactive releases to the air and to the Columbia River. As for airborne releases, the HEDR Project studies showed that more than 98 percent of the radiation doses that most people outside of Hanford's boundaries received came from iodine-131 released from December 1944 through 1957. Consumption of milk from cows and goats that grazed on pastures downwind of Hanford was the most important iodine-131 exposure pathway. The highest organ doses (to the thyroid) were received by children who lived the closest to Hanford from 1944 through 1951; these doses ranged from 24 to 350 rad. The highest effective dose equivalent to an adult from air emissions was about 1 rem and was accrued over the period from 1944 to 1972. The lifetime risk of a fatal cancer associated with a dose of 1 rem is about 1 in 1,600. Project studies also revealed that the largest releases of radioactive material to the Columbia River occurred from 1950 through 1971 from Hanford production reactors.

The five most prominent contributors to dose were sodium-24, phosphorus-32, zinc-65, arsenic-76, and neptunium-239. Consumption of nonmigratory fish species was the most important exposure pathway. The maximum individual dose during this time period was estimated to be 1.4 rem (TSP 1994).

Many epidemiological studies of Hanford workers have been conducted over the years. The studies have consistently shown a statistically significant elevated risk of death from multiple myeloma associated with radiological exposure among male Hanford workers. The elevated risk was observed only among those workers with a total occupational exposure of 10 rad (approximately 10 rem) or more. Other studies also identified an elevated risk of death from pancreatic cancer, but a recent reanalysis indicated no such risk. Studies of female Hanford workers have shown an elevated risk of death from musculoskeletal system and connective tissue conditions. For a more detailed description of the studies reviewed and their findings, as well as a discussion of the epidemiologic surveillance program implemented by DOE to monitor the health of current workers, refer to Section M.4.2 of the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a: M-224–M-230).

More recently, additional studies have been performed regarding Hanford mortality rates. One study completed in 2005 examined whether there are associations between occupational exposure to external ionizing radiation and mortality among Hanford workers. This study suggests that external radiological exposures of Hanford workers 55 years of age and older increase their risks of dying from lung cancer; owing to data limitations, however, the possible contributions of plutonium and smoking to this risk could not be directly estimated. Another study concluded that workers who have routine potential exposure to plutonium have lower mortality rates than other Hanford workers (NIOSH 2005).

3.2.10.4 Accident History

In the more than 15 years since weapons material production ceased at Hanford, there have been no nuclear-related accidents or accidental releases of hazardous or radioactive materials that caused injury or posed any threat to the offsite public. However, a number of incidents that had actual or potential health impacts on workers have occurred in the course of routine facility operations, decommissioning, and environmental remediation activities in and near the 200 Areas. The most notable of these was a May 1997 explosion caused by spontaneous reaction of nonradioactive chemicals left over from discontinued activities in the Plutonium Recovery Facility. Although no one was directly injured by the explosion and no radioactive materials were released to the environment (DOE 2000a:3-133), eight workers who may have been exposed to unidentified fumes later complained of symptoms that included headaches, dizziness, and an unidentified metallic taste. All were transferred to a nearby medical center where they were examined and released.

Incidents with worker health implications over the period from 2000 through June 2010, as reflected in Occurrence Reporting and Processing System records (DOE 2007a, 2008c, 2010c), include the following:

- Workers were injured from falls resulting in broken bones (January 2009, July 2009, June 2010).
- Workers' skins were contaminated during demolition activities, with subsequent decontamination being successful (May 2009, March 2010).
- Workers received mild electrical shocks (January 2004, May 2005, August 2005, May 2009, August 2009, February 2010, July 2010).
- A worker suffered chemical burns to the face and neck from a solution of sodium hydroxide (December 2009).

- A worker was potentially exposed to asbestos from a truck while unloading asbestos waste at an offsite disposal facility (August 2009).
- A worker cut his fingers with a circular saw while cutting wooden shims (August 2009).
- A worker broke a bone in his hand when drilling a hole in metal ductwork (May 2009).
- Two workers were contaminated when one or more glovebox gloves were breached in the Plutonium Recovery Facility. The workers were decontaminated (April 2009).
- Workers were exposed to high noise levels that exceeded the 8-hour time-weighted average (March 2008, April 2009).
- A worker fractured a bone in his hand while installing rebar at the WTP (May 2008).
- Workers were potentially exposed to chromium while conducting welding operations (March 2003, October 2005, December 2006, January 2007).
- A worker was exposed to lead while torch-cutting a pipe (August 2005).
- Workers were exposed to carbon monoxide levels exceeding occupational limits at the CWC (August 2000) and WTP (February 2005).
- Two workers were exposed to plutonium and americium while performing radiological surveys in a high-contamination area at the 300 Area Remediation Project, resulting in a committed effective dose equivalent of 3 rem to one worker and 0.8 rem to the other (December 2004).
- A painter was overexposed to methylene chloride while cleaning painting equipment (October 2004).
- A worker was exposed to plutonium (an uptake of less than 0.5 millirem) at the Plutonium Finishing Plant while preparing waste for storage in a drum (July 2004).
- A worker received a 15-rem dose to an extremity from curium-244 at the 244-CR vault, pit CR-002, while pulling a thermocouple (July 2004).
- A worker was potentially exposed to mercury from a manometer being removed in the 105-KE Basin (June 2004).
- Workers were exposed to unknown vapors/fumes in tank farms (March 2004).
- A worker injured an eye while manipulating metal stanchions (February 2004).
- Workers in the Plutonium Finishing Plant were exposed to toxic chemicals, including nitrobenzene (September 2002) and nitrogen oxides (March 2003).
- A worker was potentially exposed to asbestos fibers at Building 1717K (December 2002).
- Tank farm workers suffered respiratory irritation as a result of severe wind/dust following the 2000 Hanford 24 Command Fire (March 2001).

Since about 1987, exposure of tank farm workers to chemical vapors has been of concern at Hanford. The tanks are continuously vented to the atmosphere and inhalation is assumed to be the primary route of

chemical exposure to workers during routine operations. Evaluations conducted at different times by the tank farms contractor, Hanford DOE officials, the Defense Nuclear Facilities Safety Board, the DOE Office of Independent Oversight and Performance Assurance, and the Office of the Inspector General have resulted in the implementation of physical (engineered) and administrative controls to reduce or eliminate the potential for worker chemical vapor exposures. The history of this issue and the actions taken to resolve it are described in Appendix K, Section K.2.1.2.3.

The most recent incident involving radiological and chemical exposures occurred in July 2007 (DOE 2007b). Approximately 322 liters (85 gallons) of highly radioactive mixed waste from tank 241-S-102 in the 200-West Area was spilled on the ground. Overpressurization of a hose in a dilution line was determined to be the cause. In the hours and days following the spill, a number of Hanford workers identified odors, experienced symptoms or health effects, or expressed concerns about their potential exposure to the waste chemicals from the spill. As of September 1, 2007, 24 workers had reported possible exposure to tank vapors resulting from the spill. The worker health impacts could be attributed to other causes, so it is unclear whether the spill directly contributed to these health effects. Because of the low concentrations and short duration of the event, overexposure or chronic health impacts are unlikely. Consequences of the tank 241-S-102 event could have been more severe if workers had been in the immediate vicinity of the spill at the time of the release, and thus had been exposed to higher radiation or chemical vapor concentrations for a longer period. The board reviewing the accident made a number of recommendations to help prevent future spills and to mitigate worker exposures through, among other things, improvement in safety programs and coordination of emergency and medical response.

In nearly all of these cases, the worker health impacts were minimal or temporary. Information concerning these and other safety-related events at Hanford and other sites is maintained in DOE's Occurrence Reporting and Processing System.

In addition to the incidents reported above, a report by the Government Accountability Project cited evidence of 45 chemical vapor exposure events that required medical attention for at least 67 workers over the period January 2002 to August 2003 (GAP 2003:11).

3.2.10.5 Emergency Preparedness

As required by DOE orders and policies, Hanford has established a comprehensive emergency management program that provides detailed, hazard-specific planning and preparedness measures to minimize the health impacts of accidents involving loss of control over radioactive material or toxic chemicals. This emergency management program embodies the following principles:

- Identification and characterization of the hazardous substances
- Analysis of potential accidents and hazardous releases
- Prediction of consequences of the releases at various locations
- Planned response actions to minimize exposure of workers and the public to the hazard

Emergency response procedures are practiced and exercised regularly to ensure that optimum protective measures can be taken in response to most identified accident conditions and to provide the capability for flexible, effective responses to accidents that were not specifically considered in the emergency planning scenarios.

DOE-RL maintains the Hanford emergency plan and implementing procedures by which DOE and its contractors will respond in the event of an accident. DOE-RL also provides technical assistance to other Federal agencies and to state and local governments. Hanford contractors are responsible for maintaining emergency plans and response procedures for all facilities, operations, and activities under their

jurisdiction and for implementing those plans and procedures during emergencies. The DOE-RL, contractor, and state and local government plans are fully coordinated and integrated. Emergency control centers have been established by DOE-RL and its contractors for the principal work areas to provide oversight and support to emergency response actions within those areas.

3.2.11 Environmental Justice

Under Executive Order 12898, DOE is responsible for identifying and addressing disproportionately high and adverse impacts on minority and low-income populations. As discussed in Appendix J, 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 multiracial. The Office of Management and Budget defines Hispanic or Latino as "a person of Cuban, Mexican, Puerto Rican, South or Central American or other Spanish culture or origin regardless of race"; therefore, all persons self-identified as Hispanic or Latino, regardless of race, are included in the "Hispanic or Latino" population. Persons whose incomes are below the Federal poverty threshold are designated as low-income. Consistent with Council on Environmental Quality (CEQ) guidance, minority and low-income populations were identified where the percentage of either of those populations in the impacted areas was "meaningfully greater" than those percentages in other reasonable geographic areas of comparison, defined here as the potentially affected counties and states in which the impacted areas are located. While this analysis is based on CEQ guidance, CEQ does not provide numerical (percentage point) guidance; however, the U.S. Nuclear Regulatory Commission, when identifying minority and low-income populations, defines "significantly," similar to "meaningfully greater," as 20 percentage points, and that percentage point guidance definition is used in this *TC & WM EIS* (69 FR 52040). Therefore, meaningfully greater minority and low-income populations are identified where the total minority or low-income population in the impacted area exceeds that population county- or statewide by 20 percentage points, or where either the minority or low-income population is more than 50 percent of the general population in the impacted area.

CEQ guidelines (CEQ 1997) recognize that many minority and low-income populations derive part of their sustenance from subsistence hunting, fishing, and gathering activities (sometimes for species unlike those consumed by the majority population) or depend on water supplies or other resources that are atypical or are used at different rates than they are by other groups. These differential patterns of resource use are to be identified where practical and appropriate. American Indians of various tribal affiliations live in the greater Columbia Basin, and several rely at least partly on natural resources for subsistence. For example, there is some dependence on natural resources for dietary subsistence by some members of the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Confederated Tribes and Bands of the Yakama Nation. American Indian tribes have historically lived on what is now Hanford and continue to live adjacent to the site. They fish on the Columbia River and gather food resources near Hanford. Some tribes are also recognized to have cultural and religious ties to the site.

During preparation of this *TC & WM EIS*, risks and consequences of both normal operations and accidents were evaluated in terms of potential releases of contaminants from various candidate facilities throughout Hanford. The facilities in the 200 Areas at Hanford include STTS-East, STTS-West, and the HLW Vitrification Facility stack for the WTP facilities. Another potential release point is FFTF in the 400 Area at Hanford. In the analysis of the health impacts of normal operations and accidents, all persons living within 80 kilometers (50 miles) of these facilities were assumed to be potentially affected. For this environmental justice analysis, special emphasis was accorded minority and low-income populations shown to be at risk.

3.2.11.1 Minority Populations

3.2.11.1.1 General Site Description

Minority Populations Surrounding the Hanford Site, 2010

- Minority individuals constituted approximately 39 percent of the total population.
- Approximately 80 percent of the minority population lived in four counties: Benton, Franklin, Grant, and Yakima.
- Hispanic or Latino individuals accounted for approximately 84 percent of the total minority population.

The area within an 80-kilometer (50-mile) radius of the candidate facilities at Hanford encompasses parts of 10 counties in two states: Adams, Benton, Franklin, Grant, Kittitas, Klickitat, Walla Walla, and Yakima Counties in Washington, and Morrow and Umatilla Counties in Oregon. Tables 3–16 and 3–17 provide, for 1990 and 2000, respectively, a breakdown of minority populations in the 10-county area and the two-state region. Over the 10-year period between 1990 and 2000, the total population of the 10-county area increased approximately 23 percent. During that decade, the total minority population in the area increased by approximately 87 percent; the number of people self-identified as Hispanic or Latino, by approximately 93 percent; and the American Indian and Alaska Native population, by approximately 24 percent. The two-state region of Oregon and Washington experienced trends in population growth similar to those observed in the potentially affected 10-county area. The total population increased by approximately 21 percent; the total minority population, by approximately 99 percent; people self-identified as Hispanic or Latino origin, by approximately 119 percent; and the American Indian and Alaska Native population, by approximately 15 percent.

Table 3–16. Populations in the Potentially Affected 10-County Area Surrounding the Hanford Site and the Two-State Region of Washington and Oregon, 1990

Population Group	Counties Surrounding the Hanford Site		Washington and Oregon	
	Population	Percentage of Total	Population	Percentage of Total
Nonminority				
White non-Hispanic	448,454	79.3	6,801,354	88.2
Minority				
Black or African American[a]	6,239	1.1	195,979	2.5
American Indian, Eskimo, or Aleut[a]	13,242	2.3	119,979	1.6
Asian or Pacific Islander[a]	7,564	1.3	280,227	3.6
Some other race[a]	69,713	12.3	167,104	2.2
White Hispanic	20,659	3.7	144,370	1.9
Total minority	**117,417**	**20.7**	**907,659**	**11.8**
Total Hispanic or Latino[b]	**91,395**	**16.2**	**327,277**	**4.2**
Total	**565,871**	**100.0**	**7,709,013**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals who identified themselves as Hispanic or Latino, regardless of race.

Source: Census 2007a.

Table 3–17. Populations in the Potentially Affected 10-County Area Surrounding the Hanford Site and the Two-State Region of Washington and Oregon, 2000

Population Group	Counties Surrounding the Hanford Site		Washington and Oregon	
	Population	Percentage of Total	Population	Percentage of Total
Nonminority				
White non-Hispanic	475,146	68.4	7,510,106	80.6
Minority				
Black or African American[a]	7,308	1.1	245,929	2.6
American Indian and Alaska Native[a]	16,432	2.4	138,512	1.5
Asian[a]	8,869	1.3	423,685	4.5
Native Hawaiian and Other Pacific Islander[a]	828	0.1	31,929	0.3
Some other race[a]	112,624	16.2	373,755	4.0
Two or more races[a]	20,717	3.0	318,264	3.4
White Hispanic	52,851	7.6	273,340	2.9
Total minority	**219,629**	**31.6**	**1,805,414**	**19.4**
Total Hispanic or Latino[b]	**176,821**	**25.5**	**716,823**	**7.7**
Total	**694,775**	**100.0**	**9,315,520**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals who identified themselves as Hispanic or Latino, regardless of race.

Source: Census 2007b.

Table 3–18 contains a breakdown of minority populations in the surrounding 10-county area and two-state region (Washington and Oregon) from the *2010 Decennial Census* (Census 2011a). These data show that the total population of the 10-county area has increased by approximately 17 percent since the 2000 census. During that same period, the total minority population increased by approximately 44 percent; the number of people self-identified as Hispanic or Latino, by approximately 50 percent; and the American Indian and Alaska Native population, by approximately 12 percent. The White Hispanic population experienced the largest population increase in the 10-county area at approximately 92 percent, followed by the Asian population at approximately 36 percent. The two-state region experienced trends in population growth similar to those observed in the potentially affected 10-county area, except for the Native Hawaiian and Other Pacific Islander population, which grew by approximately 69 percent in the two-state region, but increased by only approximately 20 percent in the 10-county area. The total population increased by approximately 13 percent; the total minority population, by approximately 48 percent; people self-identified as of Hispanic or Latino origin, by approximately 68 percent; and the American Indian and Alaska Native population, by approximately 13 percent. Similar to that of the 10-county area, the White Hispanic population in the two-state region experienced the largest population increase at approximately 90 percent.

Table 3–18. Populations in the Potentially Affected 10-County Area Surrounding the Hanford Site and the Two-State Region of Washington and Oregon, 2010

Population Group	Counties Surrounding the Hanford Site		Washington and Oregon	
	Population	Percentage of Total	Population	Percentage of Total
Nonminority				
White non-Hispanic	494,342	60.9	7,882,652	74.7
Minority				
Black or African American[a]	9,299	1.1	309,248	2.9
American Indian and Alaska Native[a]	18,396	2.3	157,072	1.5
Asian[a]	12,083	1.5	622,330	5.9
Native Hawaiian and Other Pacific Islander[a]	997	0.1	53,879	0.5
Some other race[a]	146,862	18.1	554,424	5.3
Two or more races[a]	27,808	3.4	457,685	4.3
White Hispanic	101,708	12.5	518,324	4.9
Total minority	**317,153**	**39.1**	**2,672,962**	**25.3**
Total Hispanic or Latino[b]	**265,921**	**32.8**	**1,205,852**	**11.4**
Total	**811,495**	**100.0**	**10,555,614**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals who identified themselves as Hispanic or Latino, regardless of race.

Source: Census 2011a.

3.2.11.1.2 200 Areas Description

According to the *2010 Decennial Census* (Census 2011a), approximately 589,700 people resided in the area within an 80-kilometer (50-mile) radius of the facilities in the 200 Areas—STTS-East, STTS-West, and the WTP. Minorities accounted for approximately 45 percent of the total population. Those who identified themselves as Hispanic or Latino accounted for approximately 86 percent of the minority population and 39 percent of the total population. Table 3–19 provides a breakdown of the populations within 80 kilometers (50 miles) of the 200 Areas.

Table 3–19. Populations Within 80 Kilometers of the 200 Areas at the Hanford Site, 2010

Population Group	Population	Percentage of Total
Nonminority		
White non-Hispanic	325,185	55.1
Minority		
Black or African American[a]	7,172	1.2
American Indian and Alaska Native[a]	11,933	2.0
Asian[a]	9,509	1.6
Native Hawaiian and Other Pacific Islander[a]	643	0.1
Some other race[a]	128,641	21.8
Two or more races[a]	20,858	3.5
White Hispanic	85,712	14.5
Total minority	**264,483**	44.9
Total Hispanic or Latino[b]	**228,660**	38.8
Total	**589,668**	100.0

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals who identified themselves as Hispanic or Latino, regardless of race.

Note: To convert kilometers to miles, multiply by 0.6214. Total may not equal the sum of the contributions due to rounding.

Source: Census 2011a.

Figures 3–20 and 3–21 reflect the concentrations of various minority populations as a function of distance from the 200 Areas at Hanford. Block-group data generated from the *2010 Decennial Census* (Census 2011a) reflect a total population of 589,668 within an 80-kilometer (50-mile) radius of the 200 Areas. Outward from the 200 Areas, populations tended to increase sharply near the outskirts of the population centers of Richland, Kennewick/Pasco, and Yakima. It is estimated that 18 percent of the minority population lived within 40 kilometers (25 miles) of the 200 Areas and approximately 57 percent within 56 kilometers (35 miles). Approximately 39 percent of the total population living in the potentially affected 80-kilometer (50-mile) radius of the 200 Areas were self-identified as Hispanic or Latino.

Figure 3–22 shows meaningfully greater minority and nonminority populations living in block groups surrounding the facilities in the 200 Areas. Approximately 92 percent of the minority populations lived in four Washington counties: Benton, Franklin, Grant, and Yakima; approximately 46 percent were concentrated in Yakima County. Of the 406 block groups surrounding the 200 Areas, 145 contained meaningfully greater minority populations.

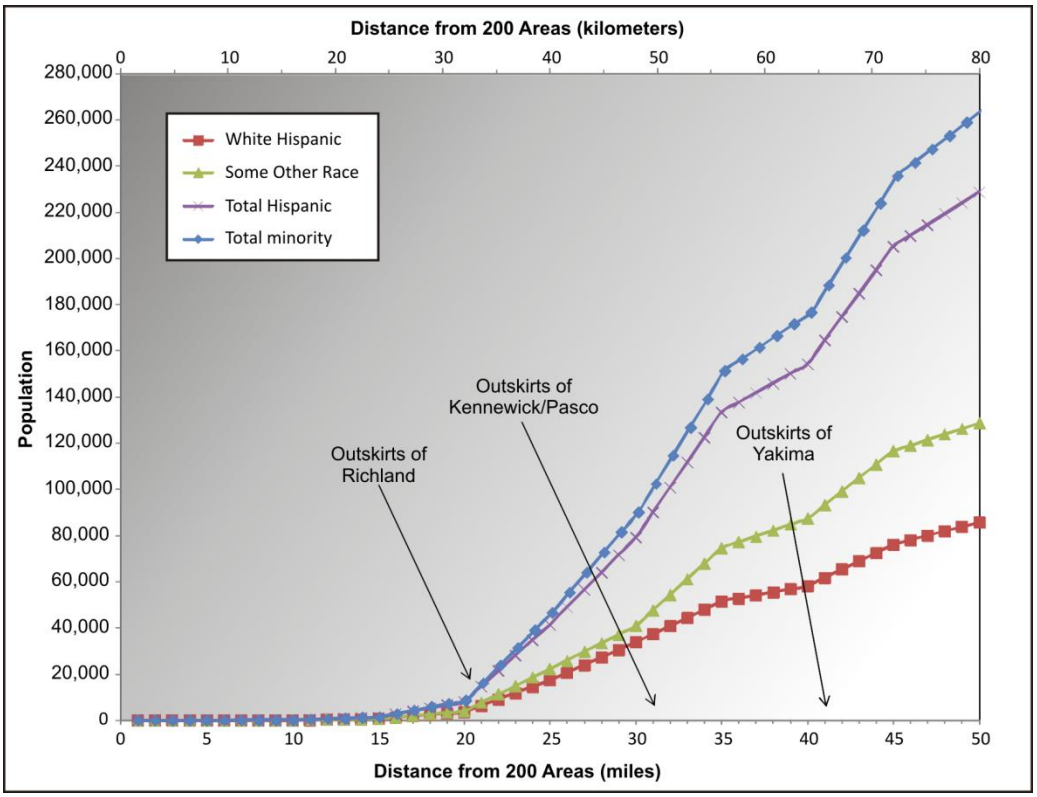


Figure 3–20. Cumulative Larger-Scale Minority Populations Surrounding the 200 Areas at the Hanford Site as a Function of Distance

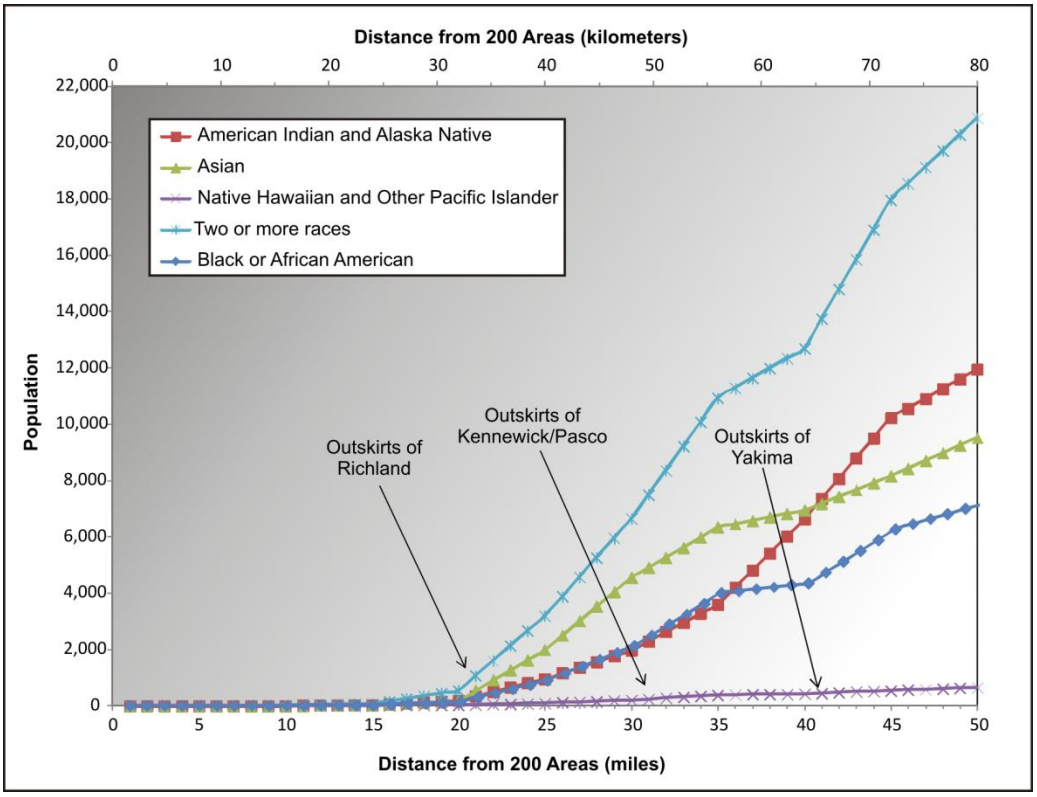


Figure 3–21. Cumulative Smaller-Scale Minority Populations Surrounding the 200 Areas at the Hanford Site as a Function of Distance

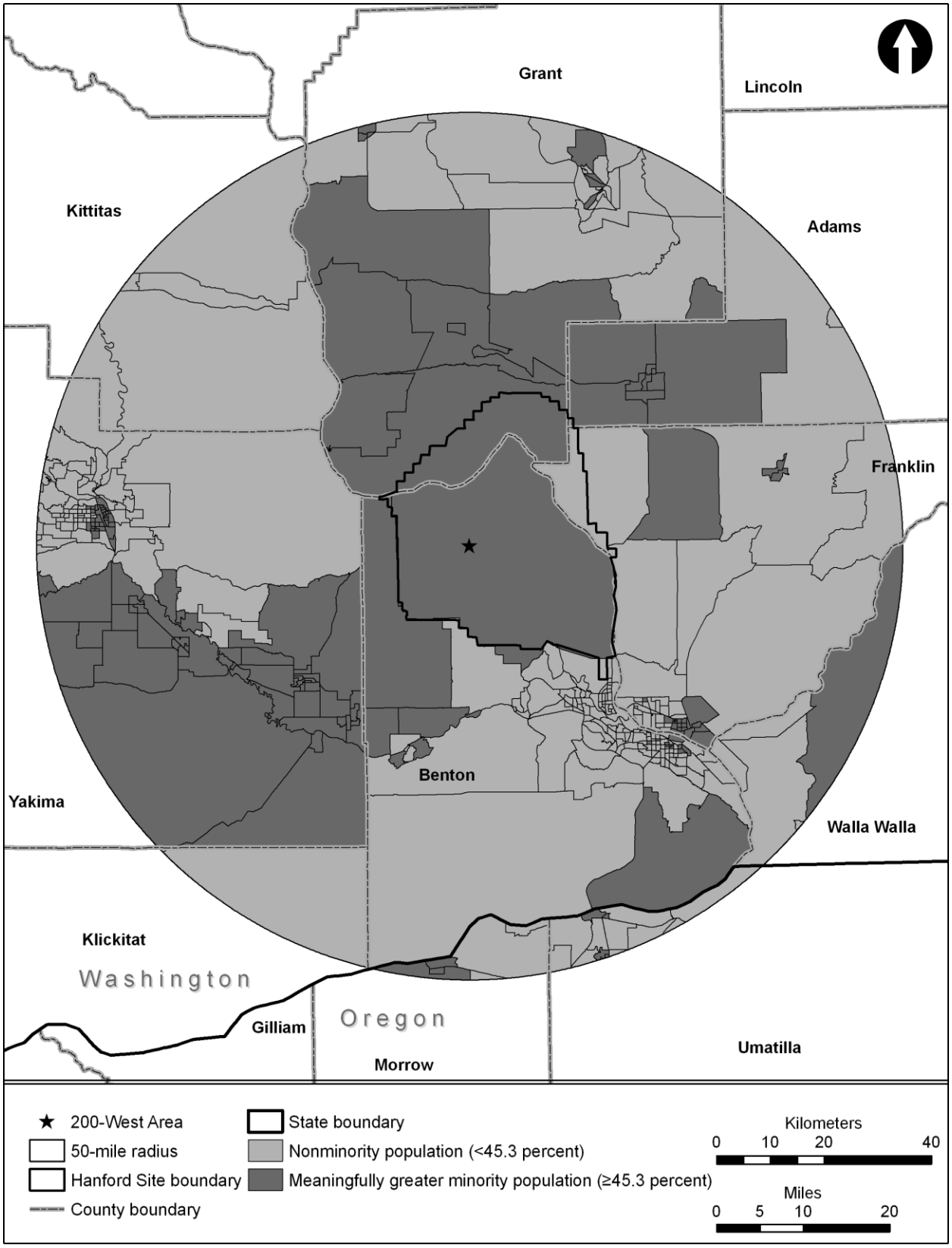


Figure 3–22. Meaningfully Greater Minority and Nonminority Populations Living in Block Groups Surrounding the 200 Areas at the Hanford Site

3.2.11.1.3 400 Area Description

According to the *2010 Decennial Census* (Census 2011a), approximately 445,000 people resided in the area within an 80-kilometer (50-mile) radius of the 400 Area at Hanford. In this area, minorities accounted for approximately 45 percent of the total population. The largest minority group was Hispanic or Latino; they accounted for approximately 88 percent of the minority population and approximately 39 percent of the total population. Table 3–20 provides a breakdown of the population within 80 kilometers (50 miles) of the 400 Area.

Table 3–20. Populations Within 80 Kilometers of the 400 Area at the Hanford Site, 2010

Population Group	Population	Percentage of Total
Nonminority		
White non-Hispanic	246,786	55.5
Minority		
Black or African American[a]	5,272	1.2
American Indian and Alaska Native[a]	6,504	1.5
Asian[a]	7,559	1.7
Native Hawaiian and Other Pacific Islander[a]	528	0.1
Some other race[a]	96,006	21.6
Two or more races[a]	14,941	3.4
White Hispanic	67,387	15.1
Total minority	**198,216**	44.5
Total Hispanic or Latino[b]	**173,540**	39.0
Total	**445,002**	100.0

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals who identified themselves as Hispanic or Latino, regardless of race.

Note: To convert kilometers to miles, multiply by 0.6214. Total may not equal the sum of the contributions due to rounding.

Source: Census 2011a.

Figures 3–23 and 3–24 show the minority populations as a function of distance from the 400 Area at Hanford. Block-group data generated from the *2010 Decennial Census* (Census 2011a) reflect a total population of 445,002 surrounding the 400 Area. The significantly lower population here than in other areas in the environs of Hanford, as indicated in this *TC & WM EIS*, can be attributed to Yakima City's location outside the 80-kilometer (50-mile) radius. Sharp increases in population could be seen on the outskirts of Richland and Kennewick/Pasco and at a point approximately 64 kilometers (40 miles) from the 400 Area, most likely attributable to the population center of Hermiston, Oregon. Approximately 36 percent of the minority population in the vicinity of the 400 Area lived within 32 kilometers (20 miles) of it; approximately 50 percent lived within 45 kilometers (28 miles). It is estimated that 39 percent of the population living within 80 kilometers (50 miles) of the 400 Area were Hispanic or Latino.

Figure 3–25 shows meaningfully greater minority and nonminority populations living in block groups surrounding the 400 Area at Hanford. Over 84 percent of the minority populations lived in four Washington counties: Benton, Franklin, Grant, and Yakima; approximately 28 percent were concentrated in Yakima County. Of the 323 block groups surrounding the 400 Area, 111 contained meaningfully greater minority populations.

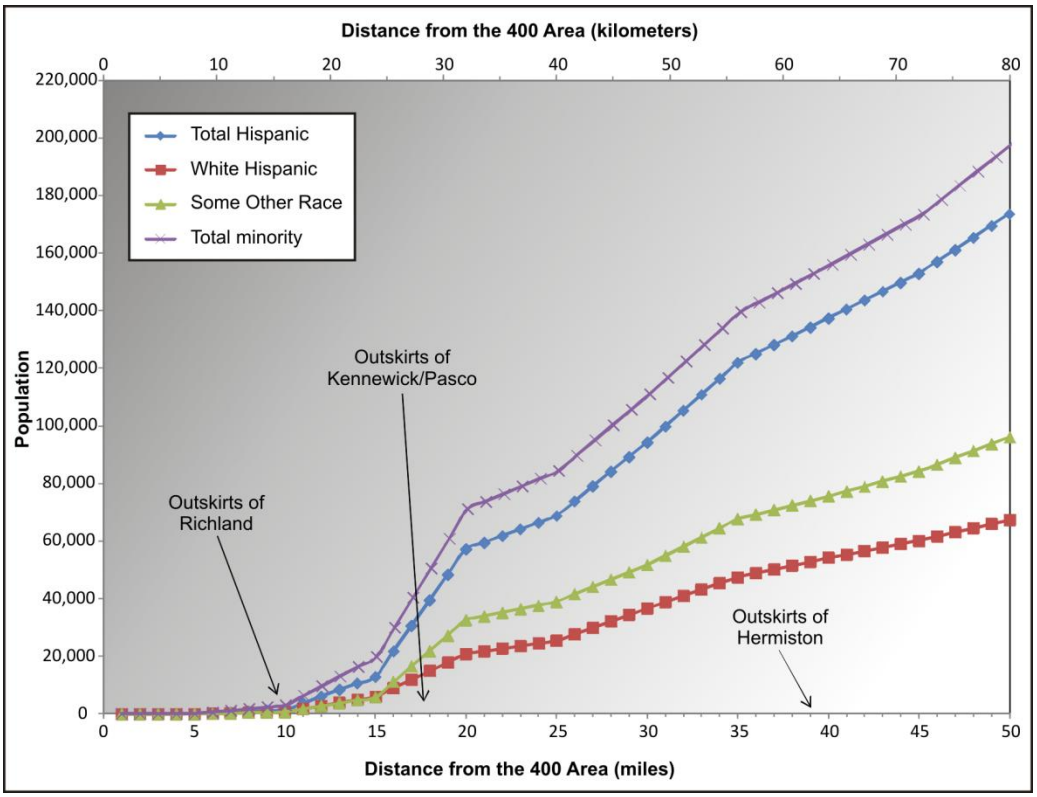


Figure 3–23. Cumulative Larger-Scale Minority Populations Surrounding the 400 Area at the Hanford Site as a Function of Distance

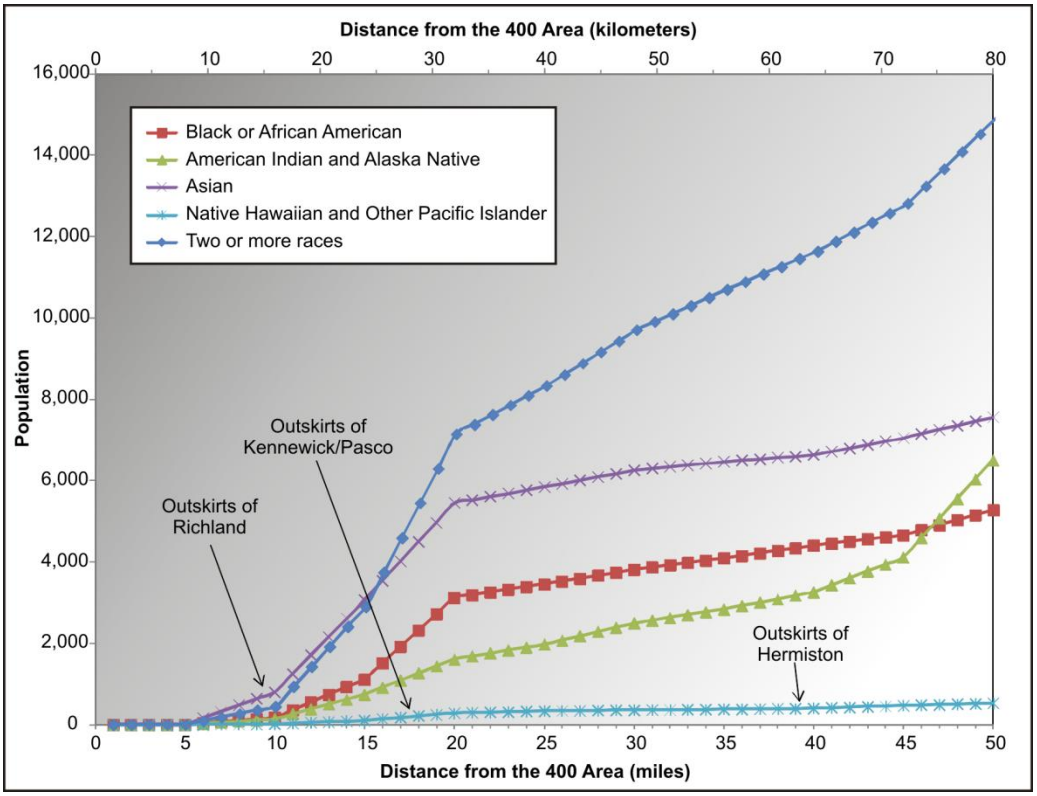


Figure 3–24. Cumulative Smaller-Scale Minority Populations Surrounding the 400 Area at the Hanford Site as a Function of Distance

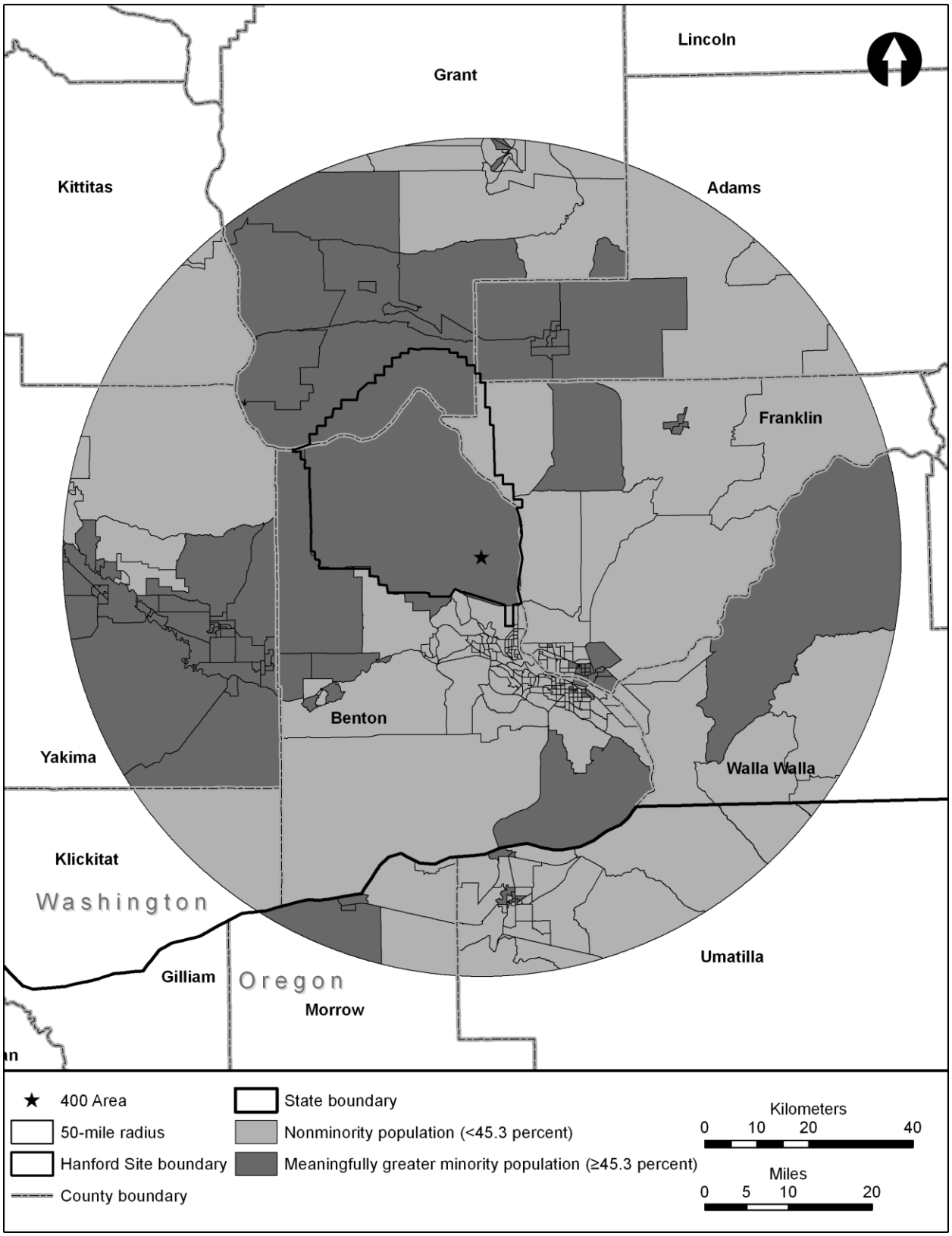


Figure 3–25. Meaningfully Greater Minority and Nonminority Populations Living in Counties Surrounding the 400 Area at the Hanford Site

3.2.11.2 Low-Income Populations

3.2.11.2.1 General Site Description

Low-Income Populations Surrounding the Hanford Site, 2006–2010

- Low-income persons constituted approximately 19 percent of the total population.
- Eighty percent of the low-income population lived in five counties: Benton, Franklin, Grant, Yakima, and Umatilla.
- Approximately 36 percent of the low-income population lived in Yakima County.

