

**BERKELEY
LAB**



Site Environmental Report for 2019

September 2020

Lawrence Berkeley National Laboratory
Environment, Health & Safety Division



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September 30, 2020

DISTRIBUTION

Subject: 2019 Site Environmental Report (SER) for the Ernest Orlando Lawrence Berkeley National Laboratory (LBNL)

This report, prepared by LBNL for the U.S. Department of Energy, Bay Area Site Office (DOE/BASO), provides a comprehensive summary of the environmental program activities at LBNL for calendar year 2019. SERs are prepared annually for all DOE sites with significant environmental activities, and distributed to relevant external regulatory agencies and other interested organizations or individuals.

To the best of my knowledge, this report accurately summarized the results of the 2019 environmental monitoring, compliance, and restoration programs at LBNL. This assurance can be made based on the reviews conducted by DOE/BASO, and LBNL, as well as quality assurance protocols applied to monitoring and data analyses at LBNL.

A reader survey form is posted with the SER at the LBNL website to provide comments or suggestions for future versions of the report. Your response is appreciated.

Questions or comments regarding this report may also be made directly to DOE/BASO, by contacting Jose Roldan of the Bay Area Site Office at (510) 486-4377, or by mail to the address above, or by email at mary.gross@science.doe.gov.

Sincerely,

A handwritten signature in blue ink, appearing to read "Paul Golan".

Paul Golan
Site Office Manager

Site Environmental Report for 2019

September 2020

Cover photo: Berkeley Lab's new Integrative Genomics Building against the backdrop of a San Francisco Bay sunset. Photograph by Thor Swift. © 2020 The Regents of the University of California, through the Lawrence Berkeley National Laboratory.

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Executive Summary

Lawrence Berkeley National Laboratory (LBNL, Berkeley Lab) is a multi-program scientific facility operated by the University of California (UC) for the U.S. Department of Energy (DOE). Berkeley Lab's research is focused on the physical, biological, environmental, and computational sciences, with the objective of delivering scientific knowledge and discoveries pertinent to DOE's mission. This annual report describes environmental protection activities and potential impacts resulting from LBNL operations conducted in 2019. The format and content of this report satisfy the requirements of both DOE Order 231.1B, Administrative Change 1 (Environment, Safety, and Health Reporting) and the operating contract between UC and DOE (DOE Contract No. DE-AC02-05CH11231, also known as Contract 31).

LBNL activities are planned and conducted with full regard to protecting employees, contractors, the public, and the environment, as well as complying with all applicable environment, safety, and health laws and regulations. In accordance with Executive Order (EO) 13834, *Efficient Federal Operations*, Berkeley Lab implements and integrates the key elements of its Integrated Safety and Environmental Management System (ISM) to achieve the site's integrated safety and environmental management system goals. Berkeley Lab implements the Environmental Management System (EMS) component of the ISM to oversee environmental compliance activities and continually improve overall environmental performance while maintaining operational capability and sustaining its overall mission. Berkeley Lab ensures the site is operated in a safe and environmentally responsible manner, and it complies with applicable environment, safety, and health laws, regulations, standards, and other requirements. LBNL managers and supervisors are responsible for ensuring that policies and procedures are understood and followed to protect both the environment and worker safety and health.

Throughout 2019, Berkeley Lab continued to strengthen its management systems. These systems provided a structured framework for Berkeley Lab to implement programs required by EO 13834 and DOE Order 436.1. The effectiveness of the EMS and environmental programs is reviewed annually as part of the performance evaluation process of Contract 31. For fiscal year (FY) 2019, which began October 1, 2018, and ended September 30, 2019, the EMS was given a performance rating of A for its management of environmental activities (on a scale from A plus as the highest grade, to F as the lowest). The measurement and rating system were developed jointly by Berkeley Lab, UC, and DOE. The FY 2019 rating was based on how Berkeley Lab met the objective in DOE's FY 2019 Performance Evaluation and Measurement Plan (Appendix B in Contract 31, Section J) of providing an efficient and effective EMS. Four significant accomplishments, which ranged from effective collaboration with the Sustainability office to integrating environmental project manager and EMS considerations into large capital projects, were factors in the rating.

Overall, environmental management systems at Berkeley Lab are effective, supporting compliance with all relevant environmental statutory and regulatory requirements. Berkeley Lab continues to make progress achieving performance metrics on key environmental goals, including energy, sustainable buildings, fuel/fleet efficiencies, increases in recycling, and decreases in waste generated, greenhouse gases generated, and use of water.

The EMS was also graded through the federal Office of Management and Budget's annual EMS performance metrics, in which a reporting scorecard rates elements of the International Organization for Standardization (ISO)

14001 standard and the degree of integration between the EMS and Berkeley Lab's sustainable practices. Overall scores fall into one of three categories: green (highest), yellow (middle), or red (lowest). For FY 2019, Berkeley Lab received a score of green, as described in more detail in [Chapter 2](#).

An overview of environmental protection and restoration programs is provided in [Chapter 3](#), including information about compliance activities, operating permits, and regulatory agency inspections and audits that occurred during 2019. Six minor violations, which have all been closed out, were issued during agency inspections of programs governing aboveground and underground storage tanks, hazardous waste treatment units, and hazardous waste storage areas. Environmental monitoring data of emissions and discharges from LBNL operations were below environmental compliance thresholds.

This report also includes information on environmental monitoring performed in 2019 ([Chapter 4](#)). The results of these monitoring activities confirmed that groundwater cleanup actions have been effective in reducing concentrations of volatile organic compounds (VOCs) in the groundwater, although concentrations appear to be reaching asymptotic levels in some areas. Site groundwater plumes are stable or are attenuating, and VOCs are not migrating off site.

In 2019, any potential radiological impacts to the public or the environment from LBNL operations were extremely low and fell well below regulatory thresholds. The radiological dose assessments ([Chapter 5](#)) performed in 2019 concluded that the maximum potential dose to a hypothetical resident from Berkeley Lab's potential airborne radionuclide releases was approximately 0.04% of the DOE and U.S. Environmental Protection Agency annual limit of 10 millirem per year (mrem/yr); the potential dose from all radiation sources at Berkeley Lab was approximately 0.19% of the average natural background radiation dose of 310 mrem/yr in the United States, and approximately 0.5% of the DOE annual limit of 100 mrem/yr from all sources related to LBNL operations.

Preface

Each year Lawrence Berkeley National Laboratory (LBNL, Berkeley Lab) prepares a Site Environmental Report that describes its environmental programs and performance for the most recent calendar year. This report provides an overview of Berkeley Lab, its Environmental Management System, and the status of environmental compliance programs, surveillance and monitoring activities, radiological dose assessment results, and quality assurance measures conducted in 2019. The document meets the reporting requirements of U.S. Department of Energy Order 231.1B, *Environment, Safety, and Health Reporting*.

This report was prepared under the direction of Robert Fox, an environmental manager for the LBNL Environmental Services Group (ESG). Primary contributors to the report were David Baskin, Ned Borglin, Carl Palladino, John Jelinski, Kelley Etherington, Ken Kievit, Jennifer Larson, Gary Lucks, Brendan Mulholland, Ron Pauer, Jeff Philliber, Karen Salvini, Nancy Sutherland, Patrick Thorson, and Suying Xu.

The Site Environmental Report can be viewed or downloaded from the Environmental Publications page of the ESG website (<https://ehs.lbl.gov/service/environmental-services/>), where many of the documents cited in this report can also be found. Questions about the report can be directed to Robert Fox at rafox@lbl.gov or 510-486-7327. Feedback on the report can be provided via a short reader survey form that is also located on the ESG Environmental Publications webpage. Bound copies of Site Environmental Reports are available at the Berkeley Public Library, Oakland Public Library, and UC Berkeley Public Health Library.

1 Site Overview

Lawrence Berkeley National Laboratory (LBNL, Berkeley Lab) is a member of the national laboratory system supported by the U.S. Department of Energy (DOE) through its Office of Science. Under management by the University of California (UC), Berkeley Lab is a multidisciplinary scientific research facility where more than 3,000 scientists, engineers, support staff, and students work year-round, and several thousand more researchers visit each year. This chapter provides a description of the location and physical aspects of the main site.

1.1 LOCATION

Figure 1-1 shows the locations of the LBNL main site and nearby satellite facilities, which are in the eastern region of the San Francisco Bay Area, commonly known as the East Bay. The main site is situated on the ridges and in the draws of Blackberry and Strawberry Canyons in the East Bay Hills about 3 miles east of San Francisco Bay. The site occupies approximately 200 acres of land immediately east of the UC Berkeley campus, and straddles the border of the cities of Berkeley and Oakland in Alameda County.



Figure 1-1 LBNL Main Site and Satellite Facility Locations in the East Bay

The LBNL site and the majority of the land bordering it is owned by UC (see Figure 1-2). Most of the land to the south and east of the site is maintained in its natural state and adjoins wilderness and recreation areas. Nearby points of interest include UC Berkeley's Strawberry Canyon Recreational Area, Botanical Garden, Lawrence Hall of

Science, and East Bay Regional Park District's Tilden Regional Park. To the north of Berkeley Lab is a low-density residential neighborhood of single-family homes, and to the west and southwest is a highly urbanized area that includes the UC Berkeley campus, commercial zones, and residential areas. LBNL satellite facilities in Berkeley, Emeryville, Oakland, and Walnut Creek consist of leased buildings in developed urban areas.

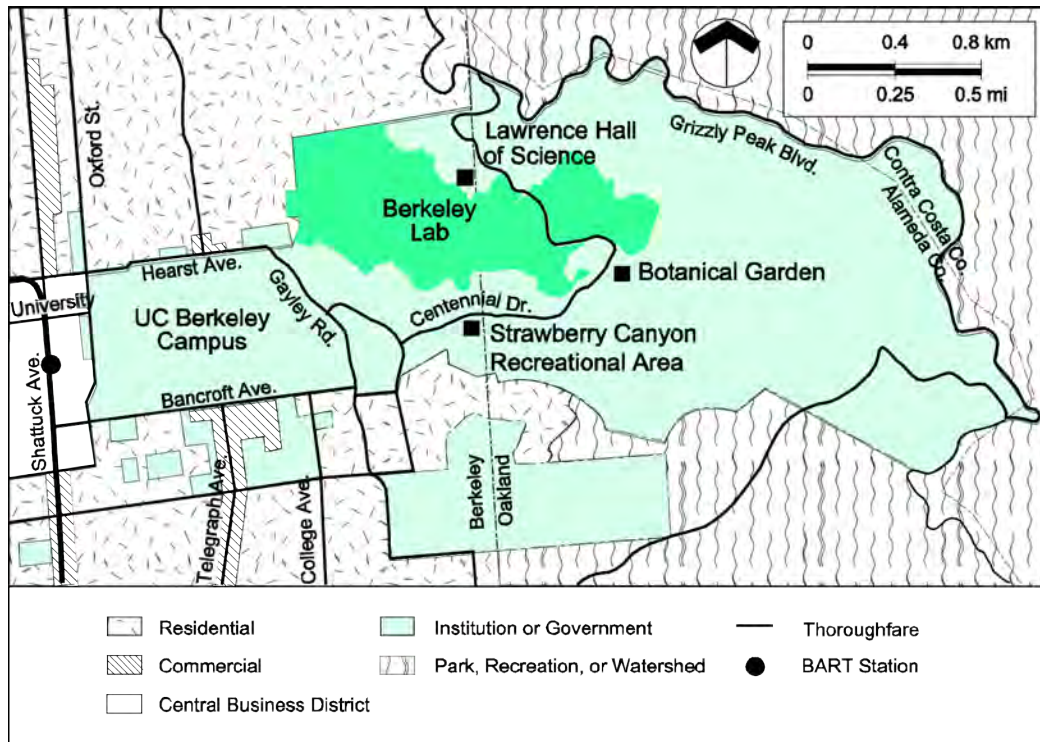


Figure 1-2 LBNL Main Site and Adjacent Land Use

1.2 ENERGY SUPPLY

Electricity and natural gas are the two sources of energy used to operate research and support facilities at Berkeley Lab. Nearly all electric power for the LBNL site is provided by the Western Area Power Administration, with a small amount of renewable power obtained from a solar power array located at Lawrence Livermore National Laboratory. Power purchases are arranged through DOE's Northern California Power Purchase Consortium, which serves the electric power needs of the DOE facilities in the San Francisco Bay Area: Berkeley Lab, Lawrence Livermore National Laboratory, and the SLAC National Accelerator Laboratory. Natural gas is provided by the Defense Logistics Agency and is transported through infrastructure belonging to the Pacific Gas and Electric Company. In 2019, renewable electricity energy consumption accounted for 16% of total energy use by Berkeley Lab.

1.3 WATER SUPPLY

The East Bay Municipal Utility District (EBMUD) supplies domestic water, which originates in Sierra Nevada watershed lands and is conveyed to the Bay Area and ultimately to Berkeley Lab through a system of rivers, lakes, aqueducts, treatment plants, supply lines, and pumping stations. EBMUD tests the water for contaminants and

treats it to meet disinfection standards required by the 1974 Safe Drinking Water Act. Three large tanks store water on site for emergencies. No water supply wells are located on site.

