4.7 METEOROLOGY

Situated between the Pacific Coast and warmer inland valleys, the Livermore area experiences climatic conditions that are dominated by the differential heating between these land and water surfaces and local undulating terrain. In summer, cold water welling up along the coast and hot inland temperatures cause a strong onshore pressure gradient. Together with the semi-permanent high-pressure area centered over the northeastern Pacific Ocean, summers are characterized by plentiful clear skies, negligible precipitation, and strong, afternoon winds. By winter, the inflow of maritime air is not as prevalent because the differential heating between the coast and inland valleys is less pronounced. High pressure along the coast weakens and shifts southward, allowing winter storms to frequent the area.

Further detail on temperature, precipitation, winds, and storm events is provided below. Much of the information is gleaned from long-term records compiled by the National Weather Service from its recording station in the city of Livermore and two locations (Tracy Carbona and Tracy Pumping Plant) within the nearby city of Tracy. These long-term profiles are supplemented with data collected onsite. Meteorological data (including wind speed, wind direction, rainfall, humidity, solar radiation, and air temperature) are continuously gathered onsite at the Livermore Site and at Site 300. Onsite monitoring programs are discussed in detail in the LLNL Site Annual Environmental Report (SAER), which is published annually, and some data have been extracted from recent reports.

4.7.1 Temperature

Average daily maximum and minimum temperature plots for National Weather Service stations at Livermore and Tracy are provided in Figure 4.7.1–1. Although the area is some distance from the coast, summer temperatures are moderated to a degree by an inflow of cooler marine air to replace the rising warm air in the San Joaquin Valley. In the Livermore Valley, the daily temperature ranges from a low of 55 degrees Fahrenheit (°F) in the early morning to almost 90°F by late afternoon. Afternoon temperatures in the summer at Site 300 are typically about 10°F warmer than the Livermore Site.

Temperatures begin to drop noticeably in October. Average daily highs and lows are approximately 6 degrees lower than in the summer months, and continue to drop by another 10 degrees in November, and almost 7 degrees more in December. Average daily low and high temperatures range from 37°F to 57°F during the winter months at Livermore. Temperatures at Tracy are a couple of degrees cooler, typically ranging from 35°F to 55°F. As spring approaches, temperatures begin to increase by about 4°F per month, beginning as early as February, until reaching peak temperatures in July.

4.7.2 Precipitation

Annual rainfall is typically 10 to 15 inches within the Livermore Valley, and about 8 to 13 inches closer to Site 300. However, fluctuations from year to year may produce rainfall totals ranging from 8 to 32 inches. About 80 percent of the annual rainfall occurs during November through March, and, although temperatures can drop below freezing, measurable snowfall is extremely rare, as is hail. Summer months are quite dry; it is not uncommon to go for months without more than a few tenths of an inch of precipitation. Summer thunderstorms are infrequent, occurring fewer than 10 days per year, and are not intense.

Average monthly rainfall totals collected and compiled by the National Climatic Data Center for both Livermore and Tracy are shown in Figure 4.7.1–1. Measurements from onsite monitoring programs show very similar totals. Annual and maximum hourly precipitation rates measured onsite at the Livermore Site and Site 300 from 1997 through 2002 are provided in Table 4.7.2–1.

TABLE 4.7.2–1.—*Annual and Maximum Hourly Precipitation Rates, 1997-2002*

	Total Annual Rainfall (inches)						6-Year Average
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	
Livermore Site	9.8	20.6	9.6	11.6	13.4	10.7	12.6
Site 300	7.6	18.7	7.8	10.0	9.7	8.7	10.4
	Maximum Hourly Rainfall (inches)						**6-Year Maximum**
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	
Livermore Site	0.33	0.34	0.31	0.27	0.33	0.47	0.47
Site 300	0.28	0.66	0.34	0.32	0.38	0.41	0.66

Sources: LLNL 2002bx, 2002ci, and 2003am.

4.7.3 Winds

Winds are often characterized in terms of a joint frequency distribution, which provides the frequency of occurrence in percent of wind speeds (using wind speed classes) and wind directions (direction from which the wind is blowing). These data are often depicted graphically as a wind rose. Seasonal and annual wind roses for the Livermore Site and Site 300 are provided in Figures 4.7.3–1 and 4.7.3–2, respectively.

Data collected at the Livermore Site show a predominant southwest to westerly wind flow (direction from). This prevailing pattern occurs about 50 percent of the time. On average, highest wind speeds occur in conjunction with the westerly sea breezes during spring and summer. In winter and fall, winds are typically lighter, but very strong winds can accompany winter storm events. Peak winds associated with storms are generally from the south in advance of storms and from the north after storm passage. Wind direction is more varied in winter, although there is a tendency for winds from the southwest, and a relatively strong northeast component associated with frequent high pressure over the Great Basin and cold air spilling out of the San Joaquin Valley. Further east, the undulating terrain near Site 300 exerts a more pronounced influence on local wind patterns. Winds are more consistently from the west-southwest, and wind speeds are generally higher than those measured at the Livermore Site. Local slope flows (up during day and down during night) occur during periods of fair skies and light, large-scale winds.

4.7.4 Storm Events

The Livermore Site and Site 300 environs rarely experience severe weather. A database search of severe storm events, as compiled by the National Climatic Data Center (NCDC) for the period January 1950 through February 2003, is provided in Table 4.7.4–1.

TABLE 4.7.4–1.—*Regional Storm Events*

Storm Event Listing for Areas near LLNL Facilities[a]		
Location	**Date**	**Comments**
Tracy	February 2, 1993	Dense fog on Highway 33 led to a fatal traffic accident.
Livermore	April 25, 1994	Small tornado (Category F0 – speeds of 40 – 72 mph) skipped across a residential housing development, causing minor damage.
3 miles east of Tracy	May 17, 1994	Funnel cloud reported.
South of Livermore	May 17, 1994	Funnel cloud reported.
Pleasanton	November 17, 1996	Flash flood - After nearly 3 inches of rain in the fairly arid hills of Alameda County, a series of levees were breached.
Tracy	January 10, 1997	Flash flood - levee breached
Livermore	February 3, 1998	Flash flood - levee breached
8 miles southeast of Tracy	March 28, 1998	Small and brief tornado (Category F0 – speeds of 40 – 72 mph) ripped up 60 feet of fence on one home lot.
2 miles northwest of Tracy	May 5, 1998	Two funnel clouds reported from one thunderstorm.
Livermore	November 6 – 9, 2002	A very strong weather system affected Alameda, San Francisco, and Sonoma counties for a 3-day period. High winds, to 115 mph maximum, were reported (unspecified location). Rainfall totaling 2 – 5 inches fell across the North Bay counties; 2.90 inches (storm total) were reported for Livermore Airport.

Additional Storm Events with Unspecified or County-wide Locations			
County	**No. of Events**	**Event Type**	**Comments**
Alameda	1	Excessive heat	
San Joaquin	5	Excessive heat	
San Joaquin	5	Fog	
San Joaquin	6	Flood	
San Joaquin	3	Heavy rain	
Alameda	2	Heavy rain, high winds	The November 6 – 9, 2002, weather event affecting Alameda, San Francisco, and Sonoma counties is described above.
San Joaquin	26	High winds	44 – 78 mph
San Joaquin	5	Thunderstorm wind	58 mph, 71 mph
Alameda	13	High winds	69 – 112 mph
Alameda	2	Tornado	Category F0 – speeds of 40 – 72 mph
San Joaquin	6	Tornado	Category F0 – speeds of 40 – 72 mph
San Joaquin	2	Tornado	Category F1 – speeds of 73 – 112 mph
San Joaquin	2	Tornado	Category not specified

TABLE 4.7.4–1.—*Regional Storm Events (continued)*

Additional Storm Events with Unspecified or County-wide Locations			
County	**No. of Events**	**Event Type**	**Comments**
Alameda	1	Heavy snow	
Alameda	5	Winter storm, high winds	
San Joaquin	1	Winter storm	
San Joaquin	4	Extreme cold	

Source: NCDC 2002b.
[a] The NCDC Storm Event database, http://www.ncdc.noaa.gov/oa/climate/linktoed.html, contains data from the following sources: all weather events from 1993, as entered into storm data, plus additional data from the Storm Prediction Center, including tornadoes 1950 – 1992, thunderstorm winds 1955 – 1992, and hail 1955 – 1992. The events listed above include all reported events in the local areas, from January 1, 1950 through February 28, 2003, as available on the website accessed July 6, 2003.
LLNL = Lawrence Livermore National Laboratory; mph = miles per hour; NCDC = National Climatic Data Center.

4.7.5 Dispersion Meteorology and Atmospheric Pollution Potential

A combination of topographic and climatologic factors affects the atmosphere's ability to mix and disperse air pollutants. This ability is limited under certain conditions. The Bay Area Air Quality Management District (BAAQMD) has evaluated past high air pollutant episodes and determined the mix of conditions most conducive to pollutant buildup in the air basin. By looking for these conditions, BAAQMD is able to predict periodic episodes, and preemptive actions are taken to limit pollutant loading during such periods. The primary atmospheric processes that tend to concentrate pollutants are discussed below. Air pollutants and potential health impacts are further discussed in Section 4.10.

Inversions and Pollutant Trapping

Inversions often form on clear, calm winter nights through radiation cooling of air in contact with the earth's cold surface. When cool air near the earth's surface is trapped by warmer air above, vertical mixing is limited and air contaminants are not effectively dispersed. In such cases, as more pollutants are emitted but not dispersed, the total loading (pollutant level per volume of air) is increased. Low wind speeds also limit dilution, and the Livermore Valley is characterized by a high frequency of light winds due to the sheltering effect of surrounding terrain. Light winds occur most frequently during nighttime and early morning hours of fall and winter, which further enhances the radiation inversion.

There are frequent winter dry periods lasting over a week. These are particularly conducive to concentrating pollutants emitted close to the ground, such as carbon monoxide from auto exhaust. In contrast, during winter rainy periods, inversions are weak or nonexistent, winds are often moderate, ventilation and vertical mixing are usually high, and consequently air pollution potential is very low.

Inversions can also form under high pressure, through compression warming of sinking air. These subsidence inversions occur most frequently during summer under the dominance of the Pacific Coast high-pressure cell. When the inversion is strong, the air beneath the inversion is decoupled from the larger scale system. Dilution is then limited, and locally high pollutant buildup can occur if stagnation is prolonged.

Although prevalent during certain seasons, both inversion mechanisms may operate at any time of the year. At times, surface inversions formed by radiation cooling may reinforce the subsidence inversion aloft, particularly in fall and winter. The thick, strong inversion resulting in this case is especially effective in trapping pollutants (BAAQMD 1999).

Sheltering Terrain and Dispersion

In addition to supporting the formation of inversions, the sheltering terrain around the Livermore Valley reduces the amount of vertical exchange between air in the basin and the larger scale synoptic flow. The surrounding hills also restrict horizontal wind flow and dilution. This is more problematic when the thermal gradient between inland desert and coastal areas is less pronounced, allowing the air in sheltered valleys to become relatively stagnant. Air pollutants in the air mass can accumulate as they pass back and forth across valley areas under the typical up-valley daytime and down-valley nighttime flow regimes.

Solar Radiation and Photochemical Pollutant Buildup

Ozone is formed in the atmosphere through a number of complex photochemical reactions that take place over several hours. Because of the required formation time, more distant, upwind pollutant sources, rather than local sources, are responsible for ozone in the Livermore Valley. The primary reactants are hydrocarbons and oxides of nitrogen, key components of automobile exhaust. These are emitted during morning commute hours and transported inland as the sea breeze begins to develop. Ideal conditions for ozone formation occur in summer and early fall, with high temperatures and intense ultraviolet light. Ozone begins to break down during late afternoon, as the intensity of the sunlight decreases (BAAQMD 1999).

4.8 GEOLOGY AND SOILS

This section provides an overview of the affected physical environment, including discussions of the local and regional geologic setting, stratigraphy (rock and sediment types), soils, economic geology, structural geology, and geological hazards (including seismicity). A discussion of existing contamination in the soils at the sites is included in Section 4.17.

4.8.1 General Geology

The general understanding of geology for LLNL has not changed to any great degree from that presented in the 1992 LLNL EIS/EIR (LLNL 1992a).

Topography and Geomorphology

The Livermore Site and Site 300 are located in the California Coast Ranges geologic province (Dibblee 1980a, 1980b), which is characterized by low rugged mountains and relatively narrow intervening valleys. Figures 4.2.1.1–1 and 4.2.1.2–1 show the locations of the Livermore Site and Site 300 relative to the surrounding area, respectively.

Livermore Site

The Livermore Site is located in the southeastern portion of the Livermore Valley. The valley forms an irregularly shaped lowland area about 16 miles long east-to-west and 7 to 10 miles wide north-to-south. The floor of the valley slopes to the west at about 20 feet per mile.

The Livermore Site slopes gently to the north-northwest at an inclination of less than 1 degree (USDA 1966). The Livermore Site property ranges in elevation from 676 feet in the southeast corner to 571 feet in the northwest corner. Hills border the Livermore Site to the east and south.

Site 300

Site 300 is located in the Altamont Hills near the western boundary of San Joaquin County. The site occupies approximately 7,000 acres of steep ridges and canyons with a decrease in elevation toward the southeast. Slopes vary greatly in the canyons and can exceed 45 degrees in places. The slopes are much gentler in the GSA, located in the southeastern portion of the site and can be as low as 2 or 3 degrees (USDA 1990). The maximum elevations onsite are found in the northwest portions of Site 300 and range from 1,476 feet to 1,722 feet above mean sea level. The lowest elevation onsite, where Corral Hollow Creek follows the Site 300 southern boundary, is approximately 500 feet above mean sea level.

Structural Geology

A generalized map of the regional structural geology of the San Francisco Bay Area is presented in Figure 4.8.1–1. The Livermore Site is located near the boundary between the North American and Pacific tectonic plates, and the structural geology of the area is characterized by the San Andreas Fault system, which trends northwest southeast.

The Diablo Range, which includes the Altamont Hills, is part of the northwest-trending Coast Ranges, and parallels three major faults in the area (Nilsen 1977, Atwater 1970): the San Andreas Fault system, the Sur-Nacimiento Fault, and the Coast Range thrust fault system. The Sur-Nacimiento Fault and the Coast Range thrust are not exposed in the area shown in Figure 4.8.1–1. These faults can generally be considered to define three different lithologic blocks (Page 1966). The westernmost block, or Salinian Block, lies west of the San Andreas Fault

(Figure 4.8.1–1) and consists primarily of mixed metamorphic and intrusive igneous granitic rocks. East of the Salinian Block, between the San Andreas and the Coast Range thrust fault zones, lies the Franciscan Assemblage composed of marine sedimentary and volcanic rocks. Rocks positioned above the Coast Range thrust fault zone consist of late Mesozoic to late Tertiary marine sediments which overlie structurally complex rocks of continental and oceanic origins. This block lies primarily along the eastern margin of the Coast Range Province. Structural relationships along the Coast Range thrust are complex due to later reactivation of the structure by high-angle normal and strike-slip faulting.

The Hayward Fault, which is part of the San Andreas Fault system, forms the western boundary of the East Bay Hills and is located about 17 miles west of the Livermore Site. An additional element of the San Andreas Fault system, the Calaveras Fault zone, trends northwest southeast through the San Ramon Valley which borders the Livermore Valley to the west. A major structural feature north of the Livermore Valley is the Mount Diablo Complex, a deformed package of rock in the vicinity of Mount Diablo and the surrounding hills (Page 1966). This complex is bordered on the northeastern edge by the Green Valley-Clayton Fault system. The Suisun Bay is to the north and the Livermore Valley is to the southeast flank of the Diablo Complex. As depicted in Figure 4.8.1–2, the two regional structural features located closest to the Livermore Site are the Greenville and Las Positas fault zones.

A geologic map showing folds and faults mapped in the vicinity of the Livermore Site is presented in Figure 4.8.1–3. More detailed discussions of faulting in the Livermore area are presented in Section 4.8.3 and Appendix H.

Stratigraphy

Geologic maps outlining the distribution of geologic materials outcropping in the vicinity of the Livermore Site and Site 300 are shown in Figure 4.8.1–3 and Figure 4.8.1–4, respectively. The distribution of rock types mapped at Site 300 is shown in Figure 4.8.1–4. The Diablo Range consists primarily of metamorphic and igneous rocks known as the Mesozoic Franciscan Assemblage (Dibblee 1980a, 1980b). These formations extend to, and in places are overlain by, oceanic crustal and marine sedimentary rocks from late Mesozoic and late Tertiary ages (CDMG 1964).

Figure 4.8.1–5 presents a schematic stratigraphic column of geologic units outcropping at the Livermore Site and Site 300.

The Franciscan Assemblage generally contains graywacke, metagraywacke, shale, argillite, blueschist, and greenstone, with minor limestones, cherts, and assorted igneous rocks. Deformed igneous rocks, such as gneiss, are present throughout the Franciscan Assemblage in laterally discontinuous exposures.

Overlying the Franciscan Assemblage are sedimentary rocks known as the Great Valley Sequence, which consists of layers that are somewhat deformed (Ingersoll 1981). The Great Valley Sequence is thought to have formed during the late Mesozoic within a basin resting between the Sierra Nevada, which was then the location of a volcanic island-arc, and a trench to the west (Page 1981, Atwater 1970). Outcrops of the Great Valley Sequence are seen in the Altamont Hills east of Livermore and especially along the eastern edge of the Coast Ranges. The Franciscan Assemblage is thought to have been formed as an accretionary wedge of trench sediments that were thrust beneath the western edge of the Great Valley Sequence deposits (Hamilton 1969, Ernst 1970, Hsu 1971). The contact between the Great Valley Sequence and the Franciscan Assemblage is defined by the Coast Range thrust which outcrops along the eastern margin of the Coast Ranges.