Tables 3–21 and 3–22 show the total and low-income populations in the potentially affected 10-county area surrounding the candidate facilities at Hanford and in the two-state region of Washington and Oregon in 1989 and 1999, respectively. From 1989 to 1999, the total population of the 10-county area increased by approximately 23 percent, while the low-income population increased by approximately 13 percent. Over the same period, the two-state region of Washington and Oregon saw an increase in total population of approximately 21 percent, with an increase in low-income population of approximately 16 percent over the 10-year period.

Table 3–21. Total and Low-Income Populations in the Potentially Affected 10-County Area Surrounding the Hanford Site and in the Two-State Region of Washington and Oregon, 1989

Population Group	Counties Surrounding the Hanford Site		Washington and Oregon	
	Population	Percentage of Total	Population	Percentage of Total
Total population	551,346	100.0	7,516,910	100.0
Low-income population	96,773	17.6	862,800	11.5

Note: The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).
Source: Census 2007c.

Table 3–22. Total and Low-Income Populations in the Potentially Affected 10-County Area Surrounding the Hanford Site and in the Two-State Region of Washington and Oregon, 1999

Population Group	Counties Surrounding the Hanford Site		Washington and Oregon	
	Population	Percentage of Total	Population	Percentage of Total
Total population	676,966	100.0	9,112,868	100.0
Low-income population	109,693	16.2	1,001,110	11.0

Note: The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).
Source: Census 2007d.

Table 3–23 shows the total and low-income populations in the surrounding 10-county area and two-state region (Washington and Oregon) according to the 2006–2010 American Community Survey (ACS) 5-year estimates (Census 2011c). These data show that the total population of the 10-county area has increased by approximately 12 percent, and the low-income population, by approximately 28 percent, since the 2000 census. Over the same period, the two-state region saw an increase in total population of approximately 11 percent, with an increase in the low-income population of approximately 29 percent.

Table 3–23. Total and Low-Income Populations in the Potentially Affected 10-County Area Surrounding the Hanford Site and in the Two-State Region of Washington and Oregon, 2006–2010

Population Group	Counties Surrounding the Hanford Site		Washington and Oregon	
	Population	Percentage of Total	Population	Percentage of Total
Total population	760,486	100.0	10,118,976	100.0
Low-income population	140,906	18.5	1,296,280	12.8

Note: The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).
Source: Census 2011c.

3.2.11.2.2 200 Areas Description

Table 3–24 shows the total and low-income populations within 80 kilometers (50 miles) of the 200 Areas at Hanford according to the 2006–2010 ACS 5-year estimates (Census 2011c). Low-income persons constituted approximately 19 percent of the total population. Over 92 percent of the low-income population lived in four counties: Benton, Franklin, Grant, and Yakima; approximately 46 percent were concentrated in Yakima County.

Table 3–24. Total and Low-Income Populations Within 80 Kilometers of the 200 Areas at the Hanford Site, 2006–2010

Population Group	Population	Percentage of Total
Total population	554,131	100.0
Low-income population	104,758	18.9

Note: The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).
To convert kilometers to miles, multiply by 0.6214.
Source: Census 2011c.

Figure 3–26 shows the total, low-income, and non-low-income populations as a function of distance from the 200 Areas at Hanford. Block-group data generated from the 2006–2010 ACS 5-year estimates (Census 2011c) reflect a total population of 554,131 within an 80-kilometer (50-mile) radius of the 200 Areas. Outward from the 200 Areas, populations tended to increase sharply near the outskirts of the population centers of Richland, Kennewick/Pasco, and Yakima.

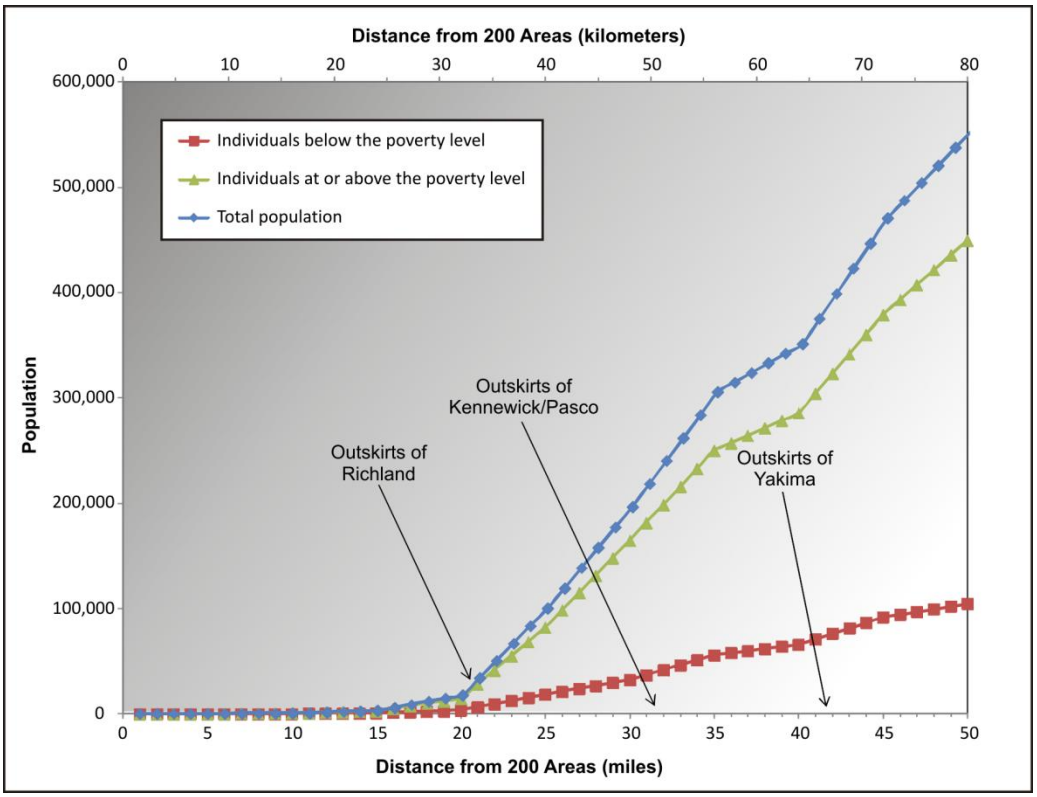


Figure 3–26. Cumulative Low-Income and Non-Low-Income Populations Surrounding the 200 Areas at the Hanford Site as a Function of Distance

Figure 3–27 shows meaningfully greater low-income and non-low-income populations living in the block groups surrounding the 200 Areas at Hanford. Of the 406 block groups surrounding the 200 Areas, 69 contain meaningfully greater low-income populations.

3.2.11.2.3 400 Area Description

Table 3–25 shows the total and low-income populations within 80 kilometers (50 miles) of the 400 Area at Hanford according to the 2006–2010 ACS 5-year estimates (Census 2011b). Low-income individuals constituted approximately 18 percent of the total population. Eighty-four percent lived in four counties: Benton, Franklin, Grant, and Yakima; 25 percent were concentrated in Yakima County.

Table 3–25. Total and Low-Income Populations Within 80 Kilometers of the 400 Area at the Hanford Site, 2006–2010

Population Group	Population	Percentage of Total
Total population	414,101	100.0
Low-income population	74,606	18.0

Note: The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).

To convert kilometers to miles, multiply by 0.6214.

Source: Census 2011c.

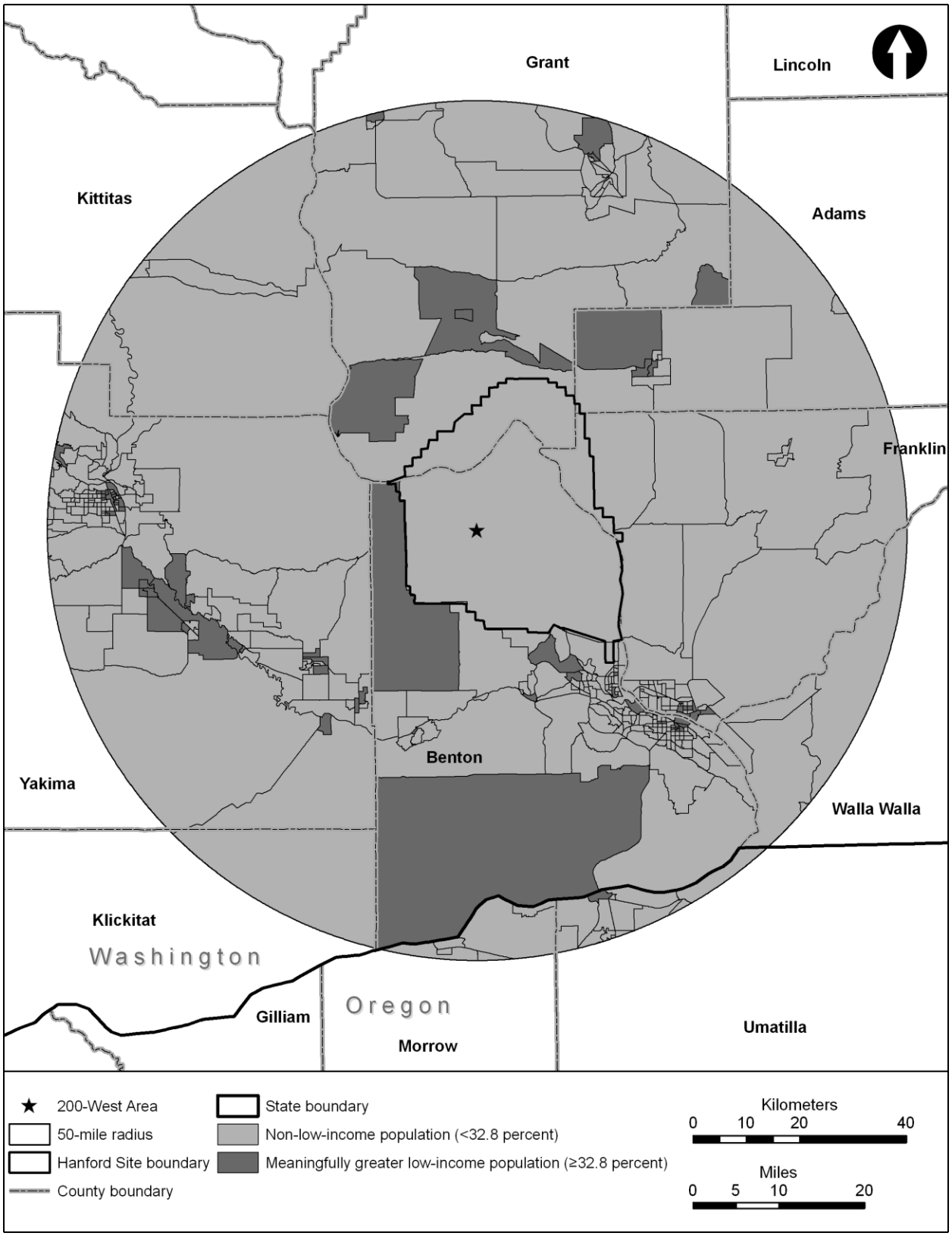


Figure 3–27. Meaningfully Greater Low-Income and Non-Low-Income Populations Living in Block Groups Surrounding the 200 Areas at the Hanford Site

Figure 3–28 illustrates the total, low-income, and non-low-income populations as a function of distance from the 400 Area. Block-group data generated from the 2006–2010 ACS 5-year estimates (Census 2011c) reflect a total population of 414,101 within an 80-kilometer (50-mile) radius of the 400 Area. Low-income individuals constituted approximately 18 percent of the total population in this area. Outward from the 400 Area, populations tended to increase sharply near the outskirts of the population centers of Richland, Kennewick/Pasco, and Hermiston.

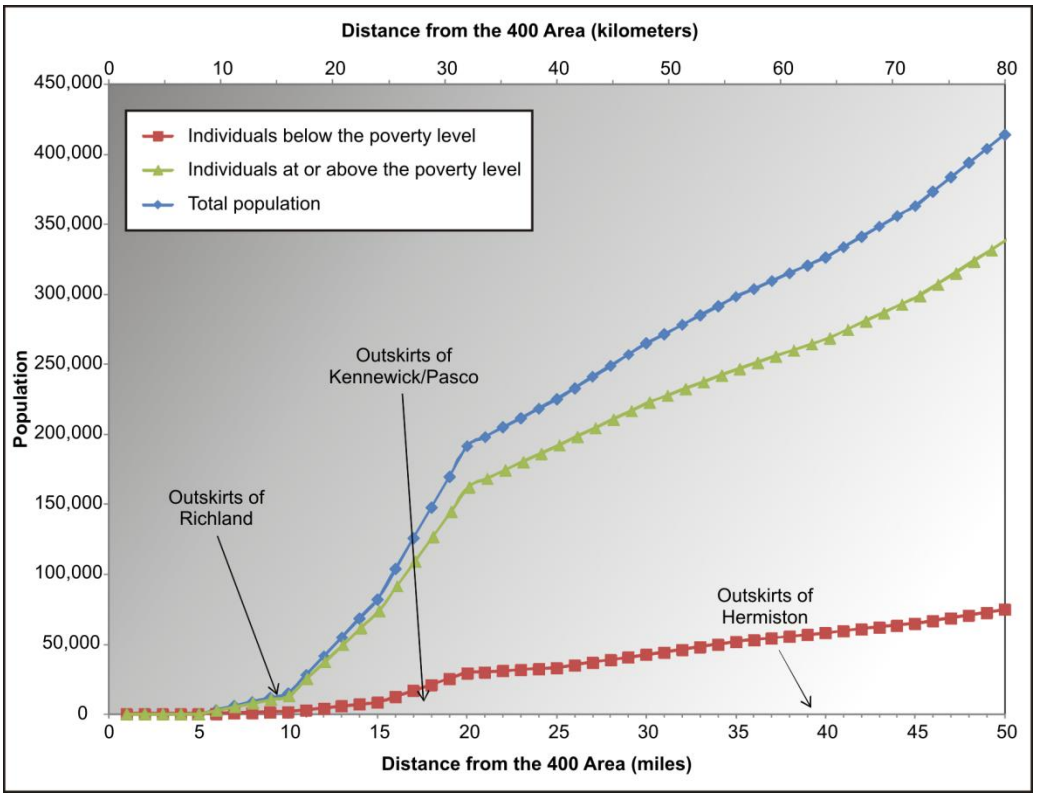


Figure 3–28. Cumulative Low-Income and Non-Low-Income Populations Surrounding the 400 Area at the Hanford Site as a Function of Distance

Figure 3–29 shows meaningfully greater low-income and non-low-income populations living in the block groups surrounding the 400 Area at Hanford. Of the 323 block groups surrounding the 400 Area, 51 contain meaningfully greater low-income populations.

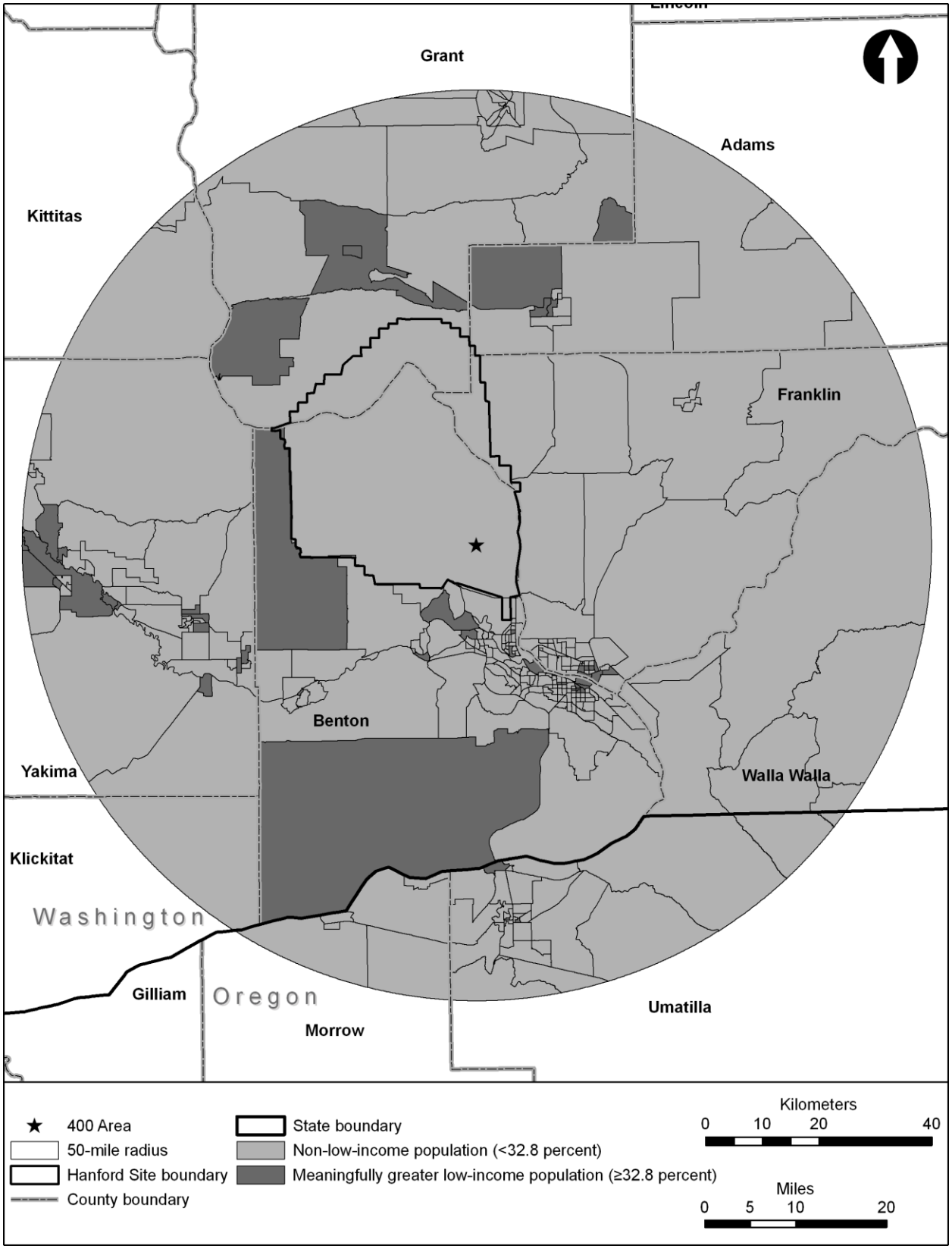


Figure 3–29. Meaningfully Greater Low-Income and Non-Low-Income Populations Living in Block Groups Surrounding the 400 Area at the Hanford Site

3.2.12 Waste Management

Waste management includes minimization, characterization, treatment, storage, transportation, and disposal of waste generated from DOE activities, including management of waste in the 149 SSTs and 28 DSTs. The waste is managed using appropriate TSD technologies in compliance with all applicable Federal and state statutes and DOE orders. In support of the discussion that follows, data on the various technological aspects of waste management are provided in Appendix E.

3.2.12.1 Waste Inventories and Activities

Hanford manages the following types of waste: HLW, transuranic (TRU) waste, mixed TRU waste, LLW, mixed low-level radioactive waste (MLLW), hazardous waste, and nonhazardous waste. Radioactive waste may be contact-handled (CH) or remote-handled (RH). The CH waste has a dose rate lower than 200 millirem per hour when measured at the surface of the container and may be handled without shielding.[4] The RH waste classification applies to containers with a contact dose rate higher than 200 millirem per hour. RH waste requires the use of additional shielding and special facilities to protect workers (P.L. 102-579).

Information on the solid waste generated from activities at Hanford from 2000 through 2006 is provided in Table 3–26. Liquid waste quantities generated and stored within the tank farm system at Hanford from 2000 through 2006 are provided in Table 3–27. The tables show typical waste generation rates in recent years when no substantial waste generation from tank waste treatment and SST closure activities occurred. Projected waste generation shown in Table 3–28, includes the total volumes of waste that would be generated from 2006 through 2035. More-detailed descriptions of TRU waste, LLW, and MLLW management system capabilities at Hanford are included in Appendix E.

Table 3–26. Quantities of Solid Waste[a] Generated on the Hanford Site, 2000–2006

Waste Category	Year						
	2000	2001	2002	2003	2004	2005	2006
	(kilograms)						
Mixed[b]	441,000	328,500	1,025,000	421,000	144,512	349,416	315,188
Radioactive[c]	700,000	1,675,200	1,588,000	758,000	906,591	1,188,212	465,340

a Includes containerized liquid waste but not waste in the tank farm system.

b Includes transuranic and low-level radioactive waste and has both radioactive and dangerous nonradioactive constituents.

c Categorized as transuranic and low-level radioactive waste.

Note: To convert kilograms to pounds, multiply by 2.2046.

Source: Poston et al. 2006:6.18; 2007:6.20.

[4] This legal definition of CH-TRU and RH-TRU waste is from the Waste Isolation Pilot Plant Land Withdrawal Act (P.L 102-579). The 200-millirem-per-hour dose rate at the surface of a container has its basis in transportation requirements and encompasses the assumption that a worker carrying packages with a surface dose rate of 200 millirem per hour for 30 minutes a day will not exceed the recommended local exposure of 100 millirem per day. The legal definition for a waste package emitting exactly 200 millirem per hour is ambiguous. TRU waste packages approaching the definitional limit (200 millirem per hour) are handled directly or remotely, depending on site-specific practices.

Table 3–27. Quantities of Liquid Waste[a] Generated and Stored Within the Tank Farm System on the Hanford Site, 2000–2006

Type of Waste	Year						
	2000[b]	2001	2002	2003	2004	2005	2006
	(liters)						
Liquids added to double-shell tanks	8,920,000	2,980,000	9,280,000	9,710,000	3,316,000	3,668,000	3,547,000
Total waste in double-shell tanks (year end)	79,630,000	79,980,000	87,683,000	92,693,000	95,275,000	98,943,000	101,411,000
Liquid waste evaporated at 242-A Evaporator	2,580,000	2,580,000	1,578,000	4,720,000	734,000	706,700	1,052,000
Liquids pumped from single-shell tanks	2,250,000	590,000	5,288,000	6,185,000	2,778,000	888,000	2,953,000[b]

[a] Liquid waste sent to underground double-shell storage tanks during these years, rounded to the nearest 1,000 liters. This does not include containerized (e.g., barreled) solid waste.

[b] Volume includes dilution or flush water; volumes for 2000–2005 do not.

Note: To convert liters to gallons, multiply by 0.26417.

Source: Poston et al. 2006:6.25; 2007:6.27.

Table 3–28. Projected Waste Generation, 2006–2035[a]

Source	Mixed TRU Waste	LLW	MLLW	Hazardous Waste[a]	Nonradioactive/ Nonhazardous Waste[a]
	(cubic meters)				
Onsite non-CERCLA	29,726	17,363	16,074	871	NR
Offsite	N/A	5,564[b]	N/A[b]	N/A	N/A
Total	**29,726**	**22,927**	**16,074**	**871**	**–**

[a] Hazardous and nonhazardous waste is shipped directly off site, and thus is generally not forecast.

[b] This does not include the 62,000 cubic meters of LLW and 20,000 cubic meters of MLLW from the U.S. Department of Energy's Settlement Agreement with the State of Washington regarding *State of Washington v. Bodman* (Civil No. 2:03-cv-05018-AAM).

Note: To convert cubic meters to cubic feet, multiply by 35.315.

Key: CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; N/A=not applicable; NR=not reported; TRU=transuranic.

Source: Barcot 2005:1-5, 1-42; 2006:6-54–6-58.

3.2.12.1.1 High-Level Radioactive Waste

HLW was generated from the reprocessing of SNF to recover uranium and plutonium generated in the production reactors. This radioactive waste is considered mixed waste because it also contains toxic and hazardous constituents subject to RCRA. It must be RH because of its high radiation levels. The waste, generated as liquids and sludges, was stored in underground tanks where the salts in the liquid precipitated out of solution as porous solids (called salt cake) and settled with the sludges in the bottom of the tanks. The liquid above the solids was pumped from the older SSTs into newer DSTs. The storage tanks are described in more detail in Chapter 2. The waste contained in the 177 underground storage

tanks (149 SSTs and 28 DSTs) is managed by DOE as HLW to provide consistent protection of the environment, workers, and public.

In addition to this liquid and solid material managed as HLW, an inventory of encapsulated cesium and strontium, also managed as HLW, is stored in the Waste Encapsulation and Storage Facility in a water-cooled pool (DOE 2000a:3-138). The Waste Encapsulation and Storage Facility provides safe storage and monitoring of radioactive cesium and strontium capsules. The facility contains seven hot cells and 12 storage/transfer pools. The current inventory consists of 1,312 cesium capsules, 23 overpacked cesium capsules, and 601 strontium capsules (Collins 2001:39). DOE is investigating the possibility of placing the capsules in dry storage.

The 242-A Evaporator is an RCRA-permitted facility in the 200-East Area that concentrates dilute liquid tank waste by evaporation. This reduces the volume of liquid waste sent to the DSTs for storage, and thus the need for more DSTs. Based on historic operating data, production rates achieved in the 242-A Evaporator average about 3.78 million liters (1 million gallons) per campaign and two campaigns per year, each lasting approximately 21 days. During 2006, the 242-A Evaporator completed one cold-run campaign for training purposes and one waste campaign. The volume of waste treated was 2.095 million liters (553,400 gallons) of waste, thereby reducing the waste volume by 901,682 liters (238,200 gallons), or approximately 43 percent of the total volume. The volume of process condensate transferred to the LERF for subsequent treatment in the ETF was 1.249 million liters (330,000 gallons) (Poston et al. 2007). The evaporator has a capacity of 270,000 liters (71,000 gallons) per day. Concentrated waste is returned to the waste storage DSTs, and condensate, as LLW, is discharged to the ETF (DOE 2002c).

3.2.12.1.2 Low-Activity Waste

LAW is waste resulting from the reprocessing of SNF that is determined to be incidental to the reprocessing and, therefore, is not HLW. The waste is managed under DOE regulatory authority in accordance with the requirements for LLW or TRU waste, as appropriate. When determining whether waste from the reprocessing of SNF waste is HLW or another waste type, either the citation or the evaluation process as presented in *Radioactive Waste Management Manual* (DOE Manual 435.1-1, Change 2) is used. As described in Chapter 2, certain alternatives being considered in this *TC & WM EIS* follow from an assumption that some of the tank waste would be determined to be incidental and would be treated as LAW by vitrification in the WTP or by an alternative treatment technology such as bulk vitrification, cast stone, or steam reforming. Because LAW comes from tank waste designated as mixed waste, it would also be managed as MLLW. Vitrification treatment capacity for a portion of the LAW is currently being constructed in the WTP. Additional treatment is analyzed in this *TC & WM EIS*. Hanford does not currently have disposal capability for LAW; however, the analysis allows for disposal of 213,000 cubic meters (7.52 million cubic feet) of WTP-vitrified LAW in an IDF.

3.2.12.1.3 Transuranic and Mixed Transuranic Waste

The waste contained in the 177 underground storage tanks (149 SSTs and 28 DSTs) is managed as HLW; however, the DOE Office of River Protection believes it can demonstrate that some of the tanks should be classified as containing TRU waste, based on the origin of the waste. Appendix E, Section E.1.2.3.11, covers this waste in more detail.

Not all currently generated CH-mixed TRU waste is tank-derived. Nontank waste is being placed in above-grade storage buildings at the 27,871-square-meter (300,000-square-foot) CWC in the 200-West Area (DOE 2002d). The wastes stored at the CWC are segregated to ensure compatibility of the contents of the various storage containers (e.g., acidic and basic materials are stored separately). All waste containers are CH, although some RH-TRU waste is stored at the CWC after it is shielded to CH levels. The CWC can store as much as 20,796 cubic meters (734,418 cubic feet) of MLLW and TRU waste.

Treatment reduces the amount of waste in storage and makes room for newly generated mixed waste. The dangerous waste designation of each container of waste is established at the point of origin from process knowledge or sample analysis. The current volume of waste stored at the CWC totals approximately 6,950 cubic meters (245,430 cubic feet) (Poston et al. 2007). The TRU waste will be maintained in storage until it is shipped to DOE's Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, for disposal (DOE 2002d).

Inspection, verification, opening, headspace gas sampling, sorting, and limited treatment and repackaging of TRU waste containers are performed in the 2706-T Facility of the T Plant complex. The T Plant canyon and tunnel (221-T Building) are used for processing of CH and RH materials. Dry decontamination, inspection, segregation, verification, and repackaging of CH- and RH-TRU waste and large items of contaminated equipment are performed in the canyon. The 2706-T Facility provides verification, treatment, and repackaging of CH-TRU waste. Treatment processes consist of the addition of sorbent material to the waste matrix, neutralization of the waste, and the amalgamation of mercury and other metals (DOE 2002e).

The major function of WRAP is inspection, repackaging, and certification of CH-TRU waste to prepare it for transport and disposal at WIPP. The facility is also used to verify that LLW meets Hanford waste acceptance criteria and to characterize MLLW for quality assurance purposes. WRAP provides the capability for nondestructive examination and assay of incoming waste. Nondestructive examination is an x-ray process used to identify the physical contents of the waste containers. Nondestructive assay is a neutron or gamma energy assay system used to determine radiological content and distribution. WRAP also has limited TRU waste and MLLW treatment capabilities, including deactivation, solidification or absorption of liquids, neutralization of corrosives, amalgamation of mercury and waste, microencapsulation, macroencapsulation, volume reduction by supercompaction, stabilization of reactive waste, and repackaging of waste. WRAP is designed to process 6,800 drums of TRU waste annually (DOE 2000a:3-139). This facility, which began operations in 1997, processed and shipped off site 586 cubic meters (20,694 cubic feet) of waste during 2006 (Poston et al. 2007).

Mobile TRU waste processing facilities or accelerated process lines have been proposed for Hanford to accelerate the rate at which TRU waste can be certified and shipped to WIPP. The functions of these facilities are similar to those of WRAP. They are expected to be developed in stages or modules so that the first module will process standard 208-liter (55-gallon) drums; a second module will process larger boxes. The mobile systems will provide an additional capacity to process about 4,000 CH-TRU drums per year. Units will be located outside near the CWC buildings on ground that has already been disturbed (DOE 2000b).

TRU waste disposal began in 1999 with the opening of WIPP, and Hanford began shipping waste to WIPP in July 2000. Waste to be shipped to WIPP must be certified according to the WIPP Waste Acceptance Criteria. WRAP was designed and built at Hanford to perform, among various other functions, certification of most CH-TRU waste for disposal at WIPP. Currently, CH-TRU waste drums are being removed from the CWC, certified at WRAP, and shipped to WIPP. WIPP is designed to annually receive and handle 14,160 cubic meters (500,000 cubic feet) of CH waste and 283 cubic meters (10,000 cubic feet) of RH waste. WIPP has a designated disposal capacity of 175,600 cubic meters (6.2 million cubic feet) of TRU waste and sufficient capacity to handle the 7,080 cubic meters (250,000 cubic feet) of RH waste that was established in the ROD for WIPP as a total volume (46 FR 9162). As of January 2008, 53,001 cubic meters (1,871,713 cubic feet) of waste has been disposed of at WIPP (DOE 2008d). In 2006, Hanford made 69 shipments (508 cubic meters [17,940 cubic feet]) of waste to WIPP (McKenney 2006).

3.2.12.1.4 Low-Level Radioactive Waste

Radioactive materials handling may result in the contamination of various items and materials with LLW. At Hanford, solid LLW includes protective clothing, plastic sheeting, gloves, paper, wood, analytical waste, contaminated equipment, contaminated soil, nuclear reactor hardware, nuclear fuel hardware, and spent deionizer resin from the purification of water in radioactive material storage basins.

Hanford's solid LLW is sent to the LLBG 218-W-5 (trenches 31 and 34) and the ERDF. The LLBGs are a landfill facility comprising eight separate waste disposal areas in the 200-East and 200-West Areas (DOE 2003a:E-2). The LLBGs cover a noncontiguous combined area of about 220 hectares (544 acres) (DOE 1997a). Two of these LLBGs are used for the disposal of LLW and MLLW (i.e., LLW with a dangerous waste component regulated by WAC 173-303). Seven LLBGs were previously used for disposal of LLW. TRU waste was placed in retrievable storage in four LLBGs; one LLBG (218-W-6) was never used. The LLBGs have been permitted under an RCRA Part A permit since 1985.

Three trenches receive mixed waste regulated by WAC 173-303. Trenches 31 and 34 in LLBG 218-W-5 are lined trenches with leachate collection and removal systems. Trench 94 is an unlined trench in LLBG 218-E-12B that is currently used for disposal of defueled U.S. Navy reactor compartments. LLW and TRU waste have been placed in the other LLBGs. TRU waste has not been placed in the LLBGs without specific DOE approval since August 19, 1987. The TRU waste was placed in a manner that allows for retrieval and/or removal in the future (Poston et al. 2007:6.24).

On June 23, 2004, DOE issued a ROD (69 FR 39449) for the Solid Waste Program at Hanford. Part of the ROD stated that DOE will dispose of LLW in lined disposal facilities. Only two of the LLBG trenches are lined (trenches 31 and 34); therefore, since that date, all LLW, as well as MLLW, is being placed in these two trenches. Disposal of U.S. Navy reactor compartments in the LLBGs is not affected by this ROD (Poston et al. 2007:6.24).

Typically, the trenches (ditches) are about 12 meters (40 feet) wide at the base and are excavated to a depth of approximately 6 meters (20 feet). After they are filled with waste to the desired level, a 2.4-meter (8-foot) layer of soil is placed over the waste so the surface is near the original grade (DOE 1997b). The current combined packaged waste volume in trenches 31 and 34 is 4,301 cubic meters (151,886 cubic feet); however, some of the waste in these trenches has been radiologically stabilized in grout monoliths, which take up additional space. Taking the monoliths into account, the current realized disposal volume in the two trenches is approximately 5,620 cubic meters (198,465 cubic feet) (Poston et al. 2007).

Between 1962 and 1999, Hanford disposed of 283,000 cubic meters (9,994,145 cubic feet) of solid LLW in the LLBGs. The average rate of disposal of offsite waste is about 5,663 cubic meters (200,000 cubic feet) per year (DOE 2002f). In addition, 115 defueled U.S. Navy reactor compartments from nuclear-powered vessels have been disposed of (Poston et al. 2007:6.22).

Within the LLBGs, several techniques can be used to provide extra confinement for higher-activity LLW. These techniques include placement deep within the trench (ditch), burial in high-integrity containers, and in-trench grouting. Generally, high-integrity containers are used for RH-LLW and in-trench grouting for high-activity CH-LLW.

Both on- and offsite generators of LLW are required to meet specific criteria for their waste to be accepted for disposal at Hanford. Those criteria, defined in the *Hanford Site Solid Waste Acceptance Criteria* (Fluor Hanford 2005b), include requirements regarding the waste package, waste package contents, radiological content, physical size, and chemical composition. To verify that generators conform to the waste acceptance criteria, a random sample of incoming CH waste is periodically selected for verification at WRAP, the T Plant complex, or other appropriate locations. Verification of RH waste

is typically conducted at the generating facility. Discovery of nonconforming waste can result in rejection of the waste and its return to the generator, or in the required removal or treatment of prohibited items at the generator's expense. Most LLW is stored for only short periods awaiting verification or disposal. LLW that requires some type of treatment before it can be disposed of is stored at the CWC. Three percent of the waste stored at the CWC is LLW (DOE 2002d).

LLW resulting from CERCLA cleanup activities is disposed of at the ERDF, which has been the central Hanford disposal site for contaminated waste generated during such activities since 1996. The ERDF, near the 200-West Area, is an RCRA- and Toxic Substances Control Act–compliant landfill designed to provide disposal capacity for Hanford waste over the next 20 to 30 years. Constructed to RCRA Subtitle C Minimum Technology Requirements, the facility features a double liner and leachate collection system that constitute an effective barrier against contaminant migration to the environment. Environmental restoration waste disposed of in the ERDF includes soil, rubble, or other solid-waste materials classified as hazardous waste, LLW, or mixed (combined hazardous and radioactive) waste (Poston et al. 2007).

There are currently eight waste cells associated with the ERDF site. Cells 1 and 2 were the first constructed, and placement of waste in these cells is nearly complete. An interim cover has been placed over the parts of these two cells that have been brought up to grade. Construction of cells 3 through 8 is complete and they are receiving waste.

During 2006, approximately 475,792 metric tons of remediation waste was disposed of at the facility. The total for the period from operations startup through 2006 was approximately 6.2 million metric tons. Under the 1995 EPA Superfund ROD (EPA 1995), expansion of the ERDF to as much as 414 hectares (1,024 acres) was authorized (Poston et al. 2007).