1.4 METEOROLOGY

The temperate climate at the main site – cool, dry summers and relatively warm, wet winters – is heavily influenced by the moderating effects of nearby San Francisco Bay and the Pacific Ocean to the west, and the East Bay Hills to the east. Temperatures typically range between 40 degrees Fahrenheit (°F) and 70°F, with an average annual temperature of 58°F. The temperature seldom exceeds 90°F or drops below 32°F. The maximum and minimum temperatures in 2019 were 105°F and 34°F, respectively.

Based on measurements taken on site from 1974 thru 2019 the historical precipitation “water year” total average is 30.35 inches of rain (with no record of measurable snow). Hydrologists and climatologists use the term *water year* to represent rainfall occurring between October 1 of one year and September 30 of the next year because it characterizes California’s seasonal rainfall cycle better than a calendar year. The precipitation total for the 2018/2019 water year – at 36.42 inches – is 121.2% of normal compared to the historical average water year.

Wind patterns recorded at the on-site meteorological station change little from year to year, as shown by the “wind rose” graphical comparison on Figure 1-3. The wind rose on the left shows the distribution of wind patterns for 2019, while the one on the right summarizes the wind patterns at the site since 1994. The most common wind pattern occurs with westerly winds blowing off the bay and ocean. The other predominant wind pattern is associated with stormy weather when south-to-southeast winds precede a storm system, then shift to the west or northwest after it passes.

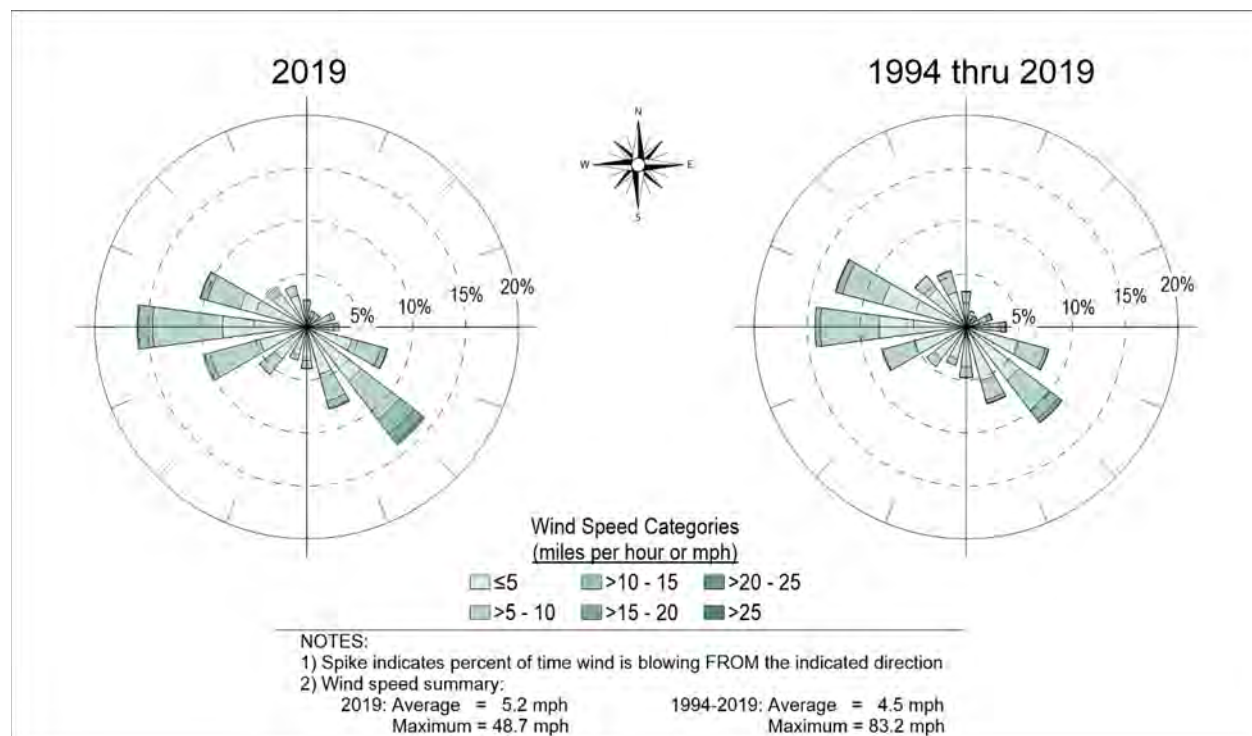


Figure 1-3 Annual Wind Patterns from 1994 to 2019

1.5 VEGETATION

Vegetation at Berkeley Lab and the area surrounding it comprises native plants, naturalized exotics, and ornamental species. Figure 1-4 presents an aerial view of the site's vegetation and ground cover. Extensive grazing and farming occurred in this region for about 150 years before Berkeley Lab development began in the 1930s. Vegetation is now managed in harmony with the local natural succession of native plant communities, as is evident in the less developed areas, where the wooded and savanna character is being maintained. Ornamental species are generally restricted to courtyards and areas adjacent to buildings. No known rare, threatened, or endangered plant species are present on site.



Figure 1-4 Vegetation at LBNL Site and the Surrounding Area

1.6 WILDLIFE

Wildlife is common at Berkeley Lab as the site is adjacent to large tracts of open space land owned by the East Bay Regional Park District and UC. More than 120 species of birds, mammals, reptiles, and amphibians are thought to inhabit or traverse the site. These species are typical of those found in disturbed (previously grazed) areas of mid-latitude California with a temperate climate. The most abundant large mammal is the Columbian black-tailed deer.

The following habitats on site are protected by environmental laws or LBNL land use policies for species at risk:

- A small area of about 1 acre on the south-facing slope of Blackberry Canyon may be inhabited by the arachnid Lee's micro-blind harvestman (*Microcina leei*). *M. leei* is extremely rare and considered a California "special animal."

- An approximately 5-acre area at the site's eastern boundary is included in the U.S. Fish and Wildlife Service's designated critical habitat for the Alameda whipsnake (*Masticophis lateralis euryxanthus*). This subspecies of the California whipsnake is listed as threatened under both federal and state law.

1.7 GEOLOGY

Three principal bedrock units underlie most of the site, as follows:

1. **Great Valley Group.** Marine mudstones, sandstones, and shales of this unit underlie the western and southern portions of the site. The permeability of these rocks is relatively low, so the rate of groundwater flow is also low.
2. **Orinda Formation.** Non-marine sedimentary rocks of this unit overlie the Great Valley Group and constitute the exposed bedrock underlying most of the site's developed area. The Orinda Formation consists primarily of sandstones, mudstones, and conglomerates deposited in fluvial and alluvial environments. The permeability of this formation is generally much lower than that of the underlying Great Valley Group or overlying Moraga Formation, so groundwater flow rates in this unit are also very low.
3. **Moraga Formation.** This unit consists of volcanic rocks that underlie most of the higher elevations, as well as much of the central developed area, which is commonly referred to as "Old Town." The Moraga Formation constitutes the main water-bearing unit at the site. Permeabilities and groundwater flows are significantly higher in this unit than in the Great Valley Group and the Orinda Formation.

In addition to the bedrock units described above, the Claremont Formation (primarily marine chert and shale) and the San Pablo Group (primarily marine sandstones) underlie small areas in the easternmost part of the site. In many areas of the site, the main bedrock units described above are overlain by unconsolidated surficial materials consisting primarily of soil, colluvium (sedimentary deposits that have accumulated by mass wasting processes on, or at the foot of, hill slopes), and artificial fill. Soil derived primarily from the bedrock units has accumulated to typical thicknesses of 3 or more feet across much of the site. Engineered cutting (i.e., excavation of rock and soil) and filling (i.e., placement of fill composed of compacted soils derived from nearby areas) of the hilly terrain has been necessary to provide suitable building sites for some building locations.

1.8 SURFACE WATERS

Berkeley Lab lies within the Strawberry Creek watershed. The two main creeks in this watershed receiving stormwater discharges from the LBNL site are the South Fork of Strawberry Creek (in Strawberry Canyon) and the North Fork of Strawberry Creek (in Blackberry Canyon). The creeks, which merge downstream from the LBNL site on the UC Berkeley campus, are shown on Figure 1-5, along with key tributaries on or near the site.

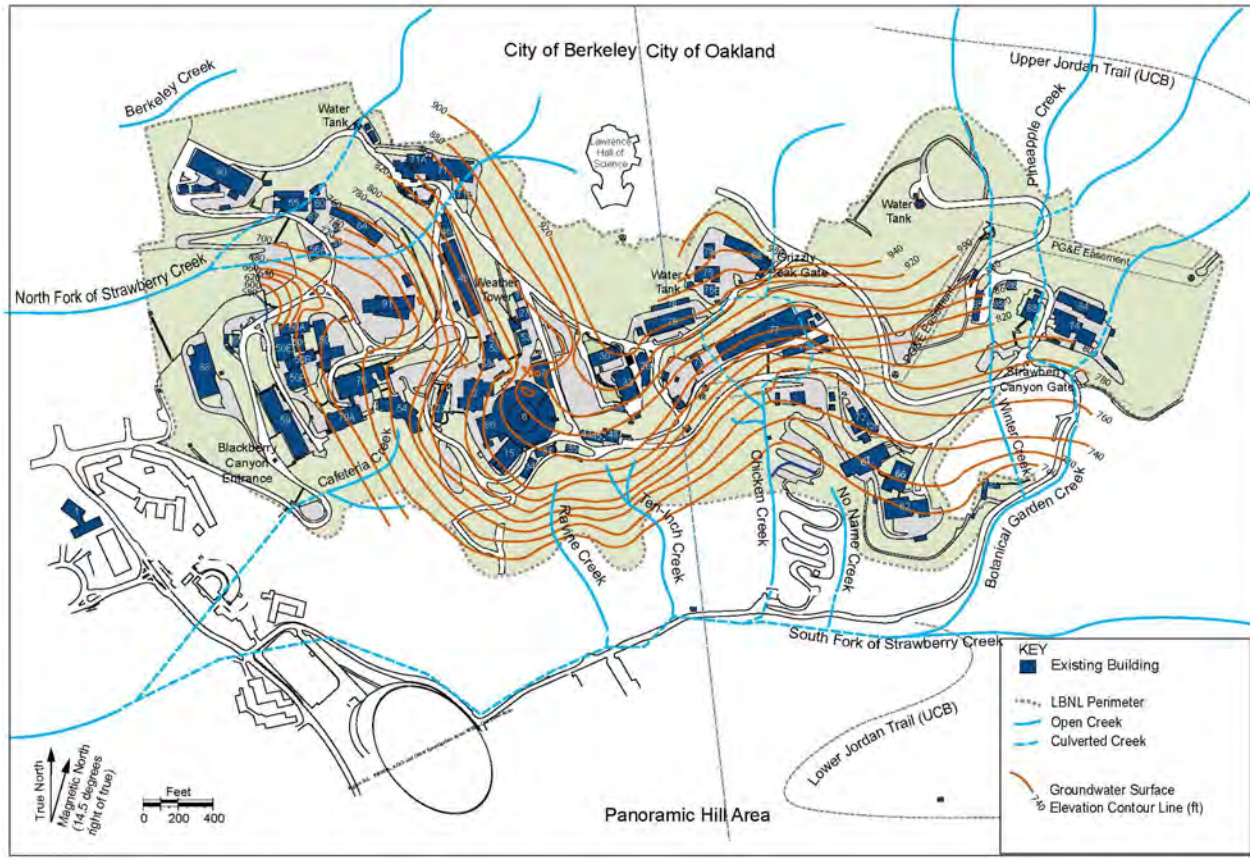


Figure 1-5 Surface Water Locations and Groundwater Elevations at Berkeley Lab

1.9 GROUNDWATER

Figure 1-5 also depicts groundwater elevation contours. The water table approximately mirrors surface topography, flowing from higher to lower elevation. Groundwater flow in the western portion of the site is generally westward toward Blackberry Canyon, while flow in other parts of the site is generally southward toward Strawberry Canyon. The depth to groundwater varies from the ground surface to 100 feet below the surface, depending on location.

2 Environmental Management System

2.1 INTRODUCTION

This chapter provides an overview of the LBNL management approach, and Environmental Management System (EMS) implementation used to protect the environment. The results for the various environmental compliance measures and activities are discussed below are contained in [Chapter 3](#), “Environmental Program Summary.”