Livermore Site

The rocks underlying the Livermore Site are late Tertiary and Quaternary age sediments comprising the Livermore Formation (Figure 4.8.1–5) (Carpenter et al. 1984, Huey 1948) which has a maximum thickness of approximately 4,000 feet. This formation has been divided into Upper and Lower Members (Huey 1948, Thorpe et al. 1990). Massive gravel beds mixed with sand, silt, and clay characterize the Upper Member. The Lower Member is dominated by greenish- to bluish-grey silt and clay, with lenses of gravel and sand (Huey 1948, Thorpe et al. 1990). For additional information on the local stratigraphic units and hydrogeology at the Livermore Site (see Section 4.11.3.2).

Site 300

Sedimentary rocks at Site 300 are generally older than the alluvial sediments that underlie the Livermore Site in the eastern Livermore Valley. This hilly terrain contains sedimentary units that dip 5 degrees or more to the east and southeast. Some older formations, including the Upper Cretaceous Panoche Formation, are exposed in limited areas of the northwest and northeast corners of the site. A majority of the exposed strata onsite are of Tertiary age, including the Miocene Cierbo and Neroly Formations. The Miocene Neroly Formation is exposed over the greatest areal extent of all sedimentary units onsite. Nonmarine sedimentary rocks of Pliocene age occupy a similar position in the local stratigraphy (see Figure 4.8.1–5) and possibly formed simultaneously with the lower portion Livermore Formation rocks in the Livermore Valley. Additionally, younger Quaternary alluvial landslide deposits are present onsite in limited areas. Additional information on the local Site 300 stratigraphy and hydrogeology is presented in Section 4.11.3.2.

Soils

Soil properties and extent are important factors in evaluating potential transport of contaminants. A discussion of the distribution of soil and sediment contamination at the Livermore Site is presented in Section 4.17. Hazardous materials, if sorbed to surficial soil, could leave the Livermore Site and Site 300 as components of airborne dust particles or be transported by surface water flow. Soil properties, especially infiltration capacity, govern the transport of

hazardous material to the saturated zone. For example, the infiltration rates in the LLNL retention basin, located in the center of the Livermore Site, varied from 0.01 foot per day near the center, where a silt layer had been deposited on the basin floor, to 1.9 feet per day in the banks of the basin (Toney 1990). Based on percolation and whole-trench tests, reported surface infiltration rates in the recharge basin south of the Livermore Site range from 0.24 to 10 feet per day, depending on lithology (LLNL 1998b). The U.S. Department of Agriculture estimated the permeability for undisturbed soils covering the central and eastern areas of the Livermore Site at approximately 0.4 to 1.6 feet per day. Most Livermore Site soil, excepting parts of the western and northern areas, has been paved over, compacted, or reworked for landscaping, thus lowering its natural permeability.

Livermore Site

A generalized soil map of the Livermore area is shown in Figure 4.8.1–6. The soils in the Livermore Valley beneath the Livermore Site are formed primarily upon sediments deposited by local streams. Most of the deposits in the eastern part of the valley are relatively young, and thus, the soils are only moderately developed. These soils, generally loam, have minimal horizon or development of layers and can be locally several meters thick. The soils are used for crop production when provided with sufficient water and nutrients or minerals (Brady 1990, USDA 1966). Four soils cover most of the Livermore Site vicinity. In order of decreasing extent, they are Rincon loam, Zamora silty clay loam, San Ysidro loam, and Yollo gravelly loam. These soils are primarily Alfisols, or moderately developed soils, and grade into Mollisols, which are grassland soils (Brady 1990).

Site 300

A generalized map of Site 300 soils is provided in Figure 4.8.1–7. Site 300 soils have developed on marine shales and sandstones, uplifted river terraces, and fluvial deposits. They are classified as loamy Entisols. Entisols are young soils that have little or no horizon development. Clay-rich soils, known as Vertisols, are also present and have been mapped as the Alo-Vaquero Complex. Vertisols are mineral soils characterized by high clay content that display shrink/swell capability. The remaining soil types identified at Site 300 occur only in limited areas. These units are mixtures of the soils described and are not readily separable, including grassland Mollisols, or are poorly developed Inceptisols (USDA 1966, 1990). The Wisfiat-Arburnia-San Timoteo Complex soils cover most of Site 300, differing slightly depending upon slope. The Alo-Vaquero Complex and Vaquero-Carnoa Complex soils cover most of the rest the site. All Site 300 soil types are potentially useful for limited agriculture but are constrained by location and steepness of the slopes. The loamy soils easily erode, and vegetation can be churned into the soil by moderate livestock or other traffic during wet periods. Vertisols exhibit low permeability and are subject to moderate erosion. Wildlife habitat and limited grazing by livestock are the best uses of these soils.

4.8.2 Geologic Resources

The geologic resources found on or near the Livermore Site and Site 300 include aggregate deposits, mineral deposits, fossil occurrences, and petroleum. These resources are described below.

Aggregate Deposits

The present and potential stone and aggregate resources of the eastern Livermore Valley and western San Joaquin County were assessed in 1987 and 1988 (CDMG 1987, 1988). Mineral Resource Zones have been established that identify sand, gravel, and stone source areas. Most of the Livermore Valley floor south of I-580 has been classified as an area of significant mineral resources. The areas north of I-580 and within and immediately surrounding the Livermore Site are classified as having no significant mineral deposits or areas where information is inadequate to indicate the presence of significant mineral resources (City of Livermore and LSA 2002). Several deposits within the eastern Livermore Valley have been identified as recoverable and marketable resources. Land that is currently developed for urban areas, industry, or research, including the Livermore Site, was not included in these inventories. The estimated gravel resource for the eastern Livermore Valley, western San Joaquin County, and vicinity is 570 million tons with 242 million tons of reserves. Several gravel quarries have operated in the Livermore-Pleasanton Valley, west of the city of Livermore. Large reserves and resources of gravel are described for the area of western San Joaquin County, south of Tracy (CDMG 1988); this area contains at least one large-scale gravel quarry. No sand or gravel resources have been assessed within the drainage basin of Corral Hollow Creek; i.e., Corral Hollow and Site 300 (CDMG 1988).

Mineral Resources

Clay, coal, and silica are the three types of mineral resources that have been mined or have the potential to be mined in the vicinity of the Livermore Site and Site 300 (CDMG 1950). Clays found in this region have been used for brick, sewer pipe, and roofing tile. Substantial clay deposits are associated with outcrops of the Eocene Tesla Formation near the old settlement of Tesla in Corral Hollow, and some clay has been excavated from the perimeter of the Livermore Valley (CDMG 1950). The clay beds near Tesla were mined from 1897 to 1912. Extensive clay deposits still remain, but the need for and cost of subsurface mining prevents the economic exploitation of these deposits (CDMG 1957).

Lignite coal was discovered near the settlement of Tesla before 1857. This coal was often found layered with clay in the Tesla Formation and was mined between 1897 and 1902. More than 70,000 tons per year of lignite coal were produced during that time (CDMG 1950). Silica was mined in an unspecified location in the hills north and west of Corral Hollow from high silica Tesla Formation sandstone. The extent of this resource is presently unknown. Silica was mined only intermittently for use in manufacturing machine parts and for furnace linings (CDMG 1950).

Several occurrences of other potentially economically valuable mineral deposits are within a 10-mile radius of the Livermore Site. These include deposits of manganese, chromium, clay, gemstones, pyrite, dimension stone, sand and gravel, and natural gas. Past production statistics and the current development status of these mineral resources are unknown. No commercially

exploitable mineral deposits are known to exist within the boundaries of the Livermore Site and Site 300.

Fossil Occurrences

Fossils in the eastern Livermore Valley and the hills to the east are principally found in unconsolidated and poorly consolidated Cenozoic deposits. The primary fossil-bearing units are the Miocene Neroly and Cierbo Formations (Figure 4.8.1–5), and some younger units of the Pleistocene age (Hansen 1991). Four late Pleistocene vertebrate fossils were discovered in the peripheral parts of the excavation for the NIF: two of the locations yielded fragmentary remains of Equus or horse, the third location included remains of proboscidean or elephant order, probably Mammuthus or mammoth, and the fourth location yielded remains of Columbian Mammoth or *Mammuthus columbi*. The geologic unit in which all four localities occur is a geographically restricted fluvial valley fill deposit (Hansen 2000). The fossil localities were found 20 to 30 feet below the present surface.

Livermore Site

The only vertebrate fossil deposits in the vicinity of the Livermore Site, other than those from the NIF excavation mentioned above, are in the Quaternary deposits of the surrounding low hills of the east Livermore Valley. These fossils are few in number and quite scattered. They have been tentatively identified as Pleistocene age, specifically Rancho La Brean and Blancan, and consist of bone fragments of the mammoth and giant sloth (Hansen 1991). Invertebrate shells and leaf and stem fossils have also been found. These appear to be randomly dispersed, mainly within the Neroly Formation. No invertebrate or botanical fossil deposits of significance are believed to be present in the eastern Livermore Valley (Hansen 1991).

Site 300

Several vertebrate fossil deposits have been found on Site 300 and in the vicinity of Corral Hollow. Most finds have been a result of road improvement or erosion along stream banks. Nearly all bone fragments found are considered to be Miocene age, specifically Clarendonian, and are scattered within the Neroly Formation. An assortment of mammalian groups is represented: camelids, mastodon, assorted early horses, shrews, beavers, and squirrels. Fossil finds are generally widely scattered, and none consist of more than one or a few fragments of bone. The eroded terraces of exposed Neroly Formation rocks on the south side of Corral Hollow Creek adjacent to Site 300 are the only locations where numerous fragments have been recovered (Hansen 1991).

Gravels from the Franciscan Assemblage are known to contain Icthyosaurus fossils, but no fossil locales have been mapped (CDMG 1964). An occasional vertebrate bone fragment has been found within Site 300. In May 1991, numerous fossil bones and bone fragments were found on the fire trail and road improvement areas along the ridge south of Building 827. The locale is protected from disturbances caused by LLNL operations. The fossils are within the Neroly Formation and were tentatively identified as mastodon, horse, and an extinct predator. Invertebrate shells, primarily oysters, have been recovered from the Cierbo Formation. Stem and leaf fossils are found in many places within the finer-grained sediments of the Lower Neroly Formation. The fossils are generally scattered, and no significant invertebrate or botanical fossil locales have been identified on Site 300 or in the surrounding area (Hansen 1991).

Petroleum Production

The Livermore oil field, just east of the Livermore Site, was discovered in 1967 and is the only oil field in the Livermore-San Ramon Valley area to date (California Division of Oil and Gas 1982). The Livermore oil field was originally operated by the Hershey Corporation and consisted of 10 producing wells. These wells are located east of the northeastern corner of the Livermore Site. Production is primarily from Miocene Cierbo Formation sandstones from depths of 900 to 2,000 feet. The XL Operating Company of Fort Worth, Texas, now operates the Livermore oil field. Four of the original 10 wells are still producing an average of 40 barrels of oil per day, 1 well has been plugged and abandoned, 4 wells have been shut in, and 1 well is used for water injection (Blake 2003). Reserves are thought to be only about 200,000 barrels and production is declining (California Division of Oil and Gas 2003). No oil or gas exploration is being conducted in the hills to the east of the Livermore Site (Reid 1991).

4.8.3 Geologic Hazards

Seismicity of the Livermore Site

The LLNL Site Seismic Safety Program recently performed a new assessment of the geologic hazards at the Livermore Site (LLNL 2002dk). Although new data and updated methodologies were used, the most recent study reports essentially the same results as previous studies for the prediction of the peak ground acceleration as previous studies. This evaluation of seismic hazards for the Livermore Site was performed by a team of LLNL staff and outside consultants from academia and private consulting firms (LLNL 2002dk). Appendix H presents the results of these seismic hazard analyses and the evaluation of structures.

The Livermore Site is located near the northwest-southeast trending boundary separating the North American and Pacific tectonic plates, or San Andreas Fault system (Figure 4.8.1–1). Local plate interaction generally results in the accumulation of strain along fault structures, which may be released during an earthquake event. The high level of seismicity active locally has resulted in the area's classification of Seismic Risk Zone 4, the highest risk zone in the California Building Code (City of Livermore and LSA 2002).

Faults

Faults that show evidence of Holocene and earlier activity in Quaternary time comprise the source of potential seismic hazard to the Livermore Site. Regionally significant structures are associated with the San Andreas Fault system, including the Hayward and Calaveras faults east of the San Francisco Bay Area (Figure 4.8.1–1). The closest structure to the Livermore Site associated with the San Andreas Fault system, the Calaveras Fault, is situated approximately 15 miles west of the site. The San Andreas, Hayward, and Calaveras faults have produced the majority of significant historical earthquakes in the Bay Area, and accommodate the majority of slip along the Pacific North American plate boundary. These structures will likely continue generating moderate to large earthquakes more frequently than other faults in the region (LLNL 2002dk). Local structures include the Greenville, Mount Diablo, Las Positas, and Corral Hollow faults (Figure 4.8.1–2). Although the Greenville Fault outcrops are within 1 mile of the Livermore Site, it contains the lowest slip rate of any structures associated with the San Andreas Fault system. The Mount Diablo Thrust Fault, postulated to underlie the Livermore and Sycamore Valleys on the basis of seismic reflection data, is related to the development of fold structures in the area. The Las Positas Fault passes within 1 mile southeast of the Livermore Site

and is considered capable of generating relatively infrequent moderate earthquakes. Additionally, the Corral Hollow Fault zone passes approximately 2 miles east of the site. In a recent study (LLNL 2002dk) assessing local seismic hazards, the existence and characteristics of the Verona, Williams, Livermore, and Springtown faults were considered.

Earthquakes

Major earthquakes have occurred in the region in the past and can be expected to occur again in the future. The greatest probability for large earthquakes is associated with the San Andreas Fault zone. However, the large earthquakes that have occurred in the San Francisco Bay Area such as the 1906 Great San Francisco Earthquake, with an estimated magnitude of 8.3 on the Richter Scale, produced limited structural damage in the Livermore Valley.

The local faults in the Livermore Valley region are still the main seismic hazard to the Livermore Site (Scheimer 1985). The potential for local, damaging earthquakes was highlighted by the January 1980 Livermore earthquake sequence on the Greenville Fault, which produced two earthquakes of magnitudes 5.5 and 5.6 on the Richter Scale (Bolt et al. 1981). The first earthquake caused discontinuous surface displacements along 3.9 miles of the fault and produced a maximum peak ground acceleration of 0.26 *g* at nearby Lake Del Valle. The unit *g* is equal to the acceleration due to the Earth's gravity or 9.8 meters/second/second (32 feet/second/second). The earthquake caused structural and nonstructural damage to the Livermore Site.

The most recent study (LLNL 2002dk) found that the Greenville Fault system contributes the most to the estimate of seismic hazard at the Livermore Site. The contributions from the Calaveras and Corral Hollow faults closely follow the Greenville Fault. The Mount Diablo thrust and Springtown and Livermore faults together contribute as much seismic hazard as the Greenville Fault. At lower frequencies, the more distant Hayward and San Andreas faults are substantial contributors to the total hazard. Additional information regarding seismic activity in the vicinity of the Livermore Site is presented in Appendix H.

Seismic Hazards

Ground Motion. Strong earthquake ground motion is responsible for producing almost all of the damaging effects of earthquakes, except for surface-fault rupture. The intensity of ground motion or shaking that could occur at LLNL as a result of an earthquake is related to the size of the earthquake, its distance from LLNL, and the response of the geologic materials beneath LLNL. Ground shaking generally causes the most widespread effects, not only because it propagates considerable distances from the earthquake source, but also because it may trigger secondary effects from ground failure and water inundation. Potential sources for future ground motion at the Livermore Site include the major regional faults, as well as the local faults.

A recent U.S. Geological Survey (USGS) study of the likelihood of major earthquakes in the San Francisco Bay Area has determined that there is a 62 percent probability of one or more earthquakes with a magnitude of 6.7 on the Richter Scale or greater occurring within the next 30 years (USGS 2003). The study concluded that the probability of these earthquakes occurring along the Calaveras and Greenville faults, and the Mt. Diablo Thrust Fault within the next 30 years was 11 percent, 3 percent, and 3 percent, respectively. The study calculated that there was a 50-percent chance of the Livermore area exceeding a ground shaking of Modified Mercalli (MM) intensity VII to VIII. The Association of Bay Area Governments (ABAG) has mapped the distribution of ground-shaking intensity (Association of Bay Area Governments 2001). A large

earthquake on the Greenville Fault is projected to produce the maximum ground-shaking intensities in the Livermore area with intensity ranging from strong (MM VII) to very violent (MM X). The MM IX level is associated with damage to buried pipelines and partial collapse of poorly built structures (City of Livermore and LSA 2002).

Seismic hazard analyses have been performed for the Livermore Site to quantify the hazard. The analyses identify the probability of exceeding a given peak ground acceleration. Maximum horizontal peak ground accelerations at the Livermore Site for return periods of 500, 1,000, and 5,000 years are 0.38 *g*, 0.65 *g*, and 0.73 *g*, respectively. The technical basis for these peak ground acceleration values is provided in Appendix H.

Surface Faulting. Surface faulting is the displacement of ground along both sides of a "trace," the surface expression of an earthquake fault. The potential for surface faulting within the Livermore Site is very low, although potential for surface faulting does exist south of the Livermore Site at SNL/CA.