US Ecology, Inc., operates a licensed, commercial disposal site (the US Ecology Commercial LLW Disposal Site) on land southwest of the 200-East Area that is leased to the State of Washington. This disposal site is not a DOE facility and is not considered part of DOE's Hanford operations (DOE 2000a:3-138).

3.2.12.1.5 Mixed Low-Level Radioactive Waste

Hanford's MLLW was generated from the operation, maintenance, and cleanout of reactors, chemical separation facilities, tank farms, and laboratories. MLLW contains the same types of contaminated materials as LLW; it typically consists of materials such as sludges, ashes, resins, paint waste, lead shielding, contaminated equipment, protective clothing, plastic sheeting, gloves, paper, wood, analytical waste, and contaminated soil. Hazardous components may include lead and other heavy metals; solvents; paints; oils and other hazardous organic materials; or components that exhibit characteristics of ignitability, corrosivity, toxicity, or reactivity as defined by "Dangerous Waste Regulations" (WAC 173-303). Hanford has some LLW that contains polychlorinated biphenyls, which are regulated under the Toxic Substances Control Act. Such waste is managed much like mixed waste, and it is included in MLLW inventories and projections.

The CWC includes 12 small, mixed waste storage buildings, 27 modules for low-flash-point MLLW, and 12 modules for alkali metals (DOE 2002d). During 2006, MLLW was treated and/or directly disposed of in trenches 31 and 34 and the ERDF. Specific operations included the following (Poston et al. 2007):

- MLLW totaling 670 cubic meters (23,660 cubic feet) was treated and disposed of in support of treatment objectives in Hanford Federal Facility Agreement and Consent Order (also known as the Tri-Party Agreement [TPA]) Milestone M-91-42.

- MLLW totaling 154 cubic meters (5,438 cubic feet), or approximately 740 drum equivalents (based on a standard 208-liter [55-gallon] drum), was shipped from Hanford and nonthermally treated to RCRA land-disposal-restriction treatment standards by offsite commercial waste processors. The treated waste was returned to Hanford and disposed of in trenches 31 and 34.

- MLLW totaling 516 cubic meters (18,222 cubic feet), or approximately 2,481 drum equivalents, was shipped from Hanford and nonthermally treated to RCRA land-disposal-restriction treatment standards by offsite commercial waste processors. The treated waste was returned to Hanford and disposed of at the ERDF.

- MLLW totaling 239 cubic meters (8,440 cubic feet), or approximately 1,149 drum equivalents, was treated and disposed of in support of treatment objectives in TPA Milestone M-91-12. This waste was shipped from Hanford and thermally treated to RCRA land-disposal-restriction treatment standards by offsite commercial waste processors. The treated waste was returned to Hanford and disposed of in trenches 31 and 34.

- MLLW totaling 79 cubic meters (103 cubic yards), or approximately 380 drum equivalents, was disposed of in trenches 31 and 34. This waste came from various Hanford generators and was treated either off site by commercial waste processors or on site by the generator, or was not treated because it met land-disposal-restriction treatment standards in the "as-generated" state.

Immobilization or destruction of the hazardous component is generally required before most of the MLLW can be sent to a permitted land disposal facility. The current approach to treatment of MLLW at Hanford involves a combination of on- and offsite commercial treatment facilities. Hanford currently has limited capacity for MLLW treatment at facilities such as trenches 31 and 34 (Brockman 2008), WRAP, and the T Plant complex. WRAP, located near the CWC, also inspects, treats, and repackages MLLW to ensure that it meets the acceptance criteria of the appropriate disposal facility. MLLW received from offsite generators is expected to arrive in a form compliant with regulations that is ready for disposal (DOE 2002g).

Miscellaneous dilute aqueous LLW and liquid MLLW are temporarily stored in the LERF until treated in the ETF. The ETF, in the 200-East Area, treats liquid effluent (wastewater) to remove toxic metals, radionuclides, and ammonia and to destroy organic compounds. The effluent comes from the 242-A Evaporator; the groundwater from the site pump-and-treat projects; and the leachate from onsite solid waste disposal facilities and a variety of other generators, including site cleanup facilities (DOE 2002d).

The LERF, in the 200-East Area, consists of three RCRA-compliant surface basins used to temporarily store process condensate from the 242-A Evaporator and other aqueous waste. The LERF ensures a steady flow and consistent pH of the feed to the ETF. Each basin has a maximum capacity of 29.5 million liters (7.8 million gallons). Generally, spare capacity is maintained to allow for control of any leak that should develop in an operating basin. Each basin is constructed of two flexible, high-density, polyethylene membrane liners. A system is provided to detect, collect, and remove leachate from between the primary and secondary liners. Moreover, a soil and bentonite clay barrier beneath the secondary liner guards against failure of the primary and secondary liners. Each basin has a floating membrane cover constructed of very low-density polyethylene to keep out windblown soil and weeds and to minimize evaporation of small amounts of organic compounds and tritium that may be present in the basin contents. The facility began operating in April 1994 and receives liquid waste from both RCRA- and CERCLA-regulated cleanup activities (Poston et al. 2007).

The volume of wastewater received for interim storage during 2006 was approximately 7.08 million liters (1.87 million gallons). Included were approximately 3.90 million liters (1.03 million gallons) of

RCRA-regulated wastewater (primarily 242-A Evaporator process condensate and mixed-waste trench leachate) and approximately 3.19 million liters (843,000 million gallons) of CERCLA-regulated wastewater (primarily ERDF leachate). Most of the wastewater was received via pipeline direct from the originating facility. Approximately 1.77 million liters (468,000 gallons) of wastewater was received from various facilities via tanker trucks. The treated effluent is stored in tanks, sampled and analyzed, and discharged to the SALDS (also known as the 616-A Crib). The volume of wastewater transferred to the ETF for treatment and disposal during 2006 was 15.6 million liters (4.12 million gallons) (Poston et al. 2007:6.24, 6.25).

The volume of wastewater being stored in the LERF at the end of 2006 was 31.42 million liters (8.30 million gallons). This included 8.10 million liters (2.14 million gallons) of RCRA-regulated wastewater and 23.32 million liters (6.16 million gallons) of CERCLA-regulated wastewater (Poston et al. 2007:6.25).

The treatment of MLLW is primarily accomplished through a series of offsite commercial contracts (e.g., Perma-Fix Northwest). Treated waste is then returned for disposal at Hanford in either the LLBGs or the ERDF. Onsite treatment (primarily macroencapsulation) is conducted on a limited basis. In addition to treatment by generator, treatment has also been performed at the T Plant complex and on a limited basis within Hanford's disposal trenches. For example, MLLW is treated within the boundaries of the ERDF, and greater-than-Category 3 LLW is treated in a similar manner within the LLBGs (Johnson and Parker 2004).

Trenches 31 and 34 are located in LLBG 218-W-5 in the 200-West Area. They are rectangular trenches with approximate floor dimensions of 76.2 by 30.5 meters (250 by 100 feet) and depths of 9.1 to 10.7 meters (30 to 35 feet). These trenches are RCRA-compliant, featuring double liners and leachate collection systems (DOE 2000a:3-139). The bottom and sides of the facilities are covered with a layer of soil 1 meter (3.3 feet) deep to protect the liner system during fill operations. A recessed section at the end of each excavation houses a sump for leachate collection. The leachate generated from operation of the lined MLLW disposal trenches is mostly rainwater or melted snow trapped by the collection systems. The liquid waste is removed from the lined trenches and trucked to the ETF, where it is treated along with other liquid MLLW (Poston et al. 2007:6.23).

The 400 Area waste management unit is located within the FFTF Property Protected Area and consists of two container storage units: the Fuel Storage Facility and the Interim Storage Area. The mixed waste stored in these two container storage units is limited exclusively to debris (e.g., piping, equipment, components) contaminated with elemental sodium and sodium hydroxide generated from FFTF deactivation activities in the FFTF Fuel Storage Facility and the 400 Area Interim Storage Area. Once this waste has been treated, removed, and disposed of, appropriate closure of the 400 Area waste management unit facilities will be done under applicable regulations.

3.2.12.1.6 Hazardous Waste

There are no treatment facilities for hazardous waste at Hanford; therefore, the waste is accumulated in satellite storage areas (for less than 90 days) or at interim RCRA-permitted facilities. The common practice for newly generated hazardous waste is to ship it off site using U.S. Department of Transportation–approved transporters for treatment, recycling, recovery, and disposal at RCRA-permitted commercial facilities (DOE 2000a:3-139).

3.2.12.1.7 Nonhazardous Waste

Sanitary wastewater is discharged to onsite treatment facilities such as septic tanks, subsurface soil adsorption systems, and wastewater treatment plants. These facilities treat an average of 598,000 liters (158,000 gallons) per day of sewage (DOE 2000a:3-139). Sewage at Hanford is treated by various means

and in various systems. The sewer system in the 300 Area was recently connected to the City of Richland's system, thereby providing for treatment of that area's sewage at the municipal plant. Moreover, the 400 Area, which until recently used a septic tank and drain field, currently sends its sewage for processing to the Energy Northwest sanitary sewer system. Sanitary waste in the 200 Areas is currently disposed of through septic tanks and drain fields (DOE 1999a:4-112).

The 200 Area TEDF collects the treated wastewater streams from various plants in the 200 Areas and disposes of the clean effluent at two 2-hectare (5-acre) ponds permitted by the State of Washington (DOE 2000a:3-139). The design capacity of the facility is approximately 13,000 liters (3,400 gallons) per minute (DOE 2002d).

Nonhazardous solid waste includes construction debris, office trash, cafeteria waste, furniture and appliances, nonradioactive friable asbestos, powerhouse ash, and nonradioactive/nonhazardous demolition debris (DOE 2000a:3-139). Such waste is disposed of at the Roosevelt Regional Landfill near Goldendale, Washington (Poston et al. 2006:6.17). Nonradioactive friable asbestos and medical waste are shipped off site for disposal at commercial facilities (DOE 2000a:3-139).

3.2.12.2 Waste Minimization

The Hanford Site Pollution Prevention Program is a comprehensive, continual effort to systematically reduce the quantity and toxicity of hazardous, radioactive, mixed, and sanitary wastes; conserve resources and energy; reduce hazardous substance use; and prevent or minimize pollutant releases to all environmental media from all operations and site cleanup activities. In accordance with sound environmental management practices, the pollution prevention program seeks to prevent pollution through establishing goals related to affirmative procurement (the purchase of environmentally preferable products containing recycled material), source reduction, and environmentally safe recycling. DOE Order 436.1, *Departmental Sustainability*, was approved on May 2, 2011. The purpose of this order is to ensure that DOE carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges and advances sustainable, efficient, and reliable energy for the future; to institute wholesale cultural change to factor sustainability and greenhouse gas reductions into all DOE corporate management decisions; and to ensure that DOE achieves the sustainability goals.

DOE-RL is responsible for the Hanford pollution prevention program. The office provides program guidance for Hanford contractors. Integration activities are managed by Fluor Hanford, Inc., under the Project Hanford Management Contract. In 2006, Hanford recycled 1,115 metric tons of sanitary and hazardous wastes. Affirmative procurement at Hanford achieved 100 percent of the 2006 goal. Hanford generated 4,278 cubic meters (151,073 cubic feet) of cleanup and stabilization goal waste (i.e., LLW, MLLW, and hazardous waste) (Poston et al. 2007).

3.2.12.3 *WM PEIS* Records of Decision

Decisions regarding management of the various waste types at Hanford were announced in a series of RODs following publication of the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste (WM PEIS)* (DOE 1997b). The effects of these decisions for the waste types analyzed in this *TC & WM EIS* are shown in Table 3–29. The hazardous waste ROD was issued on July 30, 1998 (63 FR 41810); the HLW ROD, on August 12, 1999 (64 FR 46661); and the LLW and MLLW ROD, on February 18, 2000 (65 FR 10061). The TRU waste ROD was issued on January 20, 1998 (63 FR 3629), and modified on December 19, 2000 (65 FR 82985); July 13, 2001 (66 FR 38646); and August 27, 2002 (67 FR 56989).

Table 3–29. Preferred Treatment of Various Hanford Wastes as Stipulated in the *WM PEIS* Records of Decision

Waste Type	Preferred Actions
HLW	DOE decided that Hanford should store its HLW on site pending the transfer of such waste to an HLW geologic repository.[a]
LLW	DOE decided to treat Hanford's LLW on site. It also selected Hanford as one of the regional disposal sites for LLW.[b]
MLLW	DOE decided to regionalize treatment of MLLW at Hanford. This entails onsite treatment of Hanford's own waste and possibly some MLLW generated at other sites. Hanford was selected as one of the regional disposal sites for MLLW.[b]
TRU waste and mixed TRU waste	DOE decided that Hanford should prepare for storage and store its own TRU waste and small quantities of TRU waste from other sites, pending the disposal of such waste at the Waste Isolation Pilot Plant or another suitable geologic repository.[c]
Hazardous waste	DOE decided to continue using commercial facilities to treat Hanford's nonwastewater hazardous waste and onsite facilities to treat its wastewater hazardous waste.[d]

[a] 64 FR 46661.

[b] 65 FR 10061.

[c] 63 FR 3629; 65 FR 82985; 66 FR 38646; and 67 FR 56989.

[d] 63 FR 41810.

Key: DOE=U.S. Department of Energy; Hanford=Hanford Site; HLW=high-level radioactive waste; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; TRU=transuranic; *WM PEIS=Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*.

According to the HLW ROD, immobilized HLW will be stored at the site of generation pending its transfer to an HLW geologic repository. As stipulated in the first TRU waste ROD, DOE will develop and operate mobile and fixed facilities to characterize TRU waste and prepare it for disposal at WIPP. Each DOE site that has generated, or will generate, TRU waste will, as needed, prepare its TRU waste for storage and store it on site. The LLW and MLLW ROD states that, for management of LLW, minimal treatment will be performed at all sites and disposal will continue, to the extent practicable, on site at INL, Los Alamos National Laboratory, the Oak Ridge Reservation (ORR), and the Savannah River Site (SRS). In addition, Hanford and the Nevada National Security Site (NNSS), formerly the Nevada Test Site, will be available to all DOE sites for LLW disposal. MLLW will be treated at Hanford, INL, ORR, and SRS and will be disposed of at Hanford and NNSS. Commercial facilities may also be used for the treatment and disposal of LLW and MLLW. The hazardous waste ROD states that most DOE sites will continue to use offsite facilities for the treatment and disposal of major portions of the nonwastewater hazardous waste, and that ORR and SRS will continue treating some of their own nonwastewater hazardous waste on site in existing facilities where this is economically favorable.

More-detailed information concerning DOE alternatives for the future configuration of waste management facilities at Hanford is presented in the *WM PEIS* (DOE 1997b) and the HLW, TRU waste, hazardous waste, and LLW and MLLW RODs.

3.2.13 Spent Nuclear Fuel

The Nuclear Waste Policy Act of 1982, as amended, assigned the Secretary of Energy responsibility for developing a repository for disposal of HLW and SNF. When such a repository is available, SNF will be transferred from the various nuclear reactor sites to the repository for disposal. Until that repository is available, SNF will be stored in the reactor vessel or another acceptable containment, such as a dry cask storage system.

Several strategies for management—i.e., transportation and treatment or storage—of the SNF from FFTF have been evaluated in depth by DOE. The specific strategies and documentation thereof are as follows:

- As part of previous NEPA reviews, transportation and storage of FFTF fuel at either Hanford or INL (formerly Idaho National Engineering Laboratory) was evaluated in the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DOE 1995a) and ROD (60 FR 28680); the *Environmental Assessment, Shutdown of the Fast Flux Test Facility, Hanford Site, Richland Washington* (DOE 1995b) and Finding of No Significant Impact (DOE 1995c); and the *Environmental Assessment, Management of Hanford Site Non-defense Production Reactor Spent Nuclear Fuel, Hanford Site, Richland, Washington* (DOE 1997c) and Finding of No Significant Impact (DOE 1997d).

- Transportation and treatment of the FFTF sodium-bonded SNF at the Materials and Fuels Complex (MFC) was evaluated in the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DOE 1995a) and ROD (60 FR 28680), and the *Final Environmental Impact Statement for the Treatment and Management of Sodium-Bonded Spent Nuclear Fuel* (DOE 2000b) and ROD (65 FR 56565).

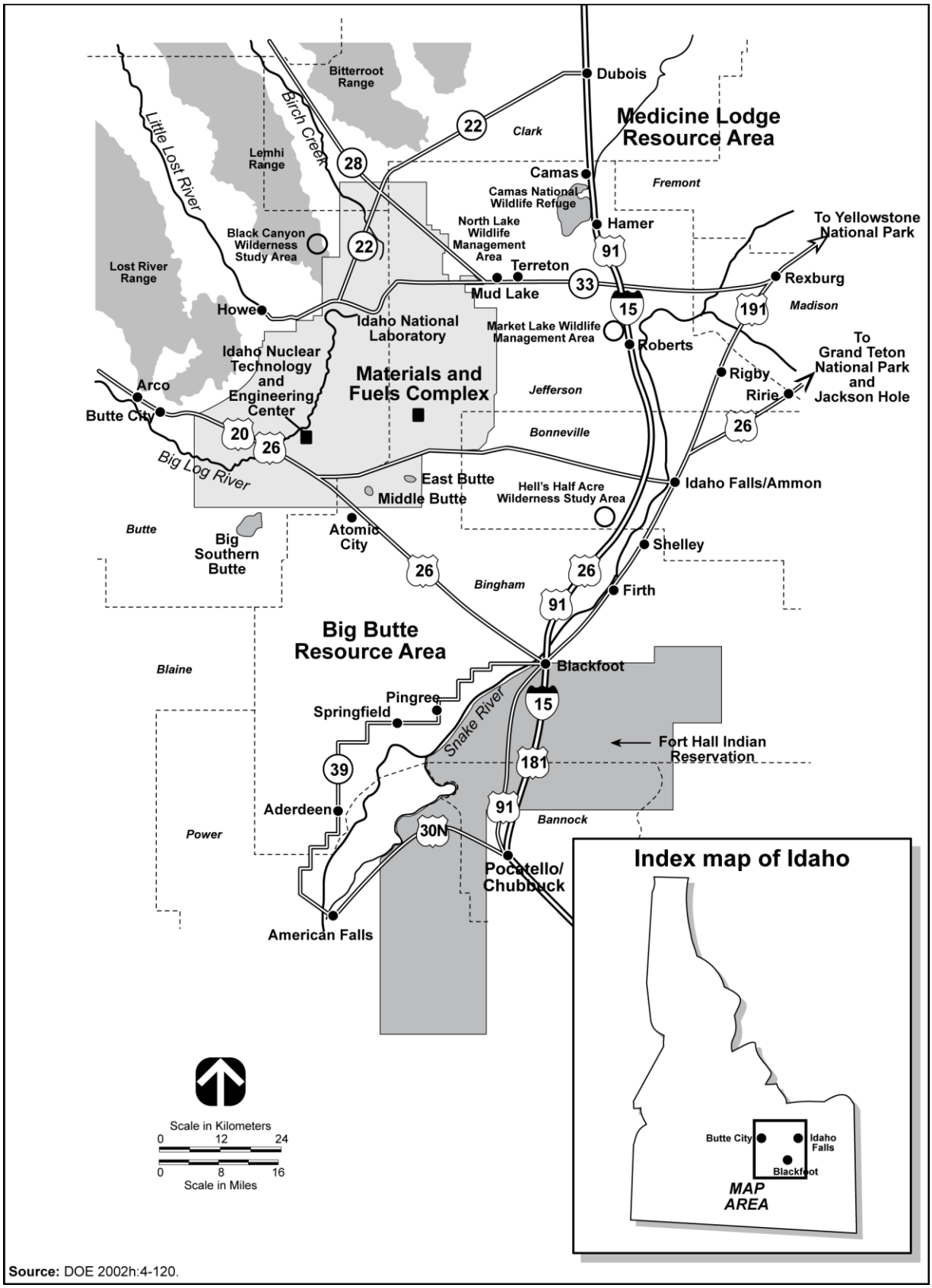
In December 2007, Hanford began to ship sodium-bonded SNF from FFTF to INL, and shipments were completed in April 2008 (Cary 2007). As management and disposition of the FFTF fuel, including the FFTF sodium-bonded fuel, have already been addressed in the above NEPA documents (and decisions), they are not being addressed in this *TC & WM EIS*.

3.3 IDAHO NATIONAL LABORATORY

INL occupies 230,323 hectares (569,135 acres) in southeastern Idaho; the nearest boundary is 39 kilometers (24 miles) west of Idaho Falls, 40 kilometers (25 miles) northwest of Blackfoot, and 16 kilometers (10 miles) east of Arco (see Figure 3–30). Much of the current site was originally withdrawn from public domain in 1943 and commissioned by the U.S. Department of the Navy as the Naval Proving Ground. Presently, INL is administered, managed, and controlled by DOE. Most of the site is within Butte County, but portions are also in Bingham, Jefferson, Bonneville, and Clark Counties. The site is roughly equidistant from Salt Lake City, Utah, and Boise, Idaho (O'Rourke 2006:4, 11).

There are 450 buildings and 2,000 support structures at INL, with more than 279,000 square meters (3 million square feet) of floor space in varying conditions of utility. INL has approximately 25,100 square meters (270,000 square feet) of covered warehouse space and an additional 18,600 square meters (200,000 square feet) of fenced yard space. The total area of the various machine shops is 3,035 square meters (32,665 square feet) (DOE 2000a:3-43).

Fifty-two research and test reactors have been used at INL over the years to test reactor systems, fuel and target design, and overall safety. One such facility, the Experimental Breeder Reactor I, is a designated National Historic Landmark. It was the first reactor to achieve a self-sustaining chain reaction using plutonium as its principal fuel component. Various INL facilities are operated to support reactor operations. These facilities include HLW and LLW processing and storage sites; hot cells; analytical laboratories; machine shops; and laundry, railroad, and administrative facilities. Other activities include management of one of DOE's largest storage sites for LLW and TRU waste (DOE 2000a).



Source: DOE 2002h:4-120.

Figure 3–30. Idaho National Laboratory Vicinity

The Idaho Nuclear Technology and Engineering Center (INTEC) is located in the south-central portion of INL, approximately 64 kilometers (40 miles) west of Idaho Falls. There are more than 150 buildings within INTEC; the Fuel Process Facility is the largest. Facilities at INTEC include SNF storage and processing areas, a waste solidification facility and related HLW storage facilities, remote analytical laboratories, warehouse facilities, and a coal-fired stream-generating plant that is in standby status (DOE 2002a:4-3; 2011a:3-69).

The MFC, located in the southeastern portion of INL, is about 61 kilometers (38 miles) west of the city of Idaho Falls. It is a testing center for advanced technologies associated with nuclear power systems and comprises 52 major buildings occupying 55,700 square meters (600,000 square feet) of floor space. Included are reactor buildings, laboratories, warehouses, technical and administrative support buildings, and craft shops (DOE 2002h). Five nuclear test reactors have operated at the MFC, although only one is currently active—a small reactor used for radiographic examination of experiments, waste containers, and SNF. Principal facilities at the MFC include the Fuel Manufacturing Facility, Assembly and Testing Facility, Transient Reactor Test Facility, Fuel Conditioning Facility, Hot Fuel Examination Facility, Zero Power Physics Reactor, and Experimental Breeder Reactor II (EBR-II).

3.3.1 Land Resources

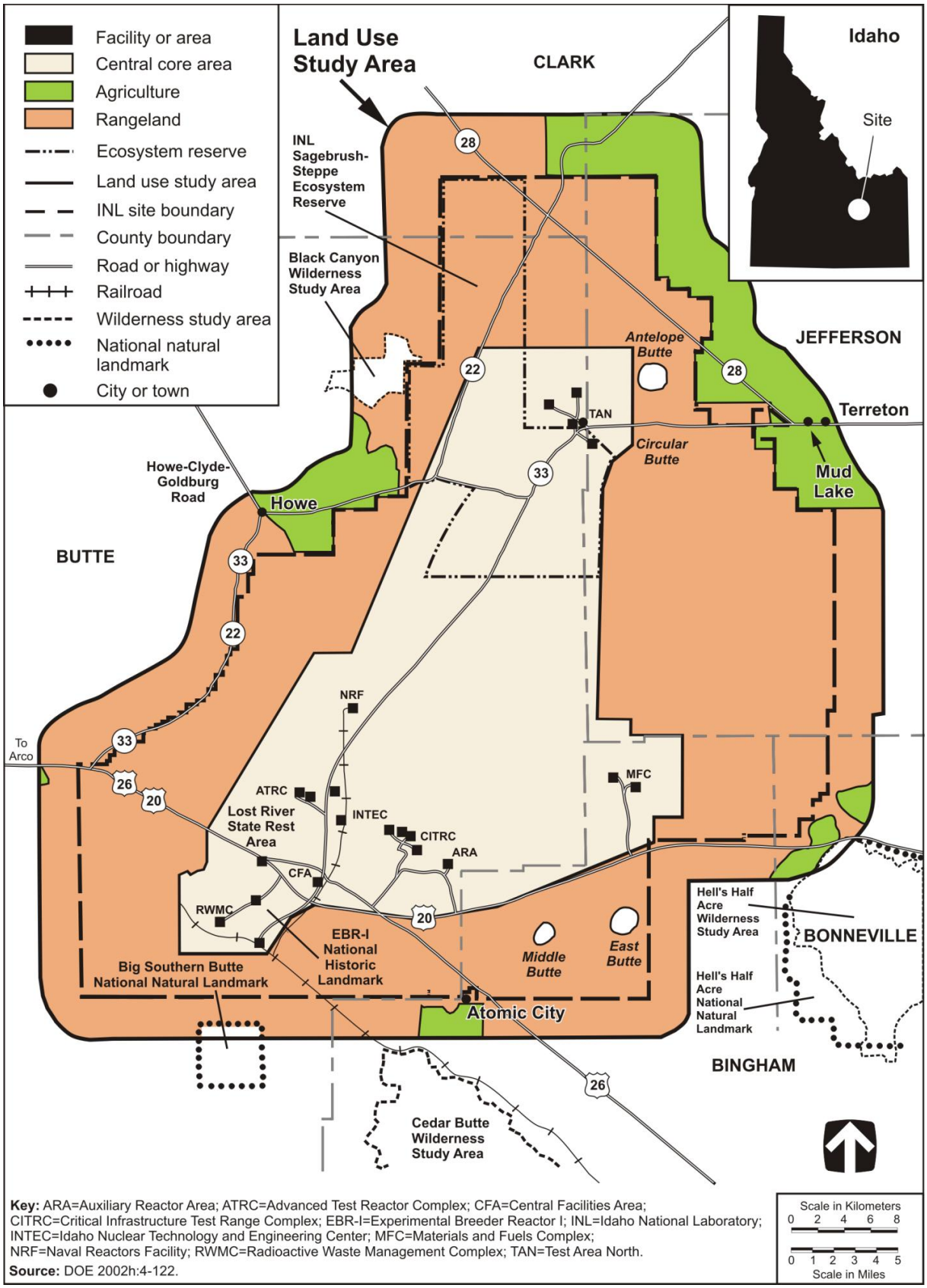
The scope of the discussion of land resources in this *TC & WM EIS* is stipulated in Section 3.2.1.

3.3.1.1 Land Use

3.3.1.1.1 General Site Description

The Federal Government, the State of Idaho, and various private parties own lands immediately surrounding INL; BLM administers about 75 percent of the adjacent land. Regional land uses include grazing, wildlife management, mineral and energy production, recreation, and crop production (O'Rourke 2006:13). Small communities and towns near the INL boundaries include Mud Lake and Terreton to the east; Arco, Butte City, and Howe to the west; and Atomic City to the south. Two national natural landmarks border INL: Big Southern Butte (2.4 kilometers [1.5 miles] south) and Hell's Half Acre (2.6 kilometers [1.6 miles] southeast). A portion of Hell's Half Acre National Natural Landmark is designated as a Wilderness Study Area. The Black Canyon Wilderness Study Area is adjacent to INL, and the Craters of the Moon Wilderness Area is about 19 kilometers (12 miles) southwest of the site's western boundary. On November 9, 2000, the President signed a Presidential Proclamation that added 267,500 hectares (661,000 acres) to the 21,850-hectare (54,000-acre) Craters of the Moon National Monument, which encompasses this wilderness area.

Land use designations at INL include Facility Operations, Grazing, General Open Space, and Infrastructure (e.g., roads). Generalized land uses at INL and the surrounding vicinity are shown in Figure 3–31. Facilities are sited within a central core area of about 93,100 hectares (230,000 acres). Public access to most facilities is restricted (DOE 2002h:4-122, 4-123). Approximately 94 percent of INL is undeveloped; 60 percent of the site is used for cattle and sheep grazing (INL 2010; O'Rourke 2006:vi). Facility Operations include industrial and support operations associated with energy research and waste management activities. Land is also used for environmental research associated with the designation of INL as a National Environmental Research Park. During selected years, depredation hunts of game animals managed by the Idaho Department of Fish and Game are permitted in an area that extends 0.8 kilometers (0.5 miles) inside the INL boundary on portions of the northeastern and western borders of the site. Much of INL is open space that has not been designated for specific use. Some of this space serves as a buffer zone between INL facilities and other land uses. In 1999, a total of



Key: ARA=Auxiliary Reactor Area; ATRC=Advanced Test Reactor Complex; CFA=Central Facilities Area; CITRC=Critical Infrastructure Test Range Complex; EBR-I=Experimental Breeder Reactor I; INL=Idaho National Laboratory; INTEC=Idaho Nuclear Technology and Engineering Center; MFC=Materials and Fuels Complex; NRF=Naval Reactors Facility; RWMC=Radioactive Waste Management Complex; TAN=Test Area North.

Source: DOE 2002h:4-122.

Figure 3–31. Land Use at Idaho National Laboratory and Vicinity

29,244 hectares (72,263 acres) of open space in the northwest corner of the site was designated as the INL Sagebrush-Steppe Ecosystem Reserve. This area represents one of the last sagebrush-steppe ecosystems in the United States and provides a home for a number of rare and sensitive species of plants and animals (O'Rourke 2006:26, 53). DOE land use plans and policies applicable to INL are discussed in the *Idaho National Laboratory Comprehensive Land Use and Environmental Stewardship Report* (O'Rourke 2006).

All county plans and policies encourage development adjacent to previously developed areas to minimize the need for infrastructure improvements and to avoid urban sprawl (Id. Stat. 67-65). Because INL is remote from most developed areas, its lands and adjacent areas are not likely to experience residential and commercial development, and no new development is planned near the site. Recreational and agricultural uses, however, are expected to increase in the surrounding area in response to greater demand for recreational areas and the conversion of rangeland to cropland (DOE 2002h:4-123).

As shown in Figure 3–30, the Fort Hall Reservation is southeast of INL. The Fort Bridger Treaty of July 3, 1868, secured this reservation as the permanent homeland of the Shoshone-Bannock Peoples. According to the treaty, tribal members reserved rights to hunting, fishing, and gathering on surrounding unoccupied lands of the United States. While INL is considered occupied land, it was recognized that certain areas of the INL site have significant cultural and religious significance to the tribes. A 1994 Memorandum of Agreement with the Shoshone-Bannock Tribes provides tribal members with access to the Middle Butte area to perform sacred or religious ceremonies or other educational or cultural activities. Further, in 2002, DOE and the Shoshone-Bannock Tribes signed an Agreement in Principle to continue to improve on the government-to-government relationship established in the Fort Bridger Treaty. This agreement also reaffirmed the Shoshone-Bannock Tribes' rights under the articles of the treaty and DOE trust responsibility to the tribes (DOE 2005a).

3.3.1.1.2 Idaho Nuclear Technology and Engineering Center

The total fenced area at INTEC is 85 hectares (210 acres), with an additional 22 hectares (54 acres) outside the fence. INTEC is 12 kilometers (7.5 miles) north of the site boundary and 3.2 kilometers (2 miles) north of U.S. Route 20. The site is 0.8 kilometers (0.5 miles) to the southeast of Big Lost River. Land within the fenced portion of the site has been heavily disturbed, with buildings, parking lots, and roadways occupying most areas and no natural habitat present. Ongoing activities at INTEC include storage of SNF, management of high-level waste calcine and sodium-bearing liquid waste, and the operation of the INL CERCLA Disposal Facility, which includes a landfill, evaporation ponds, and a storage and treatment facility. In the future, INTEC will continue to provide management of HLW and SNF (DOE 2011a:3-69; IDEQ 2010).

3.3.1.1.3 Materials and Fuels Complex

The total land area at the MFC, formerly Argonne National Laboratory-West, is 328 hectares (810 acres); however, site facilities are principally situated within about 20 hectares (50 acres), or 6 percent of the site. The MFC is 7 kilometers (4.3 miles) northwest of the nearest site boundary. Land within the fenced portion of the site has been heavily disturbed, with buildings, parking lots, and roadways occupying most areas and no natural habitat present. The Fuel Manufacturing Facility is within the main fenced portion of the site, while the Transient Reactor Test Facility is about 1.2 kilometers (0.75 miles) to the northeast. Land within the site will continue to be used for nuclear and nonnuclear scientific and engineering experiments for DOE, private industry, and academia (DOE 2002h:4-123).

3.3.1.2 Visual Resources

3.3.1.2.1 General Site Description

The Bitterroot, Lemhi, and Lost River Mountain ranges border INL on the north and west (see Figure 3–30). Volcanic buttes near the southern boundary of INL can be seen from most locations on the site. INL generally consists of open desert land covered by big sagebrush and grasslands. Uncultivated grazing range borders much of the site. There are a number of facility areas located throughout INL. Although INL has prepared a comprehensive land use and environmental stewardship plan, no specific visual resource standards have been established (O'Rourke 2006). INL facilities have the appearance of low-density commercial/industrial complexes that are widely dispersed throughout the site. Structure heights generally range from 3 to 30 meters (10 to 100 feet); a few stacks and towers reach 76 meters (250 feet). Although many INL facilities are visible from highways, most are more than 0.8 kilometers (0.5 miles) from public roads (DOE 2000a:3-46). The operational areas are well defined at night by security lights. Such light pollution is a key element of the nighttime visual environment surrounding INL facility complexes. However, given the distances between INL facility complexes across the site and the distances from public areas to INL facilities, this light does not substantially impair offsite visual observation of celestial features.

Public lands adjacent to INL are under BLM jurisdiction and have a VRM Class II rating. Undeveloped lands within INL have a VRM rating consistent with Classes II and III. Management activities within these classes may be seen, but should not dominate the view. The VRM class rating of developed areas of the site is consistent with Class IV, indicating that management activities dominate the view and are the focus of viewer attention (BLM 1986:6, 7). The Black Canyon Wilderness Study Area adjacent to INL is under consideration by BLM for Wilderness Area designation. The Hell's Half Acre Wilderness Study Area is located 2.6 kilometers (1.6 miles) southeast of INL's eastern boundary. This area, famous for its lava flow and hiking trails, also is managed by BLM. The Craters of the Moon Wilderness Area is approximately 19 kilometers (12 miles) southwest of INL's western boundary (DOE 2000a:3-46).

3.3.1.2.2 Idaho Nuclear Technology and Engineering Center

Developed areas within INTEC are consistent with a VRM Class IV rating. While the Fuel Processing Facility is the largest facility at INTEC, the tallest structure is the main stack, which is 76 meters (250 feet) tall. INTEC is visible in the middle ground from U.S. Routes 20 and 26, with Saddle Mountain in the background (DOE 2011a:3-70). Natural features of visual interest within a 40-kilometer (25-mile) radius of INTEC include Big Lost River at 60 meters (200 feet), Middle Butte and Big Southern Butte National Natural Landmark at 17.7 kilometers (11 miles), East Butte at 22.5 kilometers (14 miles), Hell's Half Acre National Natural Landmark and Hell's Half Acre Wilderness Study Area at 37 kilometers (23 miles), and Craters of the Moon National Monument at 40 kilometers (25 miles).

3.3.1.2.3 Materials and Fuels Complex

Developed areas within the MFC are consistent with a VRM Class IV rating. The tallest structure at the MFC is the Fuel Conditioning Facility stack, which is 61 meters (200 feet) in height. The site is visible from U.S. Route 20. Facilities that stand out from the highway include the Transient Reactor Test Facility, Hot Fuel Examination Facility, EBR-II containment shell, and Zero Power Physics Reactor. Natural features of visual interest within a 40-kilometer (25-mile) radius of the MFC include East Butte at 9 kilometers (5.6 miles), Middle Butte at 11 kilometers (6.8 miles), Hell's Half Acre National Natural Landmark and Hell's Half Acre Wilderness Study Area at 15 kilometers (9.3 miles), Big Lost River at 19 kilometers (11.8 miles), and Big Southern Butte National Natural Landmark at 30 kilometers (18.6 miles) (DOE 2002h:4-124).

3.3.2 Infrastructure

The scope of the discussion of infrastructure in this *TC & WM EIS* is stipulated in Section 3.2.2. Characteristics of INL's utility and transportation infrastructure are described below and are summarized in Table 3–30. Section 3.3.9.4 provides further discussion of the local transportation infrastructure, and Section 3.3.12, a description of the site's waste management infrastructure.

Table 3–30. Idaho National Laboratory Sitewide Infrastructure Characteristics

Resource	Usage	Capacity
Transportation		
Roads (kilometers)	140[a]	N/A
Railroads (kilometers)	23	N/A
Electricity		
Energy (megawatt-hours per year)	159,800[b]	481,800
Peak load (megawatts)	36	55
Fuel		
Natural gas (cubic meters per year)	510,000[b]	N/A
Fuel oil (heating) (liters per year)	9,080,000[b]	(c)
Diesel fuel (liters per year)	2,050,000[b]	(c)
Gasoline (liters per year)	1,475,000[b]	(c)
Propane (liters per year)	577,000[b]	(c)
Water (liters per year)	4,200,000,000[b]	43,000,000,000[d]

[a] Includes asphalt-paved roads only.

[b] Average value for fiscal years 2001 through 2004.

[c] Limited only by the ability to ship resources to the site.

[d] Water right allocation.

Note: To convert cubic meters to cubic feet, multiply by 35.315; kilometers to miles, by 0.6214; liters to gallons, by 0.26417.

Key: N/A=not applicable.

Source: DOE 2002a:4-65, 4-79; 2002h:4-124, 4-125; 2005b:90, 91.

3.3.2.1 Ground Transportation

3.3.2.1.1 General Site Description

Two interstate highways serve the INL regional area. Interstate 15, a north-south route that connects several cities along the Snake River, is approximately 40 kilometers (25 miles) east of INL. Interstate 86 intersects Interstate 15 approximately 64 kilometers (40 miles) south of INL and provides a primary linkage from Interstate 15 to points west. Interstate 15 and U.S. Route 91 are the primary access routes to the Shoshone-Bannock Reservation. U.S. Routes 20 and 26 are the main access routes to the southern portion of INL and the MFC (see Figure 3–31). Idaho State Routes 22, 28, and 33 pass through the northern portion of INL, and State Route 33 provides access to the northern INL facilities. The road network at INL provides for onsite ground transportation. From the 444 kilometers (276 miles) of roads on the site, about 140 kilometers (87 miles) of nonpublic paved surface roads have been developed (see Table 3–30). Most of the roads are adequate for the current level of normal transportation activity and could handle increased traffic volume (DOE 2002a:4-64; 2005c:3-9).