2.2 INTEGRATED SAFETY AND ENVIRONMENTAL MANAGEMENT SYSTEM

Berkeley Lab’s commitments to protecting the health and safety of on-site personnel, the public, and the environment are embodied in the LBNL Environment, Safety, and Health (ES&H) Core Policy. Work at Berkeley Lab follows the five core functions of Integrated Safety Management (ISM), which is consistent with the EMS process (policy, planning, implementation, checking and corrective action, and management review):

- Analyze the hazards
- Develop and implement hazard controls
- Perform work within controls
- Provide feedback
- Continuous improvement

The laws and regulations that specify ES&H policy and other external requirements of Berkeley Lab are derived from the following:

- The prime contract between DOE and the University of California (UC) for Berkeley Lab (DOE Contract No. DE-AC02-05CH11231, also known as Contract 31)
- DOE-approved site compliance plans for contractual DOE directives
- LBNL program documentation included in the *ES&H Manual* (PUB-3000)
- *Environmental Management System Program Manual* (2019a)

The EMS portion of the ISM is essentially a systematic approach to ensuring environmental improvement. DOE Order 436.1, *Departmental Sustainability* (DOE, 2011a), requires DOE sites such as Berkeley Lab to develop and maintain an EMS that conforms to the ISO 14001 standard, *Environmental Management Systems – Requirements with Guidance for Use* (ISO, 2015). Berkeley Lab has established an EMS that is designed to ensure that LBNL activities reduce environmental impacts and are well managed, cost-effective, and compliant with environmental regulations. The EMS strives for continual improvement in environmental performance through the four-step “Plan-Do-Check-Act” framework for management systems.

DOE Order 436.1 also requires that a site’s sustainability goals be integrated into the EMS. Berkeley Lab’s annual Site Sustainability Plan sets performance goals in the following areas:

- Greenhouse gas reduction
- Sustainable buildings
- Clean and renewable energy

- Water use efficiency and management
- Fleet management
- Sustainable acquisition
- Pollution prevention and waste reduction
- Energy performance contracts (accelerate investment in cost-effective energy conservation measures)
- Life-cycle stewardship of electronics
- Climate change resilience

In total, more than 30 sustainability goals are set forth in these areas by Executive Order (EO) 13834, *Efficient Federal Operations*, issued in 2018. Berkeley Lab's annual Site Sustainability Plan is available online at <http://sbl.lbl.gov/results/reports.html>.

2.3 ENVIRONMENTAL TRAINING

To ensure that personnel are both aware and capable of fulfilling their responsibilities, Berkeley Lab maintains an extensive catalog of classroom and computer-based environmental trainings. For example, personnel who handle hazardous chemicals and waste are provided training in chemical and waste management, waste minimization, pollution prevention, stormwater protection, on-site transportation of hazardous chemicals and waste, and basic spill and emergency response. Details on Berkeley Lab's training program are available at training.lbl.gov. Workers are required to complete all appropriate environmental training before they can perform the work assigned to them. Training is documented in the Berkeley Lab Training System for every worker and contractor receiving training, and notifications of new and expiring trainings are sent to workers and supervisors as required.

2.4 FRAMEWORK OF THE ENVIRONMENTAL MANAGEMENT SYSTEM

Key elements of the ISO 14001 standard that contribute to the framework of Berkeley Lab's EMS are described in the following subsections.

2.4.1 Leadership and Commitment

The mission of Berkeley Lab's Operations directorate is to anticipate and deliver environmentally sound, exceptional operational services in support of the scientific mission of Berkeley Lab through effective and efficient infrastructure and programs. The framework for LBNL operations is defined in a collection of policies, the *Requirements and Policies Manual* (PUB-201), which covers a broad range of topics, including policies for EMS and specific environmental programs. The objective of the manual is to translate DOE and UC requirements and federal, state, and local requirements into actionable everyday language for LBNL employees.

The Environment, Health & Safety (EHS) Division of LBNL Operations is chartered with the mission of helping Berkeley Lab achieve its commitment to perform all work safely and in a manner that strives for the highest degree of protection for employees, guests, the public, and the environment.

The EMS specifically demonstrates Berkeley Lab's commitment to the following environmental practices:

- Complying with applicable environmental, public health, and resource conservation laws and regulations
- Preventing pollution, minimizing waste, and conserving natural resources

- Mitigating environmental hazards and cleaning up existing environmental problems
- Continually improving environmental performance while maintaining operational capability
- Sustaining Berkeley Lab's overall mission

These practices are incorporated into Berkeley Lab's *Environmental Management System Program Manual* (LBNL, 2019a), which provides guidance on implementing environmental policy in compliance with the ISO 14001 standard. An EMS "Core Team," consisting of representatives from various divisions at Berkeley Lab, assists with implementing the integrated environmental and sustainability goals. Links to the *Environmental Management System Program Manual* and related documents can be found on the [EMS website](#).

2.4.2 Environmental Aspects

As part of the "plan" step for a management system, Environmental Services Group (ESG) subject matter experts and the EMS Core Team periodically review environmental aspects associated with LBNL Research and Operations. An environmental aspect is any activity, product, or service that interacts, whether adversely or beneficially, with the environment. These environmental aspects serve as the master list of potential risks and opportunities to improve environmental compliance and stewardship under Berkeley Lab's EMS. When evaluating environmental aspects, reviewers consider change (e.g., planned or new developments) and new or modified activities, as well as abnormal conditions and reasonably foreseeable emergency situations. Federal, state, and local agency requirements are considered during the aspects review.

As of 2019, the inventory of potential individual environmental aspects totals approximately 40 environmental aspects, which are grouped under three general categories, as follows:

1. Environmental compliance aspects
 - a. Air emissions (e.g., from diesel-powered equipment)
 - b. Storing hazardous material and accumulating hazardous wastes
 - c. Wastewater and contaminated runoff into the storm drain system
2. Materials and resources use
 - a. Energy consumption
 - b. Water consumption
 - c. Life-cycle stewardship of electronics
3. Environmental compliance optimization
 - a. Standard operating procedures
 - b. Environmental regulatory registries
 - c. Management of change

In determining which aspects have the potential to be significant, reviewers evaluate the following risk factors for each aspect:

- Likelihood of occurrence
- Impact from occurrence

This approach is consistent with risk severity guidelines from Berkeley Lab's Office of Institutional Assurance and Integrity (OIAI). The approach also follows OIAI's definitions of low (1), moderate (2), and high (3) risk for likelihood of occurrence and impact of occurrence. Multiplying the numeric values for both risk factors results in a score. In general, an aspect with risk combinations of high-high and high-moderate from this first step in the process will likely be considered significant. When deciding on risk factors for these environmental aspects, reviewers may consider the life cycle of the activity or service, along with the following:

- Cost
- Duration
- Effect on Berkeley Lab's mission
- Effect on public image
- Potential for improvement
- Potential legal exposure

The next step is to foster a discussion between the reviewers and the EMS Program Manager on aspects that are found to be significant from the initial risk scoring so that their combined professional judgment can be used to determine a final classification (e.g., significant) for each aspect in this group. If any aspect is significant, the rationale for that rating is documented and an Action Plan is developed. If reviewers determine that additional information is needed to evaluate a particular product or activity, the EMS Program Manager can assign the responsibility for collecting that information to an appropriate reviewer.

2.4.3 Objectives and Plans to Achieve Them

As part of the "do" step for a management system, aspects deemed significant require developing and maintaining an EMS Action Plan document to define the objective, target, strategy, and actions for reducing significant impacts to the environment. The EMS Action Plans in place at the end of fiscal year (FY) 2019 are listed in Table 2-1, along with a summary of each plan's objective, target, and status.

Berkeley Lab's Site Sustainability Plan, available online at sbl.lbl.gov/reports, summarizes Berkeley Lab's planned sustainability actions and performance status on the sustainability goals derived from EO 13834, as adopted by DOE in its *Fiscal Year 2019 Site Sustainability Plan Guidance* (DOE, 2018). The executive order and DOE goals provide quantifiable objectives and time frames, consistent across the federal complex.

2.4.4 Awareness and Communication

The success of the EMS depends on ongoing and multiple lines of communication. These lines vary depending on factors such as the level of environmental impact, the types of control, the degree to which an environmental concern vertically and horizontally permeates the organization, and the level of effort needed to promote environmental compliance or performance goals.

Table 2-1 Environmental Management Programs

Aspect/Activity	Objective(s)	Target(s)	Status at End of 2019
Energy Management	Implement sustainable practices to achieve energy efficiency	30% energy intensity (Btu per gross square foot) reduction in goal-subject buildings by FY 2015 from a FY 2003 baseline and a 1.0% year-on-year reduction thereafter	4% lower than FY 2015 baseline for subject buildings, not meeting goal
Water Management	Implement sustainable practices to reduce water use intensity	Reduce 20% potable water intensity (gallons per gross square foot) reduction by FY 2015 from a FY 2007 baseline and 0.5% year-on-year thereafter Non-potable water consumption (gallons) reduction of industrial, landscaping, and agricultural (ILA) water year-on-year reduction; no set target	13% lower than FY 2007 baseline, not meeting goal No baseline use, approximately 500,000 gallons of ILA water annually
Waste Management	Increase solid waste diversion	Reduce at least 50% of nonhazardous solid waste, excluding construction and demolition debris, sent to treatment and disposal facilities Reduce construction and demolition materials and debris sent to treatment and disposal facilities. year-on-year reduction; no set target	75% diversion, exceeding the target goal 84% diversion
Petroleum Use	Reduce vehicle fleet petroleum consumption	20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline and 2.0% year-on-year thereafter 10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter 75% of light-duty vehicle acquisitions must consist of alternative fuel vehicles	Goal achieved, 78% reduction Goal achieved, 110% increase Not applicable. No new light-duty vehicles acquired in FY2019
Renewable Energy	Increase clean and renewable and alternative energy	"Renewable Electric Energy" requires that renewable electric energy account for not less than 7.5% of a total agency electric consumption in FY 2019 and FY 202.	35% counting a doubling bonus for renewable electric energy generated on federal land, exceeding the target goal
Green Buildings	Expand sustainable and net-zero buildings.	At least 15% (by building count) of owned existing buildings to be compliant with the revised <i>Guiding Principles for Sustainable Federal Buildings</i> (CEQ, 2016) by FY 2020, with annual progress thereafter Net-zero energy buildings: All new buildings (>5,000 GSF) entering the planning process designed to achieve net-zero energy consumption beginning in FY 2020 Increase regional and local planning coordination and involvement	20% by count, exceeding the target goal No net-zero energy buildings Meeting goal

Aspect/Activity	Objective(s)	Target(s)	Status at End of 2019
Sustainable Acquisition / Electronic Stewardship	Increase procurement opportunities for environmentally sustainable products.	Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring that BioPreferred and biobased provisions and clauses are included in all applicable contracts	98% of applicable contracts
		Purchases: 95% of eligible acquisitions each year are EPEAT-registered products	94%
		Power management: 100% of eligible PCs, laptops, and monitors to be power management enabled	100%, meeting goal
		Automatic duplexing: 100% of eligible computers and imaging equipment have automatic duplexing enabled	100% of EPEAT-registered equipment purchased since FY 2014 and meeting the goal
		End of Life – 100% of used electronics are reused or recycled using environmentally sound disposition options each year	100%, meeting the goal
Greenhouse Gas (GHG) Emissions	Track, report, and reduce GHG emissions from LBNL activities.	Reduce Scope 1 and 2 GHG emissions by 50% by end of FY 2025 (baseline: FY 2008). ^a	31% lower than FY 2008 baseline
		Scope 3 emissions 25% by end of FY 2025 (baseline: FY 2008). ^a	27% lower than FY 2008 baseline, exceeding respective goals
Stormwater Management	Return to “Baseline” compliance status under California’s General Permit for Storm Water Discharges Associated with Industrial Activities.	Maintain or reduce pollutant concentrations to below California Numeric Action Levels for the parameters being monitored under the General Industrial Permit.	For stormwater reporting year (RY) 2018/2019 achieved Baseline status. For RY 2019/2020, status changed from Baseline to Level 2, not meeting the target goal.

^a Scope 1 and 2 emissions are, respectively, direct and indirect GHG emissions from sources owned or controlled by Berkeley Lab. Scope 1 can include emissions from fossil fuels burned on site or entity-leased vehicles. Scope 2 can include emissions resulting from the generation of purchased electricity.

^b Scope 3 emissions include indirect GHG emissions from sources not owned or directly controlled by Berkeley Lab, but related to Berkeley Lab’s activities. The most common activity is GHG emissions associated with employee travel and commuting.

EMS-related matters may be communicated in a number of ways at Berkeley Lab, as follows:

- The annual Site Environmental Report and Environmental Restoration Program Progress Report.
- Information (e.g., environmental documents and operating permits) posted on websites and lessons-learned databases.
- Articles in LBNL publications (e.g., *Elements*) prepared by ESG staff or EMS Core Team members.
- One-on-one or small-group conversations between colleagues affiliated with Berkeley Lab, DOE, and UC.
- Access to ems@lbl.gov for LBNL employees and external parties to express ES&H concerns and interests.

Relationships established with colleagues over years of working together are also an excellent way to communicate EMS-related matters. These relationships may be within the Berkeley Lab community or external, such as with DOE and UC communities.

Whenever appropriate, articles on EMS topics are included in LBNL publications, such as *Elements*. These articles may be prepared by ESG staff or EMS Core Team members. The LBNL community can also learn more about EMS program activities through occasional presentations provided by a Core Team member to groups such as the Safety Advisory Committee and Division Safety Coordinators.