Liquefaction. Liquefaction is a type of soil failure in which a mass of saturated soil is transformed from a solid to a fluid state in response to earthquake shaking. The liquefaction potential of a soil deposit is controlled by several factors, including the depth to groundwater, the type and density of the soil, and the intensity and duration of ground shaking. Depths to groundwater range from about 30 to 130 feet beneath the Livermore Site (Carpenter et al. 1984). Based on the fairly deep groundwater levels, the uniformly distributed, poorly sorted sediments beneath the site, and a relatively high degree of sediment compaction, the potential for damage from liquefaction at the Livermore Site is quite low. The ABAG map of liquefaction susceptibility in the Bay Area shows a low susceptibility for the majority of the Livermore Site with a moderate susceptibility in the southwestern 20 percent of the site (Association of Bay Area Governments 2001).

Seismically Induced Landslides. The Livermore Site consists of a relatively flat land surface that slopes gently to the northwest. Ground surface elevations within the Livermore Site range from a low of 571 feet at the northwest corner of the site to 676 feet at the southeast corner. Little potential for slope instability exists at the Livermore Site because of the very low relief.

Seismicity of Site 300

The evaluation of seismic hazards for Site 300 was based on a review of the literature, an aerial photographic analysis of the faults and landslides prior to field reconnaissance mapping, and a review of features identified in detailed studies of faulting and geology at the site (Carpenter et al. 1991, Dugan et al. 1991).

Site 300 is located near the eastern edge of the Coast Range Province, which is characterized by northwest trending, strike-slip faults of the San Andreas Fault system. The boundary between the Coast Ranges and the San Joaquin Valley lies immediately east of Site 300 and is characterized by east-northeast compression, resulting in reverse and thrust faulting and folding (Wong et al. 1988, Wentworth and Zoback 1989).

The principal faults in the vicinity of Site 300 are the Corral Hollow-Carnegie, Black Butte, and Midway (Figure 4.8.1–2). These faults are further described in Appendix H. The active Carnegie Fault of the Corral Hollow-Carnegie Fault zone crosses the southern portion of the site (Carpenter et al. 1991). The Elk Ravine Fault, a complex structure composed of pre-Holocene strike-slip faults, reverse faults, normal faults, and local folds, crosses Site 300 from the

northwest corner to the southeast corner (Dibblee 1980a). No significant recorded earthquakes have occurred on any of the local faults.

Seismic Hazards

Ground Motion. The region surrounding Site 300 has experienced strong ground shaking during historic earthquakes. In 1906, the Great San Francisco Earthquake on the San Andreas Fault produced structural damage a few miles west of Site 300 (Nason 1982). Potential sources for future ground motion at Site 300 include major regional faults such as the San Andreas, Hayward, and Calaveras, as well as smaller faults including the Greenville, Las Positas, Corral Hollow-Carnegie, Black Butte, and Midway.

A seismic hazard analysis of Site 300 produced hazard curves that display peak horizontal ground acceleration versus return period for two locations within Site 300: the Building 854 Complex near the western boundary of the site and the Building 834-836 Complex near the eastern boundary. Peak ground accelerations corresponding to return periods of 500, 1,000, and 5,000 years were calculated at 0.32 *g*, 0.38 *g*, and 0.56 *g*, respectively, for the Building 854 Complex; and 0.28 *g*, 0.34 *g*, and 0.51 *g*, respectively, for the Building 834-836 Complex (TERA Corp. 1983).

Using another approach which is described in more detail in Appendix H, the largest ground motions produced at the Building 854 Complex would be from a magnitude 6.5 earthquake on the Corral Hollow-Carnegie Fault zone at a distance of 0.9 miles. Average peak horizontal ground accelerations from various mean and standard deviation relations range from 0.53 to 0.82 *g*. The ground motions at the Building 834-836 Complex would be greatest when considering a magnitude 6.6 earthquake on the Black Butte Fault at a distance of 1.5 miles. Average values of peak horizontal ground acceleration range from 0.59 to 0.91 *g*. Values for maximum ground acceleration at both Site 300 locations for return periods of 500, 1,000, and 5,000 years would be similar to those for the Livermore Site, 0.38 *g*, 0.65 *g* and 0.73 *g*, respectively.

Larger earthquakes on more distant faults such as the San Andreas do not significantly affect the hazard estimation.

Surface Faulting. Potential for surface faulting exists at Site 300. The areas adjacent to the active Carnegie Fault could experience ground deformation should a major earthquake occur on the fault. A 10- to 13-foot-wide zone of faulting is present in Holocene and late Pleistocene deposits near the Carnegie Fault, attesting to the potential for surface rupture. In addition to the principal Holocene strike-slip Carnegie Fault strand, two subsidiary faults subsequently named the Elk Ravine Fault) could produce minor amounts of surface rupture (Dugan et al. 1991). The only structures located adjacent to the Holocene strand of the Carnegie Fault, and, therefore, subject to the hazard of surface faulting, are Buildings 899A and 899B at the pistol range.

Liquefaction. Site 300 is underlain almost entirely by Tertiary bedrock, which is not liquefiable. The Quaternary alluvium at the site is limited to generally unsaturated Pleistocene gravel-bearing terrace deposits above Corral Hollow and minor amounts of younger alluvium in canyon bottoms (LLNL 1983). Based on the presence of bedrock beneath Site 300 and the age, composition, and unsaturated condition of the terrace deposits, the potential for liquefaction at Site 300 is low.

Seismically Induced Landslides. Numerous ancient landslides are located at Site 300 with the largest landslide covering approximately 0.5 square mile (see Figure 4.8.1–4). Potential exists for

seismically induced landslides at Site 300. The potential for slope instability is greater on northeast-facing slopes that have exposed strata of the Cierbo Formation. Buildings 825, M825, 826, M51, 847, 851A, 851B, 854, 855, and 856 are located on old landslides. The potential for ground deformation at these buildings is considered to be moderate to high.

Nonseismically Induced Landslides

Livermore Site

At the Livermore Site, there is generally little potential for nonseismically induced landslides because the site is situated on gently sloping to nearly flat topography.

Site 300

At Site 300, the topography ranges from gently sloping to nearly vertical in places, and numerous landslide features have been mapped (Figure 4.8.1–4). The potential for nonseismically initiated landslides is great along the canyon walls, especially where soils consist of deep loams and clay loams. During periods of extended wet weather, the saturated soils can become structurally weakened and expand, with resulting slope failure. The potential for localized slope instability greatly increases if slopes are made steeper by road cutting or building excavation. The presence of landslide deposits and colluvium or other historic evidence of slope failure increases the probability of a failure in the future.

4.9 BIOLOGICAL RESOURCES

The biological resources considered in this section consist of the following components: vegetation, wildlife, protected and sensitive species, and wetlands. The information in this section is a summary of a more detailed analysis of the ecological characteristics and the status of threatened and endangered species in Appendix E and of wetlands in Appendix F. The scientific names of species mentioned in this section appear in Appendix E.

4.9.1 Vegetation

Livermore Site

The Livermore Site covers 821 acres of which approximately 640 acres are developed. The vegetation at this site was initially altered in the 1800s when livestock grazing began on a large scale in the Central Valley and surrounding areas of California. The intensity of grazing that took place on lands at this site is not known; however, it is highly likely that grazing and other agricultural activities adversely altered the perennial grasslands and riparian plant communities. Grazing is one of the principal reasons for the significant loss and degradation of wetland riparian plant communities in the Central Valley and surrounding areas (LLNL 1992a).

The plant communities at the Livermore Site were further degraded and destroyed when the U.S. Navy acquired the land in 1942 and covered the site with runways, roads, and buildings. In addition, Arroyo Las Positas, which flowed through the site, was channeled and now traverses part of the eastern boundary and flows through the northern part of the site (LLNL 1992a).

Vegetation surveys at the Livermore Site have been conducted as part of previous projects (LLNL 1992a, Jones and Stokes 1997). In June 2002, an additional survey was conducted. This recent survey confirmed that site conditions and species composition have changed relatively little during the past 10 years. The developed areas at the Livermore Site are planted with ornamental vegetation and lawns. There are also small areas of disturbed ground with early successional plant species. The undeveloped land in the security zone is an introduced grassland plant community dominated by nonnative grasses such as wild oat, brome grasses, foxtail barley, curly dock, and wild radish (Jones and Stokes 2002a).

The Arroyo Seco bisects SNL/CA and traverses the southwest corner of the Livermore Site. Arroyo Seco is a steep-sided channel at the Livermore Site. The tree canopy consists of both native and nonnative species including willows, oaks, California buckeye, glossy privet, and black locust. Vegetation along the arroyo's channel includes perennial peppergrass, sweet fennel, and common cocklebur (Jones and Stokes 2002a).

Plant species along Arroyo Las Positas were surveyed in 2002 and observed to be essentially as those found during a 1997 survey. Common species in the annual grassland along the upper channel bank of the arroyo include wild oats, brome grasses, alkali mallow, and yellow star-thistle (Jones and Stokes 1997, 2002a). See Section 4.9.4 for wetland plants observed along the Arroyo Las Positas.

Site 300

Site 300 covers approximately 7,000 acres of land in eastern Alameda County and western San Joaquin County. The northern portion is characterized by rolling hills while the southern part consists of steep, deep canyons. The site was acquired in 1953, and since then no grazing or farming has taken place. A relatively small part (approximately 5 percent) has been developed for LLNL activities; the remainder is undisturbed, except for controlled burning. Controlled burning takes place every year on approximately 2,000 acres of land during late May to early June depending on weather conditions (LLNL 2004a). Approximately 620 acres of formerly designated California red-legged frog critical habitat and 385 acres of formerly designated Alameda whipsnake critical habitat fall within the prescribed burn zones as shown in Figure 4.9.1–1 (Jones and Stokes 2001, USFWS 2002b). As a result of court orders in November 2002 and May 2003, designation of critical habitat for these two species was rescinded including habitat at Site 300 (USDCDC 2002, CC Times 2003). In April 2004, the USFWS issued a proposed rule to reinstate formerly designated critical habitat for the California red-legged frog at the Livermore Site and Site 300 (69 FR 19620, 69 FR 32966). No proposal to redesignate critical habitat for the Alameda whipsnake had been released as of early July 2004. In, August 2004, the USFWS issued a proposed rule to designate critical habitat for the California tiger salamander in parts of Alameda and San Joaquin Counties, but not at Site 300 (69 FR 48570).

Several site-wide vegetation surveys have been conducted at Site 300. These surveys have identified a total of 406 plant species at this site (Jones and Stokes 2002a).

The 1986 botanical survey identified four upland major plant community types that are located within Site 300: (1) introduced grassland, (2) native grassland, (3) coastal sage scrub, and (4) oak woodlands (BioSystems 1986a). A recent survey (Jones and Stokes 2002a) expanded that number to eight major upland plant-type categories, based primarily on the classification in the List of California Terrestrial Natural Communities recognized by the California Natural Diversity Data Base, and also accounted for disturbed and urban habitat. The revised list of major communities was further divided into the following vegetation types: annual grassland, native grassland, coastal scrub, coastal sage scrub oak, poison oak scrub, cottonwood riparian forest/woodland, Great Valley willow scrub, Mexican elderberry, blue oak woodland, valley oak forest/woodland, juniper-oak woodland/scrub, juniper-oak cismontane woodland, disturbed land, and urban habitat (Jones and Stokes 2002a).

Annual grassland covers more than 5,000 acres, and is dominated by annual grasses introduced from Mediterranean Europe during the Spanish Colonial Era (e.g., slender oat and ripgut brome); native grassland covers more than 700 acres, and is dominated primarily by one-sided bluegrass and purple needlegrass. The coastal sage scrub plant community type is dominated by California matchweed, California sagebrush, *Eriogonum fasiculatum*, and black sage. Oak woodland, dominated by blue oak, occurs in scattered areas on steep slopes in the southern half of the site and covers approximately 150 acres. The understory is dominated by grassland species such as brome grass and slender oat. Small areas of wetlands occur at the site and are discussed in Section 4.9.4 (LLNL 1992a).

Ongoing practices at Site 300 that affect site vegetation include the exclusion of grazing and other agricultural uses; annual maintenance of fire roads and breaks; an annual controlled burn; weed control along roads, power poles, and security fences; planned minor construction in or adjacent to existing facilities; and road-widening projects. The maintenance of fire roads and breaks, and weed control measures, for example, have resulted in sparse vegetative cover dominated by early successional plant species including introduced grass species. The area of land disturbed for fire roads, weed control, buildings, and other facilities, however, occupies less than 5 percent of Site 300 total area. This area is designated as disturbed or urban habitat in the recent plant survey. Acreage including facilities and adjacent landscaping are considered urban habitat, while that for fire roads, perimeter fences, and power poles are considered disturbed habitat (LLNL 1992a).

No prime or unique farmland protected by the *Farmland Protection Policy Act* exists at Site 300. No grazing or other agricultural activities occur at Site 300. As a result, a greater diversity of plant community types occurs on the installation than in nearby offsite lands that are grazed. In addition, steep onsite slopes show less instability and erosion than nearby grazed lands because of a more stable plant cover, including soil-building native plant species (LLNL 1992a).

Approximately 2,000 acres are burned annually at Site 300 to control vegetation that could become an uncontrolled fire hazard (Figure 4.9.1–1) (LLNL 2004a). These burns have been conducted for the last 41 years (Jones and Stokes 2001). The development of stands of native grassland is strongly correlated with the burn area. The exclusion of grazing and other agricultural practices in 1953 may also have contributed to the presence of the more than 700 acres of native perennial grasslands onsite (LLNL 1992a).

Tritium Levels in Vegetation and Commodities

LLNL has been monitoring tritium in vegetation since 1966 and has performed vegetation sampling in the vicinity of the Livermore Site and Site 300 since 1971. The monitoring program is designed to measure changes in the environmental levels of radioactivity, to evaluate the environmental effect of LLNL operations, and to calculate potential human doses from tritium in the food chain. In 1977, wine was added to the monitoring program (LLNL 2002cc). The results of this monitoring program and LLNL impacts on vegetation in the Livermore Valley are provided in Section 5.2.7.

4.9.2 Fish and Wildlife

Livermore Site

Four species of fish, 6 species of amphibians and reptiles, 52 species of birds, and 10 species of mammals were reported observed at the Livermore Site during the biological survey conducted for the 1992 LLNL EIS/EIR or in subsequent documentation (LLNL 1992a, USFWS 1998, LLNL 2003bz) (see Appendix E for lists of species).

Wildlife includes species that live in the undeveloped grassland in addition to a number of species that live in the developed areas of the site or along the arroyo. Representative species observed in the undeveloped grassland areas include the fence lizard, black-tailed hare,

California ground squirrel, red fox, and western meadowlark. The California red-legged frog has been observed in the Arroyo Las Positas and the Drainage Retention Basin (DRB) and is discussed in greater detail in Section 4.9.3 (LLNL 2003ab). The bullfrog, a known predator of the California red-legged frog, has been observed since 1997. Nesting birds include the American crow, American robin, house finch, mockingbird, and house sparrow. These species nest in the planted trees onsite. Canada geese and muskrats have been observed at the DRB. A raven's nest was observed among some pipes at the Livermore Site. Some bird species observed include the mourning dove, Nuttall's woodpecker, Cooper's hawk, and turkey vulture (LLNL 1992a). Catfish, mosquito fish, goldfish, and sculpin have been observed in the DRB (LLNL 2003bz, USFWS 1998). Recent studies have provided new information about raptor activity at the Livermore Site. In 1996, the red-shouldered hawk, not previously known to occur on LLNL property, nested at the Livermore Site (LLNL 1997e). Between 1994 and 2003, the white-tailed kite, a state-protected bird of prey, was observed foraging, nesting, and fledging young at the Livermore Site. The kites were marked with aluminum leg bands in 1999 to initiate long-term studies of the species in a semi-urban edge habitat. In 2000, a pair of white-tailed kites attempted to nest, but the nesting was unsuccessful, possibly due to climatic conditions or low incidence of prey. This reduced nesting trend was observed in other parts of California in 2000 (LLNL 2000a, LLNL 2001v). Breeding success improved in 2003 with nine young fledged from two nests.

Site 300

Site 300, with large areas of wildland vegetation, interspersion of various plant community types, and availability of water at springs, provides habitat for a diversity of wildlife.

Twenty amphibian and reptile species have been observed at Site 300 (Table E.1.2.2–1 in Appendix E). Aquatic habitat is available at some of the drainages containing aquatic vegetation supported by underground springs and seeps. In addition, aquatic species may opportunistically use existing wastewater treatment facilities like the domestic sewage oxidation ponds and the class II surface impoundments (near Building 817). Two species of salamanders were observed: the California slender salamander and the California tiger salamander. The former species was observed during 1986 biological surveys (BioSystems 1986b), but not during 1991 surveys, although both species are currently known to occur onsite. Frog and toad species known to occur onsite are the western toad, western spadefoot toad, Pacific treefrog, and California red-legged frog. Section 4.9.3 contains additional information on the California red-legged frog and California tiger salamander (LLNL 1992a). No exotic bullfrogs have been observed onsite to date.

Conditions are far more favorable for reptiles than for amphibians at Site 300. Grassland provides ideal habitat for racers and gopher snakes. Rocky sites provide suitable habitat for such species as the western fence lizard, western skink, common kingsnake, and the western rattlesnake. Seeps and springs provide excellent habitat for the northern alligator lizard. Side-blotched lizards and California horned lizards frequent areas with vegetation that is more open and sandy soils (LLNL 1992a).