The Union Pacific Railroad enters the southern portion of INL and provides rail service to the site. This branch connects with a DOE spur line at Scoville Siding, then links with developed areas within INL.

There are 23 kilometers (14 miles) of railroad track at INL. Rail shipments to and from INL usually are limited to bulk commodities, SNF, and radioactive waste (DOE 2002a:4-65, 4-66).

3.3.2.1.2 Idaho Nuclear Technology and Engineering Center

INTEC is north of U.S. Route 20. It can be accessed from U.S. Route 20 via 7.1 kilometers (4.4 miles) of paved site roads. While there are no physical barriers on the access road, INTEC is a restricted facility. A DOE rail spur runs south to north through INTEC.

3.3.2.1.3 Materials and Fuels Complex

The MFC can be accessed from U.S. Routes 20 and 26. A 4.8-kilometer-long (3-mile-long) paved road from U.S. Route 20 provides direct access to the MFC. No physical barriers are on the access road; however, signs indicate that access is restricted to official business, and the road can be easily blocked by security personnel. The site is also surrounded by two fences for additional security control (ANL 2003:2).

3.3.2.2 Electricity

3.3.2.2.1 General Site Description

DOE presently contracts with the Idaho Power Company to supply electric power to INL. The contract allows for power demand of up to 45 megawatts, which can be increased to 55 megawatts by notifying Idaho Power in advance. Power demand above 55 megawatts is possible, but would have to be negotiated with the company (DOE 2002a:4-79). Power is generated by hydroelectric facilities along the Snake River in southern Idaho, and by large coal-fired, thermal-electric generating plants in southwestern Wyoming and northern Nevada. This power is supplied to INL through the Antelope substation, which is owned and maintained by Rocky Mountain Power. Power can be supplied to the Antelope substation from any of three sources: (1) through the Idaho Power 230-kilovolt Antelope line; (2) from Northwestern Energy (formerly Montana Power Company) through the Rocky Mountain Power 230-kilovolt Antelope-to-Anaconda line; and (3) through the Rocky Mountain Power 161-kilovolt Goshen-to-Antelope line. The Antelope substation transmits power through two 138-kilovolt lines to the Scoville substation 138-kilovolt bus (at the Central Facilities Area substation), which is the origin of the site's distribution system (ANL 2003:7). The INL transmission system is a 138-kilovolt, 105-kilometer (65-mile) dual-loop configuration that encompasses six substations where the power is reduced to distribution voltages for use at the various INL facilities. The loop allows for a redundant power feed to all substations and facilities (ANL 2003:7; DOE 2002a:4-79).

Site electrical energy availability is about 481,800 megawatt-hours per year given the contract load limit of 55 megawatts (DOE 2002a:4-79) for 8,760 hours per year. Total INL electrical energy consumption averages 159,800 megawatt-hours annually (DOE 2005b:90). The recorded peak load for INL was about 36 megawatts; the contract-limited peak load capacity is 55 megawatts (DOE 2002a:4-79) (see Table 3–30).

3.3.2.2.2 Idaho Nuclear Technology and Engineering Center

Annual electrical consumption at INTEC is 46,270 megawatt-hours (INL 2009a).

3.3.2.2.3 Materials and Fuels Complex

Electric power for the MFC is distributed via the EBR-II substation (ANL 2003:7). The MFC uses about 28,700 megawatt-hours of electricity annually (DOE 2002h:4-125).

3.3.2.3 Fuel

3.3.2.3.1 General Site Description

Fuel consumed at INL includes natural gas, fuel oil (heating fuel), diesel fuel, gasoline, and propane. All fuels are transported to the site for use and storage. Fuel storage is provided for each facility, and the inventories are restocked as necessary (DOE 2002h:4-125). INL sitewide fuel oil consumption averages 9.08 million liters (2.4 million gallons) annually (based on data for fiscal years 2001 through 2004), while natural gas consumption averages 510,000 cubic meters (18 million cubic feet) per year. Total diesel fuel consumption averages 2.05 million liters (541,500 gallons); total gasoline consumption, 1.475 million liters (389,700 gallons); and total propane consumption, 577,000 liters (152,400 gallons) annually (see Table 3–30) (DOE 2005b:91).

3.3.2.3.2 Idaho Nuclear Technology and Engineering Center

Fuel consumption at INTEC includes fuel oil, diesel fuel, and propane. The annual consumption of fuel oil at INTEC in fiscal year 2008 was about 3.5 million liters (925,000 gallons); diesel fuel consumption, about 33,000 liters (8,700 gallons); and propane consumption, about 151,000 liters (40,000 gallons) (INL 2009a).

3.3.2.3.3 Materials and Fuels Complex

Fuel oil is used in four boilers at the MFC for heat and hot water. The annual consumption of fuel oil at the MFC in fiscal year 2008 was about 2.20 million liters (582,000 gallons). Fuel oil usage varies with the severity of the winters. Natural gas is not available at the MFC (INL 2009a).

3.3.2.4 Water

3.3.2.4.1 General Site Description

The Snake River Plain Aquifer is the source of all water used at INL. The water is provided by a system of about 30 wells, together with pumps and storage tanks. That system is administered by DOE, which holds the Federal Reserved Water Right of 43 billion liters (11.4 billion gallons) per year for the site (DOE 2002h:4-125). INL sitewide groundwater production and usage is approximately 4,200 million liters (1,100 million gallons) annually (see Table 3–30) (DOE 2005b:90).

3.3.2.4.2 Idaho Nuclear Technology and Engineering Center

Total water use at INTEC was reported as 1.8 billion liters (500 million gallons) in fiscal year 2007 (Fossum and Ischay 2009).

3.3.2.4.3 Materials and Fuels Complex

The MFC water supply and distribution system is a combined fire-protection, potable, and service water system supplied via two onsite deep production wells. These deep wells (EBR-II No. 1 and EBR-II No. 2) have a pumping capacity of 3,400 liters (900 gallons) per minute or 1,790 million liters (473 million gallons) annually. Well water is pumped to a 757,000-liter (200,000-gallon) primary storage tank and then through the distribution system for its varied uses. A second 1,514,000-liter (400,000-gallon) water storage tank is reserved for fire protection and maintained at full capacity. The deep wells can be valved to either storage tank or directly to the distribution system. The MFC's water demand and usage from its two production wells is approximately 182 million liters (48 million gallons) annually (ANL 2003:7, 8).

3.3.3 Noise and Vibration

3.3.3.1 General Site Description

Major noise sources within INL include various industrial machines and equipment (e.g., cooling systems, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, vehicles). 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 noise levels at that boundary.

Existing INL-related noises of public significance result from the transportation of people and materials to and from the site and in-town facilities via buses, trucks, private vehicles, and freight trains. Noise measurements along U.S. Route 20, about 15 meters (50 feet) from the roadway, indicate that traffic sound levels range from 64 to 86 dBA, and that the primary source is buses (71 to 80 dBA). While few people reside within 15 meters (50 feet) of the roadway, INL traffic noise might be objectionable to members of the public residing near principal highways or busy bus routes. Noise levels along these routes may have decreased somewhat with reductions in employment and bus service at INL over the last few years. The acoustic environment along the INL site boundary is typical of a rural location removed from traffic noise; the average day-night sound level is in the range of 35 to 50 dBA. Playas and remote lava flows at INL are exposed to low ambient sound levels in the range of 35 to 40 dBA (Leonard 1993:3-18–3-21). Except for the prohibition of nuisance noise, neither the State of Idaho nor local governments have established regulations that specify acceptable community noise levels applicable to INL. The EPA guidelines for environmental noise protection recommend an average day-night sound level limit of 55 dBA to protect the public from the effects of broadband environmental noise in typically quiet outdoor and residential areas (EPA 1974:21, 29). Land use compatibility guidelines adopted by the Federal Aviation Administration and the Federal Interagency Committee on Urban Noise indicate that annual day-night average sound levels less than 65 dBA are compatible with residential land uses (14 CFR 150). These guidelines further indicate that levels up to 75 dBA are compatible with residential uses if suitable noise reduction features are incorporated into structures. It is expected that, for most residences near INL, day-night average sound levels are compatible with residential land use, although noise levels may be higher than 65 dBA for some residences along major roadways.

3.3.3.2 Idaho Nuclear Technology and Engineering Center

No distinguishing noise characteristics at INTEC have been identified. INTEC is 12 kilometers (7.5 miles) from the nearest site boundary, so the contribution from the area to noise levels at the site boundary is unmeasurable (DOE 2000a:3-47).

3.3.3.3 Materials and Fuels Complex

No distinguishing noise characteristics at the MFC have been identified. The MFC is 7 kilometers (4.3 miles) from the nearest site boundary, so the contribution from the area to noise levels at the site boundary is unmeasurable (DOE 2002h).

3.3.4 Air Quality

The scope of the discussion of air quality in this *TC & WM EIS* is stipulated in Section 3.2.4.

3.3.4.1 Nonradioactive Releases

3.3.4.1.1 General Site Description

The climate at INL and the surrounding region is characterized as that of a semiarid steppe. The average annual temperature at INL (at the Central Facilities Area) is 5.6 °C (42 °F); average monthly temperatures range from a minimum of –8.8 °C (16.1 °F) in January to a maximum of 20 °C (68 °F) in July. The average annual precipitation is 22 centimeters (8.7 inches) (Clawson, Start, and Ricks 1989:55, 77). Prevailing winds at INL are southwest or northeast (DOE 1999c:4.7-1). The annual average windspeed is 3.4 meters per second (7.5 miles per hour) (DOE 1996a:3-112). Figures 3–32 and 3–33 show wind roses for the meteorological station at the MFC at 10-meter (33-foot) and 75-meter (250-foot) elevations, respectively, for the period 1997 through 2006. Applicable NAAQS and Idaho State ambient air quality standards are presented in Table 3–31.

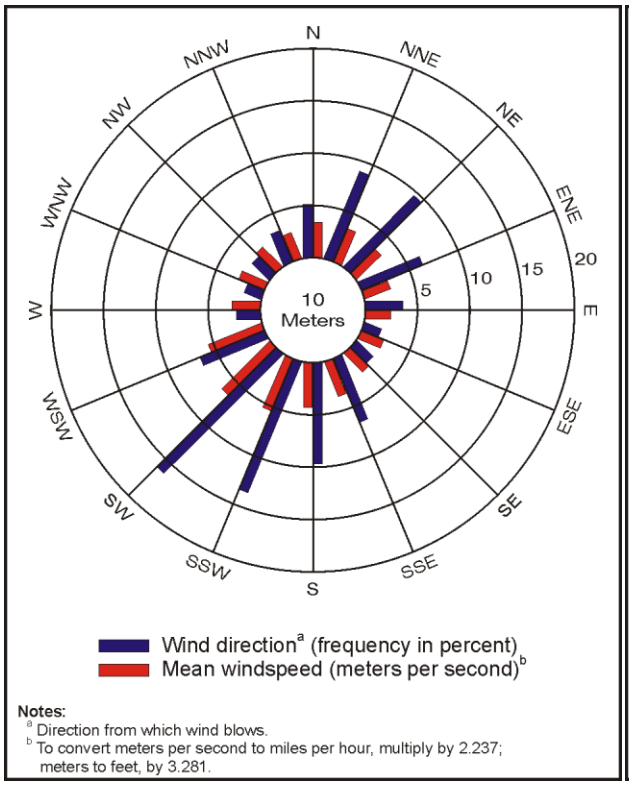


Figure 3–32. Wind Rose for the Materials and Fuels Complex Meteorological Station at Idaho National Laboratory, 1997–2006 (10-Meter Elevation)

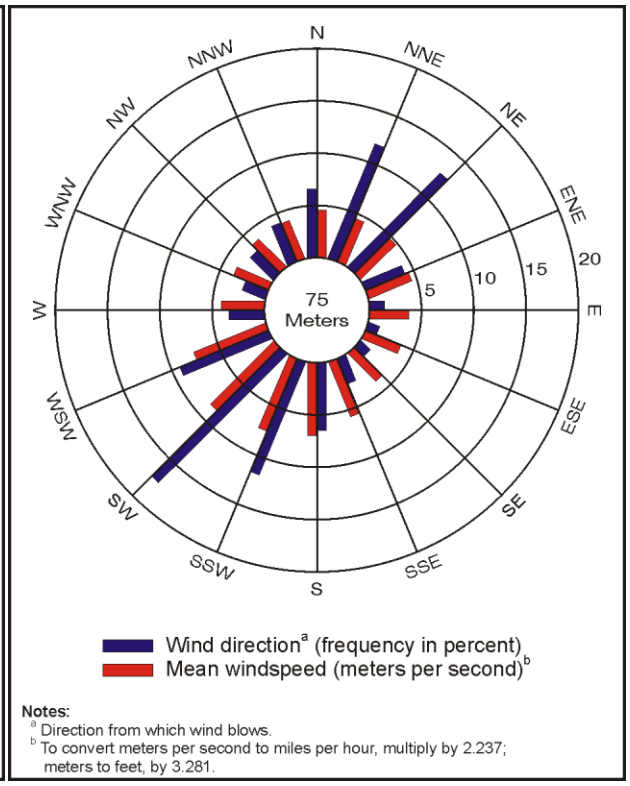


Figure 3–33. Wind Rose for the Materials and Fuels Complex Meteorological Station at Idaho National Laboratory, 1997–2006 (75-Meter Elevation)

The primary source of air pollutants at INL is the combustion of fuel oil for heating. Other emission sources include waste burning, industrial processes, stationary diesel engines, vehicles, and fugitive dust from waste burial and construction activities. Emissions for 2006 are presented in Table 3–32.

Routine offsite monitoring of nonradioactive air pollutants is performed only for total suspended particulates (DOE 2009a:4.24).

Table 3–31. Modeled Nonradioactive Ambient Air Pollutant Concentrations from Idaho National Laboratory Sources and Ambient Air Quality Standards

Pollutant	Averaging Period	More-Stringent Standard[a]	INL Concentration[b]
		(micrograms per cubic meter)	
Carbon monoxide	8 hours 1 hour	10,000[c] 40,000[c]	71 350
Lead	Quarterly	1.5[c]	0.0081
Nitrogen dioxide	Annual 1 hour	100[c] 188[c]	2.3 NR
Ozone	8 hours	147[c]	(d)
PM_{10}	24 hours	150[c]	20
$PM_{2.5}$	Annual 24 hours	15[c] 35[c]	1.3 20[e]
Sulfur dioxide	Annual 24 hours 3 hours 1 hour	80[c] 365[c] 1,300[c] 197[c]	4.5 32 140 NR

a The more stringent of the Federal and state standards is presented if both exist for the averaging period. National Ambient Air Quality Standards (40 CFR 50), other than those for ozone, particulate matter, lead, and pollutants averaged annually, are not to be exceeded more than once per year. The annual arithmetic mean $PM_{2.5}$ standard is attained when the weighted annual arithmetic mean concentration (3-year average) does not exceed the standard. The 24-hour $PM_{2.5}$ standard is met when the 98th percentile over 3 years of 24-hour average concentrations is less than or equal to the standard value. The 24-hour PM_{10} standard is met when the standard value is not exceeded more than once per year. The annual arithmetic mean PM_{10} standard is attained when the expected annual arithmetic mean concentration (3-year average) is less than or equal to the standard value. The 1-hour nitrogen dioxide standard is met when the 3-year average of the 98th percentile of the daily maximum 1-hour average does not exceed the standard value.

b Includes contributions from existing INL facilities with actual 1997 emissions, plus reasonably foreseeable sources such as the Advanced Mixed Waste Treatment Project and CPP-606 steam production boilers. The Federal 1-hour sulfur dioxide standard is met when the 3-year average 99th percentile of the daily maximum 1-hour average does not exceed the standard value.

c Federal and state standard.

d Not directly emitted or monitored by the site.

e Assumed to be the same as the concentration of PM_{10} because there are no specific data for $PM_{2.5}$.

Note: The State of Idaho also has ambient standards for fluorides.

Key: INL=Idaho National Laboratory; NR=not reported; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers.

Source: 40 CFR 50; 71 FR 61144; DOE 2002a:C.2-43; IDAPA 58.01.01.576; IDAPA 58.01.01.577.

Table 3–32. Air Pollutant Emissions at Idaho National Laboratory, 2006

Pollutant	Sources Other Than MFC and INTEC	MFC	INTEC
	(metric tons per year)		
Nitrogen dioxide	57	5.3	10
PM_{10}	1.9	0.27	0.63
Sulfur dioxide	3.7	1.9	3.3
Volatile organic compounds	1.7	0.05	0.1

Key: INTEC=Idaho Nuclear Technology and Engineering Center; MFC=Materials and Fuels Complex; PM_{10}=particulate matter with an aerodynamic diameter less than or equal to 10 micrometers.

Source: Depperschmidt 2007.

Monitoring for nitrogen dioxide has not been performed at onsite locations since 2003 (DOE 2006:3.5). In 2003 quarterly mean concentrations at the Van Buren Boulevard location ranged from 2.9 to 3.9 parts per billion (ppb), with an annual mean of 3.5 ppb. Quarterly means at the Experimental Field Station, determined from two quarters of data, ranged from 7.4 to 10.7 ppb, with a mean concentration of 9.1 ppb. The mean concentrations were well below the ambient standard of 54 ppb (DOE 2004b:4.22).

Some monitoring data have also been collected by the National Park Service at the Craters of the Moon Wilderness Area. The monitoring program has shown no exceedances of the 1-hour ozone standard, although there was some degradation in concentrations between 1993 and 2002 (NPS 2003:5). Concentrations in 2006 were about 50 percent of the ambient standard for 1-hour values and less than 60 percent of the 8-hour standard (EPA 2007). During the period of $PM_{2.5}$ monitoring, concentrations ranged from 0.409 to 25.1 micrograms per cubic meter (DOE 2006:4.25).

3.3.4.1.2 Idaho Nuclear Technology and Engineering Center

The existing ambient air pollutant concentrations attributable to sources at INL, including INTEC, are presented in Table 3–31. These concentrations are based on dispersion modeling at the INL site boundary and public roads. The modeled pollutant concentrations presented in the *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* for assessing cumulative impacts were adapted as a baseline. Sources considered included existing INL facilities with actual 1997 emissions, plus reasonably foreseeable sources such as the Advanced Mixed Waste Treatment Project (AMWTP) and the CPP-606 steam production boilers. To account for the contribution of the CPP-606 boilers, the cumulative concentrations for the Continued Operation Alternative evaluated in the aforementioned EIS were used as the baseline (DOE 2002a:C.2-43). Concentrations shown in Table 3–31 represent a small percentage of these ambient air quality standards. Given these limited contributions from INL sources and low background concentrations of criteria pollutants, it may be concluded that INL emissions should not result in air pollutant concentrations that violate the ambient air quality standards.

EPA has established PSD increments for certain pollutants such as sulfur dioxide, nitrogen dioxide, and PM. The increments specify a maximum allowable increase above a certain baseline concentration for a given averaging period and apply only to sources constructed or modified after a specified baseline date. These sources are known as increment-consuming sources, and the baseline date is the date of submittal of the first application for a PSD permit in a given area. Increment consumption for the CPP-606 boilers, for example, was analyzed in connection with its PSD permit application for INL (DOE 2002a).

EPA has also established PSD area classifications distinguished in terms of allowable increases in pollution. A PSD Class I area, for example, is one in which very little increase in pollution is allowed due to the pristine nature of the area; a Class II area, one in which moderate increases in pollution are allowed. The PSD Class I area nearest to INL is the Craters of the Moon Wilderness Area in Idaho, 53 kilometers (33 miles) west-southwest of the center of the site. There are no other Class I areas within 100 kilometers (62 miles) of INL. INL and its vicinity are classified as a Class II area. Current PSD increment consumptions in these Class I and Class II areas are stipulated in Tables 3–33 and 3–34, respectively.

Table 3–33. PSD Increment Consumption at Craters of the Moon Wilderness Area (Class I) by Existing (1996) and Projected Sources Subject to PSD Regulation

Pollutant	Averaging Period	Allowable PSD Increment[a]	Amount of PSD Increment Consumed
		(micrograms per cubic meter)	
Nitrogen dioxide	Annual	2.5	0.27
Respirable particulates[b]	Annual 24 hours	4 8	0.032 0.61
Sulfur dioxide	Annual 24 hours 3 hours	2 5 25	0.23 3.4 11

[a] All increments specified are State of Idaho standards (IDAPA 58.01.01.581).

[b] Data on particulate size are not available for most sources. For purposes of increment comparisons, however, it is conservatively assumed that all particulates emitted are of respirable size (i.e., 10 micrometers or less in diameter).

Note: Estimated increment consumption includes existing Idaho National Laboratory sources that are subject to PSD regulations, as well as the Idaho Nuclear Technology and Engineering Center CPP-606 boilers. Increment consumption was modeled using the CALPUFF model in screening mode.

Key: PSD=Prevention of Significant Deterioration.

Source: DOE 2002a:4-37.

Table 3–34. PSD Increment Consumption at Idaho National Laboratory Area (Class II) by Existing (1996) and Projected Sources Subject to PSD Regulation

Pollutant	Averaging Period	Allowable PSD Increment[a]	Amount of PSD Increment Consumed
		(micrograms per cubic meter)	
Nitrogen dioxide	Annual	25	8.8
Respirable particulates[b]	Annual 24 hours	17 30	0.53 10
Sulfur dioxide	Annual 24 hours 3 hours	20 91 512	3.6 27 120

[a] All increments specified are State of Idaho standards (IDAPA 58.01.01.581).

[b] Data on particulate size are not available for most sources. For purposes of increment comparisons, however, it is conservatively assumed that all particulates emitted are of respirable size (i.e., 10 micrometers or less in diameter).

Note: Estimated increment consumption includes existing Idaho National Laboratory sources that are subject to PSD regulations, as well as the Idaho Nuclear Technology and Engineering Center CPP-606 boilers. Class II increment consumption was modeled using the ISCST3 dispersion model.

Key: PSD=Prevention of Significant Deterioration.

Source: DOE 2002a:4-38.

3.3.4.1.3 Materials and Fuels Complex

The existing ambient air concentrations attributable to sources at INL, including MFC, are presented in Table 3–31.

3.3.4.2 Radioactive Releases

Primary releases of radioactive air pollutants at INL and localized releases at INTEC and the MFC are presented in Table 3–35. During 2008, an estimated 5,330 curies of radioactivity were released to the atmosphere from all INL sources. About 0.8 percent of this amount was from the MFC and

about 39 percent was from the Advanced Test Reactor Complex (ATRC). Approximately 50 percent was released from INTEC (DOE 2009a:4.7–4.12).

Table 3–35. Airborne Radionuclide Releases to the Environment at Idaho National Laboratory, 2008

Radionuclide[a]	INTEC	Materials and Fuels Complex	Other Facilities[b]	Total
	(curies)			
Hydrogen-3 (tritium)	3.75×10^{2}	3.15	1.22×10^{3}	1.60×10^{3}
Carbon-14	3.38×10^{-4}	–	1.95×10^{-1}	1.95×10^{-1}
Sodium-24	–	–	2.08×10^{-4}	2.08×10^{-4}
Argon-41	–	1.52	1.22×10^{3}	1.22×10^{3}
Cobalt-60	6.02×10^{-4}	–	6.76×10^{-3}	7.36×10^{-3}
Krypton-85	2.3×10^{3}	3.70×10^{1}	3.00	2.34×10^{3}
Strontium-90	2.82×10^{-1}	1.45×10^{-5}	1.22×10^{-1}	4.04×10^{-1}
Technetium-99	7.32×10^{-5}	–	9.48×10^{-5}	1.68×10^{-4}
Iodine-129	4.06×10^{-2}	–	9.34×10^{-2}	1.34×10^{-1}
Cesium-137	1.23	–	2.40×10^{-1}	1.47
Uranium-233	6.86×10^{-8}	–	3.60×10^{-4}	3.60×10^{-4}
Uranium-234	1.11×10^{-7}	–	3.88×10^{-7}	4.99×10^{-7}
Uranium-235	2.91×10^{-5}	–	9.49×10^{-5}	1.24×10^{-4}
Uranium-238	1.18×10^{-4}	–	–	1.18×10^{-4}
Neptunium-237	3.42×10^{-6}	–	2.29×10^{-4}	2.32×10^{-4}
Plutonium-238	1.03×10^{-4}	–	1.80×10^{-5}	1.21×10^{-4}
Plutonium-239	1.03×10^{-4}	1.49×10^{-6}	7.33×10^{-3}	7.43×10^{-3}
Plutonium-240	2.49×10^{-4}	–	1.30×10^{-3}	1.55×10^{-3}
Plutonium-241	9.55×10^{-3}	–	9.85×10^{-3}	1.94×10^{-2}
Americium-241	1.12×10^{-4}	–	3.07×10^{-3}	3.18×10^{-3}
Other radionuclides	1.94	–	1.64×10^{2}	1.66×10^{2}
Total releases	2.68×10^{3}	4.17×10^{1}	2.61×10^{3}	5.33×10^{3}

a Values are not corrected for decay after release.

b Includes the Advanced Test Reactor, Central Facilities Area, Critical Infrastructure Test Range Complex, Radioactive Waste Management Complex, and Test Area North.

Note: A dashed line indicates no reported release.

Key: INTEC=Idaho Nuclear Technology and Engineering Center.

Source: DOE 2009a:4.7–4.12.

Routine monitoring for radioactive air pollutants is performed at locations within, around, and distant from INL. The monitors are operated by the management and operations contractor and the environmental surveillance, education, and research contractor. The monitoring network maintained by the managing and operating contractor includes 17 onsite locations and 4 distant locations. The network maintained by the environmental surveillance, education, and research contractor includes 3 onsite locations, 8 boundary locations, and 6 distant locations. The distant monitors are as far away as Jackson, Wyoming (161 kilometers [100 miles] east), and Craters of the Moon National Monument (50 kilometers [31 miles] west-southwest). These monitoring programs and recent results are described in Chapter 4 of the *Idaho National Laboratory Site Environmental Report, Calendar Year 2008* (DOE 2009a:4.20).

3.3.5 Geology and Soils

The scope of the discussion of geology and soils in this *TC & WM EIS* is stipulated in Section 3.2.5.

3.3.5.1 General Site Description

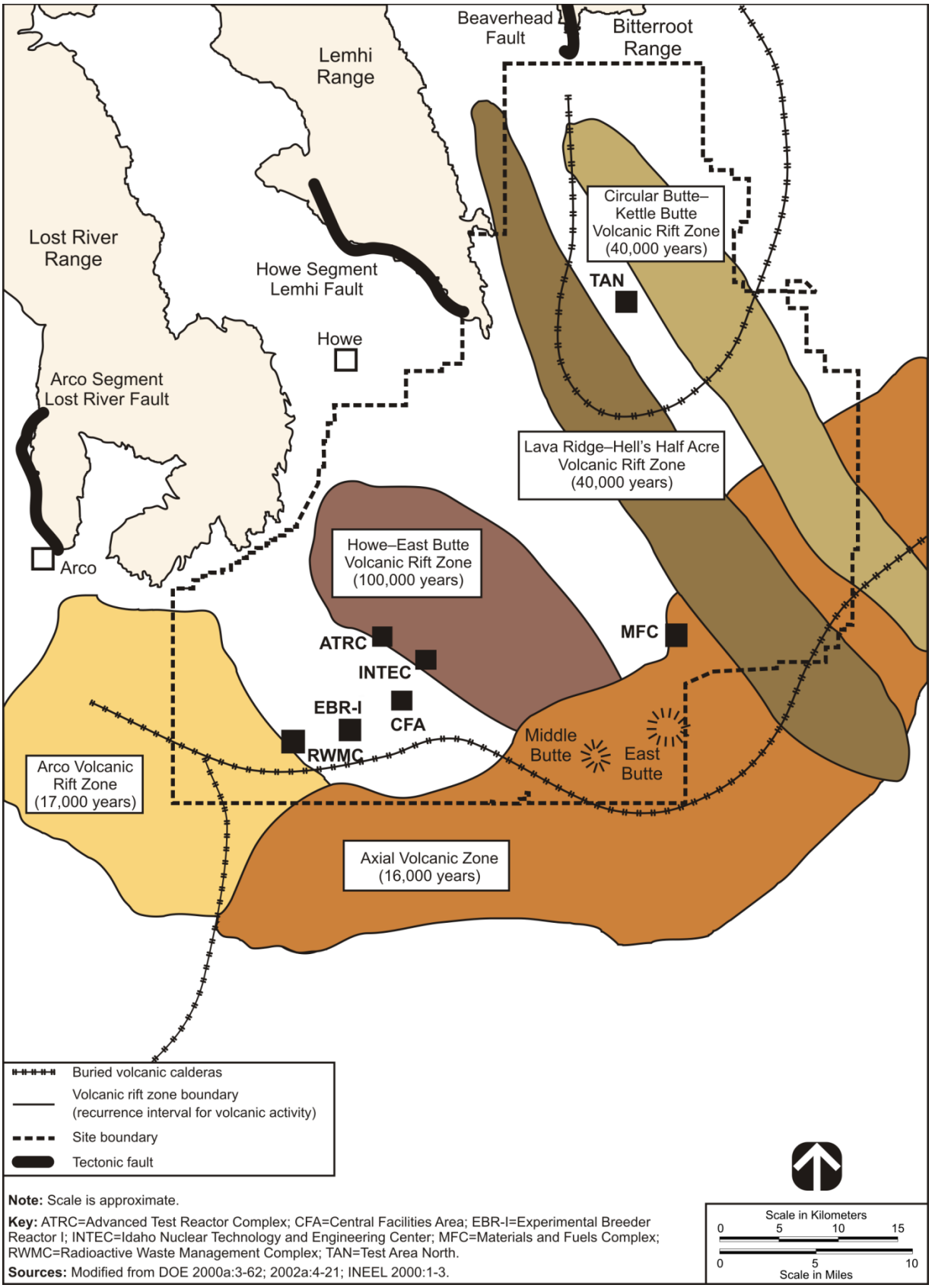
3.3.5.1.1 Physiography and Structural Geology

INL occupies a rather flat area on the northwestern edge of the Eastern Snake River Plain, which is part of the Eastern Snake River Plain Physiographic Province. The area consists of a broad plain built up from the eruptions of multiple flows of basaltic lava over the past 4 million years. Four northwest-trending volcanic rift zones that cut across the Eastern Snake River Plain have been identified as the source areas for the most recent basaltic eruptions that occurred between 2,100 and 4 million years ago. The Eastern Snake River Plain is bounded on the north and south by the north-to-northwest-trending mountains of the northern Basin and Range Physiographic Province, with peaks up to 3,660 meters (12,000 feet) in height that are separated by intervening basins filled with terrestrial sediments and volcanic rocks. The peaks are sharply separated from the intervening basins by late Tertiary to Quaternary normal faults. The basins are 5 to 20 kilometers (3 to 12 miles) wide and grade onto the Eastern Snake River Plain. Several northwest-trending front-range faults have been mapped in the immediate vicinity of INL. To the northeast, the Eastern Snake River Plain is bounded by the Yellowstone Plateau (ANL 2003:15, 16, 18; DOE 2002a:4-20, 4-21, 4-23). Figure 3–34 shows the major geologic features of INL and the vicinity.

The Yellowstone Plateau is a high volcanic plateau underlain by Pleistocene rhyolitic volcanic rock. Its elevation of about 2,100 to 2,600 meters (6,900 to 8,500 feet) is significantly higher than that of the Eastern Snake River Plain, but not as high as the mountain summits of the northern Basin and Range Province. The plateau is characterized by extremely high heat flow, very high temperatures at shallow depths, abundant hot-spring and geyser activity, and landforms controlled by thick rhyolitic lava flows. These characteristics reflect the recent volcanic activity in the area, spanning from several tens of thousands to 2 million years ago (ANL 2003:16).

The mountains northwest of the Eastern Snake River Plain and near INL are composed of thick sequences of late Precambrian through Pennsylvanian sedimentary strata, mostly limestones. They occurred within westward-dipping thrust sheets that formed during Mesozoic Era east-directed compression. The Eastern Snake River Plain formed as a result of interaction of the North American tectonic plate with a rising plume and hot mantle rocks, the so-called Yellowstone Hotspot. As the North American plate moved southwestward, its interaction with the hotspot produced the low-elevation, low-relief volcanic province that is the Eastern Snake River Plain. The crust of the INL area was directly above the hotspot about 4.3 to 6.5 million years ago (ANL 2003:16, 17).

The Arco Segment of the Lost River Fault is mapped as ending about 7 kilometers (4.3 miles) from the INL boundary. The Howe Segment of the Lemhi Fault ends near the northwest boundary of the site (see Figure 3–34). Both segments are considered capable or potentially active (DOE 2002h:4-130). A capable fault is one that has had movement at or near the surface at least once within the past 35,000 years or recurrent movement within the past 500,000 years (10 CFR 100).



Note: Scale is approximate.

Key: ATRC=Advanced Test Reactor Complex; CFA=Central Facilities Area; EBR-I=Experimental Breeder Reactor I; INTEC=Idaho Nuclear Technology and Engineering Center; MFC=Materials and Fuels Complex; RWMC=Radioactive Waste Management Complex; TAN=Test Area North.

Sources: Modified from DOE 2000a:3-62; 2002a:4-21; INEEL 2000:1-3.

Figure 3–34. Major Geologic Features of Idaho National Laboratory

3.3.5.1.2 Stratigraphy

The upper 1 to 2 kilometers (0.6 to 1.2 miles) of the crust beneath INL is composed of a sequence of Quaternary (recent to 2 million years old) basalt lava flows and poorly consolidated sedimentary interbeds that are collectively called the Snake River Group. The lava flows at the surface range from 2,100 to 2 million years old (DOE 2002a:4-20; 2002h:4-130). The sediments are composed of fine-grained silts that were deposited by wind; silts, sands, and gravels deposited by streams; and clays, silts, and sands deposited in lakes such as Mud Lake and its much larger Ice Age predecessor, Lake Terreton. The accumulation of these materials in the Eastern Snake River Plain resulted in the observed sequence of interlayered basalt lava flows and sedimentary interbeds. Basaltic volcanism on the Eastern Snake River Plain has been a sporadic process. During the long periods of inactivity between volcanic events, sediments accumulated to thicknesses of less than 1 meter (3.3 feet) to greater than 60 meters (197 feet). During short periods of volcanic activity, several lava flows commonly accumulated to thicknesses reaching several tens of meters. Basalt lava flows were erupted from vents concentrated in the four volcanic rift zones and along the central axis of the Eastern Snake River Plain (the Axial Volcanic Rift Zone) (see Figure 3–34). The basalts, along with interbedded sediments, are underlain by a great thickness of rhyolitic volcanic rocks that erupted when the area was over the Yellowstone Hotspot more than 4 million years ago (ANL 2003:18). Figure 3–35 depicts the general stratigraphy beneath INL.

Several Quaternary rhyolite domes are located along the Axial Volcanic Rift Zone near the south and southeast borders of INL. Their names and ages are Big Southern Butte (300,000 years), a rhyolite dome near Cedar Butte (400,000 years), East Butte (600,000 years), Middle Butte (age unknown), and an unnamed butte near East Butte (1.2 million years). Paleozoic carbonate rocks (limestone), late-Tertiary rhyolitic volcanic rocks, and large alluvial fans occur in limited areas along the northwest margin of INL. A wide band of Quaternary mainstream alluvium (unconsolidated gravels and sands) extends along the course of Big Lost River from the southwestern corner of INL to Big Lost River sinks area in north-central INL. Lacustrine (lake) deposits of clays and sands in the Ice Age Lake Terreton occur in the northern part of INL. Beach sands deposited at the high stand of Lake Terreton were reworked by winds in late Pleistocene and Holocene ages to form large dune fields (eolian deposits) in the northeastern part of INL. Elsewhere on INL, the basaltic lava flows are variably covered with a thin veneer of eolian silt (loess), which can be up to several meters thick, but mostly ranges in thickness from 0 to 2 meters (6.6 feet) (ANL 2003:20).

3.3.5.1.3 Rock and Mineral Resources

Mineral resources within INL include sand, gravel, pumice, silt, clay, and aggregate (e.g., sand, gravel, crushed stone). These resources are extracted at several quarries or pits at INL and are used for road and new facility construction and maintenance, waste burial activities, and ornamental landscaping. The geologic history of the Eastern Snake River Plain makes the potential for petroleum production at INL very low. The potential for geothermal energy exists at INL and in parts of the Eastern Snake River Plain; however, a study conducted in 1979 identified no economically productive geothermal resources (DOE 2002a:4-23).