LBNL employees and external parties are encouraged to visit the ESG website and submit questions or concerns about any environmental issue to ems@lbl.gov. Communications for members of the public may also be sent directly to Berkeley Lab's Government and Community Relations Office or Strategic Communications Office. The Government and Community Relations office also oversees Berkeley Lab's Community Advisory Group, which consists of LBNL staff and residents of communities adjacent to Berkeley Lab and which meets periodically each year. The group serves as a liaison between Berkeley Lab and the community for discussion of initiatives and activities, including issues related to the environment.

2.4.5 Monitoring, Measurement, Analysis, and Evaluation of Compliance

As part of the "check" step for management system, Berkeley Lab's EMS is required by DOE to undergo a formal audit once every three years. The audit is conducted by a qualified party outside the control or scope of the EMS. The purpose of the audit is to verify that the EMS conforms to the ISO 14001 standard, as required by the Contractor Requirements Document of DOE Order 436.1, *Departmental Sustainability*. An external formal audit was last performed in July 2018; the next formal audit must be performed in the summer of 2021.

Plans and procedures are prepared by EHS staff to comply with regulatory requirements for various environmental programs. These plans also describe how programs are required to monitor, measure, analyze, and evaluate compliance. For example, a Stormwater Pollution Prevention Plan details how Berkeley Lab will comply with California stormwater requirements. Similarly, a Spill Prevention, Control, and Countermeasure (SPCC) Plan describes measures that Berkeley Lab will take to prevent the discharge of oils into nearby waters, as overseen by both federal and state regulatory agencies.

ESG has developed an extensive set of internal procedures that describe how to implement one or more aspects of a program plan. For example, ESG Procedure 210, *SPCC Compliance Inspection for Petroleum Drum Storage Areas*, provides guidance on implementing part of the SPCC Plan.

Correspondence between regulatory agencies and Berkeley Lab is often vital for showing an environmental program's compliance status. ESG maintains an electronic record of correspondence between Berkeley Lab and regulatory agencies. The record, an Excel spreadsheet, is organized by fiscal year and can be accessed by everyone in the group.

Many of the monitoring records are found in an ESG database that is used for storing sampling results from all environmental monitoring programs reported in Chapter 4 of this document. Other monitoring records, such as calibration results for monitoring instrumentation, are maintained and available on a shared computer drive.

Records management is a line-management function at Berkeley Lab. The EMS Program Leader is responsible for the care, maintenance, disposition, and archiving of EMS-related records in accordance with Berkeley Lab's record management policies and procedures, as listed in PUB-201, *LBNL Requirements and Policies Manual*, Information Management section.

2.4.6 Management Review

As part of the “act” step for a management system, senior management of organizations involved in implementing the EMS meet periodically with the EMS Program Manager to conduct management reviews of the program’s status. The meetings are attended by a representative who reports to the Deputy Director for Research and a representative who reports to the Deputy Director for Operations. These senior representatives can then share relevant information with others in the Research and Operations areas who do not attend the management review meetings. Because the EMS is required to be integrated with sustainability goals, and Berkeley Lab is developing an ISO 50001 (Energy Management) program, the LBNL Chief Sustainability Officer participates in management reviews.

At a minimum, the review meetings cover the following topics cited in the ISO 14001 standard:

- Results of internal audits and evaluations of compliance with legal and other requirements
- Communications from external interested parties
- Berkeley Lab’s environmental performance
- The extent to which objectives and targets have been met
- Status of corrective and preventive actions
- Follow-up actions from previous management reviews
- Changing circumstances, including developments in legal and other requirements
- Recommendations for improvement

Management reviews were held on December 6, 2019, and January 24, 2020. Key topics of discussion were program accomplishments, such as implementation of a streamlined risk-ranking process for environmental aspects; linking EHS Division systems with the Facilities Division’s work order database Maximo; new underground storage tank regulations; and Berkeley Lab’s stormwater program’s return to Baseline compliance status. In addition, management was informed of the need to improve processes by the Facilities Division to track environmental compliance requirements in which they play a role.

2.4.7 Environmental Management Performance and Highlights

At the end of the federal fiscal year, which begins October 1 and ends September 30, Berkeley Lab is required to report on the performance of its EMS. As discussed below, one report, with an EMS scorecard, is associated with EO 13834, and is required of all federal agencies and their contractors. This EMS scorecard evaluated environmental impacts, environmental performance objectives, the performance of operational controls for environmental impacts, and compliance with regulatory requirements/corrective actions. The second report is required by Contract 31, which required an assessment of performance for numerous functional areas.

The federal Office of Management and Budget (OMB) collects annual performance information online to measure performance against goals established in EO 13834 for five categories, as follows:

1. Environmental aspects
2. Environmental objectives
3. Operational controls
4. Compliance with regulatory requirements / corrective actions

5. EMS/EO 13834 goals integration

The fifth category, EMS/EO 13834 goals integration, is graded by responses to how a site has addressed the following 13 sustainability goals:

1. Energy reduction
2. Renewable energy
3. Water management
4. Performance contracting
5. Sustainable buildings
6. Waste management
7. Energy management, building evaluations, benchmarking
8. Fleet management
9. Sustainable acquisition
10. Electronic stewardship
11. Data center management
12. Greenhouse gas management and reporting
13. Resilience

For FY 2019, Berkeley Lab reported that the EMS goal areas were addressed by the EMS team and the Sustainable Berkeley Lab Office.

Based on collective ratings in the five OMB categories for the FY 2019 reporting period, Berkeley Lab's EMS program earned the highest score of "green." Each category is scored from A (best) to D (worst). A green score signifies that at least three A's and the rest B's were received. Berkeley Lab received all A's for the reporting period. BSO accepted the FY 2019 EMS Scorecard information in the Fed Center database in January 2020. The site score for Berkeley Lab was "green." The following activities and accomplishments contributed to earning an A performance rating and were described in the report:

- **EMS/Executive Order Goals Integration:** The EMS team, together with the Sustainable Berkeley Lab Office, addressed the EMS goal areas.
- **Integrated Management Review:** Management review meetings addressed both environmental management and sustainability activities. This helped demonstrate the integration of the two as required by DOE Order 436.1 as well as to address the management review requirements of ISO 14001 and ISO 50001 (Energy and Water Management) simultaneously in an efficient manner, since many of the senior management staff members invited have a stake in both management systems.
- **Environmental Aspects Tool:** Berkeley Lab developed a Google Environmental Aspects survey to assist the EMS Core Team in identifying potentially significant environmental aspects. The survey correlates collective answers into combined scores by highlighting aspects with high potential and high risk.
- **Enhanced Coordination:** The EMS team established a standard operating procedure that formalizes the communication between ESG and the facilities staff to help ensure that environmental regulatory requirements that require operational support from both functions address relevant obligations.

- **Capturing Applicable Environmental Requirements:** ISO 14001 requires organizations to determine “at a sufficiently detailed level,” the compliance obligations that are applicable to its environmental aspects, and how they apply to the organization. The EMS Core Team is developing a program to track applicable environmental regulatory requirements.
- **New Capital Project Alignment with EMS:** To improve early EMS participation in large capital projects, the EMS Core Team worked with Facilities to establish a standard operating procedure that alerts the EMS team of capital projects in their early stages to assist in complying with EMS requirements.

Berkeley Lab received a weighted score of B plus – on a scale ranging from A plus (highest score) to D (lowest score) – in the DOE Berkeley Site Office’s (BSO) *Performance Evaluation Report of the University of California for Management and Operations of Science and Technology at the Lawrence Berkeley National Laboratory for the Period October 1, 2018 to September 30, 2019* (DOE/BSO, 2018) for its integrated environment, safety, and health program and its EMS combined. The EMS component received a score of A. This evaluation is based on objectives in DOE’s *FY 2019 Performance Evaluation and Measurement Plan* (Section J, Appendix B in DOE, 2019); both the plan and report are required by Contract 31. The following activities and accomplishments contributed to earning a B plus performance rating and were described in the report:

- Most notable are the revised Radioactive Waste Management Basis document, the improved and streamlined waste requisition application, the positive progress achieved in reducing stormwater levels for iron and aluminum, and the removal and shipment of mixed wastes.
- BSO noted that Berkeley Lab has achieved significant reductions in the quantity of hazardous chemicals across the Lab and has developed a process to remove all shock-sensitive chemicals.
- Berkeley Lab is working to remove these chemicals and is implementing an overall chemical management improvement initiative.

2.4.8 Accomplishments, Awards, and Recognition

Berkeley Lab won a 2019 DOE Sustainability Award for its policy on Sustainability Standards for New Construction. Berkeley Lab also received a 2019 Best Practice Award from the California Higher Education Sustainability Conference for advanced use of SkySpark (a building analytics platform) to support the ongoing commissioning process. DOE granted Berkeley Lab a 2019 “Accelerating Smart Labs” Project on behalf of the Better Buildings Smart Lab Accelerator. This award recognized Berkeley Lab’s innovative approach to generate energy and water savings through continual improvement in building operations. Finally, the Green Electronics Council issued Berkeley Lab an EPEAT (Electronics Product Environmental Assessment Tool) purchase award in 2019 in recognition of its efforts to purchase sustainable Information Technology products. Berkeley Lab is one of 59 organizations worldwide that received an EPEAT Purchaser Award, and more significantly, one of only 8 organizations that achieved the Five-Star level.

3 Environmental Program Summary

This chapter provides an overview of the nonradiological environmental compliance programs that Berkeley Lab implements to protect air and water quality, to manage hazardous materials in a safe and environmentally responsible manner, and to eliminate or minimize the generation of hazardous and nonhazardous waste. The sections in this chapter are organized by environmental protection programs, which describe the general regulatory requirements, permits issued by regulatory agencies, and audits and inspections conducted during the year. The status of Berkeley Lab’s environmental monitoring programs is discussed in [Chapter 4](#), and the environmental radiological program is discussed in [Chapter 5](#).

3.1 ENVIRONMENTAL PERMITS

Certain activities or equipment require an operating permit issued by a government agency. Authorizations and permits held by Berkeley Lab for activities or equipment can be found online at the ESG home page (<https://ehs.lbl.gov/service/environmental-services/>) and are summarized in Table 3-1 by permit type.

Table 3-1 Environmental Permits

Permit Type	Issuing Agency	Description (Section with Details)	Location
Air quality	BAAQMD ^a	Various activities or equipment with emissions to atmosphere (3.4.1.2)	Main Site
		Standby emergency generators (3.4.1.1)	Joint Genome Institute
CUPA ^b (permit and registration)	ACEH ^c	Hazardous Materials Business Plan and hazardous waste generator areas (3.4.2.2)	EmeryStation East
	CCHS ^d	Aboveground storage tanks (3.4.6.1)	Joint Genome Institute
		Hazardous Materials Business Plan and hazardous waste generator areas (3.4.2.2)	
	COB	Aboveground storage tanks (3.4.6.1)	Main Site
Fixed treatment units (3.4.3.1) Hazardous Materials Business Plan and hazardous waste generator areas (3.4.2.2) Underground storage tanks (3.4.3.7)			
		Hazardous Materials Business Plan and hazardous waste generator areas (3.4.2.2)	Berkeley West Biocenter
Hazardous waste	DTSC ^f	Hazardous Waste Handling Facility operations and hazardous waste generator areas (3.4.3.1)	Main Site
Stormwater	SWRCB ^g	Sitewide and construction stormwater discharges (3.4.6.3)	Main Site
Surface water and sediment	EBRPD ^h	Surface water and sediment sampling (4.2.1, 4.5.2)	Tilden Park

Permit Type	Issuing Agency	Description (Section with Details)	Location
Wastewater	CCCSD ^d	Wastewater discharges to sanitary sewer (3.4.6.1)	Joint Genome Institute
	EBMUD ^j	Sitewide and operation-specific wastewater discharges to sanitary sewer (3.4.6.1)	Main Site

^a Bay Area Air Quality Management District

^f Department of Toxic Substances Control

^b Certified Unified Program Agency

^g State Water Resources Control Board

^c Alameda County Environmental Health

^h East Bay Regional Park District

^d Contra Costa Health Services

ⁱ Central Contra Costa Sanitary District

^e City of Berkeley

^j East Bay Municipal Utility District

3.2 AUDITS AND INSPECTIONS

The regulatory agencies that enforce environmental requirements conduct periodic on-site inspections. Four minor violation notices resulted from eight inspections in 2019. Information about these inspections is summarized in Table 3-2 and discussed in Sections 3.4.3.1, 3.4.3.3, and 3.4.4.1. The table includes the self-monitoring inspections conducted by Berkeley Lab as required by EBMUD wastewater discharge permits, since the self-monitoring results expose Berkeley Lab to potential regulatory actions.