Earlier avian surveys reported 70 bird species present at Site 300 on either a resident or transient basis (BioSystems 1986b, LLNL 1992a). In 2002, an extensive survey was conducted using variable circular plot point counts and constant effort mist netting. During the 2002 survey, 90 bird species were observed, representing 73 genera and 32 families. With the integration of observations from previous years by LLNL biologists, a new Site 300 list of bird species was prepared including the documented presence of 103 species, 84 genera, and 39 families. Of the 103 species, 24 are current Federal or California species of special concern (see Section 4.9.3, Table 4.9.3–1). The Swainson's hawk is state listed as threatened and considered an occasional forager within Site 300 based on its observation on the southeastern perimeter of the site and the adjacent California Department of Fish and Game (CDFG) Ecological Reserve in 1994 (LLNL 2003by). In addition, the state endangered willow flycatcher was observed in 2003.

Although annual grasslands normally support a limited resident bird population, the Site 300 interspersion of several different plant community types and an abundance of seeds and insects provide good habitat for a variety of birds. The western meadowlark, horned lark, and savannah sparrow are the most common small birds seen throughout the open grassland areas. Vegetation at springs and seeps provides nesting habitat for red-winged and tricolored blackbirds. These permanent water sources attract a greater number of birds than normally found in the adjacent grasslands. For example, mourning dove, cliff and barn swallow, and California quail all require daily water. Oak woodland and a few cottonwoods provide nesting habitat for the western kingbird, northern oriole, loggerhead shrike, and American goldfinch. Coastal sage scrub supports scrub jay, Anna's hummingbird, rufous-crowned sparrow, and white-crowned sparrow. Ecotones (boundary areas between two habitats) of sage scrub and grassland provide ideal habitat for mourning dove, California quail, lazuli bunting, and lark sparrow. Rocky outcrops and cliffs provide breeding sites for white-throated swift, cliff swallow, Say's phoebe, and rock wren (LLNL 1992a). A relatively large population of loggerhead shrikes was present at Site 300 in 2002. Eighteen pairs of loggerhead shrike were identified during the 2002 surveys with 9 of the 18 pairs actively nesting. Six of the nests were in junipers and three were in oaks (Bloom 2002).

Site 300 also supports nesting raptors. A breeding raptor survey conducted at Site 300 in April and July 2002 identified four species of diurnal raptors and four species of owls. The raptors included the turkey vulture, red-tailed hawk, golden eagle, and American kestrel (the most frequently observed raptor on Site 300). Owls observed included the barn owl, western screech owl, great horned owl, and western burrowing owl. The survey detected the presence of four active red-tailed hawk, four great horned owl, and three burrowing owl nests. One inactive barn owl nest was found on the exterior of the Advanced Test Accelerator (ATA) Building. In addition, numerous recently fledged American kestrels and one young western screech owl were observed. Blue oaks and conglomerate cliffs were the most frequently used nest structures. The numbers of breeding pairs and diversity of these birds of prey was relatively low compared to other large land units in California. A pair of turkey vultures was observed, although no nest was found (Bloom 2002). Although no golden eagle or white-tailed kite nests were found, both species have occasionally nested onsite in the past. The golden eagle nested at Site 300 in 1996, and the white-tailed kite nested in a valley oak at Site 300 in 1997 and 1998 (LLNL 1997c, Bloom 2002). In addition to these species, the northern harrier and prairie falcon were identified in 1986 and 1991 surveys (BioSystems 1986b, LLNL 1992a). A complete list of raptor species observed at Site 300 is included in an avian monitoring program report (LLNL 2003by).

Thirty mammal species have previously been observed on site (see Appendix E). Mammals were recorded during threatened and endangered species surveys that included conducting ground surveys over the entire site, night spotlighting, establishing of scent stations in 1986 and 1991, and trapping small mammals in 1986 (LLNL 1992a). An inventory was recently conducted on small mammals at Site 300 and 10 small mammal species were identified (Jones and Stokes 2002b).

Productive and diverse grasslands on Site 300 support an abundance of rodents and lagomorphs (rabbits and hares). Conditions are ideal for California ground squirrels in the northern portion of Site 300 where the terrain is less rugged and annual prescribed burns occur. Other common rodents include the house mouse, deer mouse, brush mouse, western harvest mouse, California vole, Heermann's kangaroo rat, San Joaquin pocket mouse, California pocket mouse, and valley pocket gopher (Jones and Stokes 2002b). Lagomorphs such as black-tailed hares and desert cottontails are also widespread and abundant, with the latter tending to occupy areas with more cover (LLNL 1992a).

Many mammalian predators are supported by this rich prey base. Grassland predators include long-tailed weasels, striped skunks, coyotes, American badgers, and bobcats. Red foxes, which have been reported from nearby areas to the east and north of the site, have greatly expanded their range in the Central Valley in recent years. They show a preference for more disturbed areas, often denning in roadside culverts (LLNL 1992a). A mammal survey (carnivores) was conducted from mid-September through mid-October 2002. Species observed included badger, bobcat, and coyote (CSUS 2003). See Section 4.9.3 and Table 4.9.3–1 for discussion of the San Joaquin kit fox.

Sage scrub, wooded, and riparian habitats attract other mammalian predators not normally found in grasslands, including gray fox, raccoon, and mountain lion. Although these habitats are preferred, they are relatively limited on Site 300; consequently, grassland areas are used as well. Only limited areas of riparian vegetation are associated with the seeps and springs that occur along the canyon bottoms. Black-tailed deer prefer these habitats but are frequently seen in the open grasslands (LLNL 1992a). Feral pigs have also been observed in riparian areas.

4.9.3 Protected and Sensitive Species

The *Endangered Species Act* provides Federal protection for threatened and endangered species. Section 3 of the *Endangered Species Act* defines endangered species as any animal or plant species in danger of extinction throughout all or a significant portion of its range. This Act further defines threatened species as any species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. The *California Endangered Species Act* (California Fish and Game Code §§2050-2098) includes provisions intended to protect threatened and endangered species that may be affected by development projects subject to the *California Environmental Quality Act*.

Species that are Federal candidates for listing as threatened or endangered do not receive legal protection under the *Endangered Species Act*. However, under NEPA, both candidate and proposed species require analysis to the same level of detail as listed species. Candidate species (formerly designated as Category 1 species) include those plants and animals for which the U.S.

Fish and Wildlife Service (USFWS) has on file sufficient information on biological vulnerability and threat to support issuance of a proposed rule for listing as threatened or endangered. The USFWS encourages the consideration of impacts to these species in project planning since their status can be changed to threatened or endangered in the foreseeable future. Critical habitat may be established by the USFWS for threatened or endangered species consisting of geographic area determined essential for the conservation of a species.

The USFWS species of concern category includes former Category 2 species (i.e., species that possibly were appropriate for listing). Species of concern is a term that describes a broad realm of plants and animals whose conservation status may be of concern to the USFWS, but do not have official status.

Detailed surveys of federally listed species were conducted at the Livermore Site and Site 300. The results are summarized in this section. The details regarding these studies appear in the Biological Assessment in Appendix E, Section E.2.

Informal consultation was initiated on October 21, 2002, when the USFWS was requested to provide a list of potential sensitive species that may occur at the sites. Such a list was provided on October 29, 2002 (The USFWS letter is provided in Appendix E). The CDFG has also been requested to provide a list of potential sensitive species that may occur at the sites. This consultation process assisted in the identification of plant and animal sensitive species that are known to occur at the sites (Table 4.9.3–1).

All of the bird species listed in Table 4.9.3–1 also receive protection under the *Migratory Bird Treaty Act* (16 U.S.C. §703) and Executive Order 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds). This law governs the taking, killing, possessing, transporting, and importing of migratory birds, their eggs, parts, and nests. Of these, 23 are special status and 2 are state threatened or endangered. Further discussion is provided later in this section and in Appendix E.

The methods used to evaluate the status of the species listed in Table 4.9.3–1 are presented in Appendix E, Section E.1.2.1. The methods were consistent with Federal and/or state guidelines where such guidelines exist. Where such guidelines do not exist, survey methods consistent with accepted biological techniques were used. Surveys for the species in question were conducted by botanists and zoologists with training and experience in conducting surveys.

Livermore Site

No sensitive plants, invertebrates, reptiles, or mammals were observed during the 1992 or recent biological surveys at the Livermore Site (LLNL 1992a, 1998a; Jones and Stokes 2002a). The California red-legged frog (a federally listed threatened species) occurs at the Livermore Site. This species is the largest native frog in California, growing to more than 5 inches in length, also known as the original Calaveras jumping frog made famous by Mark Twain's writings (LLNL 1998f). It was listed as a threatened species in June 1996 (61 FR 25813). The California red-legged frog is found in the Arroyo Las Positas and in the DRB at the Livermore Site. A single adult California red-legged frog was also found in the West Perimeter Drainage Ditch during the 2002 nocturnal surveys (LLNL 1998a, LLNL 2003ab).

Critical habitat was determined for the California red-legged frog species in March 2001 (66 FR 14626). Critical habitat for this species was designated in the North Buffer Zone and eastern edge of the Livermore Site (Figure 4.9.3–1) (LLNL 2002cc). As a result of a court order in November 2002, critical habitat for this species at the Livermore Site was rescinded (USDCDC 2002). In April 2004, the USFWS issued a proposed rule to reinstate formerly designated critical habitat for the California red-legged frog at the Livermore Site (69 FR 19620, 69 FR 32966).

The DRB was drained in 2000 and 2001 in an effort to eliminate bullfrog larvae, because this species is a known predator of the California red-legged frog. Bullfrogs were first detected at the Livermore Site in 1997 (DOE 2002j). The USFWS was consulted and approved this management technique (USFWS 2002e).

Although the California tiger salamander (a federally proposed threatened species and a state species of special concern) is not presently found at the Livermore Site; it has been observed on nearby lands (69 FR 47212, LLNL 1992a, LLNL 2002cc). In August 2004, the USFWS issued a proposed rule to designate critical habitat for the California tiger salamander in the vicinity of the Livermore Site, but not on the facility itself (69 FR 48570).

The loggerhead shrike (a Federal species of concern and a state species of special concern) has recently been reported in the vicinity of the Arroyo Las Positas (LLNL 2003bz). Over 60 species of migratory birds listed in Table 4.9.3–1 have been observed in surveys at the Livermore Site and their status is monitored by LLNL wildlife biologists (LLNL 2003bz). More information is provided in Appendix E.

Site 300

Plants

The only federally-protected plant species known to occur at Site 300 is the large-flowered fiddleneck (a federally listed and state listed endangered species). A 160-acre portion of Site 300 has been designated as critical habitat for this plant (Jones and Stokes 2002c).

The large-flowered fiddleneck was considered one of the most endangered plant species in California and perhaps the Nation. This species is known to exist naturally in only three locations; two are at Site 300 (see Figure 4.9.3–2), and one is on a nearby ranch. The largest onsite population (Drop Tower population), located in designated critical habitat, was discovered in the 1960s. It fluctuates between as many as 355 individual plants and historic lows during the past 3 years with 14 plants observed in 2001, 40 plants observed in 2000, and 6 plants observed in 1999. The number of fiddleneck plants observed in the original experimental population area (59 plants) is similar to that observed during the past 2 years (45 plants in 2000 and 42 plants in 1999). A dramatic increase in seed predation by small rodents in 1998 and 1999 may be responsible for the reduction in Site 300's original experimental large-flowered fiddleneck population (LLNL 2002dj).

In addition to the Drop Tower population, a native large-flowered fiddleneck population (Draney Canyon population) was discovered onsite near the bottom of a deep canyon in 1988 approximately 2 miles west of the Drop Tower population. This smaller population of fiddleneck was wiped out in 1997 when the bank containing the population washed away. No plants have been observed at this site since 1998 (LLNL 2002cc, Jones and Stokes 2002a).

In May 1985, 160 acres surrounding the Drop Tower at Site 300 was designated as critical habitat for the large-flowered fiddleneck (LLNL 2002dj). In April 2000, the area where the Drop Tower population is located was designated the *Amsinckia grandiflora (*i.e., large-flowered fiddleneck) Reserve through a declaration by the DOE Secretary via a memorandum of agreement signed between DOE and the USFWS concerning activities within the reserve (DOE 2000b). LLNL has also established an experimental population area within the reserve. LLNL is working with USFWS on continued monitoring of native and experimental large-flowered fiddleneck populations, and further development of habitat restoration and maintenance techniques. An annual report on all management activities is prepared by LLNL and provided to USFWS (LLNL 2001v, Jones and Stokes 2002a).

In addition to the large-flowered fiddleneck, seven rare plants listed by the California Native Plant Society (CNPS) also occur at Site 300:

- The big tarplant, listed on the CNPS Rare Plant 1B List, is widespread and common at Site 300.
- The diamond-petaled poppy, a plant thought to be extinct until rediscovered in 1993 and thus on the CNPS 1B List, is present at two locations at Site 300.
- The round-leaved filaree, listed on the CNPS Rare Plant 2 List, was identified at one location at Site 300.
- The gypsum-loving larkspur, listed on the CNPS Rare Plant 4 List occurs at six locations with most being on upper slopes in perennial grassland at Site 300.
- The California androsace (or California rock jasmine), also listed on the CNPS Rare Plant 4 List, is widespread and common at Site 300.
- Stinkbells, another CNPS Rare Plant 4 List species, is found at several locations at Site 300.
- The hogwallow starfish, a CNPS Rare Plant 4 List species, is found at one location west of Building 851 at Site 300.

Additional information on these sensitive plant species and other nonsensitive plants is included in a recent site-wide plant survey at Site 300 and in Appendix E (Jones and Stokes 2002a).

Invertebrates

The valley elderberry longhorn beetle (a federally listed threatened species) is the only sensitive insect that has been observed at Site 300. This species occurs almost exclusively on elderberry bushes, so elderberries that grow within the range of this species are considered potential habitat.

In 2002, four surveys were conducted during April and May at Site 300 for the valley elderberry longhorn beetle and its host, the blue elderberry plant. Elderberry plants were surveyed at six locations at Site 300 and two locations on adjacent land southeast of Site 300 in a CDFG preserve. During these surveys, 10 exit holes, considered to be from valley elderberry longhorn beetles, were found in elderberry plants. Additionally, six adult beetles were observed in a canyon just north of Elk Ravine, with two of the adults clearly exhibiting identifying characteristics of the valley elderberry longhorn beetle (Arnold 2002).

The California linderiella fairy shrimp, a Federal species of concern, occurs in seasonal wetlands in Site 300. During a 2001-2002 wet season survey, this branchiopod species was rediscovered in a vernal pool (FS-04) in the northwest part of the installation. Another branchiopod, the California clam shrimp (which is not on Federal or California special status species lists) was also found in this vernal pool (Condor Country Consulting 2002). Appendix E contains a discussion on these species and vernal pools.

Amphibians

The California red-legged frog, a federally listed threatened species and a state species of special concern, occurs at Site 300. This amphibian was listed as a federally threatened species in June 1996 (61 FR 25813). Critical habitat was determined for the species in March 2001 (66 FR 14626). As a result of a court order in November 2002, critical habitat for this species at Site 300 was rescinded (USDCDC 2002). In April 2004, the USFWS issued a proposed rule to reinstate formerly designated critical habitat for the California red-legged frog at Site 300 (69 FR 19620, 69 FR 32966) Proposed re-designated critical habitat for the California red-legged frog at Site 300 is shown in Figure 4.9.3–3.

Breeding locations, identified in 2001 for the California red-legged frog are also shown in Figure 4.9.3–3, with one of the largest locations in an artificially created wetland near Building 865 in Upper Elk Ravine (Jones and Stokes 2001). During surveys in 2002, California red-legged frog breeding was noted in the Ambrosino Pool, Lower Juniper Slide Pool, and Elk Ravine at the ATA (LLNL 2003ab). Nonbreeding California red-legged frogs have been observed at Mid Elk Ravine, the Upper Droptower Canyon Wetland, Danger Pond, Harrier Pool, the Old Spring Wetland, Song Pond, Overflow Pond, Oasis Canyon, Lower Drop Tower Canyon Wetland, and Round Valley Wetland (Figure 4.9.3–3) (Jones and Stokes 2001, DOE 1997a).

The California tiger salamander (a federally listed threatened species and a state species of special concern) is present at Site 300 (69 FR 47212). In August 2004, the USFWS issued a proposed rule to designate critical habitat for the California tiger salamander in parts of Alameda and San Joaquin Counties, but not at Site 300 (69 FR 4580). This amphibian has been reported at a number of locations including Ambrosino Pool, Harrier Pool, Song Pond, and Danger Pond as shown in Figure 4.9.3–4 (Jones and Stokes 2001, LLNL 2002cc). The California tiger salamander has also been reported at the explosive process water surface impoundments, which are not shown in Figure 4.9.3-4.

The Western spadefoot toad is a Federal species of concern and state species of special concern. During wet years, this amphibian has been observed at the Overflow Pond located in the GSA of Site 300 (LLNL 2003ab).

Reptiles

The Alameda whipsnake (a federally listed and state listed threatened species) was observed onsite in 1986 (BioSystems 1986b). The Alameda whipsnake was collected in April 1998 during a live-trapping survey on Site 300. Fourteen Alameda whipsnakes were captured with the individuals identified as intergrades between the Alameda whipsnake and the closely related chaparral whipsnake (Jones and Stokes 2001). The Alameda whipsnake is typically found in northern coastal scrub, coastal sage scrub and chaparral plant communities, but it may also occur in adjacent grasslands (62 FR 64306). Potential Alameda whipsnake habitat at Site 300 (mostly the coastal sage scrub plant community type) is shown in Figure 4.9.3–5 (LLNL 1992a, Jones and Stokes 2001).