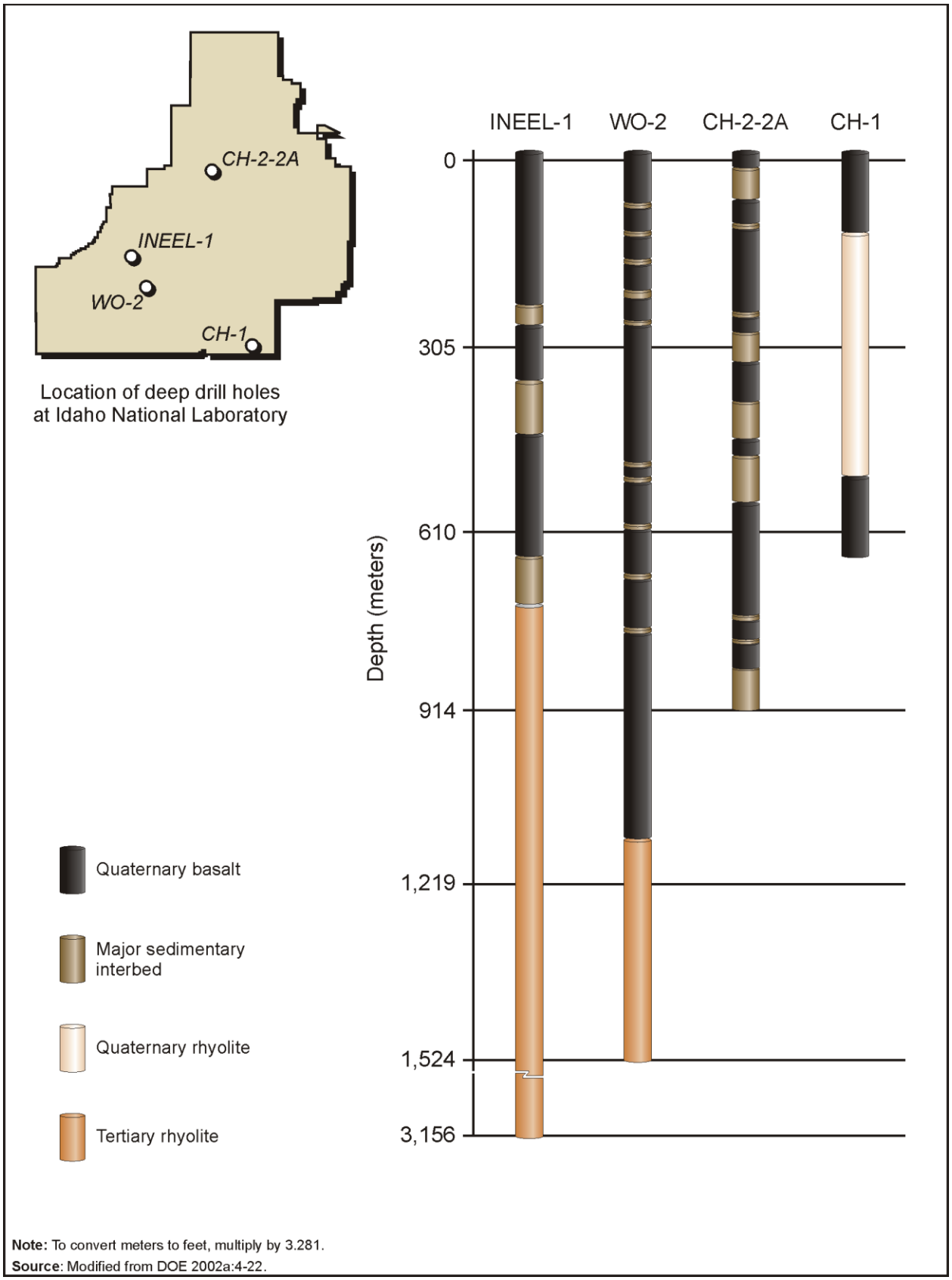


Figure 3–35. Lithologic Logs of Deep Drill Holes at Idaho National Laboratory

3.3.5.1.4 Seismicity and Geologic Hazards

The seismic characteristics of the Eastern Snake River Plain and the adjacent Basin and Range Province are different. The Eastern Snake River Plain has historically experienced infrequent small-magnitude earthquakes (DOE 2002a:4-20). In contrast, the major episode of Basin and Range faulting that began approximately 16 million years ago continues today (Rodgers et al. 2002). Since the installation of INL's seismic network in 1971, only 35 microearthquakes (magnitude of less than 2.0) have been detected within the Eastern Snake River Plain. However, INL's seismic stations record about 2,000 annually elsewhere in southeast Idaho (INL 2009b). Thus, the Eastern Snake River Plain and INL have lower seismicity than adjacent regions.

The largest historic earthquake near INL took place on October 28, 1983, about 90 kilometers (56 miles) northwest of the western site boundary, near Borah Peak in the Lost River Range (part of the Basin and Range Province). It occurred in the middle portion of the Lost River Fault. The earthquake had a surface-wave magnitude of 7.3 (moment magnitude of 7.0). An MMI of up to IX was assigned for effects at the event's epicenter (ANL 2003:22; DOE 2002h:4-132). The ATRC within the INL Reactor Technology Complex (RTC) experienced an MMI of VI during this event, with no damage to the ATRC found upon inspection (DOE 2002h:4-132). Since 1973, 27 earthquakes have been recorded within 100 kilometers (62 miles) of south-central INL, ranging in magnitude from 2.6 to 3.9. These represent minor earthquakes, with none centered closer than 76 kilometers (47 miles) from the south-central portion of the site. Most of the earthquakes had epicenters to the north and west of INL in the Basin and Range Province (USGS 2010b).

Earthquake-produced ground motion is expressed in units of percent *g* (force of acceleration relative to that of the Earth's gravity). Two differing measures of this motion are peak horizontal (ground) acceleration and response spectral acceleration. Seismic hazard metrics and maps developed by USGS and adapted for use in the *International Building Code* reflect maximum calculated ground motions of 0.2- and 1.0-second spectral accelerations for earthquakes with a 2 percent probability of exceedance in 50 years—i.e., an annual probability of occurrence of about 1 in 2,500. Appendix F, Section F.5.2, of this *TC & WM EIS* provides a more detailed explanation of the map parameters and their use. For south-central INL facilities, the calculated maximum considered earthquake ground motion is approximately 0.41 *g* for a 0.2-second spectral acceleration and 0.09 *g* for a 1.0-second spectral acceleration. The calculated peak ground acceleration for the given probability of exceedance at the site is approximately 0.12 *g* (USGS 2008). An update to the INL seismic hazard evaluation was performed to recalculate design-basis earthquake spectra for key facilities in accordance with DOE standards. For this site-specific analysis, the calculated peak ground accelerations at the RTC for earthquakes with annual probabilities of occurrence of about 1 in 1,000 and 1 in 10,000 are 0.09 *g* and 0.19 *g*, respectively (INEEL 2000:ES-1). The USGS earthquake ground motion values are cited to provide the reader with a general understanding of the seismic hazard as quantified by a well-accepted authority. However, for design of moderate- or high-hazard nuclear facilities, DOE prescribes seismic criteria that are more rigorous and provide a greater margin of safety than the values cited here (see Appendix F, Section F.5.2).

INL lies in a region in which ground motions are controlled by fault-specific sources with estimated maximum earthquake magnitudes that have rather long recurrence intervals. The Borah Peak earthquake produced peak ground accelerations ranging from 0.022 *g* to 0.078 *g* across INL. Specifically, the ATRC at the RTC experienced peak ground accelerations of 0.022 *g* to 0.030 *g* (INEEL 2005:2A-34; Jackson and Boatwright 1985:57). This caused the ATRC protective systems to automatically scram (shut down) the reactor, as the seismic switches were designed to trip at a ground acceleration of 0.01 *g* (Gorman and Guenzler 1983:14). At the MFC, recorded peak ground accelerations ranged from 0.032 *g* to 0.048 *g* (Jackson and Boatwright 1985:57). Neither the ATRC nor MFC facilities experienced structural or component damage from the Borah Peak earthquake (ANL 2003:22).

Earthquakes with moment magnitudes higher than 5.5 and associated strong ground shaking and surface fault rupture are not likely within the Eastern Snake River Plain, given the region's seismic history and geology. Moderate-to-strong ground shaking from earthquakes in the Basin and Range Province, however, could affect INL (DOE 2002a:4-23). Consequently, INL authorities have supported efforts to estimate, for all regional earthquake sources, the levels of ground shaking that are expected at INL facilities—specifically, estimates of the levels of ground shaking that would not be exceeded in specified time periods. A probabilistic ground-motion study for all facility areas was finalized in 2000. This study, which updated the 1996 INL sitewide seismic hazard evaluation, involved assessment of seismic hazard at five INL site areas using recently developed ground-motion attenuation relationships appropriate for INL (INEEL 2000). The INL ground-motion evaluation incorporated the results of all geologic, seismologic, and geophysical investigations conducted since the 1960s. The fault segments closest to INL facilities, the Lost River, Beaverhead, and Lemhi Faults, were studied in detail with a view to estimating their maximum earthquake magnitudes, their distances from INL facilities, and the timing and frequency of recent earthquakes. Results of these investigations indicated that these faults are capable of generating earthquakes of magnitude 6.6 to 7.2, and that the most recent earthquakes on the southernmost fault segments occurred more than 15,000 years ago. The data collected also continue to support historic observations that the alternating sequence of basalt and sedimentary interbeds composing the Eastern Snake River Plain tend to dampen seismic energy, resulting in reduced earthquake ground motions as compared with locations with uniform basaltic rock (INL 2009b).

Basaltic volcanic activity occurred over a period from about 2,100 to 4 million years ago in the INL site area. Although no eruptions have occurred on the Eastern Snake River Plain during recorded history, lava flows from the Hell's Half Acre lava field erupted near the southern INL boundary as recently as 5,400 years ago. The most recent eruptions within the area occurred about 2,100 years ago in an area 31 kilometers (19 miles) southwest of the site at the Craters of the Moon Wilderness Area. The estimated recurrence interval for volcanism associated with the five identified volcanic zones ranges from 16,000 to 100,000 years (DOE 2002a:4-25; 2002h:4-132). These zones are depicted in Figure 3–34.

Because the Yellowstone Hotspot is no longer present beneath the INL area, there is no threat of catastrophic volcanism such as at Yellowstone. The main volcanic threat at INL is from basaltic lava flows. INL seismic stations are located near or within identified volcanic rift zones to provide early warning of any signs of renewed volcanic activity (INL 2009b).

Seismicity concerns continue to influence facility design and construction at INL. Lessons learned from studies of INL seismic design-basis events are incorporated into facility architectural and engineering standards. New facilities and facility upgrades are designed in accordance with the requirements of applicable DOE standards and orders (DOE 2002a:4-24)—for example, DOE Order 420.1B, Change 1, which requires that nuclear or nonnuclear facilities be designed, constructed, and operated so as to protect the public, workers, and the environment from the adverse impacts of natural phenomena hazards, including earthquakes. Furthermore, expected levels of earthquake ground motion as determined in the INL probabilistic seismic hazards assessment are now part of the seismic design criteria for new and existing facilities (INL 2009b).

3.3.5.1.5 Soils

Four basic soilscapes exist at INL: river-transported sediments deposited on alluvial plains, fine-grained sediments deposited into lake or playa basins, colluvial sediments originating from bordering mountains, and windblown sediments (silt and sand) over lava flows. The alluvial deposits follow the courses of the modern Big Lost River and Birch Creek. The playa soils are found in the north-central part of the site; the colluvial sediments, along the western edge of INL; and the windblown sediments, throughout the rest of the site. Surficial sediments range in thickness from less than 0.3 meters (1 foot) at basalt outcrops east

of INTEC to 95 meters (312 feet) near the Big Lost River sinks. No soils designated as prime or unique farmland exist within the INL boundaries (DOE 2002h:4-132).

3.3.5.2 Idaho Nuclear Technology and Engineering Center

The Arco Segment of the Lost River Fault terminates approximately 32 kilometers (20 miles) to the west of INTEC. INTEC is also situated near the western edge of the Howe–East Butte Volcanic Rift Zone, which has an estimated recurrence interval for volcanic activity of 100,000 years (DOE 2005c:3-11). However, no volcanic vents in the vicinity of INTEC are younger than 400,000 years, and the probability of volcanic activity from this source is considered low based on the estimated recurrence interval (DOE 2002a:4-23–4-25). INTEC is situated adjacent to Big Lost River in relatively flat terrain. The average elevation of INTEC is approximately 1,499 meters (4,917 feet) above mean sea level. Surface sediments are alluvial deposits from Big Lost River that are composed of gravel-sand-silt mixtures that are 7.6 to 19.8 meters (25 to 65 feet) thick and that contain locally interbedded silt and clay deposits that are generally less than 2.7 meters (9 feet) thick. All soil near INTEC was originally fine loam over a sand or sand-cobble mix deposited in the floodplain of Big Lost River. However, all natural soils within INTEC fences have been disturbed. The soils beneath the INTEC area are not subject to liquefaction because of the high content of gravel mixed with the alluvial sands and silts. In addition, the sediments are not saturated (DOE 2000a:3-63).

As a result of past practices, radioactive and hazardous materials have been released to surface soils at INTEC. Contaminants found in the soil include metals, organic compounds, and radionuclides. Results from CERCLA (42 U.S.C. 9601 et seq.) risk assessments indicated that radionuclides are the most significant soil contaminants (DOE 2002a:4-23).

3.3.5.3 Materials and Fuels Complex

The MFC is within a topographically closed basin of the Axial Volcanic Rift Zone. That zone has an estimated recurrence interval for volcanism of 16,000 years. The nearest capable fault is the Howe Segment of the Lemhi Fault, 31 kilometers (19 miles) northwest of the site (see Figure 3–34).

Low ridges of basalt found east of the area rise as high as 30 meters (100 feet) above the level of the plain. Sediments cover most of the underlying basalt on the plain, except where pressure ridges form basalt outcrops. Soils in the MFC area generally consist of light, well-drained, brown-gray, silty loams to brown, extremely stony loams. Soils are highly disturbed within developed areas of the site (DOE 2002h:4-132).

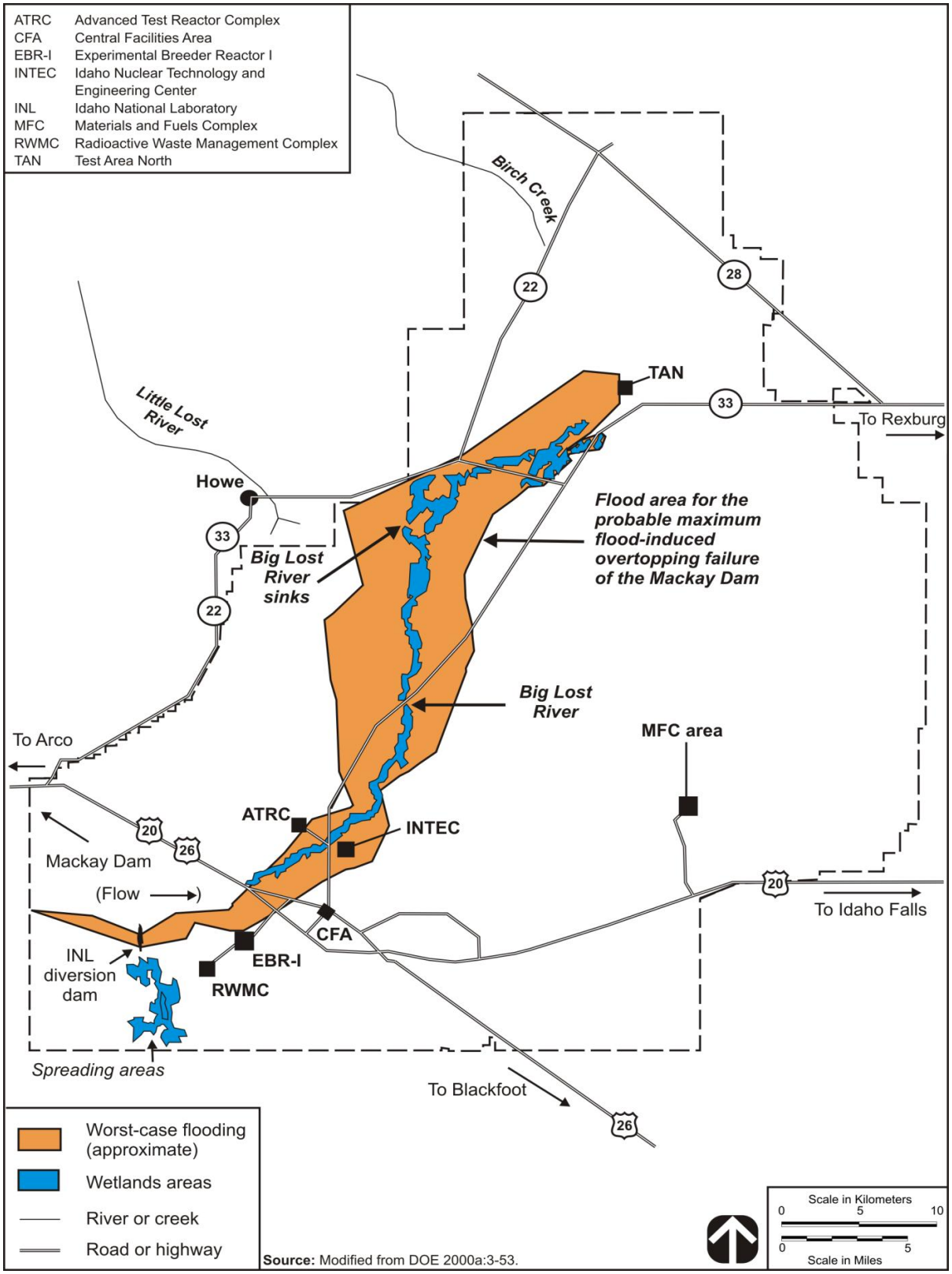
3.3.6 Water Resources

The scope of the discussion of water resources in this *TC & WM EIS* is stipulated in Section 3.2.6.

3.3.6.1 Surface Water

3.3.6.1.1 General Site Description

INL is in the Mud Lake–Lost River Basin (also known as the Pioneer Basin). This closed drainage basin includes three main streams—Big and Little Lost Rivers and Birch Creek (see Figure 3–36). These three streams are essentially intermittent and drain the mountain areas to the north and west of INL, although most flow is diverted for irrigation in the summer months before it reaches the site boundaries. Flow that reaches INL infiltrates the ground surface along the length of the streambeds in the spreading areas at the southern end of INL and, if the streamflow is sufficient in the ponding areas (playas or sinks), in the northern portion of INL as well. During dry years, there is little or no surface-water flow on the INL site.



Source: Modified from DOE 2000a:3-53.

Figure 3–36. Surface-Water Features at Idaho National Laboratory

Because the Mud Lake–Lost River Basin is a closed drainage basin, water does not flow off INL, but instead infiltrates the ground surface to recharge the aquifer or is consumed by evapotranspiration. Big Lost River flows southeast from Mackay Dam, past Arco, and onto the Snake River Plain. On the INL site near the southwestern boundary, a diversion dam prevents flooding of downstream areas during periods of heavy runoff by diverting water to a series of natural depressions or spreading areas (see Figure 3–36). During periods of high flow or low irrigation demand, Big Lost River continues northeastward past the diversion dam, passes within about 61 meters (200 feet) of INTEC, and ends in a series of playas 24 to 32 kilometers (15 to 20 miles) northwest of the MFC, where the water infiltrates the ground surface (DOE 2002a:4-40; 2002h:4-133).

Flow from Birch Creek and Little Lost River infrequently reaches INL. The waters in these streams are diverted in summer months for irrigation prior to reaching the site. Yet during periods of unusually high precipitation or rapid snowmelt, those waters can enter INL from the northwest and infiltrate the ground, recharging the underlying aquifer (DOE 2002a:4-40).

The only other surface-water bodies on the site are natural wetland-like ponds and manmade percolation and evaporation ponds (DOE 2002h:4-133). The latter are used for wastewater management at INL. Discharges to the ground surface are through infiltration ponds, trenches (ditches), and a sprinkler irrigation system. Infiltration ponds include the INTEC New Percolation Ponds, Test Area North/Technical Support Facility Sewage Treatment Plant Disposal Pond, RTC Cold Waste Pond, MFC Industrial Waste Pond and Ditch, and MFC Sanitary Lagoons. Wastewater at INTEC also is discharged to the INTEC Sewage Treatment Plant and associated infiltration trenches and to a sprinkler irrigation system at the Central Facilities Area that is used during the summer months to land-apply industrial and treated sanitary wastewater (DOE 2009a:5.4, 5.8).

Discharge of wastewater to the land surface is regulated under Idaho "Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater" (IDAPA 58.01.17). An approved Wastewater-Land Application Permit (WLAP) normally requires the monitoring of nonradiological parameters in the influent waste, effluent waste, and groundwater, as applicable. WLAPs generally require compliance of specified groundwater monitoring wells with Idaho groundwater quality primary and secondary constituent standards (IDAPA 58.01.11). WLAPs specify annual discharge volume, application rates, and effluent quality limits. As required, an annual report is prepared and submitted to the Idaho Department of Environmental Quality (DOE 2006:5.3). The facilities covered by WLAPs include the RTC Cold Waste Pond, Central Facilities Area Sewage Treatment Facility, and the INTEC New Percolation Ponds. Also, INL has submitted an application to the State of Idaho to obtain a WLAP for the MFC Industrial Waste Pond (DOE 2009a:5.4, 5.5).

Water bodies in Idaho are designated by the Department of Environmental Quality for specific and varied uses to ensure protection of the water quality for such uses. Big Lost River, Little Lost River, and Birch Creek in the vicinity of INL have been designated as cold water aquatic communities available for use in salmonid spawning and primary contact recreation, and the Big Lost River sinks and channel and lowermost Birch Creek, as domestic water supplies and special resource waters (IDAPA 58.01.02). In general, the waters of Big Lost River, Little Lost River, and Birch Creek are similar in quality because they reflect the similar carbonate mineral compositions of the mountain ranges drained by them, as well as chemically similar irrigation water return flows. Neither surface water nor the effluents discharged directly to it are used for drinking water on the site, so there are no surface-water rights issues at INL. Moreover, none of the rivers or streams on or near INL have been classified as wild and scenic (DOE 2002h:4-133, 4-135). Based on a regulatory determination made in 2005, INL site industrial activities are no longer subject to NPDES permitting requirements due to the determination that no stormwater discharge from INL industrial activities is likely to reach streams. Similarly, the regulatory determination also reduced the area (stormwater corridor) under the purview of the NPDES Storm Water for Construction Activities Program (DOE 2006:2.13). Nonetheless, INL's General Permit for Storm

Water Discharges from Construction Sites was issued in June 1993 and has been renewed twice since then. INL site contractors obtain coverage under the general permit for individual construction projects. Stormwater pollution plans are completed for individual construction projects. Inspections of construction sites are performed in accordance with permit requirements. Only construction projects that are determined to have a reasonable potential to discharge pollutants to a regulated surface water are required to have a stormwater pollution prevention plan and permit (DOE 2009a:2.13).

Flooding of Big Lost River was evaluated for its potential impact on INL facilities. Included was an evaluation of the impact of probable maximum flood due to the failure of Mackay Dam, 72 kilometers (45 miles) upstream of INL (see Figure 3–36). The maximum flood was assumed to result in the overtopping and rapid failure of Mackay Dam. This flood would result in a peak surface-water elevation at INTEC of 1,499 meters (4,917 feet)—the average elevation at that facility—as well as a peak flow of 1,892 cubic meters (66,830 cubic feet) per second in Big Lost River measured near INTEC. Thus, INTEC would be flooded, especially at the north end. Moreover, because the ground surface at INL and INTEC is rather flat, the floodwaters would spread over a large area and pond in the lower-lying areas. Although predicted flood velocities would be fairly slow and water depths shallow, some facilities could be impacted. There is no record of historical flooding at INTEC from Big Lost River, although evidence of flooding in geologic time exists (DOE 2002a:4-42, 4-43). The INL diversion dam, constructed in 1958 and enlarged in 1984, was designed to secure INL from the 300-year flood (estimated peak flow of slightly above 142 cubic meters [5,000 cubic feet] per second) of Big Lost River by directing flow through a diversion channel into four spreading areas. Effects of a systematic (noninstantaneous) failure of the diversion dam were included in the probable maximum flood analysis (DOE 2002a:4-42, 2005c:3-19; Koslow and Van Haaften 1986:24, 26, 30). Studies have also been performed that indicate the potential for varying degrees of flooding based on assumptions relative to the 100-year and 500-year floods.

A preliminary map of the 100-year floodplain for Big Lost River prepared by USGS and published in 1998 (from 1996 studies) indicated that INTEC may be subject to flooding from a 100-year flood. USGS estimated the 100-year flow at approximately 206 cubic meters (7,260 cubic feet) per second at the Arco gauging station, 19 kilometers (12 miles) upstream of the INL diversion dam. This estimate and the resulting preliminary 100-year floodplain map assumed that the INL diversion dam did not exist and that some 29 cubic meters (1,040 cubic feet) of water per second would be captured by the diversion channel and flow to the spreading areas southwest of the diversion dam. The analysis also assumed the remaining 176 cubic meters (6,220 cubic feet) per second of flow would run down the Big Lost River channel on the INL site. Both a U.S. Army Corps of Engineers analysis and an INL geotechnical analysis concluded that the INL diversion dam could withstand flows up to 170 cubic meters (6,000 cubic feet) per second. Culverts running through the diversion dam could convey a maximum of an additional 34 cubic meters (1,200 cubic feet) per second, but their condition and capacity as a function of water elevation are unknown. A subsequent DOE-commissioned flood hazard study published in 1999 by the Bureau of Reclamation was used to produce floodplain maps from flow estimates of 93 cubic meters (3,270 cubic feet) per second for the 100-year flow and 116 cubic meters (4,086 cubic feet) per second for the 500-year Big Lost River flow. The flows and frequencies were based on stream gauge data and two-dimensional modeling constrained by geomorphic evidence. The data and models showed that small areas of the northern portion of INTEC could flood at the estimated 100- and 500-year flows (DOE 2002a:4-42–4-46).

Additional studies aimed at reducing the uncertainty in flood hazard estimates at INL were recently undertaken by both USGS and the Bureau of Reclamation because of the large difference in the earlier estimates. USGS, in cooperation with DOE, published a study in 2003 providing its new estimate of the 100-year peak flow for Big Lost River at INL. The estimate was based on analysis of recorded and estimated peak-flow data, long-term gauging station data, and documented conditions in the basin during historical high-flow periods. The analysis resulted in a 100-year peak-flow estimate of 118 cubic meters

(4,170 cubic feet) per second near Arco and a flow of about 106 cubic meters (3,750 cubic feet) per second for Big Lost River immediately upstream from the INL diversion dam (Hortness and Rousseau 2003:2, 21, 22). The Bureau of Reclamation published the INL Big Lost River flood hazard study of record in 2005 (Adams 2006). This study used historic stream gauge measurements and reprocessed topographic data, in combination with geologic and geomorphic maps and trenching data, to constrain high-resolution two-dimensional hydraulic models of Big Lost River on INL. These data and analyses were independently peer reviewed with respect to meeting DOE flood hazard study and other requirements. The study yielded a series of inundation maps and stage discharge estimates for DOE Big Lost River flood hazard characterization purposes, including a 100-year peak-flow estimate of 87 cubic meters (3,072 cubic feet) per second at the INL diversion dam (Ostenaa and O'Connell 2005:iii, iv). These latest results indicate the potential for substantially less flooding at INL facilities than predicted by previous studies.

3.3.6.1.2 Idaho Nuclear Technology and Engineering Center

INTEC is situated on an alluvial plain, with its northwestern corner located approximately 61 meters (200 feet) from the Big Lost River channel near the channel's intersection with Lincoln Boulevard. INTEC is surrounded by a stormwater drainage ditch system. Stormwater runoff from most INTEC areas flows through the ditches to an abandoned gravel pit on the northeastern side of INTEC, where it infiltrates into the subsurface. Stormwater runoff volumes are usually small and spread over a wide area (DOE 2002a:4-40). The only other surface-water features at the site are the INTEC New Percolation Ponds. The two ponds constitute a rapid infiltration system and are excavated into the surficial alluvium and surrounded by bermed alluvial material. Each pond measures 93 by 93 meters (305 by 305 feet) and is 3 meters (10 feet) deep. The ponds receive wastewater from the INTEC Sewage Treatment Plant located east of INTEC and outside the INTEC security fence. The plant treats sanitary and other related waste at INTEC and uses four sewage lagoons for physical and biological treatment of sanitary waste before discharge to the percolation ponds. In 2008, the INTEC New Percolation Ponds received an average flow of 5.4 million liters (1.4 million gallons) per day, and flow and effluent concentrations were within specified Idaho Wastewater Reuse Permit limits (DOE 2009a:5.4–5.10).

INTEC and other facilities have been evaluated for susceptibility to the probable maximum flood, as discussed above. Other than natural topography, the primary choke points for probable maximum flood flows are the diversion dam on the INL site and the culverts near INTEC that allow Big Lost River to flow beneath Lincoln Boulevard between INTEC and the ATRC. The probable maximum flood would quickly overtop the diversion dam. The Lincoln Boulevard culverts are capable of passing about 42 cubic meters (1,500 cubic feet) of floodwater per second (DOE 2002a:4-42).

3.3.6.1.3 Materials and Fuels Complex

There are no named streams within the MFC area and no permanent natural surface-water features near the area. Neither the 100-year flood study nor flooding scenarios involving the failure of Mackay Dam on Big Lost River indicate that floodwaters would reach the MFC (see Figure 3–36).

Nevertheless, an unnamed dry streambed lies within several hundred feet of the Transient Reactor Test Facility Control Building adjacent to the main MFC site. As much as 1.5 million cubic meters (53 million cubic feet) of water could flow within a few hundred feet of that building during a 100-year storm if the worst-possible frozen ground conditions existed. In addition, a flood-control diversion dam is located about 0.8 kilometers (0.5 miles) south of the Hot Fuel Examination Facility. This dam was built to control surface-water flows from the south attributable to severe spring precipitation onto frozen ground. Water flowing from the south is diverted to the west and through a ditch that extends along the western boundary of the MFC site, discharging to the Industrial Waste Pond (ANL 2003:25).

Two small sewage lagoons and the Industrial Waste Pond are located outside the MFC boundary fence to the northwest. The 1-hectare (2.4-acre) Industrial Waste Pond is used for the disposal of industrial cooling water and stormwater emanating from the MFC facilities (ANL 2003:25).

3.3.6.2 Vadose Zone

3.3.6.2.1 General Site Description

The vadose zone at INL comprises the entire sequence of Quaternary-age basaltic lava flows and sedimentary interbeds that lie between the surface and the regional water table (top of the Snake River Plain Aquifer). Thus, the thickness of the vadose zone beneath INL ranges from about 61 meters (200 feet) in the northern part of the site to more than 274 meters (900 feet) in the southern portion of INL (ANL 2003:13).

This zone is important because chemical sorption to geologic materials in the vadose zone retards or prevents the downward movement of some contaminants. During dry conditions, the transport of contaminants downward toward the aquifer is very slow. Measurements taken at the Radioactive Waste Management Complex (RWMC) during unsaturated flow conditions indicated a downward infiltration rate ranging from 0.36 to 1.1 centimeters (0.14 to 0.43 inches) per year. In another study performed during near-saturated flow conditions in the same area, standing water infiltrated downward 2.1 meters (6.9 feet) in less than 24 hours (DOE 2002a:4-49).

3.3.6.2.2 Idaho Nuclear Technology and Engineering Center

The stratigraphic characteristics of the vadose zone at INTEC are similar to those of INL as a whole, but with a thickness ranging from about 140 to 146 meters (460 to 480 feet) (DOE 2002a:4-49). The geologic and groundwater environments of INTEC are further described in Sections 3.3.5.2 and 3.3.6.3.2, respectively.

3.3.6.2.3 Materials and Fuels Complex

The vadose zone beneath the MFC is approximately 213 meters (700 feet) thick and comprises the basalt flows and interbedded sediments characteristic of the Snake River Group. The geologic and groundwater environments of the MFC are further described in Sections 3.3.5.3 and 3.3.6.3.3, respectively.

3.3.6.3 Groundwater

3.3.6.3.1 General Site Description

The Snake River Plain Aquifer lies below INL. It covers an area of approximately 2.5 million hectares (6.1 million acres) in southeastern Idaho. Aquifer boundaries are formed by contact with less-permeable rocks at the margins of the Eastern Snake River Plain. These boundaries correspond to the mountains on the west and north and the Snake River on the east (ANL 2003:13). This aquifer is the major source of drinking water for southeastern Idaho and has been designated a Sole Source Aquifer by EPA (DOE 2002a:4-47; 2002h:4-135). Water storage in the aquifer is estimated at some 2,500 billion cubic meters (660,400 billion cubic gallons), and irrigation wells can yield 26,500 liters (7,000 gallons) per minute (DOE 2002a:4-47). The aquifer is composed of numerous thin basalt flows, with interbedded sediments extending to depths in excess of 1,067 meters (3,500 feet) below the land surface. Figure 3–35 shows the relationship of these strata from boreholes drilled at INL. The interbeds accumulated over time as some basalt flows were exposed at the surface long enough to collect sediment. These sedimentary interbeds lie at various depths, with their distribution and continuity controlled by basalt flow topography, sediment input, and subsidence rate. In some instances, the process of sediment accumulation resulted in discontinuous distributions of fairly impermeable sedimentary interbeds, which led to a localized

perching of groundwater. USGS has estimated that the thickness of the active portion of the Snake River Plain Aquifer at INL ranges between 76 and 250 meters (250 and 820 feet). Depth to the water table ranges from about 61 meters (200 feet) below land surface in the northern part of the site to more than 274 meters (900 feet) in the southern part (ANL 2003:13, 14).

Water movement regionally in the aquifer is mainly horizontal through basalt interflow zones, i.e., highly permeable rubble zones between basalt flows. Groundwater flow is primarily toward the southwest. Locally, the flow direction can be affected by recharge from rivers, surface-water spreading areas, and heterogeneities in the aquifer. Transmissivity in the aquifer ranges from roughly 100 to 10,000 square meters (1,000 to 100,000 square feet) per day and in places exceeds 100,000 square meters (1 million square feet) per day (ANL 2003:14). Flow rates in the aquifer have been reported to range from about 1.5 to 6.1 meters (5 to 20 feet) per day (DOE 2002h:4-135).

Big Lost River, Little Lost River, and Birch Creek terminate at sinks on or near INL and recharge the aquifer. Recharge occurs through the surface of the Eastern Snake River Plain from flow in the channel of Big Lost River and its diversion area. Additionally, recharge may occur from melting of local snowpacks during years in which snowfall accumulates on the Eastern Snake River Plain and from local agricultural irrigation activities (ANL 2003:15). Valley underflow from the mountains to the north and northeast of the Eastern Snake River Plain has also been cited as a source of recharge (DOE 2002a:4-47). Aquifer discharge is via large spring flows to the Snake River and pumping for irrigation. The aquifer discharges approximately 8,800 billion cubic meters (2,320 million cubic gallons) of water annually to springs and rivers (ANL 2003:15). Major springs and seepages from the aquifer occur in the vicinity of the American Falls Reservoir (southwest of Pocatello) and the Thousand Springs area (near Twin Falls) between Milner Dam and King Hill (DOE 2002a:4-47).

Perched water occurs in the vadose zone at INL when sediments or dense basalt with low permeability impedes the downward flow of water to the aquifer (DOE 2002a:4-47). These perched water tables tend to slow the migration of pollutants to the Snake River Plain Aquifer. Other perched water tables detected beneath INTEC and the RTC are attributable mainly to disposal ponds (DOE 2002h:4-135).

INL has an extensive groundwater-quality monitoring network maintained by USGS. USGS performs groundwater monitoring, analyses, and studies of the Snake River Plain Aquifer under and adjacent to INL.

Historical waste disposal practices have produced localized plumes of radiochemical and chemical constituents beneath the site. These areas are regularly monitored by USGS, and reports are published showing the extent of contamination plumes. Of principal concern over the years have been the movements of the tritium and strontium-90 plumes. The general extent of these plumes beneath INL is shown in Figure 3–37. Results for some monitoring wells within the plumes have shown decreasing concentrations of tritium and strontium-90 over the past 15 years. In 2008, USGS personnel collected and analyzed over 1,300 samples for radionuclides and inorganic constituents, including trace elements, and approximately 40 samples for purgeable organic compounds. Several purgeable organic compounds continue to be found by USGS in monitoring wells, including drinking water wells, at INL. The concentration of carbon tetrachloride was above the EPA MCL during 2008. Concentrations of other organic compounds were below MCLs and State of Idaho groundwater primary and secondary standards.

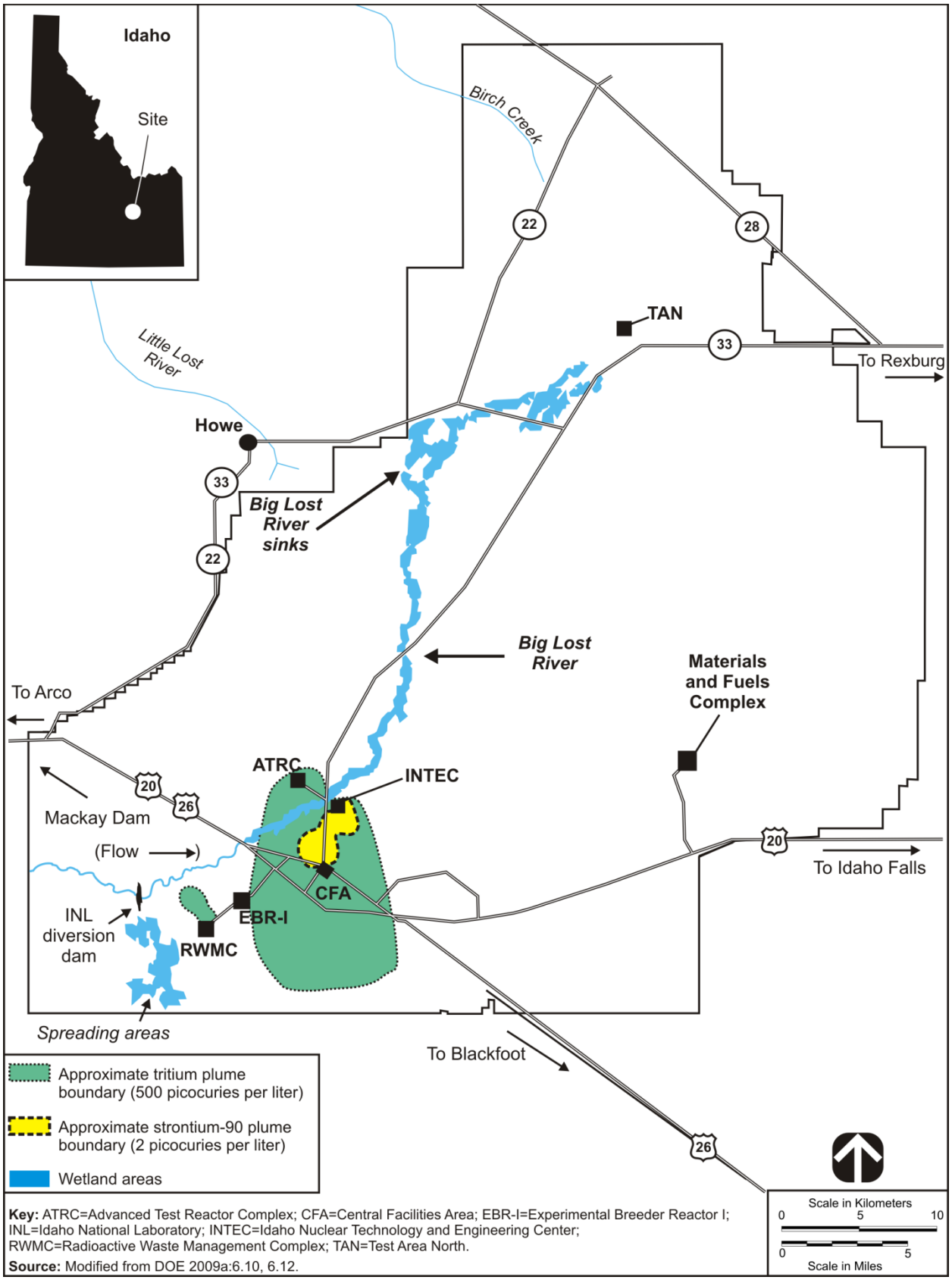


Figure 3–37. Extent of Hydrogen-3 (Tritium) and Strontium-90 Plumes Within the Snake River Plain Aquifer at Idaho National Laboratory

No contaminant exceeded an EPA MCL in a well along the southern boundary of INL or downgradient of the site during 2008. Analysis of the areal extent of the groundwater plumes detected tritium in two wells (USGS-104 and -106), which are guard wells located just south of the Central Facilities Area in the southern portion of INL. Both of these wells have a history of tritium detections. Over the past 20 years, both wells have exhibited a downward trend in tritium concentration. The tritium concentrations in these wells currently are less than 1,100 picocuries per liter and considerably less than the EPA MCL of 20,000 picocuries per liter (DOE 2009a:6.1, 6.3, 6.8–6.11, 6.31, 6.36).