Table 3-2 Summary of Environmental Audits, Inspections, and Appraisals

Organization	Inspection Type	Start Date	Violations
BAAQMD	Inspection of permitted soil vapor extraction system, paint spray booth, sand blast booth, sitewide solvent wipe-cleaning operations, and five standby generators	March 25	0
	Annual self- testing of unleaded gasoline and E85 dispensing systems.	May 13	0
CCSD	Wastewater and stormwater inspection at the Joint Genome Institute*	Nov. 14	0
COB ^a	Aboveground storage tanks, fixed treatment units, HMBP, and hazardous waste accumulation areas	Nov. 4–7	4
	Underground storage tank monitoring system certification	Sept. 10	1
	Underground storage tanks leak testing with designated operator report review	Nov. 21	1
	Underground storage tanks leak pressurized line integrity testing	Dec. 13	0
EBMUD	Building 77 Ultra-High Vacuum Cleaning Facility	Aug. 15	0
	EBMUD sampling of Hearst & Strawberry sanitary sewers	Sept. 24	0
	Advanced Biofuels and Bioproducts Process Development Unit (ABPDU)*	Aug. 30	0
LBNL	Self-monitoring inspections required by EBMUD for groundwater treatment units	Feb. 15 Sept. 26	0 0
	Self-monitoring inspections required by EBMUD for the Hearst and Strawberry sanitary sewer outfalls	March 14 Sept. 20	0 0
	U.S. EPA ^b	RCRA ^c inspection of the Hazardous Waste Handling Facility (Building 85) and Building 77A	Sept. 24

* Inspection of off-site facility

^a Permitted under California's Certified Unified Program Agency.

^b U.S. Environmental Protection Agency; COB, and DTSC representatives also attended.

^c Resource Conservation and Recovery Act.

3.3 DOE-REPORTABLE ENVIRONMENTAL INCIDENTS

The DOE Occurrence Reporting Program tracks environmental incidents across the DOE complex. No environmentally related occurrence reports associated with LBNL activities occurred during 2019.

3.4 COMPLIANCE PROGRAMS

The primary federal laws driving LBNL compliance programs for federal, state, and local environmental regulations are the Clean Air Act, the Emergency Planning and Community Right-to-Know Act, the Resource Conservation and Recovery Act (RCRA), the Toxic Substances Control Act, and Clean Water Act. The federal and state laws impacting Berkeley Lab's environmental planning for future activities are the National Environmental Policy Act of 1969 and the California Environmental Quality Act of 1970. The subsections below briefly describe each of these environmental laws and associated regulations and highlight associated LBNL activities for this reporting year.

3.4.1 Air Quality Management Program

Berkeley Lab operates various sources of regulated air emissions, including a sand blast booth, a paint booth, boilers, emergency generators, gas-insulated switchgear, research equipment, a vehicle fueling station, fleets of diesel trucks, as well as off-road equipment and forklifts. In addition, greenhouse gases (GHG) emissions, indirectly emitted via electricity use and employee travel, are actively tracked per the California Global Warming Solutions Act of 2006 (AB 32). This section describes the regulatory framework to which Berkeley Lab is subject for the purpose of air quality protection and presents the status of Berkeley Lab's air quality protection program during calendar year (CY) 2019.

3.4.1.1 Regulatory Framework for Nonradiological Emissions

In the San Francisco Bay Area, most federal and state air quality regulatory programs are implemented and enforced by the Bay Area Air Quality Management District (BAAQMD, "Air District"). The California Air Resources Board (CARB) is responsible for administering regulations on mobile air emission sources, such as vehicle fleets, as well as regulations on certain toxic air emissions and GHG emissions, including governing natural gas (e.g., methane), carbon dioxide, and sulfur hexafluoride.

Additionally, CARB administers regulations on mobile sources such as vehicles, as well as regulations on certain toxic chemicals and GHGs. CARB has several regulations applicable to LBNL, including those governing diesel fuel equipment and vehicles, large-spark ignition equipment and sources of sulfur hexafluoride, a potent GHG.

Berkeley Lab is subject to three federal air quality programs that are administered by U.S. Environmental Protection Agency (U.S. EPA) Region 9, as follows:

1. National Emission Standards for Halogenated Solvent Cleaning (40 CFR § 63.460)
2. Hazardous air pollutants (e.g., radionuclides)
3. Ozone-depleting substances (e.g., chlorofluorocarbons, halons)

At the end of 2019, Berkeley Lab held 34 permitted sources, 11 registered sources, and 1 exempt source under the Air District permits covering activities and equipment at the main site (BAAQMD, 2019). All permits issued by the Air District are listed in Table 3-3.

Table 3-3 BAAQMD-Permitted Air Emission Sources

BAAQMD Permit Category	Description (No. of Permitted Sources)	Building	Abatement Type
Combustion equipment	Standby emergency generators (4)	64, 66, 67, 70	Catalytic converter
	Standby emergency generators (6)	30, 48, 50A, 59, 72, 91	Catalyzed diesel particulate filter
	Standby emergency generators (16)	2, 33, 37 (2), 50B, 55, 62, 64, 68, 74, 77, 84B, 85, plus three portable units	None
	Standby emergency generators (2)	Two portable units	DOC, EGR, SCR
Gasoline dispensing	Fueling stations: unleaded and E85 (2)	76	Vapor recovery
Surface coating and painting	Paint spray booth (1)	77	Dry filter
Surface preparation and cleaning	Sandblast booth (1)	77	Baghouse
	Wipe-cleaning (1)	Sitewide	None
Miscellaneous	Soil vapor extraction system (1)	58	Activated carbon

E85 = 85% ethanol / 15% unleaded gasoline fuel blend

DOC = Diesel Oxidation Catalysts; EGR = Exhaust Gas Recirculation; SCR = Selective Catalytic Reduction

BAAQMD operating permits must be renewed annually. The renewal application process includes submitting usage information on permitted sources.

The Air District conducted one inspection in 2019 of permitted equipment or activities. The inspection focused on the paint spray booth, the soil vapor extraction unit, and several diesel generators, in addition to sitewide solvent wipe-cleaning operations. No violations were reported for the inspection.

3.4.1.2 Asbestos and Demolition Project Notification Program

For projects that involve the demolition or significant renovation of existing structures, or the management of regulated asbestos-containing material, Berkeley Lab is required to provide advance notice to the BAAQMD. Each year, pursuant to BAAQMD Regulation 11, Rule 2, Berkeley Lab submits a renovation notification form to the Air District that addresses small demolition/renovation projects involving removal of asbestos-containing material. Small renovation projects are those disturbing less than 100 linear feet of asbestos-containing material during demolition and or renovation activity. Large projects (those disturbing more than 100 linear feet or 35 cubic feet of building material) are managed by LBNL contractors who prepare and submit asbestos management plans to the Air District. During CY 2019, demolition projects were evaluated by the LBNL Air Quality Program Manager for the purpose of air quality protection. Based on the projects' scope and the results of pre-work asbestos surveys, four asbestos demolition/renovation notifications were submitted to BAAQMD for these projects.

3.4.1.3 Vehicle Fleet Management and Source Testing

Berkeley Lab has three different fleets of vehicles regulated by CARB as nonstationary air emission sources. The Off-Road Diesel fleet has six vehicles, all of which are designated as permanently low-use vehicles. Each vehicle in

the low-use category is used less than 200 engine hours annually. Six other vehicles are in CARB's Heavy-Duty Truck and Bus program. A total of 23 forklifts are in CARB's Large Spark-Ignition Engine program, 13 of which are registered as low use. Berkeley Lab continues to replace and upgrade its service fleet as resources allow. Berkeley Lab submitted its CY 2018 On-Road Diesel (also known as the Truck and Bus Regulation) annual report to CARB in January 2020. The CY 2018 annual Off-Road Diesel Report and the CY 2018 annual Large-Spark Ignition Report were submitted to CARB in March and June 2019, respectively.

The BAAQMD operating permit for Berkeley Lab's on-site unleaded gasoline and E85 dispensing systems requires annual testing. Testing was performed on May 13, 2019, and other than the need to replace the E85 vent cap, both systems passed and met acceptance criteria.

3.4.1.4 Greenhouse Gas Inventory and Baseline

GHG emissions are divided into three categories, or scopes. Scope 1 emissions are generated on site and are under the direct control of the facility, such as those produced by combustion of natural gas in a boiler. The majority of Berkeley Lab's GHG emissions are Scope 2, indirect emissions resulting from the generation of electricity purchased and used by an organization, due to its high demand for electricity. Scope 3 emissions are business-related but are generated off site. Employee commuting and business travel account for the majority of emissions in this category.

Berkeley Lab continues to track GHGs as required by DOE Order 436.1. In 2019, Berkeley Lab achieved a cumulative reduction in Scope 1 and 2 emissions of 31% and a 27% reduction in Scope 3 emissions, relative to the 2008 baseline.

As part of its GHG management program, CARB regulates sulfur hexafluoride (SF₆) emissions from gas-insulated switchgear by setting a maximum annual emission rate and requiring an annual usage report. SF₆ is a potent GHG having a global warming potential 23,900 times that of carbon dioxide. Berkeley Lab had 15 active SF₆-containing switches and breakers in service in 2019. Two of these switches in the Strawberry East Canyon required the addition of 3 pounds of SF₆ in December 2019. A leak check was performed on these switches before and after adding the SF₆ gas. Based on the assumption that the 3 pounds of added SF₆ had leaked, Berkeley Lab reported an annual leak rate of 0.8% to CARB in 2019. This leak rate was below the annual CARB leak rate limit of 2.0% for 2019. Maintenance is performed on a three-year cycle; however, inspections are performed every two weeks on switches at Berkeley Lab. Replacement of the two gas-insulated switches in the Strawberry East Canyon switching station is in the design phase for reducing the LBNL annual GHG emission rate for SF₆.

Since 2010, at the end of each fiscal year, Berkeley Lab has submitted a report to DOE on its annual GHG emissions. The current requirement for this reporting is EO 13834. The order contains more than 30 sustainability goals, including those for GHG emissions and fleet activities. More information on these sustainability goals is available in the *Lawrence Berkeley National Laboratory Annual Site Sustainability Plan* (LBNL, 2019b).

LBNL facilities do not emit GHGs in quantities that exceed reporting thresholds for Scope 1 emissions under other regulations such as the U.S. EPA's Greenhouse Gas Reporting Program and AB 32, the California Global Warming Solutions Act of 2006.

Since 2013, Berkeley Lab has participated in CARB's Refrigerant Management Program, which regulates stationary nonresidential refrigeration systems that use more than 50 pounds of a refrigerant with a high global warming potential, and which requires reporting and fee payment. Berkeley Lab's 52 refrigeration systems affected by this program are all on the main site. In 2019, CARB determined that Berkeley Lab's refrigeration units are all for "comfort cooling" and not process cooling; therefore, Berkeley Lab was exempt from specified rules governing leak detection, reporting, and payment of fees. However, Berkeley Lab is still subject to other aspects of the program governing certification of refrigerant service technicians.

3.4.1.5 Radiological Emissions

LBNL research activities involving radionuclide emissions to the atmosphere must comply with the following regulations:

- Code of Federal Regulations (CFR), Title 40, Part 61, Subpart H, National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities (U.S. EPA, 1989)
- DOE Order 458.1, Administrative Change 3, *Radiation Protection of the Public and the Environment* (DOE, 2013)

The U.S. EPA administers the regulations in 40 CFR 61, *National Emission Standards for Hazardous Air Pollutants* (NESHAP), which limit the dose to the public from a facility's airborne radionuclide emissions to 10 millirem per year (mrem/yr). The EPA-approved methodology was used to calculate potential dose, and the estimated potential dose from LBNL activities in 2019 was approximately 0.015% of this limit.

Berkeley Lab documents its NESHAP review and compliance status annually; the *Radionuclide Air Emissions Report for 2019* (LBNL, 2020b) is the most recent report submitted to the U.S. EPA. The report is available on the Environmental Publications page of ESG's website (<https://ehs.lbl.gov/service/environmental-services/>).

3.4.2 Hazardous Materials Management

Berkeley Lab uses hazardous materials as part of its research programs, as well as in conventional facilities operations, maintenance and construction projects. Examples of hazardous materials managed at Berkeley Lab are listed as follows:

- Cryogenics
- Compressed gases
- Acids and bases
- Solvents
- Oils and fuels, including propane
- Adhesives
- Paints and epoxies
- Metals

Hazardous materials management encompasses numerous programs at Berkeley Lab, all with the same primary goal: to ensure the safe handling of hazardous materials in order to protect employees, contractors, guests, neighbors, and the environment.

Discussed in the following sections is the regulatory framework for hazardous materials management and the status of Berkeley Lab's 2019 programs related to hazardous materials and hazardous wastes, including the Hazardous Materials Business Plan program and the Toxics Release Inventory program.

3.4.2.1 Regulatory Framework

The regulatory framework for hazardous materials regulations, especially in California, has historically been a complex and overlapping web of statutes and regulations. Some of the most important regulatory drivers at the federal level include the following laws:

- The Superfund Amendments and Reauthorization Act of 1986 (SARA – Title III), also known as the Emergency Planning and Community Right-to-Know Act (EPCRA), focuses on community safety.
- The Occupational Safety and Health Act of 1970 was enacted for protection of worker health and safety.
- The Hazardous Materials Transportation Act of 1975 is intended to ensure the safe transport of hazardous materials in commerce.
- The Toxic Substances Control Act (TSCA) of 1976 is the federal law under which polychlorinated biphenyls (PCBs) and asbestos are regulated.