Critical habitat was established for this species in October 2000 (65 FR 58933). As a result of a court order in May 2003, critical habitat for this species at Site 300 has been rescinded (CC Times 2003). However, during the next few years that critical habitat for this species may or may not be included at Site 300 when the USFWS publishes a new critical habitat proposal. Formerly designated critical habitat for the Alameda whipsnake is shown in Figure 4.9.3–5.

A research proposal has recently been coordinated with the USFWS to evaluate the effects of prescribed burning on the Alameda whipsnake at Site 300 and several other locations (Swaim 2002c). The research proposal received a favorable biological opinion by the USFWS (USFWS 2002a).

The California horned lizard (Federal species of concern and state species of special concern) was observed during the 1991 field surveys. This species was observed in the more open grasslands with sandy or gravelly areas at the northern portion of the site (LLNL 1992a). This lizard was identified at 8 locations in 2002, and at 23 locations in 2003.

The San Joaquin coachwhip (Federal species of concern and state species of special concern) is a fairly large slender snake, reaching up to 5 feet in length. It has been observed at Site 300 (Swaim 2002b).

Birds

The golden eagle (state species of special concern), and the burrowing owl and tricolored blackbird (both Federal species of concern and state species of special concern) have been observed at Site 300. The golden eagle is also afforded protection under the *Bald and Golden Eagle Protection Act* (16 U.S.C. §668). Immature and adult golden eagles were frequently observed soaring and feeding, mostly in the rolling terrain in the northern segment of the site (LLNL 1992a). In 1996, the first documented breeding pair of golden eagles nested on a live power pole at Site 300. Eggs were laid and incubated in the nest, but it was abandoned (LLNL 2000a). All of the bird species listed in Table 4.9.3–1 also receive protection under the *Migratory Bird Treaty Act* (16 U.S.C. §703). This law governs the taking, killing, possessing, transporting, and importing migratory birds, their eggs, parts, and nests. Executive Order 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds), issued on January 10, 2001, provides additional guidance on the responsibilities of Federal Agencies to protect migratory birds on property under their jurisdiction.

In 1986, the burrowing owl was a relatively common nesting species at Site 300, especially in the more gently rolling terrain in the north. Surveys in 1991 confirmed that this species is still nesting at Site 300, but at reduced levels (LLNL 1992a). Between 1991 and 2000, as many as 18 pairs of burrowing owls were observed nesting at Site 300 in a single year. In 2001, eight active burrowing owl dens were discovered and monitored throughout the breeding and wintering season (LLNL 2002cc).

A small population of tricolored blackbirds has been observed nesting in part of the Elk Ravine wetland. The presence of tricolored blackbirds is considered unusual because this species typically does not inhabit foothill areas such as those at Site 300 (LLNL 2000a). The number of tricolored blackbirds can vary greatly between survey years. For example, tricolored blackbirds were observed onsite in 1986 but not in 1991 (LLNL 1992a). However, 835 nests were found in Elk Ravine over 3-day surveys in August and September 2002. Nest location analysis determined that 91.7 percent of nests were located in stinging nettle, 6.8 percent in cattail, 1 percent in Russian thistle, and 0.5 percent in horehound (LLNL 2002di).

Mammals

Detailed surveys for the San Joaquin kit fox, a federally listed endangered and state listed threatened species, were conducted at Site 300 in 1980, 1986, and 1991. The kit fox was not recorded in the 1991 protocol-level surveys or detected subsequently. A comprehensive mitigation plan was developed for this species in 1992. The kit fox is not considered a resident species at Site 300, although this area provides potential habitat (LLNL 1992a, Jones and Stokes 2001).

The San Joaquin pocket mouse, a Federal species of concern, was observed during the 1986 (BioSystems 1986b), 1991, and 2002 (Jones and Stokes 2002b) surveys and is considered a resident species at Site 300. Potential habitat for this species at Site 300 is extensive since this species inhabits grassland with fine soils and scattered shrubs. This species is listed as a Federal species of concern.

The American badger generally occurs in the more rolling terrain at the northern segment of Site 300. During 2001, three occupied American badger dens were discovered and two unoccupied dens were identified in proposed project areas, although numerous dens are known to occur site-wide (LLNL 2002cc). This species was removed from the list of California species of special concern by the California Department of Fish and Game in 1993 (CDFG 2003).

Three special status bat species have been observed at Site 300 during a recent bat survey. These include the pallid bat (a state species of special concern), the long-legged myotis (a Federal species of concern), and the Yuma myotis (a Federal species of concern) (LLNL 2003bh).

4.9.4 Wetlands

Wetlands were mapped at LLNL using the methodology provided in the *United States Army Corps of Engineers Wetland Delineation Manual* (USACE 1987). A detailed analysis of wetlands appears in Appendix F. The locations of the wetlands at the Livermore Site and Site 300 are provided in Appendix F. The following subsections provide a summary of the results of the analysis.

Livermore Site

Wetlands, although very limited in the developed areas of the Livermore Site, do occur along Arroyo Las Positas at the northern perimeter of the site. These wetlands occur in three distinct areas and are associated with culverts that channel runoff from the surrounding area into this arroyo. In 1992, three areas totaling 0.36 acres were determined to qualify as jurisdictional wetlands. The wetlands were dominated by salt grass and a third by cattails (LLNL 1992a, Jones and Stokes 1997).

Since 1992, wetlands along Arroyo Las Positas have increased due to the release of water associated with environmental restoration activities at the Livermore Site. In 1997, an additional wetland delineation study was performed along Arroyo Las Positas (Jones and Stokes 1997). That study determined that the size of jurisdictional wetlands had expanded to 1.96 acres, and involved three different wetland plant communities as follows:

- Ruderal wetland (1.22 acres) dominated by tall flatsedge, bristly ox-tongue, bearded sprangletop, Bermuda grass, and barnyard grass.
- Freshwater marsh (0.65 acres) dominated by cattails and bullrushes.
- Riparian scrub (0.09 acres) dominated by willows and a small stand of cottonwoods.

Sedimentation and vegetation growth in the Arroyo Las Positas reduced the flood capacity less than the design capacity required by DOE O 5480.28 (Jones and Stokes 2001). As a result, LLNL initiated the Las Positas Maintenance Project to restore the channel to its original 100-year flood design capacity. The two-stage program was conducted in accordance with the 1997 and 1998 amended USFWS Biological Opinion for this project requiring Livermore Site populations of the California red-legged frog to be monitored to minimize impact from the Las Positas Maintenance Project. Subsequently, excess vegetation is removed annually (if needed) in 100- to 300-foot checkerboard sections. Measures previously coordinated with the USFWS ensure that California red-legged frogs are protected from harm in project locations during the

maintenance process. The arroyo in this part of the Livermore Site that was formerly designated as critical habitat has been proposed for reinstatement by the USFWS as shown in Figure 4.9.3–1 (LLNL 1998a, USFWS 1997, LLNL 2001v).

Approximately 1,800 feet of Arroyo Seco is on the Livermore Site. In July 2001, a wetland delineation survey was performed. Within the arroyo, six vegetated areas were determined to be potential jurisdictional wetlands, totaling 0.04 acres (LLNL 2001ap).

Site 300

A study for the 1992 LLNL EIS/EIR delineated 6.76 acres of wetlands at Site 300 (LLNL 1992a). In August 2001, another wetland delineation study was conducted identifying 46 wetlands and determining that the total size of wetlands had increased to 8.61 acres. A total of 4.39 acres were found to meet criteria for jurisdictional wetlands. These wetlands are small and include freshwater seeps, cooling tower discharges from some of the buildings, vernal pools, and seasonal ponds (Jones and Stokes 2002c). Appendix F includes additional discussion on the wetlands present at Site 300.

Many of the wetlands occur at springs in the bottom of deep canyons in the southern half of the site. These springs occur where water-bearing sandstone units outcrop in the canyon or valley bottoms. The wetlands that have developed at these springs are confined by the steep-sided canyon wall. They typically range in width from 5 to 30 feet wide with most being 10 to 20 feet wide. Most are relatively short, 100 to 600 feet; the longest, in Oasis Canyon, is approximately 2,800 feet long. The plant species observed in these wetlands grow in relatively homogenous stands. Cattail is dominant in areas of flowing or totally saturated soil, forming dense stands, typically at the spring and downstream. Species such as rush, seep-spring monkey flower, and, in some places, white watercress are common in areas of flowing water. In some limited areas, rush is dominant in standing water or saturated soil. In drier areas, the alkali ryegrass forms dense stands and then intergrades into the upland plant communities. Large, isolated cottonwoods and willows are often present in the deep canyon spring-fed wetlands (LLNL 1992a).

Several of the larger wetlands were artificially created by past operations at four building complexes onsite. The dominant plant species at these wetlands are cattail, alkali ryegrass, and rush, as in the natural wetlands. These wetlands tend to occur in drainage ditches along roads or on steep banks near the buildings.

Site 300 responsibilities under the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) include extracting and treating contaminated groundwater at the eastern GSA, and then discharging this treated water into Corral Hollow Creek. Treated groundwater from this operation has been released into Corral Hollow Creek since in June 1991. Corral Hollow Creek, in the GSA, is bordered by wooded riparian vegetation with cottonwood being the dominant canopy tree species. Mulefat and willow occur in the understory. One spring dominated by rush occurs approximately 700 feet downstream from the eastern GSA. The wooded riparian vegetation is well developed in some areas and sparse in others (LLNL 1992a).

4.10 AIR QUALITY

Air quality laws and regulations have been established to protect the public from harmful effects of air pollution. These rules take several forms. In some cases, the goal is to designate acceptable levels of pollution in ambient air, as in the establishment of ambient air quality standards (AAQSs). Other regulations establish limits on air pollutant emission sources or activities to reduce their impact. Still others establish jurisdictional authority to regulate air pollutant emission sources and enforce laws and regulations.

The following sections provide a general summary of air protection programs and ambient pollutant levels in the environs of LLNL:

- Section 4.10.1 highlights the regulatory authorities that oversee air protection programs.
- Section 4.10.2 provides summary information on the potential harmful effects of air pollutants, the primary sources, and recommended control measures.
- Section 4.10.3 provides more specific details on the requirements placed on facilities in order to control and remedy air pollutant problems.
- Section 4.10.4 details LLNL's air pollutant sources and emissions, the programs developed to manage these sources, and the program effectiveness.
- Section 4.10.5 discusses radiological air quality, providing information on LLNL's effluent monitoring and ambient air sampling programs, radionuclide emission estimates, as well as dose calculations for maximally exposed receptors and the populace.

4.10.1 Regulatory Authorities

EPA is charged with protecting the Nation's air resources. The authority is derived from the *Clean Air Act* and subsequent amendments, which provide the framework to protect the Nation's air resources. In addition to federally mandated air programs, the state of California has enacted legislation with the *California Clean Air Act* and the California Health and Safety Code to further protect the air resources. Some of these programs are similar to, but more stringent than, Federal counterparts, while others are unique to California.

Within California, the authority to administer both Federal and state air programs has been delegated to the California Air Resources Board (CARB), a department of the California EPA. The CARB, in turn, has further delegated the authority to regulate stationary air emissions sources (i.e., nonvehicular sources) to local air districts. Local program requirements must be at least as strict as any underlying state or Federal requirements.

Locally, the Bay Area Air Quality Management District (BAAQMD) and San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) hold jurisdiction. The Bay Area air basin includes Alameda County (home of the Livermore Site and a small portion of Site 300) and all or portions of eight other bay area counties. The San Joaquin Valley air basin extends to inland areas including San Joaquin County (home of Site 300) and all or portions of eight other counties. Each air district is required to assess the local air pollutant situation and to develop and implement programs to protect the air resource.

LLNL activities, therefore, are subject to air quality regulations and standards established under the *Clean Air Act,* by the State of California, and under the rules and regulations of the local air districts, as well as internal policies and requirements of NNSA and the University of California.

Summaries of program requirements and the LLNL air protection program are provided below. Table 4.10.1–1 provides a summary of air pollutant sources, potential health effects, and strategies for air pollutant prevention and control.

4.10.2 Public Health Criteria and Air Protection Programs

To support the protection of air resources, local air pollution control agencies routinely collect information related to air emission sources and measure ambient air pollutant levels. Air emission source information is collected in the form of an emissions inventory. Together, these data are used to assess and develop air pollutant programs targeted to local and regional pollutant problems and emission sources, and design long-range strategies for continued protection of the air resources while allowing for future growth.

Where air pollutant levels are problematic, more stringent requirements are placed on emission sources, and additional oversight is given to those sources responsible for a greater portion of the pollutant loading. In the development of emissions inventories, air districts work with affected facilities to gather necessary information. The task of preparing an emissions inventory involves a detailed evaluation of facility processes, hours of operation, equipment ratings, material throughput, operational efficiency, and control mechanisms. This information is used to quantify emission rates. Facilities must report all emission information for each air contaminant for which emission rates exceed a reporting threshold. The inventory process in California is quite extensive, and involves the collection of data on more than 300 compounds. Using this information, the air districts throughout the state are required to prioritize facilities for additional review. The inventory also provides a feedback loop to assist in the determination of the adequacy of placement and extent of air monitoring programs.

This section provides data developed in the air monitoring and inventory programs, specifically the criteria and toxic air pollutant programs. Locally, air pollutants are measured at air district monitoring stations in Livermore and Tracy, although monitoring in Tracy is not as extensive as that in Livermore. Both monitoring and emissions inventory data are compiled by the air districts and CARB and published in annual reports. This section draws heavily on data and assessments from these annual reports to provide an objective measure of the status of air quality.

4.10.2.1 *Criteria Air Pollutant Programs*

With the enactment of air protection programs, Congress established the National Ambient Air Quality Standards (NAAQS) for certain pervasive pollutants, termed criteria air pollutants, that were recognized as particular environmental concerns. These criteria air pollutants include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, particulate matter, and lead. Standards for particulate matter were later refined to specify smaller size particles that are more easily inhaled and retained in the lungs. NAAQS are designed to protect public health and welfare. In addition, the State of California has promulgated State Ambient Air Quality Standards (SAAQS). California standards are equal to or more restrictive than Federal standards, and include additional air contaminants; specifically, hydrogen sulfide, sulfates, vinyl chloride, and visibility-reducing particles.

Air quality standards are expressed as an allowable volume of pollutant per million volumes of air (parts per million), or as micrograms of pollutant per cubic meter of air. Each NAAQS or SAAQS is related to an averaging time. Short-term averaging times of 1 to 24 hours are designed to protect against acute (short-term) exposures to relatively high pollutant levels. Longer-term averaging times of 1 month to 1 year are designed to protect against the ongoing or day-to-day exposure to relatively lesser pollutant levels.

Ambient air pollutant measurements are used in determining an area's status with respect to NAAQS or SAAQS (i.e., as an attainment or nonattainment area). Ozone and nitrogen dioxide are measured locally in Livermore and Tracy. Particulate matter and carbon monoxide are also measured in Livermore, as well as some toxic air contaminants (discussed in Section 4.10.2.2).

While attaining and maintaining compliance with NAAQS or SAAQS is a primary goal of all air pollution control agencies, both the Bay Area and San Joaquin Valley have been designated as nonattainment areas with respect to both the Federal ozone standard and the more stringent state standard. The Bay Area air district is classified as nonattainment with respect to California standards for particulates, attainment for the Federal PM_{10} annual standard, and unclassified for both $PM_{2.5}$ and 24-hour PM_{10} standards. The San Joaquin Valley air district is classified as nonattainment for state particulate matter standards and as a serious nonattainment area for Federal PM_{10} standards. The designation for the Federal $PM_{2.5}$ standard has not yet been determined (SJVUAPCD 2002). Although particulates are not measured in Tracy, it is recognized as a regional problem. The Bay Area has been a nonattainment area for carbon monoxide; however, in 1998, the Bay Area was redesignated as an attainment area for carbon monoxide, and further problems are not anticipated (BAAQMD 2003, 1999).

Regionally, the most complex air quality problem has been ozone. Ozone is not regulated directly because it is formed in the atmosphere by photochemical reactions (i.e., in the presence of sunlight). Nitrogen oxides and many organic compounds are precursors to the formation of ozone. For this reason, air districts are particularly interested in reducing precursor organic compounds and nitrogen oxides. As discussed in Section 4.7.5, the local topography, meteorology, and proximity to large metropolitan areas upwind, contribute to the buildup of air pollutants in the Livermore Valley. This area, in fact, experiences a disproportionate number of exceedances of NAAQS. Because it takes some time for the photochemical reactions to occur, emissions of precursors, primarily from motor vehicles and the morning commute, are transported away from their sources and affect ozone concentrations in downwind areas. Although the Bay Area's highest ozone levels can fluctuate from year to year depending on weather conditions, ambient ozone standards are exceeded most often in the Santa Clara, Livermore, and Diablo valleys. These same locations typically register the highest particulate matter levels as well, although in this case, the high levels are due to the dry conditions and limited mixing within the sheltered terrain (BAAQMD 1999). The basin-wide annual criteria pollutant emissions inventory projected for years 2005 and 2010 is shown in Figure 4.10.2–1. The contribution attributable to motor vehicles is highlighted to show the dominance of this source category. Figure 4.10.2–2 provides a 7-year profile of the number of exceedances.