The INTEC facility used direct injection as a disposal method until 1984. This wastewater contained high concentrations of both tritium and strontium-90. Injection at INTEC was discontinued in 1984, and the injection well was sealed in 1990. Once direct injection ceased, wastewater from INTEC was directed to a pair of shallow percolation ponds, from which the water infiltrated into the subsurface. Disposal of low- and intermediate-level radioactive waste solutions to the percolation ponds ceased in 1993 with the installation of the Liquid Effluent Treatment and Disposal Facility. New INTEC percolation ponds went into operation in August 2002. The RTC also discharged contaminated wastewater, but mainly to a shallow percolation pond. This pond was replaced in 1993 by a flexible plastic (Hypalon®)-lined evaporation pond, which stopped the addition of tritium to groundwater (DOE 2009a:6.8, 6.9, 6.35, 6.36).

Concentrations of tritium in the area of aquifer contamination have continued to decrease. Two monitoring wells downgradient of the RTC (well 65) and INTEC (well 77) have continually shown the highest tritium concentrations in the aquifer over time and are considered representative of maximum concentration trends in the rest of the aquifer. The average tritium concentration in well 65 decreased from 6,100 ± 300 picocuries per liter in 2007 to 5,710 ± 190 picocuries per liter in 2008, and the tritium concentration in well 77 decreased from 6,690 ± 160 picocuries per liter in 2007 to 5,620 ± 150 picocuries per liter in 2008. The EPA MCL for tritium in drinking water is 20,000 picocuries per liter, which is the same as the Idaho groundwater primary constituent standard. Still, values in both wells 65 and 77 have remained below the 20,000-picocuries-per-liter standard in recent years as a result of radioactive decay, a decrease in tritium disposal rates, and dilution within the Snake River Plain Aquifer (DOE 2009a:6.9, 6.10).

Strontium-90 contamination at INTEC is a remnant of the earlier injection of wastewater. At the RTC, by contrast, disposition of strontium-90 was via infiltration ponds. Strontium-90 at the RTC is retained in surficial sedimentary deposits, interbeds, and perched groundwater zones; however, no strontium-90 contamination has been detected in the RTC vicinity. The area of the strontium-90 contamination from INTEC is approximately the same as it was in 1991. Concentrations in wells have shown a general decrease since 1990. This decrease in concentration is probably the result of radioactive decay, discontinued strontium-90 disposal, advective dispersion, and dilution within the aquifer. Increases observed prior to the last few years were probably due in part to a lack of the recharge from Big Lost River that typically acts to dilute the strontium-90. An increase in the disposal of other chemicals into INTEC percolation ponds also may have changed the affinity of strontium-90 for soil and rock surfaces, causing it to become more mobile (DOE 2009a:6.11).

From 1982 to 1985, INL used about 7.9 billion liters (2.1 billion gallons) per year from the Snake River Plain Aquifer, the only source of water at INL. This represents less than 0.3 percent of the groundwater withdrawn from that aquifer. Since 1950, DOE has held a Federal Reserved Water Right for the INL site that permits a pumping capacity of approximately 2.3 cubic meters (80 cubic feet) per second, with a maximum water consumption of 43 billion liters (11.4 billion gallons) per year. Total groundwater withdrawal at INL historically averages between 15 and 20 percent of that permitted amount. INL's production well system currently withdraws a total of about 4.2 billion liters (1.1 billion gallons) of water annually (see Section 3.3.2.4). Most of the groundwater withdrawn for use by INL facilities is returned to the subsurface via percolation ponds (DOE 2002h:4-136).

3.3.6.3.2 Idaho Nuclear Technology and Engineering Center

Groundwater directly beneath INTEC generally flows to the southwest and southeast, with some flow to the south. The local groundwater flow is complex and variable and is influenced by recharge from Big Lost River (when flow is present), percolation ponds, areas of lower-aquifer transmission, and possibly pumping from the production wells. Groundwater beyond the influence of INTEC recharge sources flows to the south-southwest. The groundwater velocity beneath INTEC has been estimated at 3 to 8 meters (10 to 25 feet) per day. Depth to the water table in the Snake River Plain Aquifer ranges from approximately 140 to 146 meters (460 to 480 feet) below the ground surface. Also, several zones of perched water lie beneath INTEC. These zones are primarily located beneath, and extend outward from, the percolation ponds and the sewage treatment plant lagoons when Big Lost River is dry. Additional perched water bodies and interactions occur in the northern part of INTEC during periods of flow in Big Lost River and subsequent infiltration (DOE 2002a:4-47).

Water is supplied to INTEC by two deep wells (CPP–01 and CPP–02) in the northwestern corner of the area. The wells are about 180 meters (590 feet) deep. These wells can each supply up to approximately 11,400 liters per minute (3,000 gallons per minute) of water for use in the INTEC fire water, potable water, treated water, and demineralized water systems. The production wells at INTEC have historically contained measurable quantities of strontium-90 (DOE 2000a:3-58). During 2008, routine drinking water compliance sampling found that all INTEC monitored parameters were below their respective drinking water limits (DOE 2009a:5.19).

3.3.6.3.3 Materials and Fuels Complex

The depth of the Snake River Plain Aquifer water table beneath the MFC ranges between 183 and 213 meters (600 to 700 feet), and groundwater flow is generally to the southwest across the site (ANL 2003:13, 14). All water used at the MFC is groundwater from the underlying aquifer and is withdrawn via two production wells (see Section 3.3.2.4.3).

The MFC samples five wells (four monitoring and one production) twice a year for radionuclides, metals, total organic carbon, total organic halogens, and water quality parameters as part of the CERCLA ROD for Waste Area Group 9. Levels of gross beta and certain uranium isotopes detected in groundwater during fiscal year 2008 were low, and were found to be consistent with levels attributable to natural sources. In addition, except for one groundwater sample that contained lead concentrations in excess of primary and/or secondary MCLs, all concentrations of metals, total organic carbon, and total organic halogens, as well as general water quality parameters, were below respective MCLs. Overall, the data show no evidence of impacts of activities at the MFC (DOE 2009a:6.30, 6.32, 6.33).

3.3.7 Ecological Resources

The scope of the discussion of ecological resources in this *TC & WM EIS* is stipulated in Section 3.2.7.

3.3.7.1 Terrestrial Resources

3.3.7.1.1 General Site Description

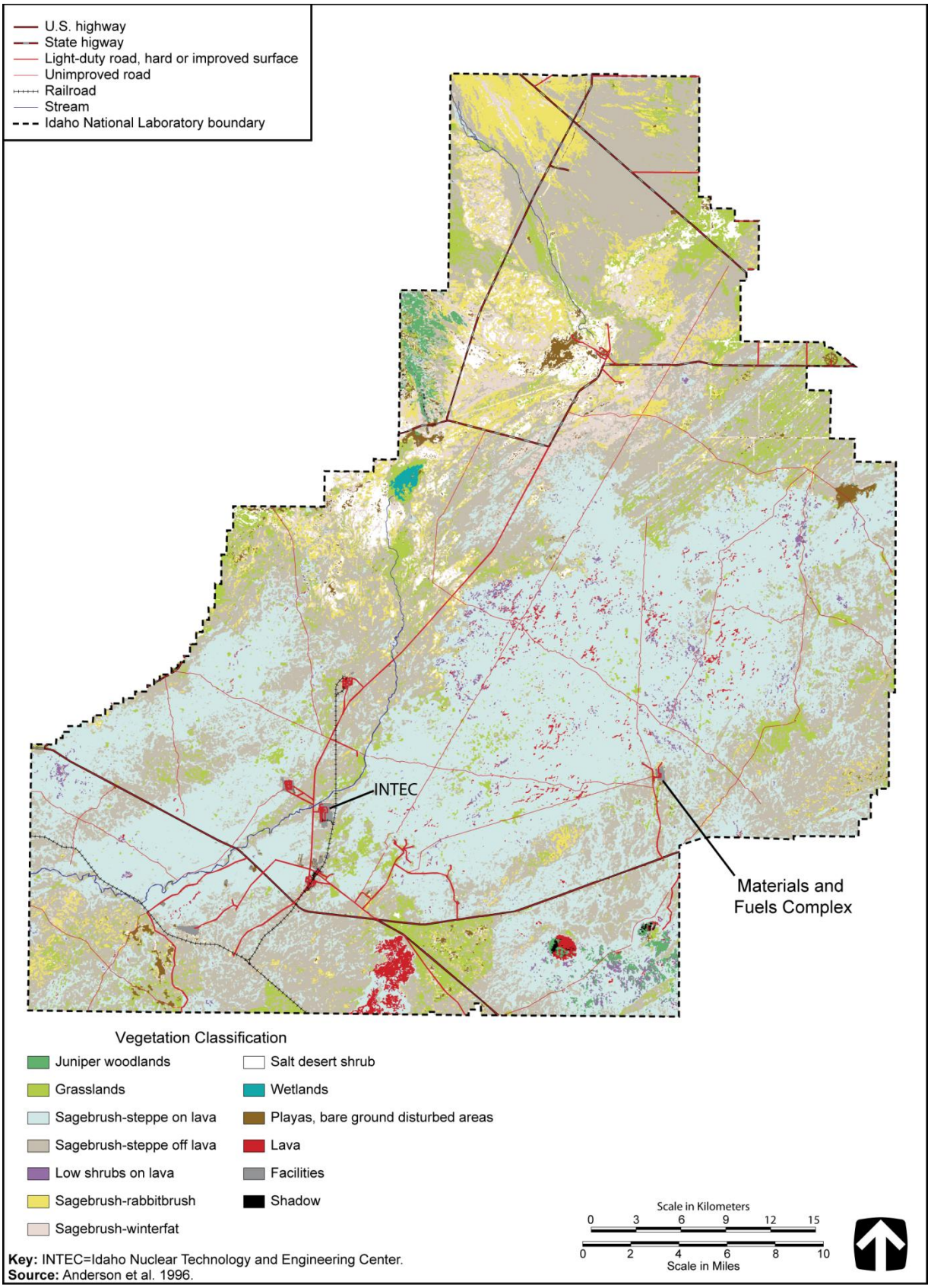
INL lies in a cool desert ecosystem dominated by some of the best-condition shrub-steppe communities in the United States. Approximately 94 percent of the site is undeveloped and provides important habitat for species native to the region (DOE 2002h:4-136; 2011b). Approximately 60 percent of the area on the periphery of the site is grazed by sheep and cattle. Although sagebrush communities occupy about 80 percent of INL, a total of 11 plant communities have been identified. Additionally, areas of lava and developed areas are present on the site (see Figure 3–38). These communities may be grouped into six types: shrub steppe; juniper woodlands; grasslands; playas, bare ground, and disturbed areas; lava; and wetlands. In total, 398 plant taxa have been documented at INL (DOE 2002h:4-136; 2002i).

Among the sensitive habitats on the INL site are the interspersions of low and big sagebrush communities in the northern portion of INL and the juniper communities in the northwestern and southeastern portions of the site. The former provide critical winter and spring range for pronghorn, while the latter are important to nesting raptors and songbirds. Riparian vegetation, primarily cottonwood and willow, along Big Lost River and Birch Creek is also important nesting habitat for hawks, owls, and songbirds (DOE 2002h:4-136). Recently, approximately 29,244 hectares (72,263 acres) of open space in the north-central portion of the site was designated as the INL Sagebrush-Steppe Ecosystem Reserve. The area was set aside because it represents some of the last sagebrush-steppe habitat in the United States and provides habitat for numerous rare and sensitive plants and animals (O'Rourke 2006:26).

INL supports numerous animal species, including 1,240 insect, 1 amphibian, 11 reptile, 210 bird, and 47 mammal species (DOE 2011b; Hampton 2005; O'Rourke 2006:24). Common animals on the site include the short-horned lizard, Great Basin gopher snake, sage sparrow, Townsend's ground squirrel, and black-tailed jackrabbit. Important game animals include the mule deer, Rocky Mountain elk, and pronghorn. Yearly estimates show that an average of 500 pronghorn live on INL during the summer and anywhere from 600 to 6,500 winter on the site (Stoller 2004). Although pronghorn may be found across INL at any time of the year, their important wintering areas are in the northeastern portion of the site, the area of the Big Lost River sinks, the west-central portion of the site along the Big Lost River, and the south-central portion of the site. Hunting Rocky Mountain elk and pronghorn is permitted only within 0.8 kilometers (0.5 miles) of the site boundary on INL lands adjacent to agricultural lands. Numerous raptors such as the golden eagle and prairie falcon, as well as carnivores such as the coyote and mountain lion, are also found on INL. A variety of migratory birds have been found on INL (DOE 2002h:3-64, 3-65).

3.3.7.1.2 Idaho Nuclear Technology and Engineering Center

INTEC is surrounded by sagebrush-steppe communities (see Figure 3–38); however, nearly the entire site has been developed. Thus, there is little or no natural habitat present, and INTEC does not support the diversity of wildlife found in surrounding areas. Breeding bird surveys designed to monitor the avifauna population in proximity to anthropogenic activities and disturbances at INL have found that the most common breeding birds in the INTEC area are Brewer's sparrow, horned lark, sage thrasher, and western meadowlark (Shurtliff and Whiting 2010:1, 28).



Key: INTEC=Idaho Nuclear Technology and Engineering Center.
Source: Anderson et al. 1996.

Figure 3–38. Vegetation Communities at Idaho National Laboratory

3.3.7.1.3 Materials and Fuels Complex

The MFC is within one of several sagebrush communities found on INL (see Figure 3–38). While sagebrush is present on undeveloped portions of the site, developed areas are nearly devoid of vegetation and thus generally not as important to animals as the surrounding areas. Rocky Mountain elk and mule deer are the most important large mammals in the general site area, but many other species common to the region are also expected. The MFC wastewater pond acts as an important source of water for wildlife found in the site vicinity (DOE 2002h:4-138).

3.3.7.2 Wetlands

3.3.7.2.1 General Site Description

National wetland inventory maps have been completed by USFWS for most of INL. These maps indicate that there are 55 hectares (135 acres) of wetland areas within INL. The primary wetland areas are associated with Big Lost River and the river's spreading areas and sinks, although smaller (less than about 0.4 hectares [1 acre]), isolated wetlands also occur intermittently. Wetlands associated with Big Lost River are classified as "riverine/intermittent," indicating a defined stream channel with flowing water during only part of the year. The only areas of jurisdictional wetlands are the Big Lost River sinks (see Figure 3–36) (DOE 2002h:4-138; O'Rourke 2006:21).

3.3.7.2.2 Idaho Nuclear Technology and Engineering Center

Riparian vegetation exists along Big Lost River, which is just to the west of INTEC; however, this vegetation is in poor condition because of only intermittent flows in recent years. The Big Lost River spreading areas and sinks are seasonal wetlands that are 14.5 kilometers (9 miles) southwest and 22.5 kilometers (14 miles) north of INTEC, respectively. These areas provide more than 809 hectares (2,000 acres) of wetland habitat during wet years (DOE 2002h:4-138). There are no wetlands within INTEC.

3.3.7.2.3 Materials and Fuels Complex

Riparian vegetation exists along Big Lost River, which is 18 kilometers (11 miles) west of the MFC; however, as noted previously, this vegetation is in poor condition. The Big Lost River spreading areas and sinks are seasonal wetlands that provide 809 hectares (2,000 acres) of wetland habitat during wet years. They are located 34 kilometers (21 miles) west-southwest and 23 kilometers (14 miles) northwest of the MFC, respectively. Within the MFC itself, small areas of intermittent marsh occur along cooling-tower blowdown ditches (DOE 2002h:4-138).

3.3.7.3 Aquatic Resources

3.3.7.3.1 General Site Description

Aquatic habitat at INL is limited to Big Lost River, Little Lost River, Birch Creek, and a number of liquid waste disposal ponds. All three streams are intermittent and drain into four sinks in the north-central part of the site. Six species of fish have been observed within water bodies on site. Species observed in Big Lost River include brook trout, rainbow trout, mountain whitefish, speckled dace, shorthead sculpin, and kokanee salmon. The Little Lost River and Birch Creek, southwest and northwest of the MFC, respectively, enter the site only during periods of high flow. The liquid waste disposal ponds on INL, while considered aquatic habitat, do not support fish (DOE 2002h:4-138).

3.3.7.3.2 Idaho Nuclear Technology and Engineering Center

Big Lost River is located 61 meters (200 feet) west of INTEC. As noted above, water flows only intermittently in the river and thus does not support permanent fish populations. INTEC contains manmade infiltration ponds (see Section 3.3.6.1.1); however, as is the case for Big Lost River, they do not support fish.

3.3.7.3.3 Materials and Fuels Complex

There is no natural aquatic habitat in the vicinity of the MFC. The nearest such habitat is Big Lost River, which is 19 kilometers (12 miles) west of the site. The MFC waste disposal ponds do not contain any fish populations, but they do provide habitat for a variety of aquatic invertebrates (DOE 2002h:4-139).

3.3.7.4 Threatened and Endangered Species

3.3.7.4.1 General Site Description

With the delisting of the gray wolf as an experimental, nonessential population in the northern Rocky Mountains, no listed or proposed threatened or endangered species and no proposed or designated critical habitat are currently known to occur in the area of INL (DOE 2009c:3; Foss 2009). The greater sage grouse is listed by USFWS as a candidate species (USFWS 2010); it is a common species on INL (GSS 2011). However, state-listed threatened and other special status species occur, or possibly occur, on INL (see Table 3–36). Idaho special status species include one threatened, two priority, three sensitive, two monitor, one imperiled, and one vulnerable. The bald eagle is listed by the state as threatened, but has been delisted in the lower 48 states by USFWS (72 FR 37346).

3.3.7.4.2 Idaho Nuclear Technology and Engineering Center

As noted above, there are no federally listed threatened or endangered species or critical habitat on INL; thus, none occur within INTEC. Also, due to the developed nature of INTEC, no state special status species are expected.

3.3.7.4.3 Materials and Fuels Complex

Although no federally listed threatened or endangered animals occur on INL, several studies have documented the presence of other state special status species in the immediate area of the MFC. The Townsend's big-eared bat has been observed using nearby caves and foraging over water sources at INL. Given the proximity of the MFC to Rattlesnake Cave and the distance to another water source, it is highly likely that Townsend's big-eared bats frequently forage at the facility (Burandt 2008). Additionally, pygmy rabbits have been observed in the area of the MFC (Vilord et al. 2005). Surveys of state-listed plants have not been conducted in the site vicinity.

A rattlesnake hibernaculum (a place to overwinter) is located a little over 1.6 kilometers (1 mile) south of the MFC. Concern for rattlesnakes within the state has grown in recent years, and, in fact, all reptiles receive protection in Idaho. The Great Basin rattlesnake could migrate as far north as the MFC once it leaves the hibernaculum in the spring (Jenkins and Peterson 2005:3, 4, 27).

Table 3–36. Idaho National Laboratory Threatened, Endangered, and Other Special Status Species

Common Name	Scientific Name	Status	
		Federal[a]	State[b]
Plants			
Cushion milkvetch	*Astragalus gilviflorus*		Priority 1
Lemhi milkvetch	*Astragalus aquilonius*		Sensitive
Puzzling halimolobos	*Halimolobos perplexa*		Monitor
Narrowleaf oxytheca	*Oxytheca dendroidea*		Sensitive
Nipple coryphantha	*Escobaria missouriensis*		Monitor
Spreading gilia	*Ipomopsis polycladon*		Priority 2
Winged-seed evening primrose	*Camissonia pterosperma*		Sensitive
Birds			
Bald eagle[c]	*Haliaeetus leucocephalus*		Threatened
Greater sage grouse	*Centrocercus urophasianus*	Candidate	
Mammals			
Pygmy rabbit	*Brachylagus idahoensis*		S2
Townsend's big eared bat	*Corynorhinus townsendii*		S3

[a] Status definition:
Candidate: Current information indicates the probable appropriateness of listing as endangered or threatened.

[b] Status definitions:
Priority 1: A taxon in danger of becoming extinct in Idaho in the foreseeable future if identifiable factors contributing to its decline continue to operate; these are taxa whose populations are present only at a critically low level or whose habitats have been degraded or depleted to a significant degree.
Priority 2: A state taxon likely to be classified as Priority 1 within the foreseeable future in Idaho if factors contributing to its population decline or habitat degradation or loss continue.
Sensitive: A state taxon 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.
Monitor: Taxa that are common within a limited range or taxa that are uncommon but have no identifiable threats.
Threatened: Any native species likely to be classified as endangered within the foreseeable future throughout all or a significant portion of its Idaho range.
S2: Imperiled; at risk because of restricted range, few populations, rapidly declining numbers, or other factors.
S3: Vulnerable; at moderate risk because of restricted range, relatively few populations, recent widespread decline, or other factors.

[c] Removed, effective August 8, 2007, from the list of threatened wildlife in the lower 48 states (72 FR 37346).

Note: The U.S. Fish and Wildlife Service does not currently distribute a list of species of concern for Idaho (Cheney 2008).

Source: Foss 2009; IDFG 2011; IDGOSC 2008; INL 2009c.

3.3.8 Cultural and Paleontological Resources

INL has a well-documented record of cultural and paleontological resources due in part to a longstanding cultural resource management program outlined in the *Idaho National Laboratory Cultural Resource Management Plan* (DOE 2005a) and adopted by a programmatic agreement between the DOE Idaho Operations Office (DOE-ID), the Idaho State Historic Preservation Office, and the Advisory Council on Historic Preservation. Past surveys have encompassed 8 to 10 percent of the INL site. These surveys have identified more than 2,200 prehistoric and historic archaeological resources and yielded an inventory of more than 200 DOE-administered buildings potentially eligible for inclusion in the National Register (O'Rourke 2006:28). In addition, consultations with local Shoshone-Bannock tribal members have served to identify TCPs.

Most cultural resource surveys have been in conjunction with major modification, demolition, or abandonment of site facilities. Approximately 40 to 50 specific projects are reviewed annually at INL for potential impacts on prehistoric and historic archaeological resources and TCPs. A similar number of project reviews are also performed to identify impacts on historic architectural properties.

Cultural sites were often occupied continuously or intermittently over substantial timespans. For this reason, a single location may have been used during both prehistoric and historic periods. In the discussions that follow, the numbers of prehistoric and historic resources are presented. The sum of these resources, however, may be greater than the total number of sites identified due to the dual-use history of various sites.

3.3.8.1 Prehistoric Resources

3.3.8.1.1 General Site Description

Prehistoric resources identified at INL are by definition physical properties reflecting human activities that predate written records; these generally reflect American Indian hunting and gathering activities. Approximately 1,980 prehistoric archaeological resources have been identified on INL. About half of these are isolates and half are sites (DOE 2005b). Most of the prehistoric sites are lithic scatters or locations (DOE 2002h:4-140). Resources appear to be concentrated along Big Lost River and Birch Creek, atop buttes, and within craters or caves. These include residential bases; campsites; caves; hunting blinds; rock alignments; and limited-activity locations such as lithic and ceramic scatters, hearths, and concentrations of fire-affected rock. Most sites at INL have not been formally evaluated for nomination to the National Register, but they are considered to be potentially eligible. Given the rather high density of prehistoric sites at INL, additional sites are likely to be identified as surveys continue.

3.3.8.1.2 Idaho Nuclear Technology and Engineering Center

The total fenced area at INTEC is 85 hectares (210 acres), with an additional 22 hectares (54 acres) outside the fence (DOE 2011a:3-69). Areas within the fence are highly disturbed and unlikely to yield significant prehistoric material. Archaeological surveys indicate that the area near INTEC contains only limited evidence of prehistoric use, though Big Lost River gravels could contain buried prehistoric artifacts (DOE 2002a:4-11).

3.3.8.1.3 Materials and Fuels Complex

The most recent cultural resource survey conducted near the MFC took place in 1996 and covered an area to the south of the site that had been burned over by a wildfire and was proposed for revegetation. A total of 12 isolated finds and 2 archaeological sites were located. Isolated finds included items such as pieces of Shoshone brownware pottery and projectile points. The archaeological sites yielded collections of projectile points, scrapers, and volcanic glass flakes. Areas within the fenced portion of the MFC site are highly disturbed and are not likely to yield significant archaeological material (DOE 2002h:4-140, 4-141).

3.3.8.2 Historic Resources

3.3.8.2.1 General Site Description

Approximately 200 historic archaeological sites are known on INL, and at least 200 historic architectural properties have been identified during surveys of nearly 500 buildings administered by DOE-ID (DOE 2005b). These resources represent European-American activities such as fur trapping and trading, immigration, transportation, mining, agriculture, and homesteading, as well as more-recent military, scientific, and engineering R&D activities. Examples of historic resources include Goodale's Cutoff

(a spur of the Oregon Trail), remnants of homesteads and ranches, irrigation canals, and a variety of structures from the World War II era.

The Experimental Breeder Reactor I, the first reactor to achieve a self-sustaining chain reaction using plutonium instead of uranium as the principal fuel component, is listed in the National Register and is designated as a National Historic Landmark. Many other INL structures built between 1949 and 1974 are considered eligible for the National Register because of their exceptional scientific and engineering significance and their major role in the development of nuclear science and engineering since World War II. Additional historic sites are likely to exist in unsurveyed portions of INL (DOE 2002h:4-141).

3.3.8.2.2 Idaho Nuclear Technology and Engineering Center

Historic trails, sites, and structures at and near INTEC have been identified as potentially eligible for listing on the National Register of Historic Places. Six INTEC structures proposed for demolition or modification have undergone State Historic Preservation Office reviews and have been determined to be eligible for listing in the National Register. These structures include the Waste Calciner Facility (CPP-633), the two monitoring stations (CPP-709 and CPP-734), the Radium-Lanthanum Process Off-Gas Blower Room (CPP-631), the Underwater Fuel Receiving and Storage Building (CPP-603), and the CPP-603 Basin Sludge Tank Control House (CPP-648). Memorandums of Agreement with the State Historic Preservation Office are in place to ensure that any adverse impacts of alteration of these facilities are mitigated (DOE 2002a:4-15).

3.3.8.2.3 Materials and Fuels Complex

A number of recent items, including farm implements, a belt buckle, broken glass, and a large scattering of cans, have been found in the MFC vicinity. Historic architectural properties are also present, including EBR-II, which has been designated as an American Nuclear Society Nuclear Historic Landmark (DOE 2002h:4-141). Future building surveys at the MFC are expected to result in the identification of additional historic architectural properties potentially eligible for nomination to the National Register.

3.3.8.3 American Indian Interests

3.3.8.3.1 General Site Description

TCPs at INL are associated with the two groups of nomadic hunters and gatherers that used the region at the time of European-American contact: the Shoshone and Bannock Tribes. Both of these used the area that now encompasses INL as they harvested plant and animal resources and obsidian from Big Southern Butte and Howe Point. Because the INL site is considered part of the Shoshone-Bannock Tribes' ancestral homeland, it contains many localities that are important for traditional, cultural, educational, and religious reasons. These include not only prehistoric archaeological sites that are important in the context of a religious or cultural heritage, but also features of the natural landscape and air, plant, water, and animal resources that have special significance (DOE 2002h:4-141).

DOE entered into an Agreement in Principle with the Shoshone-Bannock Tribes in 2002. In addition to defining a broad range of interests and working relationships and reaffirming the Tribes' rights under the Fort Bridger Treaty of 1868, the agreement devotes particular attention to the management of INL cultural resources. Its overall intent is to foster confidence on the part of the Shoshone-Bannock Tribes that INL cultural resources are managed in a spirit of protection and stewardship. To achieve this, the agreement provides for routine tribal participation in new and ongoing INL projects, with an open invitation to comment on, visit, observe, and assist in cultural resource management work (DOE 2005a; Ringe Pace et al. 2005).

3.3.8.3.2 Idaho Nuclear Technology and Engineering Center

Although INTEC and the surrounding area may contain American Indian resources, it is unlikely that undisturbed American Indian resources exist within the fenced perimeter of the site (DOE 2000a:3-71).

3.3.8.3.3 Materials and Fuels Complex

Over the past two decades, efforts have been under way to assemble complete inventories of cultural resources in the vicinity of major operating facilities at INL, including the MFC. Although prehistoric American Indian artifacts have been found in the MFC vicinity, areas within the fenced portion of the MFC site are highly disturbed and not likely to contain American Indian areas of interest (DOE 2000a:3-71).

3.3.8.4 Paleontological Resources

3.3.8.4.1 General Site Description

The region encompassing INL also has abundant and varied paleontological resources, including plant, vertebrate, and invertebrate remains in soils and lake and river sediments and organic materials found in caves and archaeological sites. Vertebrate fossils recovered from the Big Lost River floodplain consist of isolated bones and teeth from large mammals of the Pleistocene epoch, or Ice Age. These fossils were discovered during excavations and well-drilling operations. Fossils have been recorded in the vicinity of the Naval Reactors Facility. Occasional skeletal elements of fossil mammoth, horse, and camel have been retrieved from the Big Lost River diversion dam and the RWMC on the southwestern side of INL and from river and alluvial fan gravels and Lake Terreton sediments near Test Area North. A mammoth tooth dating from the Pleistocene epoch was recovered from the ATRC. In total, 24 paleontological localities have been identified on INL (DOE 2002h:4-141, 4-142).

3.3.8.4.2 Idaho Nuclear Technology and Engineering Center

To date, paleontological resources identified have included vertebrate and invertebrate animals, pollen, and plant fossils found in alluvial gravels along Big Lost River and in caves, lava tubes, and lake sediments; however, the INTEC vicinity was not identified as one of the locations where paleontological resources were found (DOE 2002h:4-141,4-142).

3.3.8.4.3 Materials and Fuels Complex

Paleontological resources have not been found in the immediate MFC vicinity (DOE 2002h:4-142).

3.3.9 Socioeconomics

Statistics for population, the regional economy, housing, community services, and local transportation have been developed for the ROI, a four-county area in Idaho (i.e., Bonneville, Bingham, Bannock, and Jefferson Counties) in which 92.3 percent of all INL employees reside (see Table 3–37).

Table 3–37. Distribution of Employees by Place of Residence in the Idaho National Laboratory Region of Influence, 2008

County	Number of Employees[a]	Total Site Employment (percent)
Bonneville	5,016	59.1
Bingham	1,276	15.0
Bannock	822	9.7
Jefferson	718	8.5
Total	**7,832**	**92.3**

[a] Number of employees includes contractors and subcontractors in the state of Idaho.
Source: Wiser 2008.

3.3.9.1 Regional Economic Characteristics

In December 2009, the civilian labor force in the ROI reached 123,000. The annual unemployment average in the four-county area at that time was 7.2 percent, slightly less than the annual unemployment average for Idaho (9.1 percent) (IDC&L 2011).

In 2009, trade, utilities, and transportation represented the largest sector of employment (22 percent). This was followed by government (19.0 percent) and education and health services (14.4 percent). The totals for these employment sectors in Idaho were 19.8, 18.6, and 12.6 percent, respectively (IDC&L 2011). In 2008, INL employed 8,483 persons (Dahl 2008; Wiser 2008).

3.3.9.2 Demographic Characteristics

The 2010 population in the four-county ROI was 259,000. As depicted in the demographic profile presented as Table 3–38, the predominant population was white; of the minority populations, Hispanic or Latino and American Indian and Alaska Native were the largest groups.

Income information for the ROI in 2010 is provided in Table 3–39. As indicated, Jefferson County had the highest median household income of the four counties ($51,600) and the lowest percentage of persons (10.2) living below the poverty level. Bingham County had the lowest median household income ($44,100) and the largest number of individuals (14.7) living below the poverty level. The average median household income in the four counties was comparable to the median household income of the state of Idaho ($46,400) during the same time period.

Table 3–38. Demographic Profile of Populations in the Idaho National Laboratory Socioeconomic Region of Influence, 2009

Population Group	Population (percentage of total)				
	Bannock County	Bingham County	Bonneville County	Jefferson County	Region of Influence
Nonminority					
White non-Hispanic	71,600 (86.4)	34,200 (74.9)	88,900 (85.3)	22,900 (87.7)	218,000 (84.1)
Minority					
Black or African American[a]	625 (0.8)	105 (0.2)	585 (0.6)	52 (0.2)	1,370 (0.5)
American Indian and Alaska Native[a]	2,620 (3.2)	2,970 (6.5)	790 (0.8)	203 (0.8)	6,580 (2.5)
Asian[a]	1,080 (1.3)	285 (0.6)	856 (0.8)	103 (0.4)	2,320 (0.9)
Native Hawaiian and Other Pacific Islander[a]	188 (0.2)	36 (0.1)	86 (0.1)	23 (0.1)	333 (0.1)
Some other race[a]	1,720 (2.1)	4,480 (9.8)	5,330 (5.1)	1,510 (5.8)	13,000 (5.0)
Two or more races[a]	2,210 (2.7)	979 (2.1)	2,170 (2.1)	401 (1.5)	5,760 (2.2)
White Hispanic	2,840 (3.4)	2,580 (5.6)	5,540 (5.3)	919 (3.5)	11,900 (4.6)
Total Minority	**11,300 (13.6)**	**11,400 (25.1)**	**15,400 (14.7)**	**3,220 (12.3)**	**41,300 (15.9)**
Total Hispanic or Latino (of any race)[b]	**5,590 (6.7)**	**7,860 (17.2)**	**11,900 (11.4)**	**2,640 (10.1)**	**28,000 (10.8)**
Total	**82,800**	**45,600**	**104,000**	**26,100**	**259,000**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals who identified themselves as Hispanic or Latino, regardless of race.

Note: Total may not equal the sum of the contributions due to rounding.

Source: Census 2011a.

Table 3–39. Income Information for the Idaho National Laboratory Region of Influence, 2010

Income Category	Bannock County	Bingham County	Bonneville County	Jefferson County	Idaho State
Median household income[a]	$44,800	$44,100	$50,400	$51,600	$46,400
Percentage of persons below the poverty level[b]	14	14.7	11	10.2	13.6

[a] Census 2011b.

[b] Census 2011c.

3.3.9.3 Housing and Community Services

Table 3–40 presents information on housing availability in the ROI, as well as data on public education and community health-care services in the region. As indicated, there were 95,500 housing units. Home values were highest in Jefferson County, with a median value of $154,000, and lowest in Bingham County, where the median value was $125,000.

Table 3–40. Housing and Community Services in the Idaho National Laboratory Region of Influence, 2010

	Bannock County	Bingham County	Bonneville County	Jefferson County	Region of Influence
Housing					
Total units[a]	32,700	15,900	38,600	8,340	95,500
Occupied housing units[a]	29,900	14,300	35,400	7,780	87,300
Vacant units for sale or rent[b]	1,190	373	1,570	306	3,440
Vacancy rate (percent)	3.8	2.5	4.3	3.8	3.8
Median value[c, d]	$136,000	$125,000	$153,000	$154,000	$142,000
Public Education[e]					
Total enrollment	14,000	10,100	21,100	5,990	51,100
Student-to-teacher ratio	19.9	18.3	20.1	18.5	19.4
Community Health Care[f]					
Hospitals	2	3	3	0	8
Hospital beds per 1,000 persons	2.6	3.4	3.2	0	2.7
Physicians per 1,000 persons[g]	2.3	1.1	2.2	0.5	1.9

[a] Census 2011d.
[b] Census 2011e.
[c] Census 2011f.
[d] Represents median value of all owner-occupied housing units.
[e] USDE 2011.
[f] Census 2011a; IDHW 2011.
[g] Census 2011a; Leonard 2011.

As also shown in the table, student enrollment in grades K–12 in the ROI in 2010 was 51,100. Bonneville County had the highest enrollment, and Jefferson County, the lowest. The average student-to-teacher ratio was 19.4 to 1, slightly higher than the state of Idaho ratio of 18.2 to 1 (USDE 2011).

A total of eight hospitals served the ROI in 2010, with a ratio of 2.7 hospital beds per 1,000 people. In that year, there was a ratio of 1.9 physicians per 1,000 residents. Bannock County had the highest ratio (2.3), and Jefferson County, the lowest (0.5) (IDHW 2011).

3.3.9.4 Local Transportation

Two interstate highways serve the INL region. Interstate 15, a north-south route that connects several cities along the Snake River, is approximately 40 kilometers (25 miles) east of INL. Interstate 86 intersects Interstate 15 approximately 64 kilometers (40 miles) south of INL and provides a primary linkage from Interstate 15 to points west. Interstate 15 and U.S. Route 91 are the primary access routes to the Shoshone-Bannock Tribes' Fort Hall Reservation (DOE 2002a:4–64).

U.S. Routes 20 and 26 are the main access routes to the southern portion of INL, with U.S. Route 20 providing the most direct access to the MFC and to INL facilities to the west of the MFC (see Figure 3–30). Idaho State Routes 22, 28, and 33 pass through the northern portion of INL, with State Route 33 providing access to the northern INL facilities (DOE 2002a:4-64). U.S. Routes 20 and 26 (two-lane, with a speed limit of 105 kilometers [65 miles] per hour) have the heaviest use because they provide direct links between INL and Idaho Falls and Blackfoot, Idaho. INL personnel living in

Pocatello, Idaho, use Interstate 15 (four-lane, with a speed limit of 120 kilometers [75 miles] per hour) and U.S. Route 26 en route to and from the site. Those living in Mud Lake, Rexburg, and Terreton (north of the site) use State Route 33. These routes connect to INL's onsite road network, which consists of about 140 kilometers (87 miles) of paved roads (see Section 3.3.2.1.1). The paved public highways running through INL total an additional 145 kilometers (90 miles) of roadway (ANL 2003:9).

Major regional roadway segments serving INL have historically operated at Level of Service A, which is defined as free-flow traffic conditions (DOE 2002a:4-64). According to data from rural traffic flow mapping performed annually by the State of Idaho, annual average daily traffic (AADT) and associated levels of service on major roadway segments serving INL did not change substantially between 1996 and 2009. The AADT on U.S. Route 20 from Idaho Falls to INL was 2,000 in 2009 as opposed to 2,100 in 1996. Corresponding AADT changes observed on other roadway segments include the following: from INL west to Arco on U.S. Route 20, 2,000 in 2009 versus 1,900 in 1996; from Blackfoot, Idaho, to INL on U.S. Route 26, 1,600 in 2009 versus 1,400 in 1996; and from Mud Lake to INL on State Route 33, 620 in 2009 versus 600 in 1996 (ITD 2010). Peak hourly traffic can be assumed to be 15 percent of the AADT. Two-lane roads servicing INL are designed for approximately 1,000 vehicles per hour in optimum weather conditions. The four-lane interstate can accommodate more than 2,000 vehicles per hour (ANL 2003:9). DOE buses provide transportation between INL facilities and surrounding communities for DOE and contractor personnel. Extensive use of this system keeps automobile traffic light.