Important drivers at the state level generally date back to the mid-1980s and include the Hazardous Materials Business Plan (HMBP) Program (see Section 3.4.2.2), the underground and aboveground storage tank programs (Sections 3.4.3.7 and 3.4.5.1), and pollution prevention and waste minimization programs (Section 3.4.3.5).

In general, the primary authority for implementing hazardous materials regulation in California is the local Certified Unified Program Agency (CUPA). The City of Berkeley, Alameda County Environmental Health, and Contra Costa Health Services are the local administering agencies (CUPAs) responsible for overseeing hazardous materials and waste management at Berkeley Lab, the EmeryStation East (Joint BioEnergy Institute and the Advanced Biofuels Process Demonstration Unit), and the Joint Genome Institute. CUPAs have broad implementation and enforcement responsibilities for Spill Prevention, Control, and Countermeasures (SPCC) plans, as well as the following four hazardous material subject areas:

1. Hazardous Materials Business Plan (HMBP) Program /Emergency Response Plan
2. Hazardous Waste/Tiered Permitting/Waste Minimization and Pollution Prevention
3. California Accidental Release Prevention Program (CalARP)
4. California Fire Code Hazardous Materials Management Plan

3.4.2.2 Hazardous Materials Business Plan Program

EPCRA establishes requirements for emergency planning, notification, and reporting. In California, the requirements of SARA Title III are incorporated into the state's Hazardous Materials Release Response Plans and Inventory law (California Health and Safety Code, 1985).

The City of Berkeley, Alameda County Environmental Health, and Contra Costa Health Services implement certain hazardous materials regulations that fall under the requirements of EPCRA and the corresponding state law. Berkeley Lab complies with applicable federal hazardous materials reporting requirements, and each year it

voluntarily submits HMBPs that meet state requirements, even though it is not subject to state hazardous materials regulations.

The HMBP includes the Hazardous Materials Inventory Statement. The inventory consists of all hazardous materials present at Berkeley Lab in amounts exceeding specified state's aggregate threshold quantities (e.g., 55 gallons for liquids, 500 pounds for solids, and 200 cubic feet for compressed gases) on a building-by-building basis. It includes hazardous materials in storage, as well as hazardous waste, oil-filled equipment, process and bulk tanks, emergency generators containing fuel, and lead/acid batteries.

In addition to the chemical inventories, each HMBP provides the following information:

- Emergency plans
- Procedures
- Training
- Facility maps

The HMBP for each facility listed below was updated in 2019 and submitted electronically to the California Environmental Reporting System (<http://cers.calepa.ca.gov/>):

- LBNL main site
- Berkeley West Biocenter
- EmeryStation East
- Joint Genome Institute

All chemicals and hazardous wastes were removed from the Joint Genome institute by the end of January 2020 obviating the need to complete an annual HMBP update for 2019 due in March 2020.

The HMBPs are also available on the Environmental Publications page of ESG's website (<https://ehs.lbl.gov/service/environmental-services/>).

In November 2019, the City of Berkeley Certified Unified Program Agency (CUPA) performed a routine inspection of HMBP hazardous materials storage areas at the LBNL main site, including laboratories, fixed treatment units, aboveground storage tanks, satellite accumulation areas (SAAs), and waste accumulation areas (WAAs). The four minor violations that resulted from this inspection are summarized in Section 3.4.3.2.

3.4.2.3 Toxics Release Inventory

As a federal facility, Berkeley Lab is subject to EPCRA Toxics Release Inventory reporting requirements (40 CFR Part 372). If annual usage exceeds threshold quantities (i.e., 10,000 pounds for the chemicals used at Berkeley Lab), a U.S. EPA Form R must be submitted. As in previous years, Berkeley Lab determined in 2019 that no chemical usage exceeded the chemical-specific Toxics Release Inventory criterion for a listed substance; therefore, preparation of a Form R was not required. Table 3-4 summarizes Berkeley Lab's assessments of highest chemical usage quantities since 2007.

Table 3-4 Trends in Highest Quantities of Chemicals Subject to EPCRA Toxics Release Inventory Reporting

Substance	Quantity Used per Year (pounds)									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Chlorofluorocarbons	142	319	183	61	132	87	327	390	270	429
Methanol	147	88	103	172	127	100	130	126	82	61
Nitric acid	592	634	633	633	556	78	90	90	21	502

3.4.3 Waste Management and Minimization

During the course of its research operations, Berkeley Lab generates a variety of waste streams, including both hazardous and nonhazardous wastes. The latter includes industrial waste, municipal solid waste, and construction and demolition debris.

3.4.3.1 Regulatory Framework

The Resource Conservation and Recovery Act (RCRA) was enacted to create a management system to regulate waste from “cradle to grave.” In 1984, the Hazardous and Solid Waste Amendments were added to the Solid Waste Disposal Act to reduce or eliminate the generation and disposal of hazardous wastes. Between 1984 and 1988, RCRA was further expanded to regulate underground storage tanks and leaking waste storage facilities.

RCRA’s primary goals are to protect the public from harm caused by waste disposal, to clean up spilled or improperly stored wastes, and to encourage reuse, reduction, and recycling. RCRA affects the following LBNL operations:

- On-site management of hazardous and mixed waste (including satellite accumulation areas [SAAs] and 90-day waste accumulation areas [WAAs])
- Treatment and storage of hazardous and mixed waste
- Investigation and cleanup of historical releases of hazardous chemicals to the environment
- Storage of petroleum products in underground storage tanks

3.4.3.2 Hazardous Waste

In California, the Department of Toxic Substances Control (DTSC) administers the hazardous waste program. The state’s program incorporates the provisions of both the federal RCRA and state hazardous waste laws (California Health and Safety Code, 1972) and includes oversight of hazardous waste generation, permitting, and enforcement. With the exception of the fully permitted Hazardous Waste Handling Facility, these programs are delegated to the City of Berkeley under the CUPA program.

At Berkeley Lab, SAAs and WAAs are used to accumulate hazardous and mixed wastes generated on site. SAAs are deployed extensively in laboratories and in some facilities’ operations. SAAs are an integral part of the hazardous waste management process at Berkeley Lab, as they allow generators to efficiently manage small quantities of hazardous and mixed waste produced during daily laboratory and facility activities. WAAs are used to temporarily accumulate larger quantities of hazardous waste, as well as hazardous waste from SAAs.

LBNL policy requires hazardous waste to be removed from SAAs, and mixed waste to be removed from mixed-waste SAAs, within 270 days of initial generation. The policy also requires that hazardous and mixed waste be removed from WAAs within 60 days of initial generation. Generally, all regulated waste is collected from generators' SAAs and WAAs and transferred to the permitted Hazardous Waste Handling Facility (HWHF) for storage and treatment as needed, then packaged and shipped off site to appropriate commercial, hazardous waste treatment, storage, and disposal facilities (TSDFs). Large quantities of hazardous waste and other waste generated from special projects, such as construction and demolition, are shipped directly from generator locations to TSDFs.

California's permitting program for hazardous waste treatment and storage facilities has five tiers, which are listed in Table 3-5 in order of decreasing regulatory complexity. Berkeley Lab has activities falling under three of the tiers.

Table 3-5 Overview of California's Tiered Permitting Program

Program Tier	Regulatory Agency	LBNL Facilities/Units Under Each Program Tier
Full permit	DTSC	Hazardous Waste Handling Facility
Standardized permit	DTSC	–
Permit-by-rule	City of Berkeley	FTU 006, FTU 007
Conditional authorization	City of Berkeley	FTU 004, FTU 005
Conditional exemption	City of Berkeley	–

FTU = fixed treatment unit (see Table 3-6 for details on each FTU)

The Hazardous Waste Handling Facility operates under a DTSC-issued full permit (the highest tier), which authorizes storage and treatment of certain hazardous and mixed wastes at the facility. In June 2016, Berkeley Lab submitted an application to DTSC to renew the permit, as required every 10 years. In January 2018, DTSC issued a first Notice of Deficiency (NOD) letter to which Berkeley Lab responded in July 2018. In 2019, DTSC provided preliminary feedback on Berkeley Lab's response. In the meantime, the 2016 permit, with the associated DTSC-approved permit modifications, including the most recent modifications issued in 2019, remains effective and enforceable. When the application is complete, DTSC will prepare a draft permit that will involve a public comment period before a final permit is issued.

Administration and enforcement for the three lower tiers are delegated to the City of Berkeley under California's CUPA program. Four fixed treatment units (FTUs) operate at Berkeley Lab under a hazardous wastewater treatment permit issued by the City of Berkeley:

1. FTU 004 (Building 70A) under the conditional authorization tier
2. FTU 005 (Building 02) under the conditional authorization tier
3. FTU 006 (Building 77 Ultra-High Vacuum Cleaning Facility) under the permit-by-rule tier
4. FTU 007 (Building 67 Molecular Foundry) under the permit-by-rule tier

This permit is renewed annually as part of the HMBP submission process for the main site. The City of Berkeley now issues electronic permits with relevant information on these permitted activities available on the California Environmental Reporting System (<http://cers.calepa.ca.gov/>).

For FTU 004, acidic wastewater is generated in various laboratories in Building 70A. Waste acids discharged to FTU 004 include hydrochloric acid, phosphoric acid, sulfuric acid, acetic acid, nitric acid, and other acids. These wastewaters are routed to the treatment system, located below Building 70A in a sheltered overhang, treated via pH adjustment, and discharged to the sanitary sewer system.

For FTU 005, acidic wastewater is generated in various laboratories in Building 2. Waste acids discharged include hydrochloric acid, phosphoric acid, sulfuric acid, acetic acid, nitric acid, and other acids. These wastewaters are routed to the treatment system, located on the ground floor of Building 2, treated via pH adjustment, and discharged to the sanitary sewer system.

For FTU 006, cleaning processes at the Ultra-High Vacuum Cleaning Facility at Building 77 include passivating (making a metal surface less chemically reactive), acid and alkaline cleaning, and ultrasonic cleaning of metal parts used in research and support activities. Acid and alkaline rinse waters that contain hazardous waste metals (listed in 22 CCR § 66261.24(a)(2)) are routed to FTU 006, treated via pH adjustment, ion exchange, and evaporation, and then returned to the Building 77 shop for reuse.

This system was significantly upgraded between April 2018 and June 2019, as follows:

- A CIX10HP rinse water recycling system was installed that uses ion exchange to purify up to 3,000 gallons of wastewater daily.
- The FTU 006 is now a closed-loop system from which no water is discharged, and 99%+ is recycled and returned to the Ultra-High Vacuum Cleaning Facility for reuse as deionized water. The only water loss is due to evaporation. It is estimated that approximately 40,000 gallons of water will be recycled each year from this system at Building 77.
- The only waste generated is from a minimal caustic waste stream (<5 gallons per week) and regeneration of the ion exchange resins. This wastewater is pH adjusted, then evaporated, and any solids are collected in a drum for disposal.

For FTU 007, wastewater from Building 67 (Molecular Foundry) is generated from the etching and rinsing of wafers used in the Nanofabrication Laboratory. The caustic waste may contain 10% or more of potassium hydroxide or similar alkaline waste. The acidic waste may contain over 10% of any of several different acids. These rinse waters are routed to the treatment system, located on the ground floor under a sheltered overhang, treated via pH adjustment, and discharged to the sanitary sewer system.

FTU treatment types and operational throughput are summarized in Table 3-6.

Berkeley Lab also sends hazardous, universal, mixed, medical, and radioactive waste generated at its operating locations to permitted off-site facilities for disposal. The state's Medical Waste Management Act (California Health and Safety Code, 2017) regulates the disposal of medical waste. DOE orders define low-level radioactive waste requirements. Mixed waste is subject to both California regulations and DOE orders and is managed at Berkeley Lab in accordance with the Site Treatment Plan for mixed waste (DOE, 1995).

Table 3-6 Summary of Fixed Treatment Unit Operations

FTU	Building No.	Treatment Types	Approx. Quantity of Wastewater Treated in 2019 (gallons)
004	70A/70F	Acid neutralization by pH adjustment	480,981
005	2	Acid neutralization by pH adjustment	104,300
006	77	Metals precipitation and acid neutralization by pH adjustment, ion exchange, and evaporation	11,460 (100% is recycled with no discharge)
007	67	Acid and alkaline neutralization by pH adjustment	42,199

In September 2019, a representative of the U.S. EPA conducted an inspection of the Hazardous Waste Handling Facility, which included a records review and inspection of hazardous waste units 1, 2, 4, 5–9, and 14; inspection of mixed-waste units 4–6; and inspection of radioactive waste storage areas. No violations were cited from this inspection.

In November 2019, the City of Berkeley Certified Unified Program Agency (CUPA) performed a routine inspection of hazardous materials storage areas/HMBP, aboveground storage tanks, fixed treatment units, and hazardous waste accumulation areas at the Berkeley Lab main site. Four minor violations were observed as follows:

1. Failure to have an adequate facility diagram in the SPCC Plan. In addition, an AST was missing from an SPCC Plan diagram but was listed in a table.
2. Failure to meet industry standards as discussed in the SPCC plan: six monthly inspection reports were missing from the binder that is used to maintain these documents.
3. Failure to test and maintain as necessary fire protection equipment (fire extinguishers) in Building 1 within the previous 12 months.
4. Failure to meet satellite accumulation area regulations: some hazardous waste containers were not closed and/or labeled properly, and some oil and absorbent waste were not contained or labeled properly.