With the goal of expeditiously attaining conformance with NAAQS, the *California Clean Air Act* requires air districts to reduce emissions of nonattainment pollutants or precursors by 5 percent per year, and requirements are adopted within each air district's clean air plan. The stringency of requirements within each local clean air plan and subsequent implementing air regulations is

based on the severity of the problem and projected timeframe when the area is expected to achieve attainment. As part of this process, both the BAAQMD and SJVUAPCD have adopted "no net increase" provisions within their clean air plans. The "no net increase" programs require that, as a precondition to the issuance of an air permit for a significant new or modified emission source, any increases in emissions of nonattainment pollutants or precursors be offset by mandatory reductions in emissions of other sources onsite or potentially at other facilities. In the BAAQMD, the offset requirement is triggered for mid-size facilities (emissions of 15 tons per year or more of nonattainment pollutants), and a greater burden is placed on large facilities (emissions of 50 tons per year or more). These large facilities must offset any proposed emission increases by a slightly greater decrease, at a ratio of 1.15 to 1.0. The added 15-percent in part satisfies the 5-percent annual emission reduction requirement of nonattainment areas (LLNL 2002e). The Livermore Site falls into the mid-size facility category and must abide by the requirements of the BAAQMD for emission offsets. Site 300, the majority of which lies within San Joaquin County, is under the jurisdiction of the SJVUAPCD.[1] In SJVUAPCD, offset requirements are triggered at 10 tons per year. Although this level is much lower than that established by the BAAQMD, emissions at Site 300 are substantially less than the offset trigger level (LLNL 2002e). Additional information on emission levels and the offset management program are provided in Section 4.10.4.

4.10.2.2 *Toxic Air Pollutant Programs*

Programs regulating toxic air contaminants differ from those regulating criteria air pollutants. Rather than establishing standards, regulating air toxics is based on managing risk. Risk can be thought of as a probability of harm. That probability can be determined for any air toxicant based on its toxicity, airborne concentration, and exposure rate. The California Office of Environmental Health Hazard Assessment classifies and determines compound toxicity. Air toxics are generally classified as carcinogenic (based on evaluations related to the substance's expected potency as a cancer-causing agent) or noncarcinogenic.

Noncarcinogenic health impacts may involve either transient or long-term impacts to either one or a number of individual organs (e.g., skin or eye irritations, kidney damage, etc.) or systems (respiratory, nervous, cardiovascular, reproductive, etc.). Noncarcinogens are further classified as acute or chronic, based on the ability to cause harm due to either short-term exposures to high levels or long-term, repeated exposure to lower levels. Many substances are classified as both acutely and chronically toxic and also have been categorized as carcinogens. Impacts of toxic air contaminants are typically evaluated cumulatively (i.e., as the sum of the impact of each air toxicant with similar effects). For example, the impact to the respiratory system is calculated as the sum of the impacts of each air toxicant identified as a respiratory irritant.

The California Office of Environmental Health Hazard Assessment has also developed standardized methods used to evaluate human health risk. The methods are designed to be conservative so as to not underestimate the risk. For carcinogens, the risk is expressed as either an individual excess lifetime cancer risk or a population risk. Excess is used here to refer to a

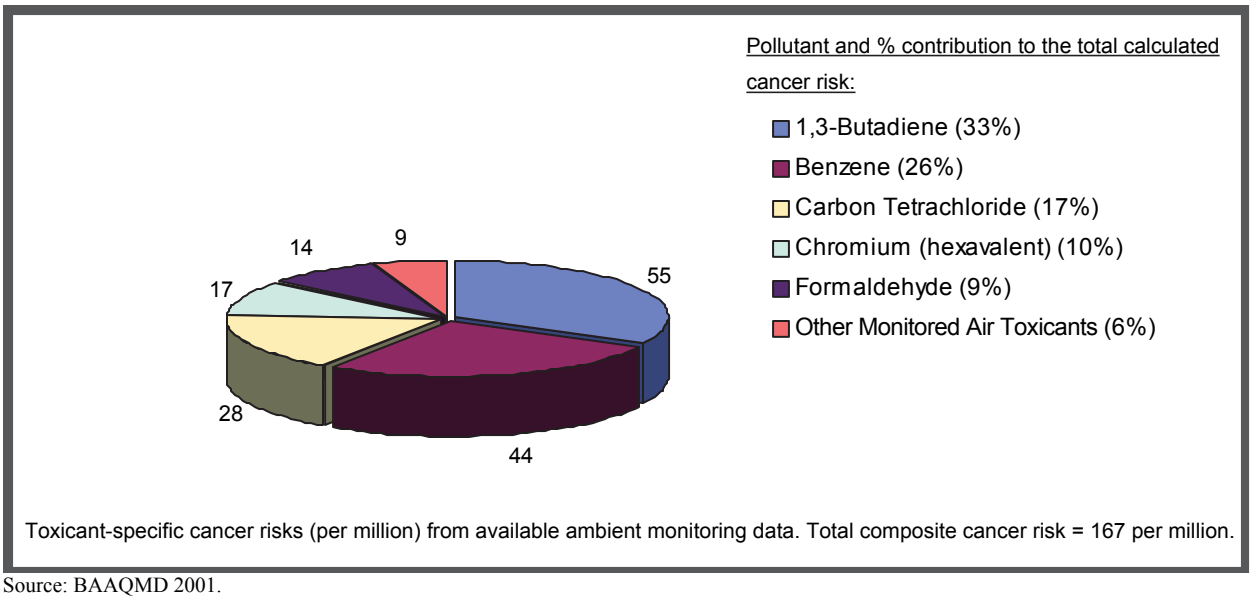
[1] As stated in Section 4.10.1, a small portion of Site 300 falls within Alameda County, which is under the jurisdiction of the BAAQMD.

risk above background (generally assumed to be 1 in 3). Cancer risk is typically calculated assuming a full-time (70-year) exposure period. In many cases, the risk is stated as a risk per million.

A cancer risk of one in one million (1×10^{-6}) is generally considered negligible. For non-cancer, the risk is presented as a health hazard index (HHI). It is simply the ratio, summed over all contaminants, of the amount of contaminant to the level of that contaminant below which health impacts are not expected to occur. An HHI less than 1 is generally acceptable; no impact is expected. The air districts, together with guidance from state agencies and considering all public input, determine generally acceptable risk levels.

Air districts monitor toxic air contaminant levels and use the data to estimate background risk. The BAAQMD monitors a number of air contaminants throughout the Bay Area and has compiled a composite cancer risk for exposure to air toxics. Figure 4.10.2–3 shows the individual excess cancer risk calculated from average measured ambient concentrations of air toxics in the Bay Area. Of the pollutants for which monitoring data[2] are available, 1,3-butadiene and benzene (which are emitted primarily from motor vehicles) account for over one-half of the average calculated cancer risk. The BAAQMD reports that ambient benzene levels declined dramatically in 1996 with the advent of reformulated gasoline, with significant reductions in ambient 1,3-butadiene levels also occurring. Due largely to these observed reductions in ambient benzene and 1,3-butadiene levels, the calculated average cancer risk has been significantly reduced in recent years. Based on 2000 ambient monitoring data, the calculated cancer risk is 167 in one million, which is about 45 percent less than that observed 5 years earlier (BAAQMD 2001). The calculated risk in and around the city of Livermore is likely to be similar, or slightly less than this composite value (on the basis of ambient levels of gaseous carcinogens monitored in Livermore in 2000, and default Bay Area composite values for substances not monitored locally). Although data are not available for Site 300 environs or the city of Tracy, ambient levels of gaseous carcinogens are likely to be lower in these less densely populated areas.

[2] Ambient monitoring data are available for a limited number of toxic air contaminants. Diesel particulate matter, recently listed by the State of California as carcinogenic, is not included in the referenced evaluation.



Source: BAAQMD 2001.

FIGURE 4.10.2–3.—*Cancer Risk Due to Average Ambient Concentrations of Toxic Air Contaminants Measured in the Bay Area in 2000*

In addition to monitoring ambient levels, air districts develop air toxic emissions inventories. The inventory is part of California's comprehensive Air Toxics "Hot Spots" program, whereby industrial facilities and air districts are required to inventory emissions of some 300 toxic air contaminants and evaluate potential risks posed by their emissions. Where the risk is considered significant, the air districts must notify the exposed public and expeditiously reduce the risk. Facilities must report all emission information for each air contaminant for which emission rates exceed a reporting threshold. Each pollutant-specific reporting threshold reflects the emission level that is estimated to result in a *de minimis* (negligible) level of health risk based on a series of conservative risk assessment assumptions (e.g., lifetime exposure and close proximity to the emission source). For carcinogens, the threshold reporting levels have been set at the emission level that corresponds to a cancer risk of one in one million (1×10^{-6}). Noncarcinogen reporting levels represent the amount estimated to result in an HHI of 1. Using this information, air districts throughout the state are required to prioritize facilities for additional review. High-priority facilities are required to submit detailed health risk assessments. Both the Livermore Site and Site 300 are ranked by the air districts as low-risk facilities (LLNL 2003l).

4.10.2.3 *National Emission Standards for Hazardous Air Pollutants*

The Federal EPA has also established programs to reduce emissions of approximately 200 hazardous air pollutants (HAPs). The National Emission Standards for Hazardous Air Pollutants (NESHAP) include requirements categorized by pollutant type, emissions level, and/or industrial category. For the most part, these standards apply to major sources of HAPs, emitting 10 tons per year or more of any single HAP, or 25 tons per year or more in the aggregate.[3] In addition to the state air toxic program, local air districts administer many of the federally mandated programs,

[3] Radiological NESHAP are detailed in Section 4.10.5.

although in most cases the local or state program has been deemed equivalent or more restrictive, and therefore supercedes Federal requirements.

4.10.3 Source Evaluation and Control

In addition to air program development and assessment, local air districts must

- Evaluate air emission sources.
- Issue air permits with operating terms and conditions.
- Inspect sources routinely to determine compliance.
- Take necessary enforcement actions.

This section summarizes some of the more specific aspects of the programs. Emphasis is placed on elements pertinent to LLNL activities.

4.10.3.1 *Permit Program and New Source Review*

All activities with the potential to emit and/or control air pollutants must operate under the requirements of the air permit, unless the activity has been specifically determined to be exempt. In fact, for most operations, a preconstruction review and permit to construct must first be issued.[4] In order to receive a permit to operate, a facility must submit all pertinent data to the air district to demonstrate equipment will be operated, or the facility will be managed, in a manner that complies with all air pollutant control regulations (local, state, and Federal). The air district must evaluate the source and make a determination that reinforces compliance, and the district will specify equipment standards and/or operating conditions within the permit. Major aspects of the review include the following:

Evaluation of Best Available Control Technology (BACT) and No-Net-Increase Program for Nonattainment Pollutants

Many sources are required to incorporate a very stringent level of control. This requirement stems, in part, from the no-net-increase program for nonattainment pollutants. In addition, sources may be required to offset new emissions by incorporating reductions in other sources. The analysis will also evaluate a facility's status with respect to threshold levels that may trigger additional requirements, such as requirements to provide a higher level of offsets. Additional air protection program requirements are triggered for larger emitting facilities. These programs include the Federal Title V Operating Permit Program and major source requirements under NESHAP.

Assessment of Potential Health Impacts of Toxic Air Contaminants and Adherence to District Risk Management Criteria

Many sources are required to incorporate a very stringent level of control on air toxic sources, commonly referred to as Toxic Best Available Control Technology (TBACT).

[4] The air districts have evaluated certain types of activities and have determined that either due to the scale of the operation (many activities have threshold levels for raw material throughput or equipment rating [horsepower or British thermal units]) or to the nature of the activity (e.g., some research activities are exempt), these activities are exempt. Exempt sources are listed in air district rules, but in some cases, in particular for unique operations, a facility may ask the district to review a source and make a case-by-case determination.

Conformity

In addition to their authority for stationary source emission control programs, local regulatory agencies are afforded an additional level of control over Federal projects through the requirements for conformity. Title I, Section 176, of the *Clean Air Act* (42 U.S.C. §7401 et seq.) defines conformity as the upholding of a set of air quality goals by eliminating or reducing violations of the national ambient air quality standards (NAAQS) and achieving attainment of these standards. Conforming activities or actions should not, through additional air pollutant emissions:

- Cause or contribute to new violations;
- Increase the frequency or severity of existing violations; or
- Delay timely attainment or interim emission reductions.

EPA established the General Conformity Rule in November 1993 (58 FR 63247) to implement the CAA conformity provision. The rule mandates that the Federal government not engage, support, or provide financial assistance for licensing or permitting, or approve any activity not conforming to an approved CAA State Implementation Plan (SIP) that describes how the region will achieve and maintain attainment of air quality standards. In general terms, conformity is designed to ensure that Federal plans, programs and/or projects are consistent with the SIP and local clean air plan, and not contribute to air quality degradation that would prevent or delay achievement of state and Federal air quality goals.

The General Conformity Rule establishes conformity as a coordination process in which the economic, environmental, and social aspects of transportation and air quality planning are considered. Therefore rules for conformity are not limited to sources, which require air district permits, but must consider total (direct and indirect) project emissions, including emissions from vehicles, construction, demolition and non-permitted sources.

Conformity analysis begins with the applicability determination. Federal agencies are required to identify, analyze, and quantify emissions associated with any action that is federally funded, licensed, permitted, or approved, where the total direct and indirect emissions for any criteria pollutant in a non-attainment or maintenance area exceed rates specified in 40 CFR §51.853, or where the emissions are deemed to be regionally significant, even if the total emissions are less than the specified (de minimis emissions) rates. A Federal action is exempt if:

- Emissions will not increase
- An increase in emissions is clearly *de minimis*, or
- Total direct and indirect emissions for criteria pollutants are less than specified threshold rates, except when emissions are deemed to be regionally significant[5].

Conformance requirements do not apply to continuing and recurring activities such as permit renewals where activities conducted will be similar in scope and operation to activities currently

[5] LLNL emissions are not considered regionally significant. Livermore Site emissions from permitted and exempt sources are less than 0.1 percent of Bay Area stationary source emissions. Similarly, Site 300 emissions are much less than 0.1 percent of San Joaquin Valley emissions (LLNL 2003l).

being conducted. EPA has published "General Conformity Guidance: Questions and Answers," June 13, 1994 which are used in assessing conformity applicability. For example, with regard to prescribed burning programs, EPA stated (in answering Question #47), "If the prescribed burning program is an ongoing program of a set number of acres per year in the same general geographic area, an action to continue the program at or below the existing level would be consistent per se de minimus under section 91.853(c)(2)(ii) of the rule and would be exempt from conformity rules." Therefore, continuance of the ongoing prescribed burning program at current levels is not subject to requirements for conformity.

Conformity is assessed on a pollutant-by-pollutant basis, and threshold levels are established for each criteria pollutant, consistent with the regional attainment or maintenance status. Within the Bay Area, conformity applies to projects projected to generate 100 tons per year or more of precursor volatile organic compounds. The same threshold level applies for projected emissions of oxides of nitrogen, and carbon monoxide. Such projects would be required to fully offset or mitigate the emissions caused by the action (BAAQMD 1999). The BAAQMD also considers PM_{10} emissions when addressing conformity issues, owing to the unclassified status.

SJVUAPCD petitioned to be classified as "Non-Attainment-Extreme" with respect to the l-hour ozone standard, and the petition was accepted by EPA. Consequently, the conformity threshold for both oxides of nitrogen and precursor volatile organic compounds is extremely stringent, 10 tons per year. SJVUAPCD is "Non-Attainment-Serious" for PM_{10} (applicable threshold for PM_{10} is 70 tons per year), and "Attainment Maintenance" for carbon monoxide (applicable threshold is 100 tons per year). SJVUAPCD has adopted a General Conformity Rule 9110, to implement the CAA conformity requirements. Rule 9110 includes an exemption in Section 51.853(b)(2)(ii), which applies to actions which would result in no emissions increase or an increase in emissions that is clearly de minimus (SJVUAPCD 2003). Specifically, subsection (ii) refers to "Continuing and recurring activities such as permit renewals where activities conducted will be similar in scope and operation to activities currently being conducted."

LLNL must comply with conformity regulations, and conformance is demonstrated in part through the NEPA process, wherein LLNL provides calculated upper-bound emission estimates for proposed alternatives. Estimates are comprehensive, in that they include construction, demolition, and vehicular emissions, in addition to emissions from stationary sources. Conformance is further demonstrated through the air permit program. Proposed activities that may generate an increase in air pollutants are reviewed for consistency with local, state and Federal air regulations. The local air district will issue construction or operating permits for equipment only after demonstration that the equipment complies with all applicable district regulations, and the owner or operator provides assurance that the equipment will be operated in compliance with imposed conditions. The districts do not permit new sources within the district boundaries that would compromise air quality goals. Therefore, conformity is assured on an ongoing basis through the district's regulatory actions and procedures, and monitored through the district emission inventory and compliance programs.

4.10.3.2 *Continuing Source Assessment and Compliance*

Air districts use various measures to monitor facility compliance with district rules and operating requirements. The emissions inventory is a key component. Facilities are required to submit emissions information to the air districts on a routine basis; typically this is done annually as part of the permit renewal application. The district evaluates this information and makes a determination prior to permit renewal. The district also routinely inspects air emission sources,

and if applicable, reviews operating logs and conducts emissions tests. If a source is operating out of compliance, applicable enforcement actions, which may include fines, imposition of additional oversight, revocation of a source's operating permit, and other measures will be imposed.