The Mackay Branch Line of the Union Pacific Railroad, the major railroad in the area, services the southern portion of INL through the Scoville Spur. Freight services are received from the Union Pacific's main lines from Butte, Montana, on the north and Pocatello, Idaho, and Salt Lake City, Utah, on the south. Interconnections are made from these locations to areas throughout the United States. INL freight comes through Blackfoot, Idaho, on the north-south track of the Union Pacific's Mackay Branch Line, 23 kilometers (14 miles) of which traverse the southern part of INL (ANL 2003:9, 10, 11). Rail shipments to and from INL usually are limited to bulk commodities, SNF, and radioactive waste (DOE 2002a:4-66). There are no navigable waterways within the area capable of accommodating waterborne transportation of material shipments to INL.

The cities of Idaho Falls and Pocatello both have airports with passenger and cargo service (ANL 2003:10). Idaho Falls Regional Airport services eastern Idaho, southern Montana, and western Wyoming. The airport is served by Skywest/Delta Airlines and United Express (CIF 2011). There is a helicopter pad on site at the MFC and at each of the other major INL facilities. A Federal Aviation Administration low-altitude airway crosses the southwest portion of INL in a northwestwardly direction (ANL 2003:10).

3.3.10 Existing Human Health Risk

The scope of the discussion of human health risk in this *TC & WM EIS* is stipulated in Section 3.2.10.

3.3.10.1 Radiological Exposure and Risk

Major sources and average levels of exposure to background radiation of individuals in the INL vicinity are shown in Table 3–41.[5] The average annual dose from background radiation near INL is approximately 670 millirem. A little more than half of the annual dose is from ubiquitous, natural background sources (354 millirem) that can vary depending on geographic location, individual buildings in a geographic area, and age, but is essentially all from space or naturally occurring sources in Earth (DOE 2009a). A little less than half of the dose is from medical exposure to radiation (300 millirem),

[5] Average doses from background radiation in the INL vicinity from radon; medical exposures; and consumer, industrial, and occupational exposures are assumed to approximate the average dose to an individual in the U.S. population.

including computed tomography, interventional fluoroscopy, x-rays and conventional fluoroscopy, and nuclear medicine (use of unsealed radionuclides for diagnosis and treatment). Another approximately 14 millirem per year are from consumer products and other sources (nuclear power, security, and research and occupational exposure) (NCRP 2009:12). Average background radiation doses from these sources are expected to remain fairly constant over the period of the proposed actions. Background radiation doses, as indicated in Table 3–41, are unrelated to INL operations.

Table 3–41. Sources of Radiological Exposure of Individual Doses Unrelated to Idaho National Laboratory Operations

Source	Effective Dose Equivalent (millirem per year)[b]
Cosmic radiation[a]	48
Terrestrial radiation[a]	66
Internal (terrestrial and global cosmogenic)[b]	40
Radon in homes (inhaled)[b]	200
Medical exposure[b]	300
Consumer, industrial, and occupational[b]	14
Total (rounded)	**670**

[a] Data for natural background radiation are from DOE 2009a:7.18. Cosmic and terrestrial doses represent site-specific Idaho National Laboratory region values that are higher than the U.S. average. This results in a higher background dose than that presented in Table 3–12.

[b] Averages for the United States (NCRP 2009).

Releases of radionuclides to the environment from operations provide another source of radiological exposure for individuals in the vicinity of INL. Types and quantities of radionuclides released from INL operations in 2008 are summarized in Section 3.3.4.2. Estimated doses to the public resulting from these releases are presented in Table 3–42. The estimated dose to an MEI in 2008 was 0.13 millirem; over the last 5 years, the annual dose to the MEI has ranged from 0.039 to 0.13 millirem. The 2008 population dose was 0.78 person-rem; over the last 5 years, the annual dose to the population has ranged from 0.32 to 0.78 person-rem. The population dose varies with the size of the population, which has grown from 281,495 to 300,656 from 2004 to 2008 (DOE 2005d:8.1; 2006:8.1; 2007c:8.3, 8.7; 2008d:8.5, 8.8; 2009a:8.1). The population dose from natural background radiation sources was approximately 106,432 person-rem. The doses to the public from INL activities fall within the radiation limits given in DOE Order 458.1, Change 2, *Radiation Protection of the Public and the Environment*, and are much lower than those from background radiation.

Table 3–42. Radiation Doses to the Public from Idaho National Laboratory Operations, 2008 (Total Effective Dose Equivalent)

Members of the Public	Atmospheric Releases[a]	Liquid Releases[b]	Total[c]
Maximally exposed individual (millirem)	0.13	–	0.13
Population within 80 kilometers (person-rem)[d]	0.78	–	0.78
Average individual within 80 kilometers (millirem)[d]	0.0026	–	0.0026

[a] DOE Order 458.1, Change 2, invokes the Clean Air Act regulations (40 CFR 61, Subpart H), which established a compliance limit of 10 millirem per year to a maximally exposed individual.

[b] No dose is calculated because no surface water flows off Idaho National Laboratory and no Idaho National Laboratory radionuclides have been detected in offsite drinking water wells.

[c] DOE Order 458.1, Change 2, establishes an all-pathways dose limit of 100 millirem per year to an individual member of the public.

[d] The collective population dose is based on an estimated 2008 population of 300,656. The average individual dose is obtained by dividing the population dose by the number of people in the population.

Note: To convert kilometers to miles, multiply by 0.6214.

Source: DOE 2009a:8.8.

Given a risk estimator of 600 cancer deaths per 1 million person-rem to the public (see Appendix K, Section K.1.1.6), the fatal cancer risk to the MEI due to radionuclide releases from INL operations in 2008 is estimated to be 8.0×10^{-8}. That is, the estimated probability of this person dying of cancer at some point in the future from radiological exposure associated with 1 year of INL operations is 1 in 13 million (it takes many years from the time of radiological exposure for a cancer to manifest itself). The hypothetical MEI is a person whose residence and lifestyle make it unlikely that any other member of the public would receive a higher radiation dose from INL releases. This person is assumed to be exposed to radionuclides in the air and on the ground from INL emissions and to ingest locally grown food.

According to the same risk estimator, 5×10^{-4} excess fatal cancers are projected in the population living within 80 kilometers (50 miles) of INL from normal operations in 2008. To place this number in perspective, it may be compared with the number of fatal cancers expected in the same population from all causes. The mortality rate associated with cancer for the entire U.S. population is 0.2 percent per year. On this basis, the number of fatal cancers expected from all causes in the population living within 80 kilometers (50 miles) of INL in 2008 would be 601. This number is much higher than the number of fatal cancers estimated from INL operations in 2008.

Members of the public may also be exposed to radioactivity through the consumption of wildlife that has access to INL. A member of the public would receive a maximum potential radiation dose of about 0.052 millirem per year from eating 225 grams (8 ounces) of waterfowl that have used the radioactive wastewater ponds on the site. One of the game animals (a mule deer) collected during 2008 had a high concentration of cesium-137 in the muscle, a concentration that could deliver a dose of approximately 0.23 millirem to someone who ate 27,000 grams (952 ounces) of muscle and 500 grams (18 ounces) of liver from the animal (DOE 2009a:8.9, 8.10).

INL workers receive the same dose as the general public from background radiation, but they also receive an additional dose from working in facilities with nuclear materials. The average dose to the individual worker and the cumulative dose to all workers at INL from operations in recent years are presented in Table 3–43. Given a risk estimator of 0.0006 LCFs per person-rem among workers (see Appendix K, Section K.1.1.6), the calculated number of LCFs among INL workers from normal operations exposures in 2009 was 0.07.

Table 3–43. Radiation Doses to Workers from Idaho National Laboratory Normal Operations (Total Effective Dose Equivalent)

Occupational Personnel	Onsite Releases and Direct Radiation					
	Standard[a]	2005	2006	2007	2008	2009
Average radiation worker (millirem)	5,000	88	80	71	61	61
Total of all radiation workers (person-rem)[b]	**None**	**181.6**	**161.7**	**133.7**	**120.1**	**111.2**

[a] No standard is specified for an "average radiation worker"; however, the maximum dose to a worker is limited as follows: The radiation limit for an individual worker is 5,000 millirem per year (10 CFR 835). However, DOE's goal is to maintain radiological exposure as low as is reasonably achievable. DOE has therefore established the Administrative Control Level of 2,000 millirem per year; the site contractor sets facility administrative control levels below the DOE level, with 500 millirem per year considered a reasonable goal for trained radiation workers.

[b] There were 2,054 workers with measurable doses in 2005, 2,023 in 2006, 1,871 in 2007, 1,957 in 2008, and 1,808 in 2009.

Note: Total radiation worker dose presented in the table differs from that calculated from data shown due to rounding.

Key: DOE=U.S. Department of Energy.

Source: 10 CFR 835.202; DOE Standard 1098-2008, Change Notice 1; DOE 2008b:3-10; 2009b:3-10; 2010b:3-10.

3.3.10.2 Chemical Environment

The background chemical environment important to human health consists of the atmosphere, which may contain hazardous chemicals that can be inhaled; drinking water, which may contain hazardous chemicals that can be ingested; and other environmental media with which people may come in contact (e.g., soil through direct contact or via the food pathway).

Adverse health impacts on the public are minimized through administrative and design controls to decrease hazardous chemical releases to the environment and to achieve compliance with permit requirements. The effectiveness of these controls is verified through the use of monitoring information and inspection of mitigation measures. Health impacts on the public may occur during normal operations at INL via inhalation of air containing hazardous chemicals released to the atmosphere by INL operations. Risks to public health from ingestion of contaminated drinking water or direct exposure are potential pathways; the water pathway is considered an unlikely source of exposure at INL because no surface water flows off the site and radioactive contaminants have not been found in drinking water wells offsite (DOE 2009a:8.2).

Baseline air emission concentrations for air pollutants and their applicable standards are presented in Section 3.3.4. These concentrations are estimates of the highest existing offsite concentrations and represent the highest concentrations to which members of the public could be exposed. These concentrations are compared with applicable guidelines and regulations.

Chemical exposure pathways to INL workers during normal operations may include inhalation, the drinking of INL potable water, and physical contact with hazardous materials associated with work assignments. Workers are protected from hazards specific to the workplace through appropriate training, personal protective equipment, monitoring, and management controls. INL workers are also protected by adherence to Occupational Safety and Health Administration and EPA occupational standards that limit atmospheric and drinking water concentrations of potentially hazardous chemicals. Monitoring that reflects the frequency and amounts of chemicals used in the operational processes ensures that these standards are not exceeded. Additionally, DOE requirements ensure that conditions in the workplace are as free as possible from recognized hazards that cause or are likely to cause illness or physical harm. Therefore, worker health conditions at INL are substantially better than required by standards.

3.3.10.3 Health Effect Studies

Epidemiological studies were conducted on communities surrounding INL to determine whether there were excess cancers in the general population. The studies discussed are representative of the health effects studies that have been performed for the impacts on the public and workers at INL. In 1991, INL completed a 3-year effort to evaluate historical releases of radioactive materials and potential doses to a hypothetical individual who may have resided at an offsite location with the highest concentration of airborne radionuclides. The evaluation found that "radiation doses from airborne releases over the operating history of INL were small compared with doses from background radiation" (CDC 2005a). No excess cancer mortality was reported, and although excess cancer incidence was observed, no association with INL was established. A study by the State of Idaho completed in June 1996 found excess brain cancer incidence in the six counties surrounding INL, but a followup survey concluded that there was nothing that clearly linked all these cases to one another or to any one thing (DOE 2002h:4-149).

Two recent health effects studies of INL-related impacts were conducted by agencies of the U.S. Department of Health and Human Services. The *Public Health Assessment: Idaho National Engineering and Environmental Laboratory*, performed by the Agency for Toxic Substances and Disease Registry, focused on INL (formerly the Idaho National Engineering and Environmental Laboratory) operations from 1987 to 2000. It was published in March 2004 and concluded that "under normal operating conditions, INL poses no past, current, or future apparent public health hazard for the surrounding community" (ATSDR 2004). A dose reconstruction was completed by the Centers for Disease Control and Prevention in 2004 as a follow-on to DOE's 1991 evaluation of potential doses from the Aircraft Nuclear Propulsion Program Initial Engine Test series and the Idaho Chemical Processing Plant. The study by the Centers for Disease Control and Prevention also found that the calculated doses "were small and not sufficient to cause human health effects" (CDC 2005a).

Under a DOE–Centers for Disease Control and Prevention cooperative agreement, an epidemiological study evaluated a group of workers at DOE's Hanford, INL, and Oak Ridge sites for evidence of a connection between paternal exposure to ionizing radiation and childhood leukemia. This study yielded no evidence of such a link (Sever et al. 1997).

The National Institute for Occupational Safety and Health reported on an epidemiologic study of mortality and radiation-related risk of cancer among INL workers in 2005. The study concerned over 63,000 civilian workers employed at INL between 1949 and 1991. It concluded that mortality risk for most causes of death was lower among INL workers than the regional population; however, the cancer mortality rate was slightly elevated among workers, but for most cancer types was not likely related to ionizing radiation. The study showed some evidence of a link between workplace radiological exposures and the risk of brain cancer, leukemia, and lymphatic cancers. The study also found elevated rates of mortality for asbestos-related diseases, particularly among asbestos workers (CDC 2005b).

In 1997, DOE began providing free medical screening for former and current workers at certain DOE sites, including INL. The goal of this program, which is ongoing, is to detect work-related illnesses at an early stage when medical intervention may be helpful. It also helps workers determine if a current health condition is the result of work-related exposure (WHPP 2008).

3.3.10.4 Accident History

Since the early 1950s, there have been eight criticality accidents at INL (DOE 2002h:4-150). Those accidents occurred during processing, control-rod maintenance, critical experiment setups, and intentional destructive power excursions. Accidents connected with experiments typically involved power excursions that were significantly larger than expected. The accidents at the site resulted in various levels of radiological exposure to the involved workers and in impacts on equipment ranging from little or no damage to total loss. Exposure of the public from these accidents was minimal.

As described in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a), DOE conducted a historical dose evaluation study to estimate the offsite radiation doses for the entire operating history of INL (Wenzel, Peterson, and Dickson 1993). Radionuclide releases resulted from a variety of tests and experiments, as well as a few accidents. The study concluded that the offsite radiation doses from operations and accidents were small compared with doses from background radiation. Releases have declined in frequency and size since the time of the study; in fact, for more than a decade of INL operation, there have been no serious unplanned releases of radioactivity or other hazardous substances.

Incidents with worker health implications over the period from 2000 through June 2010, as identified through Occurrence Reporting and Processing System records (DOE 2007a, 2010c), include the following:

- Fifteen workers were exposed during waste handling operations at the AMWTP. The highest estimated committed effective dose received was 84 millirem, but the majority of workers received estimated committed effective doses of less than 30 millirem (June 2010).
- Workers tripped or slipped and fell, suffering broken bone(s) (June 2004, July 2004, February 2006, March 2006, June 2006, August 2006, January 2007, February 2007, March 2008, November 2008, March 2009, August 2009, November 2009, January 2010, February 2010, March 2010).
- Workers received electrical shocks (March 2001, September 2001, November 2004, December 2004, March 2005, April 2006, June 2007, August 2009, November 2009, December 2009, February 2010).
- A worker was exposed to respirable quartz in excess of occupational safety limits (July 2002, May 2009).
- A worker was exposed to radiation, with an estimated dose to the left hand of 57 millirem and a dose to the right hand of 30 millirem (January 2009).
- Workers' skins were contaminated, with subsequent decontamination being successful (September 2000, October 2000, January 2001, March 2001, July 2001, September 2001, June 2003, June 2006, July 2006, January 2009).
- A worker severed a portion of a finger while using a paper cutter or saw (January 2006, September 2008).
- A worker was exposed to hexavalent chromium above the Occupational Safety and Health Administration permissible exposure limit while stick-welding stainless steel (August 2007).
- A worker suffered minor chemical burns (April 2003, December 2005).
- Workers were potentially exposed to asbestos during building maintenance activities (July 2004, June 2006).
- Two workers were exposed to noise levels above occupational safety limits during demolition activities (September 2005).
- A worker was exposed to methyl chloride, requiring medical attention (December 2003).

- A worker was exposed to crystalline silica in excess of occupational safety limits during work with bentonite (June 2005).
- A worker was exposed to iron oxide and manganese in excess of occupational safety limits (2001).
- Workers were exposed to unknown vapors/fumes in laboratory operations (April 2000).
- A worker was exposed to plutonium in the CPP-602 Laboratory, resulting in a committed effective dose equivalent of 5 millirem (March 2000).

3.3.10.5 Emergency Preparedness

Each DOE site has established an emergency management program that would be activated in the event of an accident. This program was developed and is maintained to ensure adequate response to most accident conditions and to provide response efforts for accidents not specifically considered. The emergency management program includes emergency planning, training, preparedness, and response.

Government agencies whose plans are interrelated with the INL emergency management program include the State of Idaho; Bingham, Bonneville, Butte, Clark, and Jefferson Counties; the U.S. Bureau of Indian Affairs; and the Fort Hall Indian Reservation. INL contractors are responsible for responding to emergencies at their facilities. Specifically, the Emergency Action Director is responsible for recognition, classification, notification, and protective action recommendations. At INL, emergency preparedness resources include fire protection from onsite and offsite locations and radioactive and hazardous chemical material response. Emergency response facilities include an emergency control center at each facility, at the INL Warning Communication Center, and at the INL Site Emergency Operations Center. Seven INL medical facilities are available to provide routine and emergency service. In addition, DOE has specified actions to be taken at all DOE sites to implement lessons learned from the emergency response to an accidental explosion at Hanford in May 1997.

3.3.11 Environmental Justice

The scope of the discussion of environmental justice in this *TC & WM EIS* is stipulated in Section 3.2.11. During preparation of this *TC & WM EIS*, risks and consequences of both normal operations and accidents were evaluated in terms of potential releases of contaminants from various candidate facilities at INL. Potential release points at INL include INTEC and the MFC.

3.3.11.1 Minority Populations

The 80-kilometer (50-mile) radius surrounding the candidate facilities at INL encompasses parts of 15 counties: Bannock, Bingham, Blaine, Bonneville, Butte, Caribou, Clark, Custer, Fremont, Jefferson, Lemhi, Lincoln, Madison, Minidoka, and Power Counties in the state of Idaho. Tables 3–44 and 3–45 provide a breakdown of minority populations in the potentially affected counties and the state of Idaho in 1990 and 2000. The total population of the 15-county area experienced an increase of approximately 14 percent from 1990 to 2000. During that decade, the total minority population in that area increased by approximately 63 percent; individuals who self-identified as Hispanic or Latino, by approximately 65 percent; and the American Indian and Alaska Native population, by approximately 15 percent. From 1990 to 2000, the total population of Idaho increased approximately 29 percent. The total minority population in the state increased by approximately 98 percent; the American Indian and Alaska Native population, by approximately 28 percent; and people self-identified as Hispanic or Latino, by over 92 percent.

Table 3–44. Populations in Potentially Affected Counties Surrounding the Idaho National Laboratory and in the State of Idaho, 1990

Population Group	Counties Around Idaho National Laboratory		Idaho	
	Population	Percentage of Total	Population	Percentage of Total
Nonminority				
White non-Hispanic	265,901	91.1	928,661	92.2
Minority				
Black or African American[a]	900	0.3	3,370	0.3
American Indian, Eskimo, or Aleut[a]	5,592	1.9	13,780	1.4
Asian or Pacific Islander[a]	2,361	0.8	9,365	0.9
Some other race[a]	10,704	3.7	29,783	3.0
White Hispanic	6,494	2.2	21,790	2.2
Total Minority	**26,051**	**8.9**	**78,088**	**7.8**
Total Hispanic or Latino[b]	**17,900**	**6.1**	**52,927**	**5.3**
Total	**291,952**	**100.0**	**1,006,749**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals who identified themselves as Hispanic or Latino, regardless of race.

Source: Census 2007a.

Table 3–45. Populations in Potentially Affected Counties Surrounding the Idaho National Laboratory and in the State of Idaho, 2000

Population Group	Counties Around Idaho National Laboratory		Idaho	
	Population	Percentage of Total	Population	Percentage of Total
Nonminority				
White non-Hispanic	289,942	87.2	1,139,291	88.0
Minority				
Black or African American[a]	1,181	0.4	5,456	0.4
American Indian and Alaska Native[a]	6,423	1.9	17,645	1.4
Asian[a]	2,197	0.7	11,889	0.9
Native Hawaiian and Other Pacific Islander[a]	299	0.1	1,308	0.1
Some other race[a]	17,188	5.2	54,742	4.2
Two or more races[a]	5,607	1.7	25,609	2.0
White Hispanic	9,546	2.9	38,013	2.9
Total Minority	**42,441**	**12.8**	**154,662**	**12.0**
Total Hispanic or Latino[b]	**29,492**	**8.9**	**101,690**	**7.9**
Total	**332,383**	**100.0**	**1,293,953**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals who identified themselves as Hispanic or Latino, regardless of race.

Source: Census 2007b.

Table 3–46 contains a breakdown of minority populations in the surrounding 15-county area and the State of Idaho according to the *2010 Decennial Census* (Census 2011a). These data show that the total population of the 15-county area had increased by approximately 16 percent since the 2000 census. During that same period, the total minority population increased by approximately 51 percent; the number of people self-identified as Hispanic or Latino, by approximately 62 percent; and the American Indian and Alaska Native Population, by approximately 17 percent. The White Hispanic population experienced the largest population increase in the 15-county area at approximately 107 percent, followed by the total Hispanic population at 62 percent, and the Black or African American population and the Native Hawaiian and Other Pacific Islander population at approximately 52 percent each. The State of Idaho experienced trends in population growth similar to those observed in the potentially affected 15-county area. The total population of Idaho increased by approximately 21 percent; the total minority population, by approximately 63 percent; people self-identified as of Hispanic or Latino origin, by approximately 73 percent; and the American Indian and Alaska Native population, by approximately 22 percent. Similar to that of the 15-county area, the White Hispanic population of the state experienced the largest population increase at approximately 111 percent, followed by the Black or African American population at approximately 80 percent and the total Native Hawaiian and Other Pacific Islander population at approximately 77 percent.

Table 3–46. Populations in Potentially Affected Counties Surrounding the Idaho National Laboratory and in the State of Idaho, 2010

Population Group	Counties Around Idaho National Laboratory		Idaho	
	Population	**Percentage of Total**	**Population**	**Percentage of Total**
Nonminority				
White non-Hispanic	322,969	83.4	1,316,243	84.0
Minority				
Black or African American[a]	1,798	0.5	9,810	0.6
American Indian and Alaska Native[a]	7,494	1.9	21,441	1.4
Asian[a]	3,092	0.8	19,069	1.2
Native Hawaiian and Other Pacific Islander[a]	455	0.1	2,317	0.1
Some other race[a]	23,654	6.1	79,523	5.1
Two or more races[a]	7,959	2.1	38,935	2.5
White Hispanic	19,787	5.1	80,244	5.1
Total Minority	**64,239**	**16.6**	**251,339**	**16.0**
Total Hispanic or Latino[b]	**47,695**	**12.3**	**175,901**	**11.2**
Total	**387,208**	**100.0**	**1,567,582**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals who identified themselves as Hispanic or Latino, regardless of race.

Source: Census 2011a.

3.3.11.1.1 Idaho Nuclear Technology and Engineering Center

According to the *2010 Decennial Census* (Census 2011a), approximately 152,500 people resided within an 80-kilometer (50-mile) radius of INTEC. In this area, minority populations accounted for approximately 19 percent of the total population. Those who identified themselves as Hispanic or Latino were the largest minority group, constituting about 74 percent of the minority population and approximately 14 percent of the total population. Table 3–47 shows a breakdown of the population within 80 kilometers (50 miles) of INTEC.

Table 3–47. Populations Within 80 Kilometers of INTEC at Idaho National Laboratory, 2010

Population Group	Population	Percentage of Total
Nonminority		
White non-Hispanic	124,085	81.4
Minority		
Black or African American[a]	677	0.4
American Indian and Alaska Native[a]	4,068	2.7
Asian[a]	1,126	0.7
Native Hawaiian and Other Pacific Islander[a]	123	0.1
Some other race[a]	10,655	7.0
Two or more races[a]	3,233	2.1
White Hispanic	8,470	5.6
Total Minority	**28,408**	**18.6**
Total Hispanic or Latino[b]	**21,006**	**13.8**
Total	**152,493**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals who identified themselves as Hispanic or Latino, regardless of race.

Note: To convert kilometers to miles, multiply by 0.6214. Total may not equal the sum of the contributions due to rounding.

Key: INTEC=Idaho Nuclear Technology and Engineering Center.

Source: Census 2011a.

Figures 3–39 and 3–40 illustrate minority populations as a function of distance from INTEC. Block-group data generated from the *2010 Decennial Census* (Census 2011a) reflect an estimated total population of 152,493. Sharp spikes in populations can be seen around the outskirts of large population centers. However, large spikes did not occur until a point about 64 kilometers (40 miles) away, in the vicinity of Idaho Falls. The next significant jump occurred at approximately 76 kilometers (47 miles), near Pocatello. Approximately 15 percent of the minority population live within 58 kilometers (36 miles) of INTEC, and approximately 50 percent within 71 kilometers (44 miles). It is estimated that 14 percent of the population living within the potentially affected 80-kilometer (50-mile) radius of INTEC were self-identified as Hispanic or Latino.

Figure 3–41 shows meaningfully greater minority and nonminority populations living in block groups surrounding INTEC. Over 87 percent of the minority populations lived in two Idaho counties: Bingham and Bonneville; approximately 49 percent were concentrated in Bonneville County. Of the 127 block groups surrounding INTEC, 11 contained meaningfully greater minority populations.

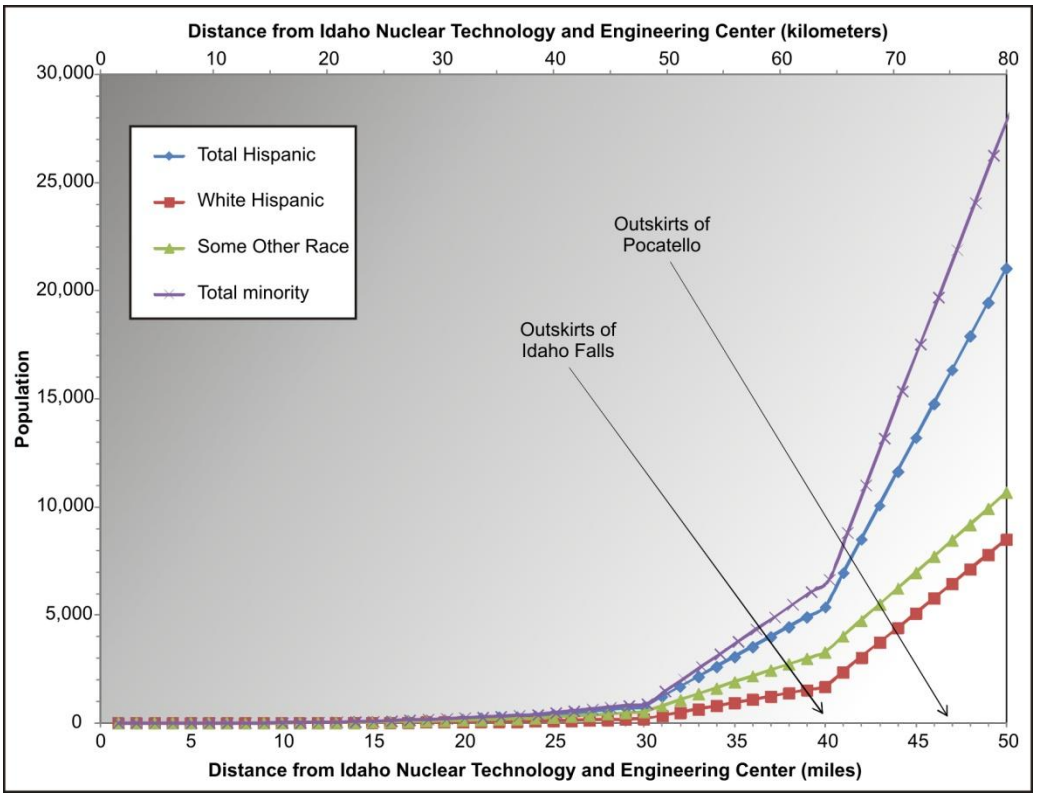


Figure 3–39. Cumulative Larger-Scale Minority Populations Surrounding INTEC at Idaho National Laboratory as a Function of Distance

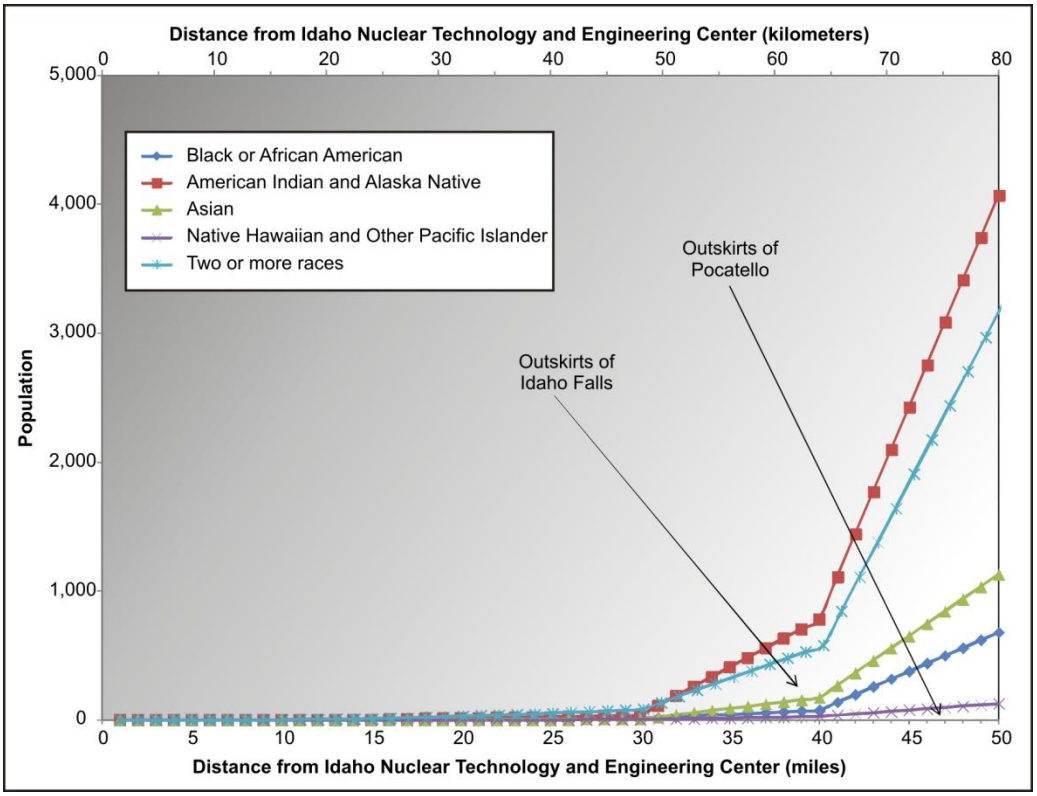


Figure 3–40. Cumulative Smaller-Scale Minority Populations Surrounding INTEC at Idaho National Laboratory as a Function of Distance

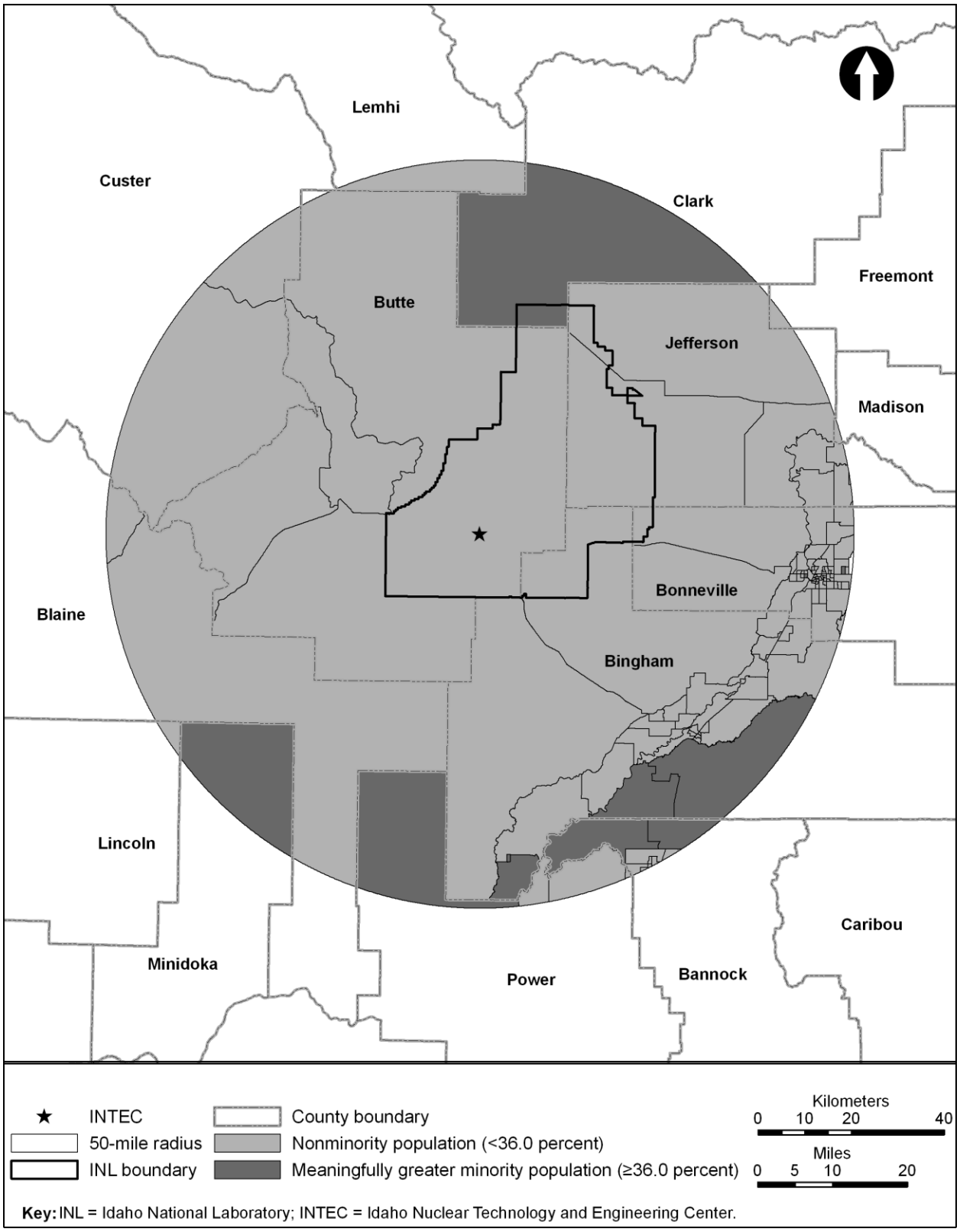


Figure 3–41. Meaningfully Greater Minority and Nonminority Populations Living in Block Groups Surrounding INTEC at Idaho National Laboratory

3.3.11.1.2 Materials and Fuels Complex

According to the *2010 Decennial Census* (Census 2011a), approximately 250,800 people resided within an 80-kilometer (50-mile) radius of the MFC. In this area, minority populations accounted for approximately 16 percent of the total population. Those who identified themselves as Hispanic or Latino were the largest minority group, constituting about 70 percent of the minority population and approximately 11 percent of the total population. Table 3–48 shows a breakdown of the population within 80 kilometers (50 miles) of the MFC.

Table 3–48. Populations Within 80 Kilometers of the Materials and Fuels Complex at Idaho National Laboratory, 2010

Population Group	Population	Percentage of Total
Nonminority		
White non-Hispanic	211,541	84.3
Minority		
Black or African American[a]	1,079	0.4
American Indian and Alaska Native[a]	5,763	2.3
Asian[a]	2,057	0.8
Native Hawaiian and Other Pacific Islander[a]	276	0.1
Some other race[a]	13,345	5.3
Two or more races[a]	5,124	2.0
White Hispanic	11,525	4.6
Total Minority	**39,297**	**15.7**
Total Hispanic or Latino[b]	**27,634**	**11.0**
Total	**250,838**	**100.0**

[a] Includes individuals who identified themselves as Hispanic or Latino.

[b] Includes all individuals who identified themselves as Hispanic or Latino, regardless of race.

Note: To convert kilometers to miles, multiply by 0.6214. Total may not equal the sum of the contributions due to rounding.

Source: Census 2011a.

Figures 3–42 and 3–43 illustrate minority populations as a function of distance from the MFC. Block-group data generated from the *2010 Decennial Census* (Census 2011a) reflect an estimated total population of 250,838. Sharp spikes in populations can be seen around the outskirts of large population centers. However, large spikes did not occur until a point about 48 kilometers (30 miles) away, in the vicinity of Idaho Falls. The next significant jump occurred at approximately 72 kilometers (45 miles), near Pocatello. Approximately 10 percent of the minority population live within 47 kilometers (29 miles) of the MFC, and approximately 50 percent, within 56 kilometers (35 miles). It is estimated that approximately 11 percent of the population living within the potentially affected 80-kilometer (50-mile) radius of the MFC were self-identified as Hispanic or Latino.

Figure 3–44 shows meaningfully greater minority and nonminority populations living in block groups surrounding the MFC. Approximately 82 percent of the minority populations lived in three Idaho counties: Bannock, Bingham, and Bonneville; approximately 39 percent were concentrated in Bonneville County. Of the 184 block groups surrounding the MFC, 11 contained meaningfully greater minority populations.