All of the above-referenced violations were corrected and documented in Berkeley Lab's Corrective Action Tracking System (CATS).

3.4.3.3 Disposal of Unwanted Chemicals

The EHS Division implemented an initiative in 2018 to reduce the unwanted chemicals stored in laboratories. Some of the specific tasks completed in 2019 to reduce chemical inventory and improve inventory management are listed as follows:

- Establishment of a multidivisional team of chemical safety, waste management and hazard analysis experts to identify and reduce inventories of unwanted chemicals, including old, expired, or potentially unstable chemicals. The team also implements safety measures when a chemical hazard is discovered, and recommends the most appropriate disposal strategy.
- Contract with a high-hazard chemical vendor to treat (stabilize) potentially unstable chemicals prior to disposal.

- Disposal of over 8,400 unwanted chemicals during lab cleanouts.
- Implementation of visual inspections of potentially high-risk waste containers by a waste management professional before the containers are transferred to the HWHF. Waste containers that cannot be safely transported to or managed at the HWHF are stabilized by a vendor at the generator location to render the container safe for transport and disposal.

3.4.3.4 Hazardous Waste Tracking

Berkeley Lab uses a computerized waste tracking system to track hazardous, mixed, and radioactive wastes from the time a pickup request is initiated, until they are transported to an appropriate disposal facility off site. The waste tracking system includes information that is required for regulatory reporting, such as the EPCRA Toxics Release Inventory Determination Report, Annual TSD Facility Report, Biennial Hazardous Waste Report, the annual waste inventory for the HMBP, and the State Bill (SB) 14 Waste Minimization Plan.

3.4.3.5 Hazardous Waste Minimization

An SB 14 Waste Minimization Plan was prepared in 2019 for waste generated in the previous calendar year. Overall, the amount of hazardous waste shipped off site for disposal declined from the 2014 baseline year. Some strategies that are used at Berkeley Lab to promote continued waste reductions are listed as follows:

- Encouraging best management practices during SAA inspections to minimize the amount of nonhazardous lab trash that is being managed as hazardous waste.
- Promoting fixing or replacing equipment that leak oil to minimize the generation of waste oil.
- Flagging procurement requests for restricted chemicals that require safety reviews prior to purchase.
- Educating researchers on the option to check Berkeley Lab's chemical inventory database before ordering chemicals, to look for stores of those chemicals that they may be able to use.
- Purchasing oil-less pumps and cyclone dewatering devices.
- Controlling the types and volumes of the parts to reduce the need for cleaning, and thus the volumes of generated waste streams.
- Discussing opportunities for chemical substitution, reduction, and elimination with LBNL employees.

3.4.3.6 Nonhazardous Waste Management and Minimization

Nonhazardous waste can be grouped into municipal solid waste, construction and demolition (C&D) debris, e-waste, and nonhazardous industrial waste. LBNL strategies for continual improvement included a waste auditing program, a new waste policy, and an online Waste Guide (<https://sbl.lbl.gov/wasteguide/>) to promote employee awareness. The guide also details the types of waste generated at Berkeley Lab and how they are treated.

Municipal solid waste diversion from the landfill in 2019 is estimated at 75%. The term *municipal solid waste* refers to the following waste streams generated at Berkeley Lab:

- Beverage containers (glass, aluminum, plastic)
- Paper (white paper, mixed paper)
- Cardboard
- Scrap wood

- Scrap metal
- Garden/landscaping waste
- Salvage sales and transfers
- Compost (food waste, food-soiled paper products, paper towels)
- Landfill (nonrecyclable waste)

Construction and demolition debris diversion is estimated at 84%. C&D debris includes a variety of nonhazardous materials generated as a result of construction projects (concrete, wood, metal, gypsum board, etc.). Berkeley Lab's major construction and renovation contracts include requirements for recycling of C&D waste to promote high diversion rates. Details on how this waste is treated can be found in the C&D Waste Management Spec, which all contractors must follow.

100% of e-waste was recycled in FY 2019. Berkeley Lab is working toward transitioning its recycling contracts to electronics recyclers certified under either the e-Stewards or Responsible Recycling (R2) programs.

3.4.3.7 Underground Storage Tanks

In the early 1980s, California began addressing groundwater contamination from leaking underground storage tanks (USTs) through a rigorous regulatory and remediation program (California Health and Safety Code, 1983). The state program's requirements for USTs containing hazardous materials address permitting, construction, design, monitoring, recordkeeping, inspection, accidental releases, financial responsibility, and tank closure; the program satisfies the provisions of the federal RCRA requirements (42 USC § 6991, 1988). The City of Berkeley is the local administering agency for UST regulations that apply to Berkeley Lab's main site. Six permitted USTs located on site contain either diesel or unleaded gasoline, as listed in Table 3-7 and shown on Figure 3-1.

Table 3-7 Underground Storage Tanks Requiring Operating Permits

Registration ID	Location (Building)	Contents	Capacity (Gallons)	Year Installed
Fiberglass tanks, double-walled				
2-TK-3	2	Diesel	4,000	1988
2-TK-4	2	Diesel	1,000	1988
85-TK-1	85	Diesel	2,500	1995
Glass-lined steel tanks, double-walled, with fiberglass-reinforced plastic corrosion protection				
55-TK-1	55	Diesel	1,000	1986
76-TK-5	76	Unleaded gasoline	10,000	1990
76-TK-6	76	Diesel	10,000	1990

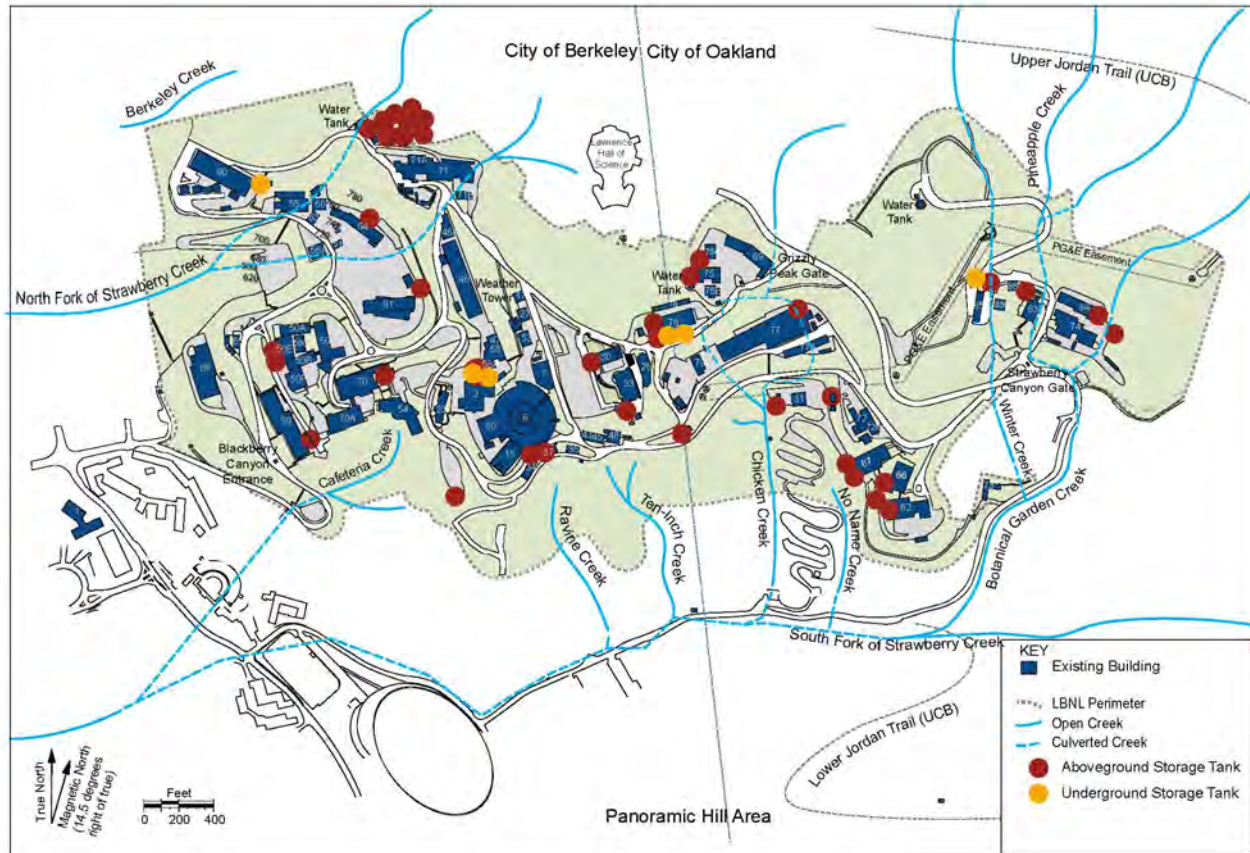


Figure 3-1 Locations of Petroleum-Containing Aboveground and Underground Storage Tanks

LBNL activities in 2019 included replacement of the spill bucket for UST 2-TK-3 in October, annual UST line testing in November (for tank systems 2-TK-3, 2-TK-4, 76-TK-5, and 76-TK-6), and suction line testing for tank systems 55-TK-001 and 85-TK-001 in December.

Berkeley Lab has removed nine USTs since 1993 following the regulatory closure process; no USTs were removed in 2019.

In September and November, the City of Berkeley conducted a routine inspection of the six permitted USTs at the main site. Two minor violations were cited, as follows:

1. The “Designated UST Operator Visual Inspection” was being performed on a monthly schedule, as opposed to at least once every 30 days, as required; this resulted in inspections that sometimes exceed their 30-day time limit.
2. A spill bucket (for 2-TK-3) was not large enough to retain the required 5-gallon volume. The bucket was replaced and retested on October 17, 2019, and it passed the leak test.

3.4.4 Corrective Action Program

Berkeley Lab is currently in the Corrective Measures Implementation phase of the RCRA Corrective Action Program. This phase consists of operating, maintaining, and monitoring the environmental restoration measures approved by DTSC in the *Corrective Measures Study Report for Lawrence Berkeley National Laboratory (LBNL,*

2005). These measures are intended to reduce or eliminate the potentially adverse effects to human health, or the environment caused by past releases of chemicals to soil and groundwater at Berkeley Lab.

The following DTSC-approved corrective measures are being used to clean up contaminated groundwater:

- **In situ soil flushing** involves extracting contaminated groundwater from the subsurface, cleaning the water on site using granular activated carbon (GAC), and then recirculating the treated groundwater by injecting it into the subsurface. In situ soil flushing increases the rate at which soil contaminants dissolve into the groundwater and promotes the flow of contaminated groundwater toward locations where it can be extracted and cleaned.
- **Groundwater capture and treatment** consists of extracting groundwater in the downgradient portions of groundwater contaminant plumes to minimize further migration, cleaning the extracted groundwater on site using GAC, and then either injecting the treated water into the subsurface, if needed for soil flushing, or discharging the treated water to the sanitary sewer system.
- **Hydrogen Release Compound (HRC®)**, an environmentally safe polylactate ester formulate, involves injection into contaminated areas to enhance the natural biodegradation of volatile organic compounds (VOCs).
- **Monitored natural attenuation** (i.e., reliance on natural processes) is also being used at some locations within the context of a controlled and monitored site cleanup approach.

The Soil Management Plan for Lawrence Berkeley National Laboratory (LBNL, 2017b) and the Groundwater Monitoring and Management Plan (LBNL, 2006) describe the nature and extent of contamination, the controls used to reduce potential risk to human health and the environment from contaminants in soil and groundwater, and the requirements for ongoing groundwater and surface water monitoring. These plans, as well as other RCRA Corrective Action Program documents prepared by Berkeley Lab, are available to the public at the main branch of the Berkeley Public Library and on the Environmental Restoration Program website at <https://ehs.lbl.gov/resource/environmental-restoration-program/>.

3.4.5 Toxic Substances Control Act

The objective of the Toxic Substances Control Act (TSCA) of 1976 is to minimize the exposure of humans and the environment to chemicals used in manufacturing, processing, commercial distribution, and disposal activities. TSCA establishes a protocol for evaluating chemicals before they are introduced to the marketplace, then regulating their use once they are approved for manufacturing. TSCA regulations are administered by the U.S. EPA.

Polychlorinated biphenyls (PCBs), the principal substances at Berkeley Lab currently subject to TSCA regulations, require additional tracking and documentation beyond that required for RCRA-only regulated wastes. The only remaining equipment containing TSCA-regulated PCBs is four large low-voltage capacitors in Building 88. These capacitors remain in use and contain an estimated 375 pounds of regulated PCB dielectric fluid, which is below the U.S. EPA annual reporting threshold for number of capacitors for PCBs.