4.10.4 Lawrence Livermore National Laboratory Air Protection Program

4.10.4.1 *Source Evaluation and Regulatory Assessment*

All LLNL activities with the potential to produce air pollutant emissions are evaluated to determine the need for air permits and assessed for continued compliance. LLNL also monitors existing and pending environmental legislation to assess potential impacts to ongoing and proposed operations. LLNL staff also work with air district representatives to evaluate and understand LLNL emission sources (e.g., LLNL Environmental Protection Department [EPD] staff worked with the SJVUAPCD to develop criteria for an explosives testing exemption rule). Sources that have been determined to be exempt from permit requirements are monitored to substantiate that each source operates in agreement with exemption specifications (e.g., throughput remains within the limits of a specified exempt quantity).

4.10.4.2 *Permitted Equipment*

As stated, air permits are obtained from the BAAQMD for the Livermore Site and from the SJVUAPCD for Site 300. In 2002, the BAAQMD issued 199 permits for operation of various types of equipment at the Livermore Site, and SJVUAPCD issued air permits for 44 air emission sources for Site 300. A general listing of air permits is provided in Table 4.10.4.2–1.[6]

4.10.4.3 *Air Pollutant Emissions Inventory*

Criteria Air Pollutants

As part of the annual permit renewal process, facilities supply information to the district on material throughput and/or usage for permitted sources at their sites. This information is entered into the district's database where it is used to estimate air emissions. The emissions inventory serves as a means to determine facility category (small, medium, or large) and thereby dictate requirements, such as those under the no-net-increase programs. The inventory and LLNL's status with respect to facility categorization is of great importance. To encourage good air protection practices, the district allows mid-size facilities, which meet stringent control requirements, to borrow offset credits from the district bank. The Livermore Site meets the emission limits for a mid-size facility in terms of the BAAQMD's no net increase programs, and the district has determined that this facility has emission controls on its precursor organic compound and nitrogen oxide emission sources, which satisfy the stringent control eligibility requirement to receive credits from the district. The conditions associated with obtaining credits from the district include continued compliance with stringent control requirements, and

[6] The number of permitted units may vary substantially from year to year. Changes in air district regulations, which categorize the types of equipment and activities that are exempt from the requirement to obtain an air district operating permit, may trigger the need to obtain permits for sources that were previously exempt. In other cases, improvements in technology or air district passage of a prohibitory rule may obviate the need for air permits for a particular source category.

maintaining emissions below the 50-tons-per-year threshold.[7] Requirements to maintain emission levels below applicable thresholds are also dictated within the Livermore Site Synthetic Minor Operating Permit which was finalized by the BAAQMD in November 2002 and forwarded to EPA for review. The Synthetic Minor Operating Permit includes requirements that limit nitrogen oxide emissions from combustion sources to less than 50 tons per year, and precursor organic compound emissions from solvent evaporating sources to less than 50 tons per year. The 50-ton-per-year emission limits within the Synthetic Minor Operating Permit establishes the Livermore Site as a minor source, which is not subject to the federally based Title V Operating Permit program. Permit conditions also require LLNL to prepare an annual emissions report for each year (LLNL 2003l).

TABLE 4.10.4.2–1.—*Summary of Lawrence Livermore National Laboratory Permits Active in 2002*

	Permitted Units	
Category	**Livermore Site**	**Site 300**
Coating, printing, and adhesives	Paint spray booths Adhesives operations Optic coating operations Printing press operations Silk-screening operations Silk-screen washers	Paint spray booth
Combustion	Boilers Generators Diesel air-compressor engines	Boilers Generators
Explosives testing	Fire test cells and firing tanks	Contained Firing Facility
Gasoline dispensing	Gasoline dispensing operation	Gasoline dispensing operation
Machining	Metal machining and finishing operations	-
Ovens	Ovens	Drying ovens
Remediation and waste management	Groundwater air strippers/dryers Oil and water separator Sewer diversion system Drum crusher Paper-pulverizer system	Groundwater air strippers Soil vapor extraction units Explosive waste treatment units Woodworking cyclone (exhaust system control device)
Solvent cleaning	Cold cleaners Ultrasonic cleaners Degreasers Manual wipe-cleaning operations	-
Miscellaneous	Storage tanks with volatile organic compound content in excess of 1% Plating tanks Semiconductor operations Image tube fabrication Material-handling equipment	Fire hazard management prescribed burning permit (see Section 4.10.4.7)
Total Permitted Units	**199**	**44**

Source: LLNL 2003l.

[7] If emissions should rise above the 50-ton-per-year threshold, the facility must immediately repay all borrowed credits. Repayment of borrowed credits must be in the form of credits obtained from another facility; it cannot be in cash. Future market values of offset credits are unknown, but current values are on the order of $10,000 per ton per year.

Livermore Site currently emits approximately 109 kilograms per day of criteria air pollutants from both permitted and exempt sources. The largest sources of criteria pollutants from the Livermore Site are surface coating operations, internal combustion engines, solvent operations, and natural gas-fired boilers. The largest sources at Site 300 are internal combustion engines, boilers, a gasoline-dispensing operation, open burning of brush for fire hazard management, paint spray booths, drying ovens, and soil vapor extraction operations (LLNL 2003l). Even though the SJVUAPCD no-net-increase threshold is much lower than the BAAQMD threshold, Site 300 is currently well below both the precursor organic compound and nitrogen oxide emission thresholds that trigger requirements for no net increase and should remain so in the foreseeable future (LLNL 2002e).

TABLE 4.10.4.3–1.—*Emission Rates for Criteria Air Pollutants and Precursors*

Pollutant [b]	Estimated releases (kilograms per day) [a]									
	Livermore Site					Site 300				
	1998	1999	2000	2001	2002	1998	1999	2000	2001	2002
Precursor organic compounds	25	24	20	19	16	0.90	1.2	0.4	0.1	0.23
Nitrogen oxides	56	81	54	52	67	2.1	3.2	2.3	0.9	1.1
Carbon monoxide [c]	11	24	14	14	17	0.48	0.71	0.5	1.1	1.0
Particulates (PM_{10})	5.7	8.6	5.5	5.5	6.1	0.53	0.33	0.2	0.3	0.09
Oxides of sulfur	0.72	0.98	0.6	0.6	2.8	0.15	0.28	0.2	0.1	0.07

Source: LLNL 2003l, LLNL 2002cc, LLNL 2001v, LLNL 2000g, LLNL 1999c.

[a] One kilogram equals 2.2 pounds.

[b] Individual air pollutants, or pollutant categories listed above, are those which are most widely regulated in air protection programs aimed at controlling sources and ambient levels of criteria air pollutants, both Federal and State of California. Organic compounds are regulated (and listed above) as precursors to the formation of the criteria air pollutant ozone. Other criteria air pollutants (state and Federal) are listed in Table 4.10.1-1.

[c] In 1999, the emission factor used to calculate carbon monoxide was 0.035 pound per 1,000 cubic feet for large boilers and 0.021 pound per cubic foot for small boilers. In previous years, the emission factor used was 0.017 pound per cubic foot for both large and small boilers. This resulted in a significant change in carbon monoxide emissions reported for 1999.

Toxic Air Contaminants

LLNL also compiles an inventory of toxic air contaminants under the California Air Toxics "Hot Spots" program (see Section 4.10.2.2). Of the more than 300 hot spot chemicals, only a few are emitted from LLNL processes at levels that exceed the *de minimis* reporting threshold. On the basis of the air toxics inventories, BAAQMD and SJVUAPCD have ranked LLNL as a low-risk facility for nonradiological air emissions (LLNL 2003l).

Hazardous Air Pollutants

A separate Federal listing of approximately 200 compounds is evaluated to confirm applicability under NESHAP. Thresholds defining a major source under NESHAP are 10 tons per year for a single hazardous air pollutant or 25 tons per year for a combination of hazardous air pollutants. Emission rates at both LLNL sites are less than one-half of these thresholds (LLNL 2002e). The Livermore Site Synthetic Minor Operating Permit (discussed above) includes a limitation on total HAP emissions (less than 23 tons per year) and annual reporting requirements, which establishes LLNL's minor source status. Although, LLNL is not a major facility in terms of HAP emission rates, specific NESHAP programs apply for beryllium (discussed in Section 4.10.4.8) and radionuclides (Section 4.10.5).

4.10.4.4 *Annual Compliance Inspections and Enforcement Actions*

Each year, BAAQMD and SJVUAPCD officials inspect operations at the Livermore Site and Site 300, respectively. Annual compliance inspections entail a review of permitted and exempt equipment, including documentation to demonstrate adherence to prohibitions; operating, record keeping, and notifications requirements; and emissions limitations. New equipment is also inspected prior to issuance of a new permit to operate, to ensure that equipment specifications comply with conditions specified in the authority to construct permit. In the last several years, there have been no enforcement actions or deficiencies noted; however, LLNL received a Notice of Violation from the BAAQMD on April 9, 2003, for an alleged record keeping violation during the period September 2002 through February 2003. The Notice of Violation was resolved by LLNL's payment of a monetary penalty to BAAQMD (LLNL 2003l, LLNL 2002cc, LLNL 2001v, LLNL 2000g, and LLNL 1999c).

4.10.4.5 *Lawrence Livermore National Laboratory Air Emissions Offsets Management Plan*

The LLNL Air Emissions Offsets Management Plan establishes responsibilities for LLNL's management of air emissions and emission credits necessary to meet offset requirements of the regional air districts (LLNL 2002e). The plan specifically states that:

> BAAQMD emissions will be maintained below the 50 tons per year pollutant-specific threshold, and SJVUAPCD emissions will be maintained below the 10 tons per year pollutant-specific threshold. Emission sources may be prioritized in the future, so that some emission sources are curtailed to allow replacement by new sources in order to maintain overall emissions below the thresholds.

The system is guided by the principal of maintaining emissions as low as reasonably achievable (ALARA) and managing emissions on the basis of cost effectiveness to obtain maximum benefit to LLNL, meet or exceed the intent of the *California Clean Air Act*, provide for timely permitting of new projects, and avoid the necessity for additional permitting associated with major source programs.

4.10.4.6 *Integrated Air Pollution Prevention Programs*

Pollution prevention is a cross-disciplinary program implemented at LLNL. Examples of LLNL pollution prevention and waste minimization activities with resultant benefit to the air resources include transportation demand management, reduced precursor organic solvent use and recycling programs, programs to substitute steel weight (rather than lead weight) at the Site 300 firing table, energy conservation, and programs to reduce the use of stratospheric ozone-depleting substances sitewide (LLNL 1997a). These are part of the Environmental Management System (EMS) and Integrated Safety Management System (ISMS) programs at LLNL, which are discussed in detail in Appendix O.

4.10.4.7 *Controlled Burning Operations at Site 300*

Site 300 has conducted controlled burns (i.e., prescribed burns) throughout its 40+ year history for wildfire control. The annual prescribed burn can cover up to 2,100 acres, which is divided into control plots ranging from less than 1 acre to 600 acres. Daily prescribed burn acreage can range between approximately 10 acres to 1,200 acres. Annual prescribed burning typically takes place from mid-May through July when the grass (i.e., fuel) is dry enough to sustain a burn and not too dry to present uncontrollable fire risk. Prior to the prescribed burn each year, LLNL

submits a prescribed burn/smoke management plan to both the SJVUAPCD and BAAQMD and meets each air district's planning and reporting requirements.

Planning and coordination with both air districts is critical. Each district imposes stringent review and approval requirements before allowing prescribed burn activities to take place to meet their smoke management objectives. In addition, each air district prioritizes burn activities requested within their air basin and provides daily burn allocations to the requesting facility based on air quality, weather conditions, declared burn days, and other scheduled burn activities. In addition to meeting air district requirements, LLNL conducts prescribed burns to meet DOE wild land management requirements and follows best management practices to minimize the creation of smoke and ensure safe burn conditions.

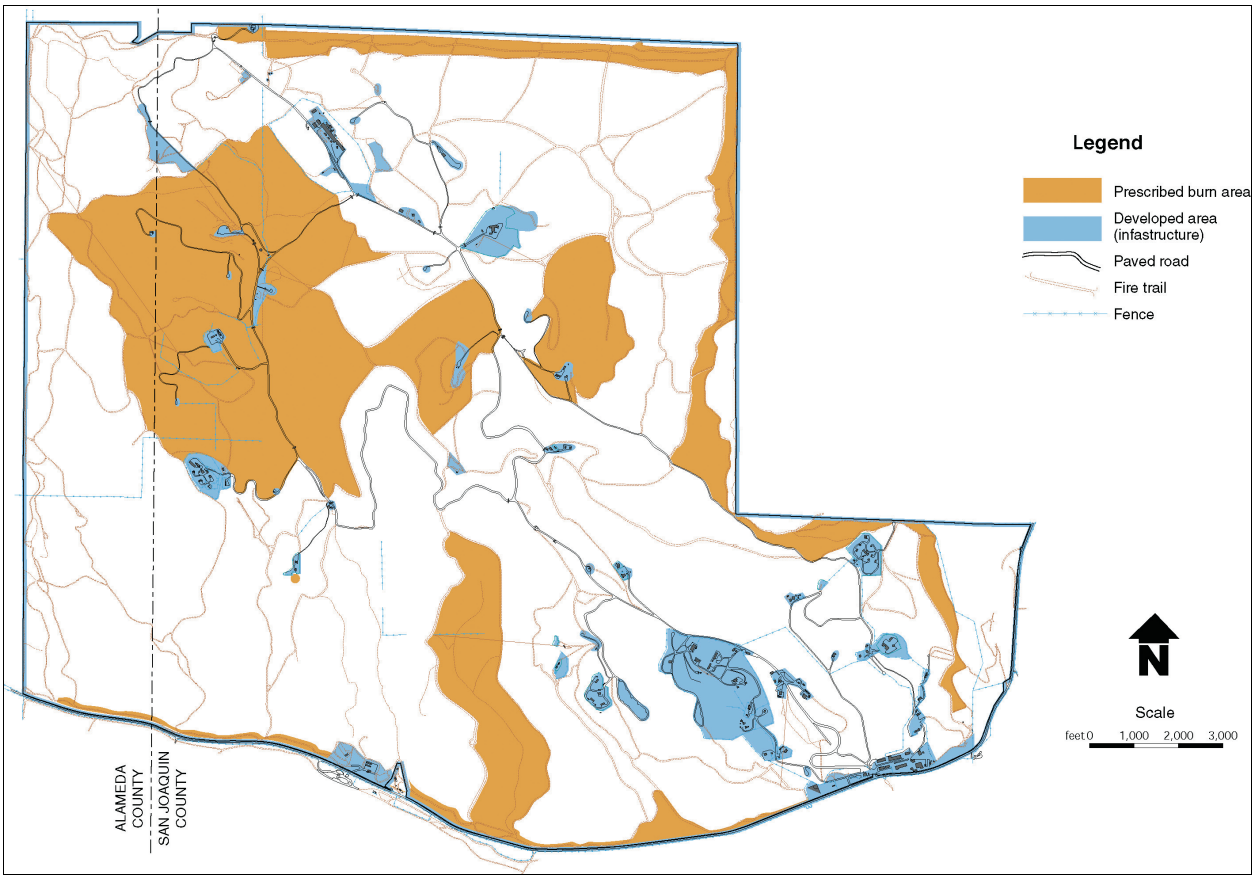
Annual prescribed burn areas are shown in Figure 4.10.4.7–1. Prescribed burning conducted at Site 300 is considered a long-term asset to air quality as it reduces the potential for destructive wildfires. In addition, fires remove potential airborne residues that accumulate, such as pollen and other respirable matter. The principal objectives of the LLNL Site 300 Explosive Test Facility Prescribed Burn/Smoke Management Plan (LLNL 2004a) are to:

- Minimize the occurrence of unnaturally intense fires by reducing the amount of vegetation that can fuel larger, more catastrophic fires.
- Preserve the capability to safely test explosives while protecting the environment.
- Minimize the occurrences of fires that could leave the Site 300 boundaries and impact neighbors and limit the extent of prescribed fires, which could reduce the air quality for neighbors.
- Use minimum impact prescribed burns and fire suppression techniques, and rehabilitate areas to protect natural and cultural resources from adverse impacts attributable to wildfire suppression activities.

Fire has been one of the primary forces that created and maintains the biodiversity and specialized wildlife habitats throughout Central California. Alternatives to prescribed burning have been researched. Livestock grazing was found to be nonbeneficial due to its threat to native grasses, wetlands, and endangered species and is also limited in value due to the restriction of areas available for grazing. Disking was found to have limited benefit but has been used on an infrequent basis on a small portion of the site perimeter in lieu of controlled burning to avoid the spread of fire to adjacent private lands. Mowing is not suited for most areas because of the terrain. Herbicides are used around facilities where controlled burning could pose a threat to the facility, but herbicides are not used in the large tracts of land where controlled burning is employed because they limit plant ecosystem diversity, unlike controlled burning which fosters the growth of native plants. The planting of fire-resistant, nonnative species would pose a further threat to native grasses, which prove a more favorable habitat for other native flora and fauna (LLNL 2001c).

4.10.4.8 *Beryllium Monitoring and Exposure Evaluation*

Beryllium metal, alloys, and compounds are used at LLNL. Although LLNL is not a major facility in terms of HAP emission rates, specific NESHAP requirements (40 CFR Part 61[c]) apply for beryllium. Beryllium is identified with respiratory and immune system toxicity, and is regulated under both state and Federal programs. The State of California has



Source: LLNL 2001c.

FIGURE 4.10.4.7–1.—*Site 300 Annual Prescribed Burn Areas*

identified a reference exposure level (air concentration) associated with long-term (chronic) exposures to the public. Chronic exposure to concentrations in excess of this level (0.007 micrograms per cubic meter)[8] require the implementation of air toxic risk reduction measures.