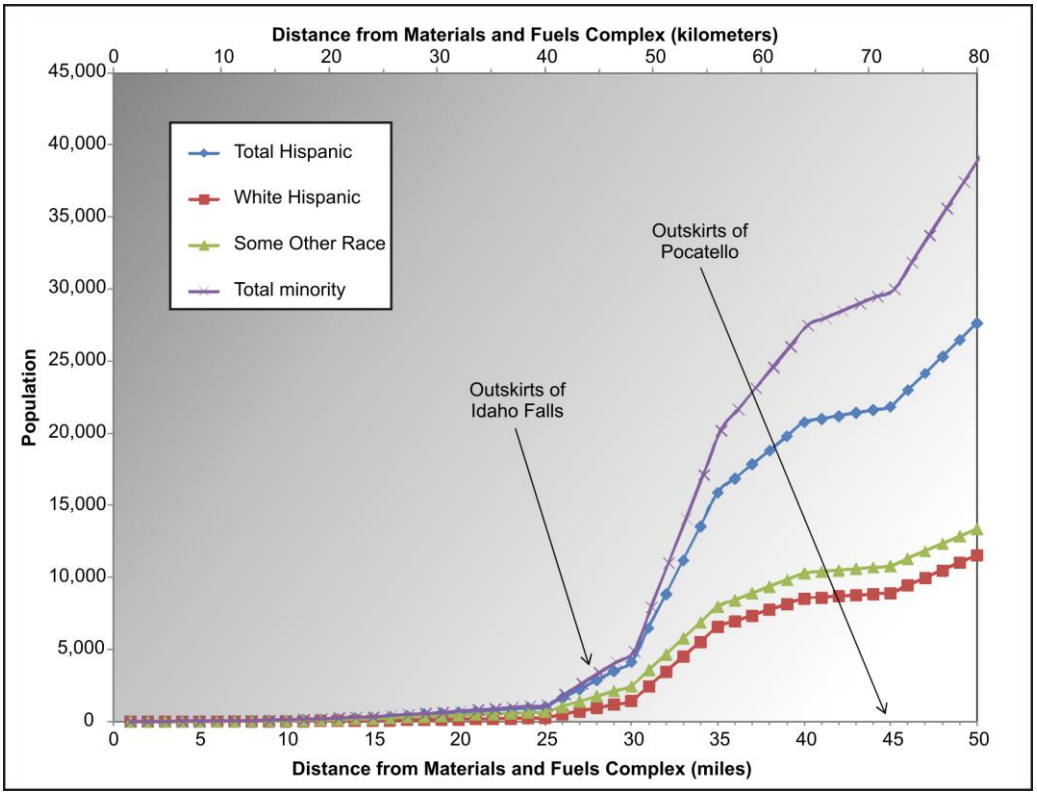


Figure 3–42. Cumulative Larger-Scale Minority Populations Surrounding the Materials and Fuels Complex at Idaho National Laboratory as a Function of Distance

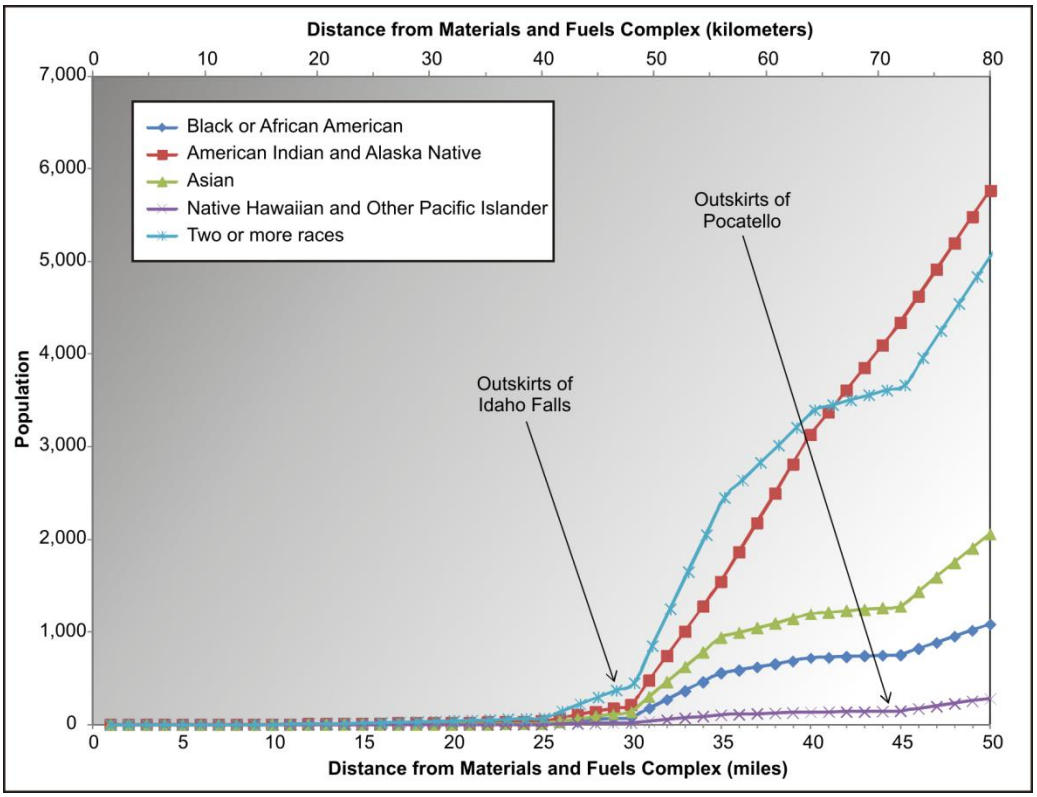


Figure 3–43. Cumulative Smaller-Scale Minority Populations Surrounding the Materials and Fuels Complex at Idaho National Laboratory as a Function of Distance

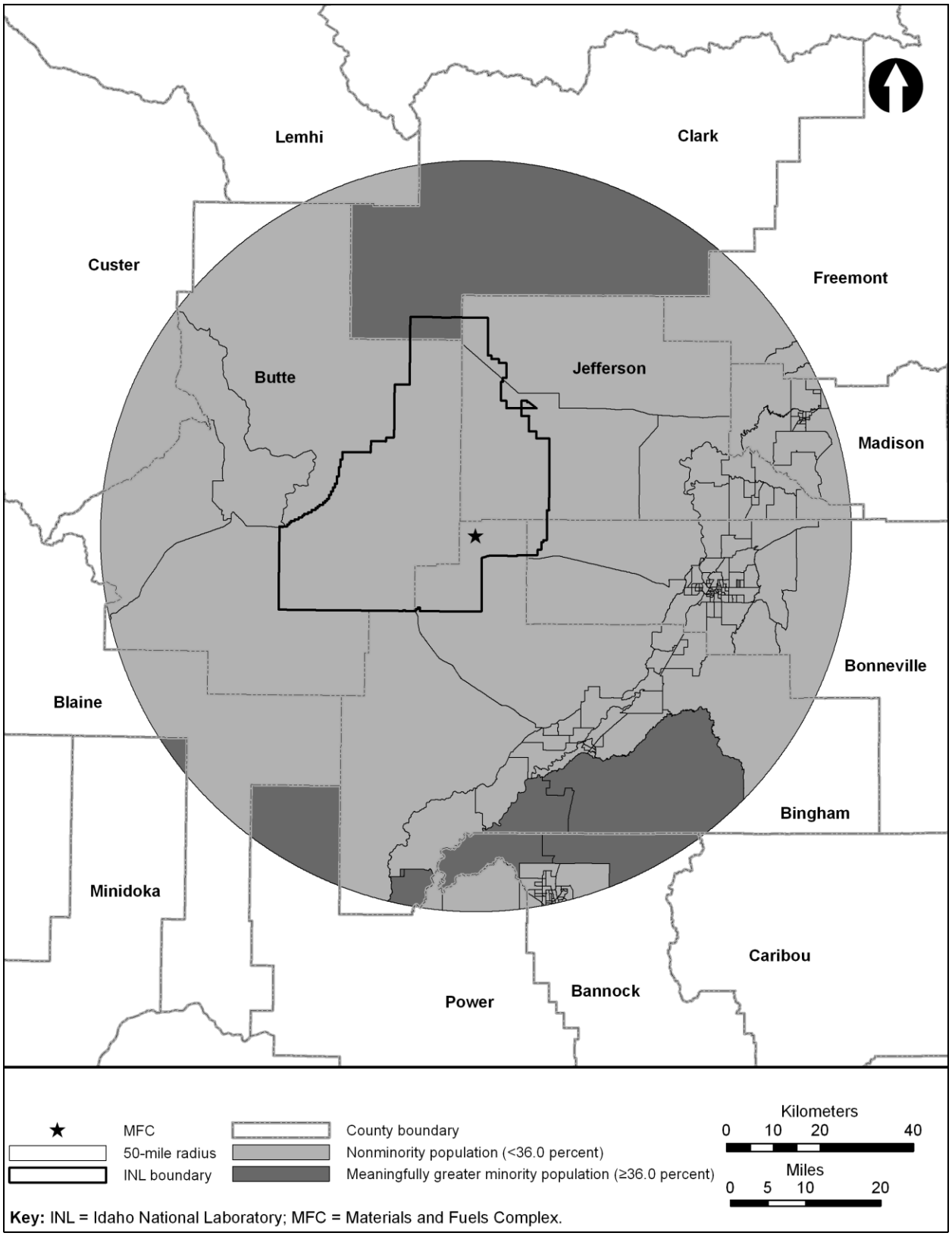


Figure 3–44. Meaningfully Greater Minority and Nonminority Populations Living in Block Groups Surrounding the Materials and Fuels Complex at Idaho National Laboratory

3.3.11.2 Low-Income Populations

Tables 3–49 and 3–50 show the total and low-income populations in the 15-county area surrounding INL and in the state of Idaho in 1989 and 1999, respectively. From 1989 to 1999, the total population of the 15-county area surrounding INL increased by approximately 14 percent, while the low-income population increased by approximately 11 percent. Over the same period, the total population of Idaho increased by approximately 28 percent, and the low-income population, by approximately 14 percent.

Table 3–49. Total and Low-Income Populations in the Potentially Affected 15-County Area Surrounding Idaho National Laboratory and in the State of Idaho, 1989

Population Group	Counties Surrounding Idaho National Laboratory		Idaho	
	Population	Percentage of Total	Population	Percentage of Total
Total population	287,513	100.0	985,553	100.0
Low-income population	40,056	13.9	130,588	13.3

Note: The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).
Source: Census 2007c.

Table 3–50. Total and Low-Income Populations in the Potentially Affected 15-County Area Surrounding Idaho National Laboratory and in the State of Idaho, 1999

Population Group	Counties Surrounding Idaho National Laboratory		Idaho	
	Population	Percentage of Total	Population	Percentage of Total
Total population	326,438	100.0	1,263,205	100.0
Low-income population	44,516	13.6	148,732	11.8

Note: The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).
Source: Census 2007d.

Table 3–51 shows the total and low-income populations in the surrounding 15-county area and the state of Idaho according to the 2006–2010 ACS 5-year estimates (Census 2011c). These data show that the total population of the 15-county area had increased by approximately 13 percent, and the low-income population by approximately 18 percent, since the 2000 census. Over the same period, the state of Idaho saw an increase in total population of approximately 18 percent, with an increase in the low-income population of approximately 37 percent.

Table 3–51. Total and Low-Income Populations in the Potentially Affected 15-County Area Surrounding Idaho National Laboratory and in the State of Idaho, 2006–2010

Population Group	Counties Surrounding Idaho National Laboratory		Idaho	
	Population	Percentage of Total	Population	Percentage of Total
Total population	369,719	100.0	1,496,581	100.0
Low-income population	52,437	14.2	203,177	13.6

Note: The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).
Source: Census 2011c.

3.3.11.2.1 Idaho Nuclear Technology and Engineering Center

Table 3–52 shows the total and low-income populations within 80 kilometers (50 miles) of INTEC. According to the 2006–2010 ACS 5-year estimates (Census 2011c), low-income individuals constituted approximately 12 percent of the total population. Approximately 90 percent of the low-income population resided in Bonneville and Bingham Counties. Approximately 55 percent were concentrated in Bonneville County.

Table 3–52. Total and Low-Income Populations Within 80 Kilometers of INTEC at Idaho National Laboratory, 2006–2010

Population Group	Population	Percentage of Total
Total population	146,824	100.0
Low-income population	17,845	12.2

Note: The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).
To convert kilometers to miles, multiply by 0.6214.
Key: INTEC=Idaho Nuclear Technology and Engineering Center.
Source: Census 2011c.

Figure 3–45 shows the total, low-income, and non-low-income populations as a function of distance from INTEC. Block-group data generated from the 2006–2010 ACS 5-year estimates (Census 2011c) reflect a total population of 146,824 within an 80-kilometer (50-mile) radius of INTEC.

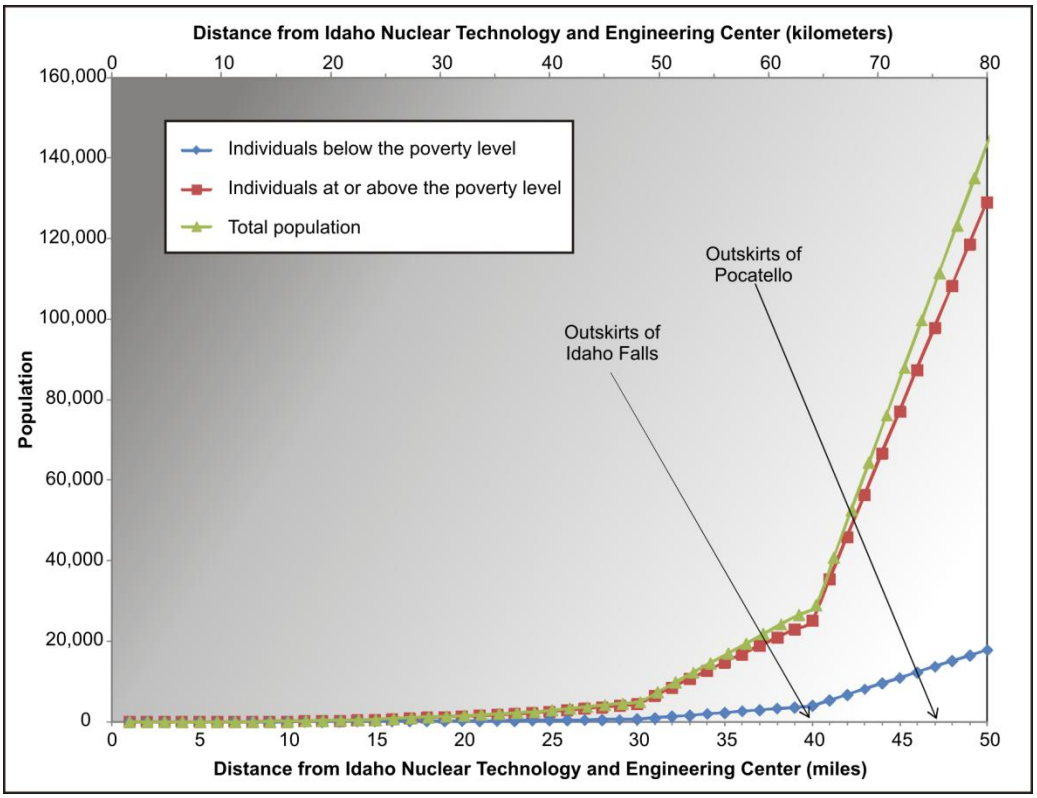


Figure 3–45. Low-Income and Non-Low-Income Populations Surrounding INTEC at Idaho National Laboratory as a Function of Distance

Figure 3–46 shows meaningfully greater low-income and non-low-income populations living in the block groups surrounding INTEC at INL. Of the 127 block groups surrounding INTEC, 4 contained meaningfully greater low-income populations.

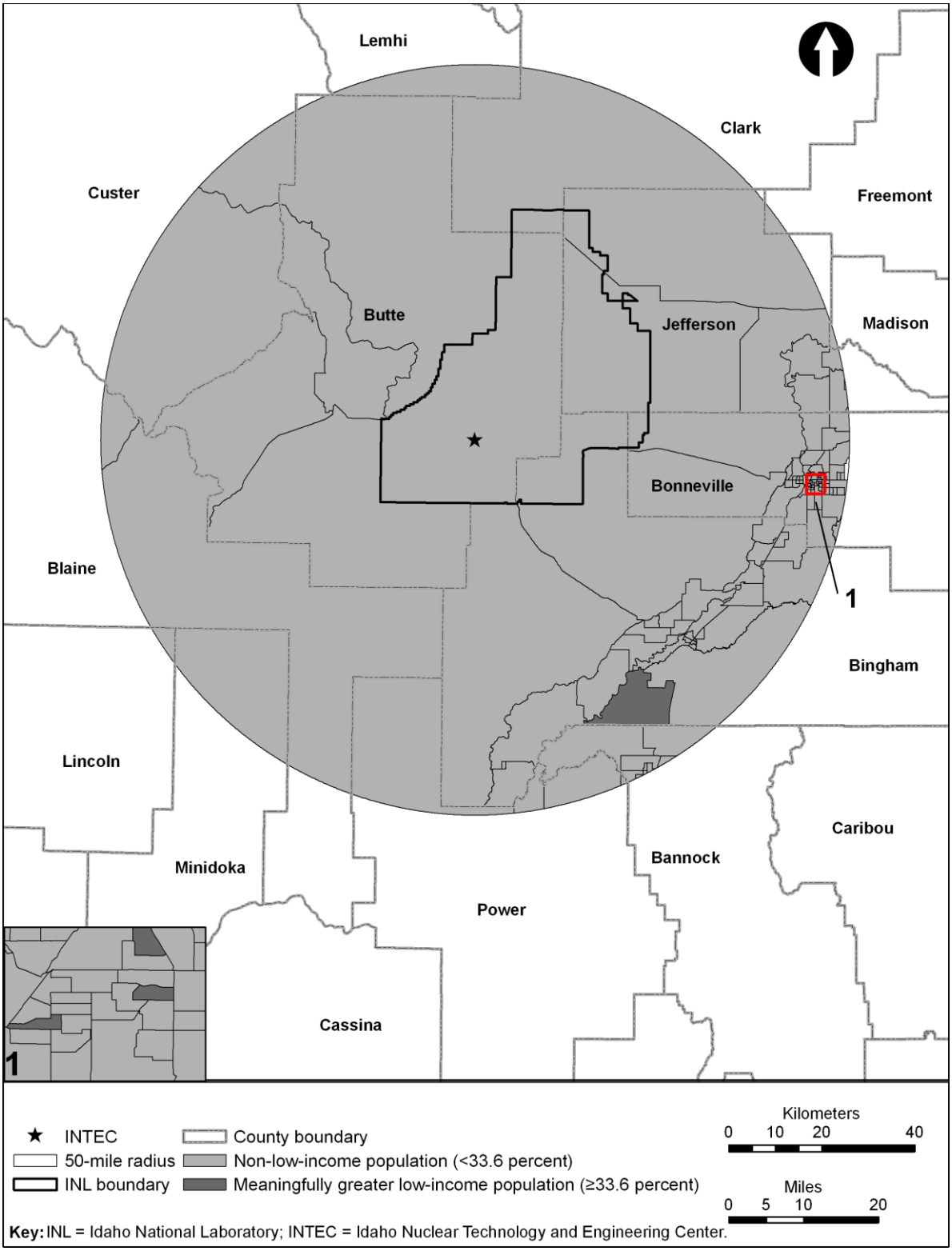


Figure 3–46. Meaningfully Greater Low-Income and Non-Low-Income Populations Living in Block Groups Surrounding INTEC at Idaho National Laboratory

3.3.11.2.2 Materials and Fuels Complex

Table 3–53 shows the total and low-income populations within 80 kilometers (50 miles) of the MFC. According to the 2006–2010 ACS 5-year estimates (Census 2011c), low-income individuals constituted approximately 14 percent of the total population. Approximately 91 percent of the low-income population resided in four counties; Bannock, Bingham, Bonneville and Madison; approximately 30 percent were concentrated in Madison County.

Table 3–53. Total and Low-Income Populations Within 80 Kilometers of the Materials and Fuels Complex at Idaho National Laboratory, 2006–2010

Population Group	Population	Percentage of Total
Total population	239,013	100.0
Low-income population	34,344	14.4

Note: The total population values used for the low-income comparison are lower than those used for the minority comparisons because the U.S. Census Bureau data relative to income do not take into account those people who live in institutions (e.g., college dormitories, rooming houses, religious group homes, communes, halfway houses).
To convert kilometers to miles, multiply by 0.6214.
Source: Census 2011c.

Figure 3–47 shows the total, low-income, and non-low-income populations as a function of distance from the MFC. Block-group data generated from the 2006–2010 ACS 5-year estimates (Census 2011c) reflect a total population of 239,013 within an 80-kilometer (50-mile) radius of the MFC.

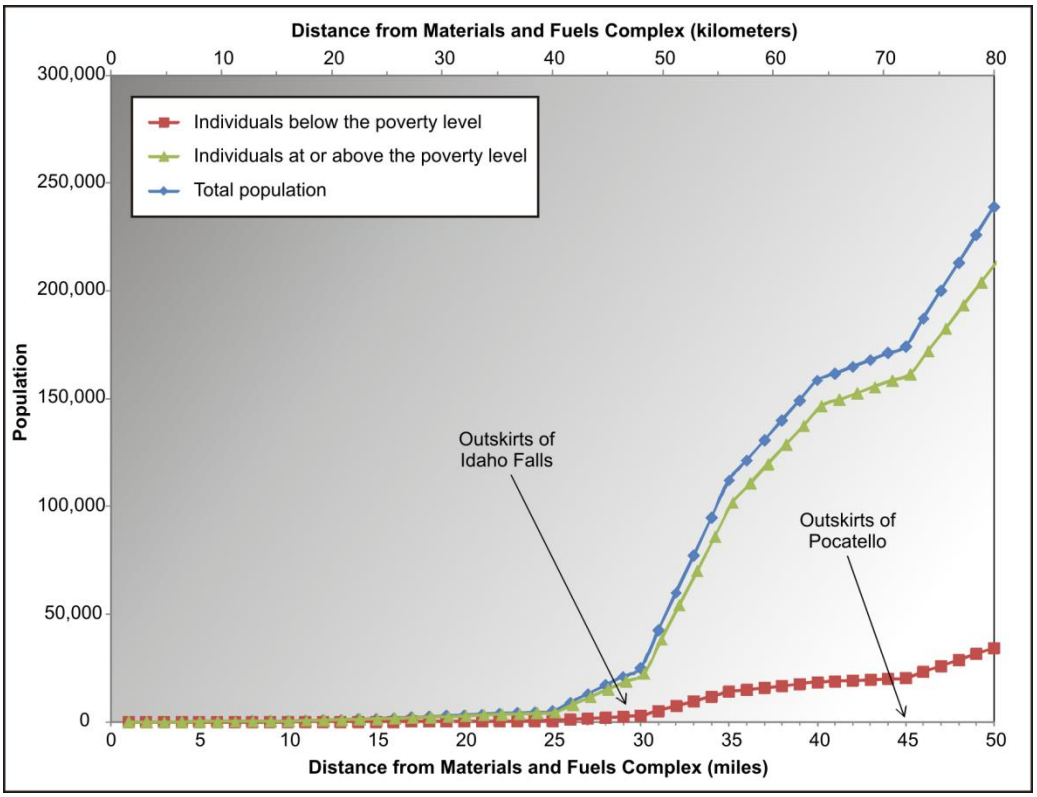


Figure 3–47. Low-Income and Non-Low-Income Populations Surrounding the Materials and Fuels Complex at Idaho National Laboratory as a Function of Distance

Figure 3–48 shows meaningfully greater low-income and non-low-income populations living in the block groups surrounding the MFC at INL. Of the 184 block groups surrounding the MFC, 13 contained meaningfully greater low-income populations.

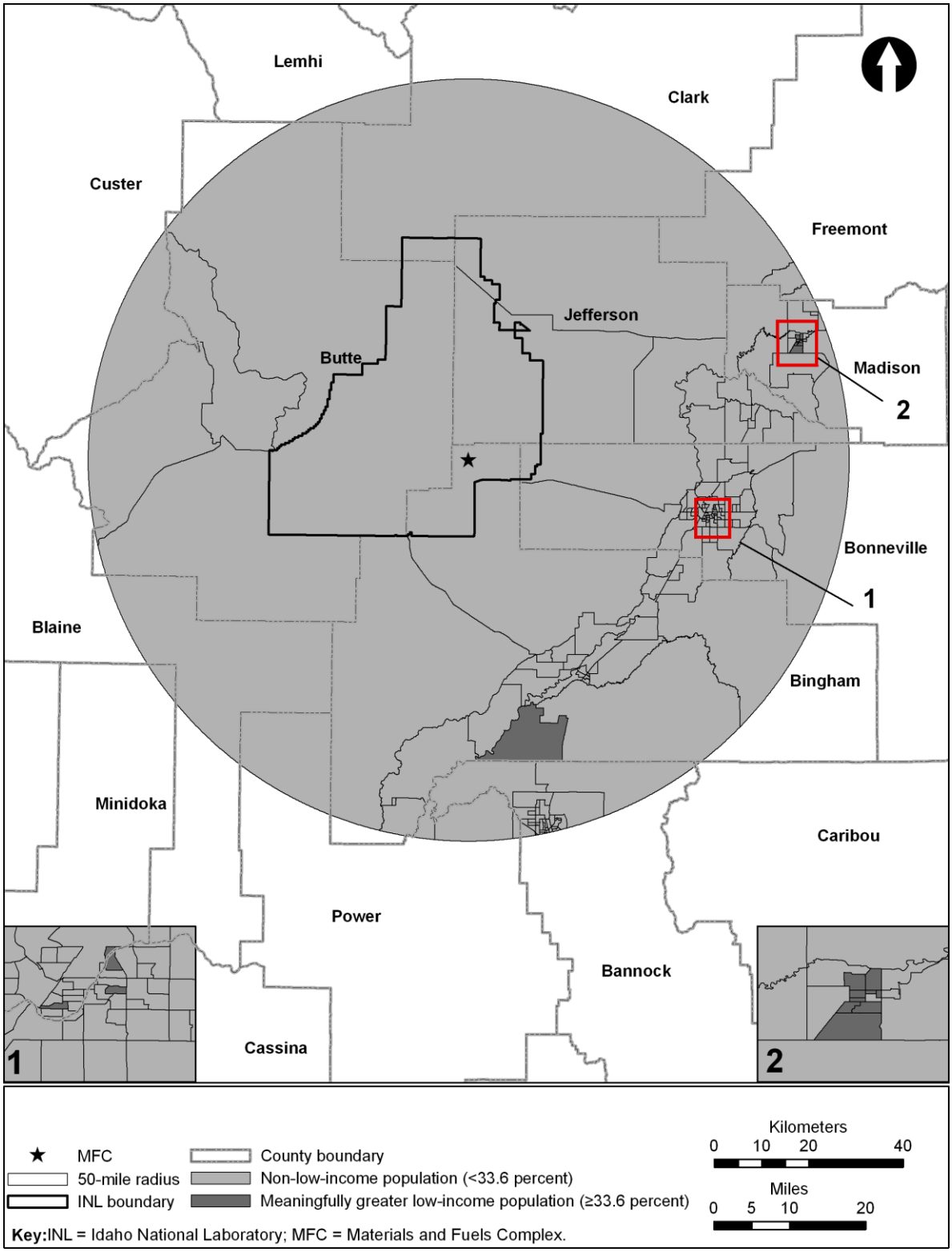


Figure 3–48. Meaningfully Greater Low-Income and Non-Low-Income Populations Living in Block Groups Surrounding the Materials and Fuels Complex at Idaho National Laboratory

3.3.12 Waste Management

The scope of the discussion of waste management in this *TC & WM EIS* is stipulated in Section 3.2.12.

3.3.12.1 Waste Inventories and Activities

INL manages the following types of waste: HLW, TRU waste, LLW, MLLW, hazardous waste, and nonhazardous waste. Because there is no HLW, TRU waste, or mixed TRU waste associated with the activities being assessed at INL under the action alternatives, these waste types are not discussed in this *TC & WM EIS*. Waste generation rates and the inventory of stored waste from activities at INL are provided in Table 3–54. INL waste management facilities are summarized in Table 3–55.

Table 3–54. Waste Generation Rates and Inventories at Idaho National Laboratory, 2006 (cubic meters)

Waste Type	Generation Rate	Inventory[a]
Transuranic[b]	185.77	51,530
Low-level radioactive	11,002	3,268
Mixed low-level radioactive	26,675	3,191
Hazardous[c]	320	88
Nonhazardous liquid[c]	78	25.81
Nonhazardous solid[c]	456	55.21

[a] Real volumes have been reported, but it must be noted that some waste streams are significantly larger due to the abatement of decontamination and decommissioning activities.

[b] Volumes include transuranic and mixed transuranic waste combined.

[c] Generally, such waste is not held in long-term storage.

Note: To convert cubic meters to cubic yards, multiply by 1.308.

Source: Willcox 2007.

3.3.12.1.1 Low-Level Radioactive Waste

Approximately 6,350 cubic meters (224,335 cubic feet) of legacy and newly generated LLW were disposed of at the Subsurface Disposal Area in 2008. The Subsurface Disposal Area is a 39-hectare (97-acre) disposal area at INL containing buried hazardous and radioactive waste (DOE 2009a:3.12, 3.16). In 2006, 11,002 cubic meters (388,525 cubic feet) of solid LLW was generated at INL (see Table 3–54).

Disposal of CH-LLW and open pit disposal of RH-LLW at the RWMC ceased September 30, 2008. The RH-LLW disposal vaults will remain open for the disposal of Naval Reactors RH-LLW through approximately the end of 2015 based on remaining disposal capacity. CH-LLW and RH-LLW previously disposed of in the open pit at RWMC will be disposed of at NNSS. INL is currently evaluating and pursuing options for uninterrupted RH-LLW disposal capability beyond 2015 (IDEQ 2000; INL 2008a).

Table 3–55. Waste Management Facilities at Idaho National Laboratory

Facility Name/Description	Facility Number	Process Design Capacity[a]	Status	Applicable Waste Types			
				TRU	LLW	MLLW	HAZ
Treatment Facility[a]							
NWCF Debris Treatment Process	CPP-659	60,020	Permitted			X	X
NWCF HEPA Filter Leach System	CPP-659	1,060	Permitted			X	X
Contaminated-Equipment Storage Building	MFC-794	56,780/Storage 1,666/Treatment	Permitted	X		X	X
Hot Fuel Examination Facility	MFC-785	40,598/Storage 1,666/Treatment	Permitted	X		X	X
Sodium Components Maintenance Shop	MFC-793	119,919/Storage 6,163/Treatment	Permitted			X	X
Transient Reactor Test Facility	MFC-720	26,649/Storage 1,666/Treatment	Permitted	X		X	X
Advanced Mixed Waste Treatment Project Waste Storage Facility	WMF-676	486,078	Permitted	X		X	
NWCF Storage	CPP-659	2,050,051 (containers) 791 cubic meters (waste pile)	Permitted			X	X
Radioactive Mixed Waste Staging Facility	CPP-1617	8,494,871	Permitted			X	X
SWEPP Storage Area	WMF-610	107,428/Storage 99,933/Treatment	Permitted	X	X	X	
Radioactive Scrap and Waste Facility	MFC-771	200,622	Permitted	X	X	X	X
Sodium Storage Building	MFC-703	181,696	Permitted			X	X
TSA Retrieval Enclosure Retrieval Modification Facility (includes the capacities for the TSA-1/TSA-R and TSA-2 storage units)	RWMC	16,810,415	Interim status	X		X	
Advanced Mixed Waste Treatment Project Waste Storage Facility	RWMC	76,791,396/Storage 99,933/Treatment	Permitted	X		X	
Fluorinel Dissolution Process Cell Container Storage	CPP-666	141,193	Permitted			X	X
Integrated Waste Treatment Unit	CPP-1696	640,766/Storage 19,078/Treatment	Permitted			X	
Sodium Process Facility Building	MFC-799	85,246/Storage 5,754/Treatment	Permitted			X	X
Experimental Breeder Reactor Complex	MFC	406,090/Storage 5.7 liters/day/tank	Permitted			X	

[a] Capacities expressed in liters unless otherwise noted.

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

Key: CPP=Chemical Processing Plant; HAZ=hazardous; HEPA=high-efficiency particulate air; LLW=low-level radioactive waste; MFC=Materials and Fuels Complex; MLLW=mixed low-level radioactive waste; NWCF=New Waste Calcining Facility; RWMC=Radioactive Waste Management Complex; SWEPP=Stored Waste Examination Pilot Plant; TRU=transuranic; TSA=Transuranic Storage Area; TSA-1=TSA Pad 1; TSA-2=TSA Pad 2; TSA-R=TSA Pad R; WMF=Waste Management Facility.

Source: INL 2008b.

3.3.12.1.2 Mixed Low-Level Radioactive Waste

MLLW and polychlorinated biphenyl–contaminated LLW are stored at several onsite areas. Such waste is stored at the Radioactive Mixed Waste Staging Facility at INTEC and the RWMC. Smaller quantities are stored in various other facilities at INL, including the Radioactive Sodium Storage Facility and Radioactive Scrap and Waste Facility at the MFC.

As part of the *Idaho National Laboratory Site Treatment Plan* (DOE 2007d), a required plan for developing treatment capacities and technologies for each facility at which DOE generates or stores mixed waste, pursuant to RCRA, Section 3021(b), as amended by Section 105(b) of the Federal Facility Compliance Act, preferred options for treatment to eliminate the hazardous waste component of many types of MLLW have been identified. MLLW is or will be processed to RCRA land-disposal-restriction treatment standards through several treatment facilities. The specific facilities and their operational status are as follows: AMWTP, operational; debris treatment, operational; high-efficiency particulate air filter leaching, operational as needed; remote-handled waste disposition project, planned/DOE approved; Sodium Processing Facility, in standby; and Sodium Component Maintenance Shop, operational. Commercial treatment facilities are also being considered, as appropriate. Currently, INL ships MLLW for treatment to the following Perma-Fix Environmental Services, Inc., treatment facilities: Perma-Fix Florida, Gainesville, Florida; Material & Energy Corporation and Diversified Scientific Services, Inc., Kingston, Tennessee; and Perma-Fix Northwest, Richland, Washington. Waste treated at these facilities is currently sent to NNSS for disposal. A limited amount of MLLW is treated and disposed of at EnergySolutions of Utah.

The AMWTP characterizes and then sorts, sizes, repackages, and compacts mixed TRU waste. If during characterization, a retrieved container is assayed as not meeting the definition of TRU waste, it is determined to be mixed low-level waste. The overall goal of the AMWTP is to prepare TRU waste now buried or stored at INL for shipment to WIPP, a permanent geologic repository near Carlsbad, New Mexico. The facility will treat waste to meet the most current requirements; reduce waste volumes and life-cycle costs to DOE; and perform all tasks in a safe, environmentally compliant manner.

A contract for treatment services was awarded to British Nuclear Fuels Limited, Inc., in December 1996. British Nuclear Fuels Limited, Inc., completed construction of the AMWTP in December 2002, fulfilling a TPA milestone. AMWTP retrieval operations commenced in March 2003, and treatment facility operations commenced in August 2004. The British Nuclear Fuels Limited, Inc., contract was terminated effective April 30, 2005, and Bechtel BWXT Idaho, LLC, assumed operation of the AMWTP on May 1, 2005. Certification of the treatment facility was obtained in May 2005, allowing for certification of treated TRU waste and shipment thereof to WIPP. Treated TRU waste was first shipped from the AMWTP to WIPP on May 31, 2005.

In 2006 approximately 26,675 cubic meters (942,028 cubic feet) of MLLW was inventoried at INL. In addition to this waste, approximately 3,191 cubic meters (112,690 cubic feet) of MLLW was generated in 2006 (see Table 3–54) (Willcox 2007). DOE assumes that new facilities would be constructed if additional MLLW treatment and disposal capacity were needed (DOE 2002a).

3.3.12.1.3 Hazardous Waste

Approximately 1 percent of the total waste generated at INL (not including liquid nonhazardous waste) is hazardous waste. The average hazardous waste generation rate for the 5-year period 2000 through 2004 was approximately 420 cubic meters (14,830 cubic feet) per year (DOE 2005b). The waste generator normally holds hazardous waste in a temporary accumulation area (not identified as a "treatment facility" in Table 3–55) until it is shipped directly to the offsite commercial treatment facility. Most of the hazardous waste generated annually at INL is transported off site for treatment and disposal. Offsite shipments are surveyed to determine that the waste has no radiological content—i.e., it is not

mixed waste. Highly reactive or unstable materials such as waste explosives are addressed case by case and managed on or off site consistent with regulatory requirements.

The operation of the AMWTP and the steam reforming technology for processing mixed TRU/sodium-bearing waste at INTEC would increase this generation rate minimally—i.e., less than 1 percent (DOE 1999c, 2002a).

3.3.12.1.4 Nonhazardous Waste

Approximately 90 percent of the solid waste generated at INL is classified as industrial waste and is disposed of on site in a landfill complex in the Central Facilities Area or off site at the Bonneville County landfill. The onsite landfill complex contains separate areas for petroleum-contaminated media, industrial waste, and asbestos waste. The landfill covers 4.9 hectares (12 acres) and is being expanded by 91 hectares (225 acres) to provide capacity for at least 30 years. The average annual volume of waste disposed of from 2000 through 2004 was approximately 40,000 cubic meters (1.41 million cubic feet) (DOE 2005b).

Sewage is disposed of in surface impoundments. Wastewater in the impoundments is allowed to evaporate, and the resulting sludge is placed in the landfill. Solids are separated and reclaimed where possible.

3.3.12.2 Waste Minimization

DOE-ID has an active waste minimization and pollution prevention program to reduce the total amount of waste generated and disposed of at INL. Waste is eliminated through source reduction or material substitution; the recycling of potential waste materials that cannot be minimized or eliminated; and the treatment of all waste generated to reduce its volume, toxicity, or mobility prior to storage or disposal. DOE-ID published its first *Waste Minimization Plan* in 1990, defining specific goals, methodologies, responsibilities, and achievements of programs and organizations. The mission of the waste minimization and pollution prevention program is to reduce, reuse, and recycle wastes generated and pollutants by implementing cost-effective pollution prevention techniques, practices, and policies. Pollution prevention is required by various Federal statutes, including, but not limited to, the Pollution Prevention Act, RCRA, and Executive Order 13423. Pollution prevention is one of the key underpinnings of the INL Site Environmental Management System. It functions as an important preventive mechanism because generating less waste reduces waste management costs, compliance vulnerabilities, and the potential for releases to the environment. INL is promoting the inclusion of pollution prevention into all planning activities, as well as the concept that pollution prevention is integral to mission accomplishment (DOE 2007c).

3.3.12.3 *WM PEIS* Records of Decision

The *WM PEIS* RODs affecting INL are shown in Table 3–56. Decisions on the various waste types were announced in a series of RODs following publication of the *WM PEIS* (DOE 1997b). The hazardous waste ROD (63 FR 41810) was published on August 5, 1998, and the LLW and MLLW ROD (65 FR 10061) was published on February 25, 2000. The LLW and MLLW ROD states that, for the management of LLW, minimal treatment will be performed at all sites and onsite disposal will continue to the extent practicable at INL, Los Alamos National Laboratory, ORR, and SRS. In addition, Hanford and NNSS will be available to all DOE sites for LLW disposal. MLLW will be treated at Hanford, INL, ORR, and SRS and disposed of at Hanford and NNSS. The hazardous waste ROD states that most DOE sites will continue to use offsite facilities for treatment and disposal of major portions of their nonwastewater hazardous waste, and ORR and SRS will continue treating some of their own nonwastewater hazardous waste on site in existing facilities, where this is economically feasible. More-detailed information concerning DOE's decisions for the future configuration of waste management facilities at INL is presented in the hazardous waste and LLW and MLLW RODs.

Table 3–56. *WM PEIS* Records of Decision Affecting Idaho National Laboratory

Waste Type	Preferred Action
LLW	DOE has decided to treat and dispose of INL's LLW on and off site.[a]
MLLW	DOE has decided to regionalize treatment of MLLW at INL. This includes the onsite treatment of INL's waste and could include treatment of some MLLW generated at other sites.[a]
Hazardous	DOE has decided to continue to use commercial facilities for treatment of INL nonwastewater hazardous waste. DOE will also continue to use onsite facilities for wastewater hazardous waste.[b]

[a] 65 FR 10061.

[b] 63 FR 41810.

Key: DOE=U.S. Department of Energy; INL=Idaho National Laboratory; LLW=low-level radioactive waste; MLLW=mixed low-level radioactive waste; *WM PEIS=Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*.

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