LLNL measures beryllium at fenceline locations, both at the Livermore Site and Site 300, and within the city of Tracy.[9] All air samplers are positioned to provide reasonable probability that any significant concentration of beryllium effluents from LLNL operations will be detected. The median beryllium concentration for Livermore Site perimeter locations for 2002 was 1.4×10^{-5} micrograms per cubic meter, and the highest value was 2.8×10^{-5} micrograms per cubic meter. At Site 300, the median was 6.8×10^{-6} micrograms per cubic meter, and the maximum was 2.0×10^{-5} micrograms per cubic meter. The median concentration in Tracy over the same period

[8] The chronic reference exposure level for beryllium (previously 0.01 $\mu g/m^3$) was reevaluated and revised by the State of California Office of Environmental Health Hazard Assessment, December 2001(OEHHA 2003).

[9] To satisfy beryllium reporting requirements and determine the effects of the Laboratory's beryllium operations, LLNL conducted a technical assessment of the beryllium monitoring locations at Site 300 in 1997. Although there is no requirement to sample for beryllium at Site 300, LLNL has decided, as a best management practice, to continue beryllium monitoring at three locations onsite and at one location in the city of Tracy.

was about 30 percent higher than that at Site 300, and the maximum value was almost 60 percent higher than the level recorded at Site 300. This is believed to be the result of the location of the sampler which is situated in a congested part of town, and therefore accumulates more industrial particulate pollutants. When compared to the reference concentration level, all values are less than one-half of one percent of this standard, and do not indicate the presence of a threat to the environment or public health. The concentrations of beryllium at both sites can be attributed primarily to resuspension of surface soil containing naturally occurring beryllium. Local soils contain approximately 1 parts per million of beryllium (LLNL 2003l, LLNL 2003cb).

4.10.5 Radiological Air Quality

Some LLNL facilities discharge low quantities of radionuclides to the air. These releases can be evaluated according to the individual and population dose they create. The degree of hazard to the public is directly related to the type and quantity of the radioactive materials released. Dose estimates are modeled from emissions determined at each facility or, in the case of diffuse sources such as soil resuspension, from air sample measurements. Separate doses are calculated for the Livermore Site and Site 300 because of their spatial separation and are compared to regulatory dose limits for the protection of public health. Historically, doses have never exceeded regulatory limits. Recent annual doses to the hypothetical site-wide maximally exposed individual (see Table 4.10.5–2) have been less than 2 percent of a chest x-ray (West and Coronado 2003).

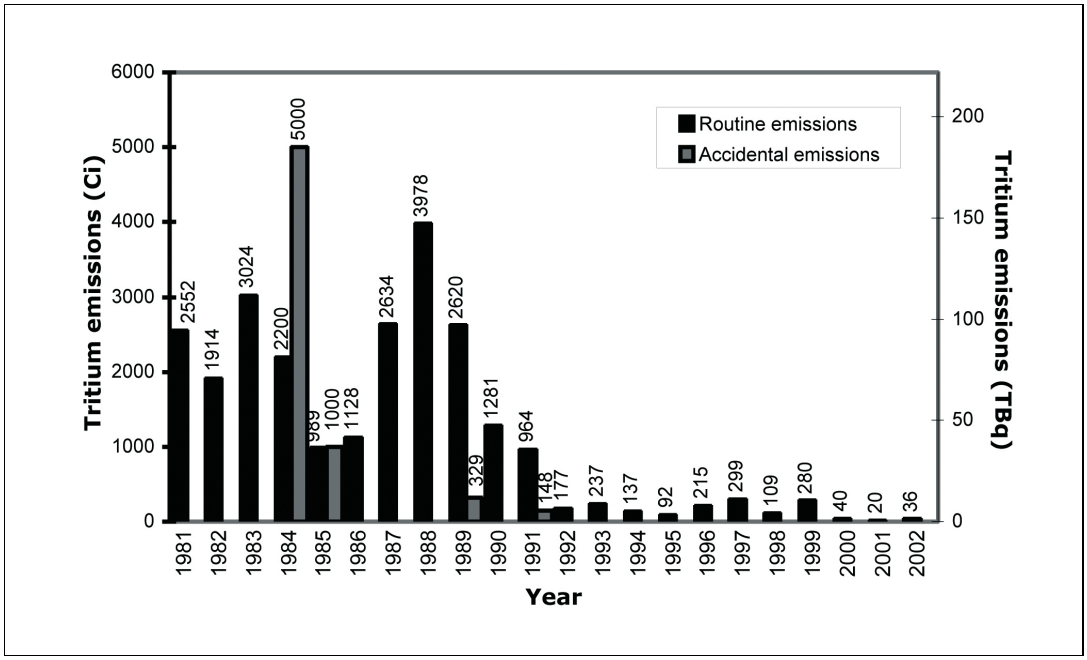
New, modified, and ongoing LLNL projects having potential radiological impact on the public and the environment are identified and assessed in NEPA reviews and Integration Work Sheets (IWSs). Such projects are documented each year in LLNL's NESHAP Annual Report and SAER. Facilities with designated Radioactive Materials Management Areas (RMMAs) report usage of radioactive materials that have potential for emission to air. Facility documents such as Safety Analysis Reports (SARs), Facility Safety Plans (FSPs), and Operational Safety Plans (OSPs) describe administrative controls designed to keep radiation exposures to workers, the public, and the environment as low as reasonably achievable.

4.10.5.1 *Radioactive Airborne Emissions*

LLNL monitors the stack effluent from its principal facilities and measures concentrations of radionuclides in ambient air both on and offsite, to determine if radionuclides are being released and in what concentrations. LLNL performs research using a variety of radioactive materials, including tritium, uranium, plutonium and other transuranic radionuclides, biomedical tracers, and mixed fission products. The contribution to the offsite dose is predominated by tritium from the Livermore Site and depleted uranium from Site 300 (see Section 4.10.5.2). Although even less important than these, other radionuclides such as carbon-14, strontium-90 and other beta emitters, and transuranics such as plutonium-239, americium-241 and other alpha emitters can also be released. A complete list of radionuclides which can potentially be emitted can be found in the NESHAP Annual Report (LLNL 2002bb).

In 2002, 74 systems sampled radioactivity from air exhausts at 7 Livermore Site facilities (MARS, Extractor Test Facility, Chemistry and Materials Science, Heavy Elements, Tritium, Plutonium, and Laser Isotope Separation) (LLNL 2003l). The only Site 300 effluent sampling, at Building 801, was installed in 2002 to measure releases from the Contained Firing Facility (LLNL 2003l).

In 2002, 36 curies of tritium were released, 90 percent of it as tritiated water, from the Tritium Facility. Emissions from this facility continued to remain considerably lower than those during the 1980s due to a reduction in programmatic work. Figure 4.10.5–1 illustrates these historical releases. None of the facilities monitored for gross alpha and beta had emissions in 2002 (LLNL 2003l).

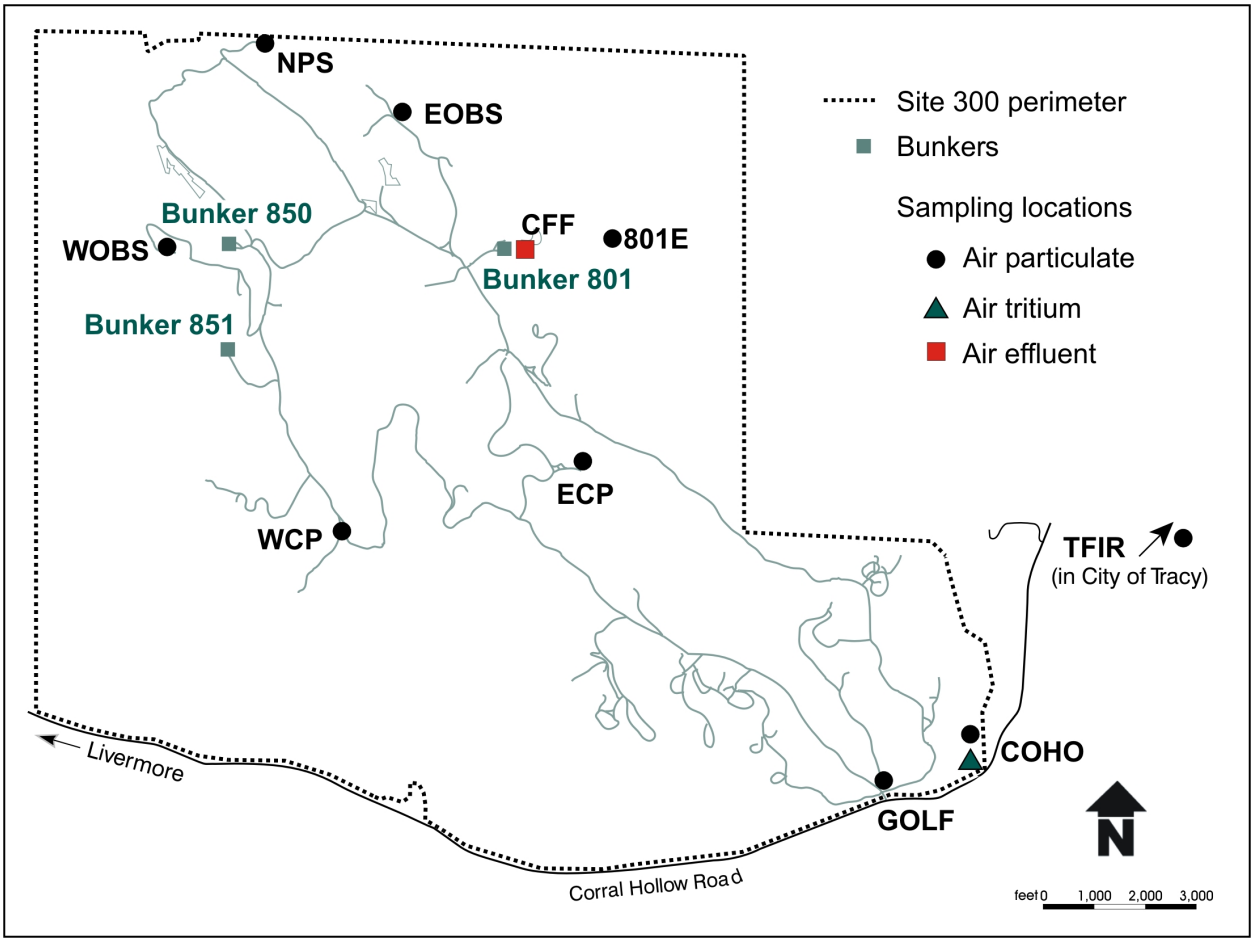


Source: LLNL 2003z.
Ci = curies; TBq = terabecquerel.

FIGURE 4.10.5–1.—*Tritium Emissions From the Tritium Facility, 1981-2002*

Ambient air is monitored by a network of air particulate and tritium samplers located on the Livermore Site (7 particulate samplers and 12 tritiated water vapor samplers), in the Livermore Valley (9 and 6, respectively), at Site 300 (8 and 1, respectively), and in Tracy (1 particulate sampler) (LLNL 2002cc). The samplers are positioned so that there is a reasonable probability that any potential release from LLNL operations would be detected (LLNL 2002bb). Figures 4.10.5–2 and 4.10.5–3 (LLNL 2001v) illustrates the effluent and ambient air sampling locations for the Livermore Site and Site 300, respectively.

Annual median concentrations of tritium (as tritiated water), plutonium-239 and 240, and uranium-238 reported at any Livermore Site location for the 5-year period beginning in 1998 range up to 4.5×10^{-10}, 1.1×10^{-18}, and 2.4×10^{-17} curies/cubic meter. Site 300 locations show even lesser concentrations of tritium and plutonium (LLNL 1999c, LLNL 2000g, LLNL 2001v, LLNL 2002cc, LLNL 2003l). The annual median concentration of uranium-238 reported at any Site 300 location for the same period is 3.0×10^{-17} curies/cubic meter.



Source: LLNL 2001v.

FIGURE 4.10.5–3.—*Site 300 Radiation Effluent and Air Sampling Locations*

Due to a recent refinement in the methodology to quantify tritium air samples (LLNL 2002bb), it is likely that tritium measurements made by site boundary and offsite tritium samplers prior to 2001 were a factor of up to 2 too low. This methodology change does not apply to effluent measurements, such as shown in Figure 4.10.5–1. Since calculations of dose to individuals and the public prior to 2001 are most significantly based on effluent releases (only the component of dose due to diffuse releases would be impacted by this concentration correction), conclusions based on the doses reported for years prior to 2001 are still valid.

4.10.5.2 *Radiation Dose to Members of the Public*

The maximally exposed individual (MEI) is a hypothetical member of the public at a fixed location who, over an entire year, receives the maximum effective dose equivalent (summed over all pathways) from a given source of radionuclide releases to air. The site-wide MEI is located where the composite dose from all site sources is greatest.

Dose is a measure of the quantity of radiation absorbed. Health effects from exposure to radiation can be estimated from this quantity (see Section 4.16.2). The radiation doses received by individual members of the public are bounded by the Livermore and Site 300 site-wide MEI. The LLNL sites, Livermore and Site 300, are far enough apart that the site-wide MEI from each site does not affect the other. Hence, a separate site-wide MEI is defined for each of the two LLNL sites.

The site-wide MEI dose is obtained by using the information gathered from effluent monitoring of point sources, knowledge of facility inventories for non-monitored locations, and ambient monitoring of diffuse sources, and then using this information in computer codes that model atmospheric dispersion, environmental transport, and human exposure. The site-wide MEI dose is also used to demonstrate compliance with 40 CFR Part 61, Subpart H (40 CFR Part 61[h]).

The population dose to a distance of 50 miles from each site, characterizes the total dose received by the surrounding resident population. A population dose is presented for each site. In addition, a total population dose from all LLNL operations is presented as the sum of the two individual site collective doses.

The site-wide MEI can change from one year to the next, chiefly as a result of varying quantities and locations of releases. The Livermore Site site-wide MEI has been located at the UNCLE Credit Union, about 10 meters outside the controlled eastern perimeter of the site, for the past dozen years or more (LLNL 2002bb).

The Site 300 site-wide MEI has been located on the south-central boundary of the site bordering the Carnegie State Vehicular Recreation Area, approximately 3.2 kilometers south-southeast of the firing table at Building 851 (LLNL 2002bb), since the year 2000. Prior to 2000, the Site 300 site-wide MEI was located in an area operated by Primex Physics International (presently by Fireworks America), 300 meters outside the east-central boundary of Site 300 (2.4 kilometers east-southeast of the present Building 801 Contained Firing Facility) (LLNL 2000h).

Table 4.10.5–1 gives annual radiological releases over the most recent 5-year period from the important dose (site-wide MEI) contributing site locations. It is generally found that a few sources (less than a dozen out of nearly 200 emissions sources at the Livermore Site) contribute over 90 percent of the individual and collective doses.

The contribution of tritium releases from Building 331 to the Livermore site-wide MEI dose is evident from Table 4.10.5–1. In 2000, 2001, and 2002 the releases from this building were markedly decreased from prior years. This decrease resulted in the Building 612 storage yard release becoming a relatively greater contributor (in terms of percent of total) to the site-wide MEI dose because of its ground-level release (as opposed to the elevated stack release from Building 331) and its proximity to the site boundary.

Doses are calculated from the releases using the CAP88-PC computer code. The code's database includes dosimetric and health affects data. It also accommodates site-specific input data characterizing meteorological conditions and population distributions for both individual and collective (population) doses (CAP88-PC 2000). Table 4.10.5–2 shows the individual (site-wide MEI) and collective doses for the recent 5-year period. The total population dose from all LLNL operations is the sum of the two site population doses shown in the table. The total population dose over the 5 years has ranged from 3.0 to 12.7 person-rem.

The EPA's radiation dose standard that applies to air emissions limits the dose (effective dose equivalent) to members of the public caused by operations to 10 mrem per year (40 CFR Part 61). The individual doses from LLNL are two to three orders of magnitude below this standard. The latter is verified by site ambient air measurements. An individual breathing air for 24 hours a day, 365 days per year containing the annual Livermore Site median concentrations of tritium, plutonium-239 and 240 and uranium-238 described in Section 4.10.5.1 would be exposed to a dose of 0.2, 0.001, and 0.06 mrem per year, respectively. These values occur at different locations around the Livermore Site. Such doses are 2, 0.01, and 0.6 percent of the NESHAP limit. Site 300 doses from measured uranium concentrations would be even less. The corresponding Site 300 dose for uranium-238 would be 0.08 mrem/yr, 0.8 percent of the NESHAP limit. The population doses can be compared with background radiation doses; population doses due to LLNL releases are approximately 200,000 times less than that received by the population from background radiation. Section 4.16.2 (Human Health and Worker Safety – Radiological Effects) describes the health effects associated with these doses.

TABLE 4.10.5–2.—*Dose to the Site-Wide Maximally Exposed Individual (Site-Wide MEI) and to the Population from LLNL Releases, 1998-2002*

Year	Livermore Site		Site 300		Total Population Dose[a]
	Site-wide MEI Dose (mrem)	Population Dose (person-rem)	Site-wide MEI Dose (mrem)	Population Dose (person-rem)	
1998	0.055	0.68	0.024	11	11.68
1999	0.12	1.7	0.035	11	12.7
2000	0.038	0.47	0.019	2.5	2.97
2001	0.017	0.16	0.054	9.4	10.1
2002	0.023	0.50	0.021	2.5	3.0

Source: LLNL 1999a, LLNL 2000h, LLNL 2001n, LLNL 2002bb, LLNL 2003z.
[a] Total population dose includes Livermore Site and Site 300 population doses.