In 2014, PCBs were detected in soil samples collected during a preliminary environmental hazard assessment of the Old Town area in preparation for demolition of Buildings 5 and 16 and the Building 52 building slab. Efforts to characterize the extent of PCB contamination continued into 2017 under the regulatory authority of U.S. EPA

Region 9. Cleanup efforts of this contamination began in early 2017 under a cleanup plan approved by the U.S. EPA, and are ongoing. More information on the Old Town Demolition Project is found in Section 3.5.1 of this report. In addition, characterization and cleanup efforts are documented in the LBNL Environmental Restoration Program's Progress Reports, which are available at the main branch of the Berkeley Public Library and on the [program's website](#).

3.4.6 Clean Water Act

The 1972 Clean Water Act regulates the discharge of pollutants from both point and nonpoint sources to the waters of the United States by establishing pollutant discharge standards and limitations, as well as a permit and licensing system to enforce the standards. California is authorized by the U.S. EPA to administer the principal components of the federal water quality management program.

The California Porter-Cologne Water Quality Control Act (California Water Code, 1969) established a comprehensive statewide system for regulating water use and provided for a three-tiered system of regulatory administration and enforcement:

1. California State Water Resources Control Board (SWRCB, "State Water Board")
2. nine Regional Water Quality Control Boards
3. local governments

For the LBNL main site, the agencies responsible for regulatory programs are the San Francisco Bay Regional Water Quality Control Board (herein referred to as the "SF Bay Regional Water Board") for stormwater discharges, and EBMUD for drinking water supply and wastewater discharges. For the Joint Genome Institute (JGI), which was located in Walnut Creek through December 2019, the responsible agency for both wastewater and stormwater discharges is the Central Contra Costa Sanitary District.

3.4.6.1 Aboveground Storage Tanks

Aboveground storage tanks (ASTs) fall under the authority of the Clean Water Act, which, together with the state's Aboveground Petroleum Storage Act (California Health and Safety Code, 1989), outlines the applicable regulatory requirements for ASTs containing chemicals or hazardous materials. At Berkeley Lab, these requirements apply to petroleum storage tanks for standby emergency diesel generators, storage drums at waste accumulation areas, and storage drums at product distribution areas. The City of Berkeley is responsible for administering and enforcing the regulations that apply to ASTs at the main site. Berkeley Lab has 35 of these tanks registered with the city. Their locations are shown on Figure 3-1.

Under the authority of the Clean Water Act, Berkeley Lab is required to prepare a Spill Prevention, Control, and Countermeasure (SPCC) Plan for petroleum-containing aboveground tanks. Berkeley Lab maintains an SPCC Plan for the main site with the goal of preventing and, if needed, mitigating spills or leaks from petroleum-containing tanks (LBNL, 2017c). These ASTs are provided with secondary containment or spill kits to capture any potential leaks. Berkeley Lab's SPCC Plan was amended in August 2019 to include a new AST (91-TK-001) at the newly constructed Integrative Genomics Building (Building 91).

As mentioned earlier, the City of Berkeley (CUPA) inspected Berkeley Lab's SPCC Plan and ASTs November 4 to 7, 2019, noting two minor violations. One corrective action required updating the SPCC Plan diagram to include mobile/portable containers. Another required providing missing monthly inspection reports for six ASTs.

A 4,000-gallon AST at the JGI facility was decommissioned and removed from service in late December 2019.

3.4.6.2 Wastewater

EBMUD is the public utility district that regulates all industrial and sanitary discharges to its wastewater treatment facilities. Berkeley Lab holds EBMUD wastewater discharge permits for the following activities at the main site:

- General sitewide wastewater (EBMUD, 2019)
- Treated groundwater from hydraugers (subsurface drains) and groundwater extraction wells (EBMUD, 2016)
- "Zero-waste-discharge" treated rinse water recycled from the metal finishing operations in the Ultra-High Vacuum Cleaning Facility at Building 77 (EBMUD, 2019)
- Treated rainwater from the Old Town Demolition Project (EBMUD, 2019)

Permits specify standard terms and conditions, individual discharge limits and provisions, and monitoring and reporting requirements. Berkeley Lab submits periodic self-monitoring reports specified under each permit, and in 2019 no wastewater discharge limits were exceeded. Therefore, no discharge violations were measured in the self-monitoring sampling events. A summary of monitoring results is provided in [Chapter 4](#).

EBMUD periodically samples the site's sanitary sewer discharge without notice. The agency collected wastewater samples from Berkeley Lab's two sewer outfalls, Strawberry and Hearst, in May and September. No discharge violations were found in the wastewater sampling results.

The sitewide wastewater discharge permit is renewed periodically by EBMUD. This permit requires annual self-monitoring, which is discussed in [Chapter 4](#). The sitewide permit also requires annual certification by Berkeley Lab that it is in compliance with the radiological conditions of the permit. Berkeley Lab was in compliance with the radiological requirements of the EBMUD permit.

Berkeley Lab also holds a special EBMUD permit for discharging treated rainwater collected within excavations at the Old Town Demolition Project site. Treatment consists of using a zeolite media bed to reduce metals, particulate filter cartridges to collect sediment, and activated charcoal to remove polychlorinated biphenyls (PCBs), total petroleum hydrocarbons, and VOCs that may have accumulated in the rainwater runoff collected at the site.

In November 2019, Berkeley Lab began moving its JGI operations from the Walnut Creek facility to the newly constructed Building 91 located at the LBNL main site in Berkeley. Berkeley Lab submitted the Periodic Compliance Reports for 2019 to the Central Contra Costa Sanitary District (Central San), in compliance with JGI's Class III Industrial User Permit for wastewater. In November, Central San performed its annual inspection of the JGI facility for wastewater and stormwater, and no citations were issued. Berkeley Lab vacated the former JGI facility on December 31, 2019, and Central San terminated the facility's Class III Industrial User Permit in January 2020.

3.4.6.3 Stormwater

Berkeley Lab's stormwater releases are permitted under the statewide General Permit for Stormwater Discharges Associated with Industrial Activities (SWRCB, 2014), commonly referred to as the Industrial General Permit. Although the State Water Board issues this permit, it is administered and enforced locally by the SF Bay Regional Water Board. Under this permit, Berkeley Lab has implemented a Stormwater Pollution Prevention Plan (SWPPP) (LBNL, 2019e), which includes the site's Stormwater Monitoring Implementation Plan (LBNL, 2019d).

The purpose of the SWPPP is to identify sources of pollution that could affect the quality of stormwater discharges, and to describe the practices implemented to reduce pollutants in these discharges. The *Stormwater Monitoring Implementation Plan* describes the rationale for selecting sampling locations, collecting and analyzing samples, and ensuring the quality and reporting of the results. Together, these documents represent Berkeley Lab's plan and procedures for identifying, monitoring, and reducing pollutants in its stormwater discharges.

Because the Site Environmental Report is based on the calendar year, and the State Water Board's reporting year is July 1 through June 30 in different calendar years, the sampling events discussed here are based on results from two stormwater reporting events: fall 2018 and spring 2019. The annual report covering stormwater activities for the 2018/2019 reporting year was submitted using the State Water Board's online Stormwater Multiple Application and Report Tracking System (SMARTS) at smarts.waterboards.ca.gov. The annual report includes results from the annual compliance evaluation, a summary of any changes made to the SWPPP, and analytical results for all sampling events during the reporting year.

Stormwater sampling results and State Water Board compliance status are discussed in more detail in Section 4.2.2.

Stormwater releases from construction activity disturbing one or more acres of soil are regulated under the state's General Permit for Stormwater Discharges Associated with Construction Activities (SWRCB, 2012), also referred to as the Construction General Permit. During 2019, three projects at Berkeley Lab required coverage under the Construction General Permit program:

1. Old Town Demolition Project
2. Integrative Genomics Building (IGB) and Modular Utility Plant (MUP) Project within the Bayview Area
3. Bayview Parcel 1 and Site Utilities Relocation Project (SURP) within the Bayview Area

Similar to the Industrial General Permit, each of these projects required that a SWPPP and an annual report be submitted to SMARTS. Unlike the Industrial General Permit, no stormwater sampling was required; however, project site inspections were required (i.e., for before a predicted rain event on a business day, during extended rain events, after rain events, and quarterly non-stormwater discharge). Inspection logs were included in the annual report. Both projects were compliant with their permit requirements for 2019.

The Construction General Permit for the Old Town Demolition Project has remained active since May 2015. The IGB/MUP Project's stormwater permit became effective in July 2016 and was terminated upon project completion in August 2019. The Bayview Parcel 1 / SURP stormwater permit became active in November 2019 and will be terminated when the project is completed.

3.4.7 National Environmental Policy Act and California Environmental Quality Act

The National Environmental Policy Act (NEPA) of 1969 and the California Environmental Quality Act (CEQA) of 1970 require that potential environmental impacts of proposed actions be considered in the decision-making process by the designated lead agency. As it upgrades facilities and expands research programs, Berkeley Lab provides subject matter expert analysis and documentation to assist DOE in meeting its NEPA compliance requirements; similar efforts are expended to support the University of California's CEQA decision making pertinent to LBNL projects and activities.

In 2019, DOE determined that approximately six proposed federally supported activities at Berkeley Lab met the criteria for categorical exclusion under NEPA. Review documents for each are available online at the DOE website for the Office of NEPA Policy and Compliance. No Environmental Assessments under NEPA were prepared for LBNL activities. Approximately eight activities were determined to be either categorically exempt under CEQA or covered under CEQA's programmatic Environmental Impact Report.

3.5 SPECIAL PROJECTS

At times, Berkeley Lab engages in projects that require additional environmental investigation and characterization activities in support of continued modernization of its research facilities. One such project was the soil vapor investigation study conducted in the Bayview Area at Berkeley Lab.

3.5.1 Soil Vapor Investigation

Historical operations have contributed to the presence of volatile organic constituents of concern in soil, soil vapor, and groundwater beneath portions of the Bayview Area. In support of design activities currently underway for the proposed BioEPIC building, a soil vapor investigation was performed to assess potential impacts to indoor air quality and building workers. The results of the soil vapor investigation activities indicate an unacceptable potential risk to future BioEPIC building workers due to the vapor intrusion pathway. An engineered vapor mitigation system is being incorporated into the building design to address this potential risk. A report summarizing investigation activities was submitted to DTSC in early 2020.

4 Environmental Monitoring

Berkeley Lab's environmental monitoring programs assess the impact of its emissions on public health and the environment, which is important for measuring environmental stewardship performance and demonstrating compliance with requirements established by federal, state, and local agencies. These programs also confirm adherence to DOE environmental protection policies and support environmental management decisions. The comprehensive *Environmental Monitoring Plan* (LBNL, 2013a) provides the basis and current scope for each program. This chapter presents summaries of 2019 sampling and monitoring results for the following media and processes:

- Stack air
- Surface water
- Wastewater
- Groundwater
- Soil and sediment
- Vegetation and foodstuffs
- Penetrating radiation monitoring
- Radiological clearance of property

4.1 STACK AIR

Berkeley Lab's air monitoring program is designed to assess the impacts from radiological air emissions. The program consists of emissions sampling and monitoring to measure contaminants released from building exhaust systems. The program meets the U.S. EPA and DOE requirements discussed in Section 3.4.1.1.

Various radionuclides are used in Berkeley Lab's radiochemical and biomedical research programs, and radioactive materials are generated by particle accelerators. These research and accelerator operations may produce very small amounts of airborne radionuclides, which are typically emitted from a stack via a building's exhaust system. Berkeley Lab is required to assess the potential impacts from radionuclide emissions where radionuclides are used or generated. If the dose from potential emissions exceeds U.S. EPA Region 9-approved thresholds listed in Table 4-1, Berkeley Lab must follow U.S. EPA-approved methods for measuring emissions by sampling or monitoring stacks through which emissions are released. *Sampling* is the collection of radionuclides on a filter or absorbent media, and subsequent analysis of the filters or media at an analytical laboratory, and *monitoring* is the continuous measurement of radionuclides in real time.

Each year, all new activities using a significant amount of radionuclides are evaluated for their potential to emit radionuclides, then compared with the thresholds listed in Table 4-1. In 2019, all potential doses were found to be less than 0.1 mrem/yr, indicating that the applicable requirements are either Category 3, which requires periodic sampling, or Category 4, which requires dose evaluation but no sampling or monitoring. At some locations, Berkeley Lab follows a more conservative approach that may include either real-time monitoring or more frequent sampling than required to better characterize emissions. In 2019, sampling was performed on a total of 13 stacks,

and real-time monitoring was performed on 4 stacks; 1 stack was both sampled and monitored. Sampling and monitoring locations are shown on Figure 4-1.

Table 4-1 U.S. EPA–Approved Radionuclide Emissions Measurement Approach

Category	AEDE (mrem/yr)	Requirements
Noncompliant	AEDE ≥ 10	Reduction or relocation of the source and re-evaluation before authorization
1	10 > AEDE ≥ 1	Continuous sampling with weekly collection and real-time monitoring for short-lived radionuclides
2	1 > AEDE ≥ 0.1	Continuous sampling with monthly collection or real-time monitoring for short-lived radionuclides
3	0.1 > AEDE ≥ 0.01	Periodic sampling 25% of the year
4	0.01 > AEDE	Potential dose evaluation before project starts and when project changes; no sampling or monitoring required

AEDE = annual effective dose equivalent

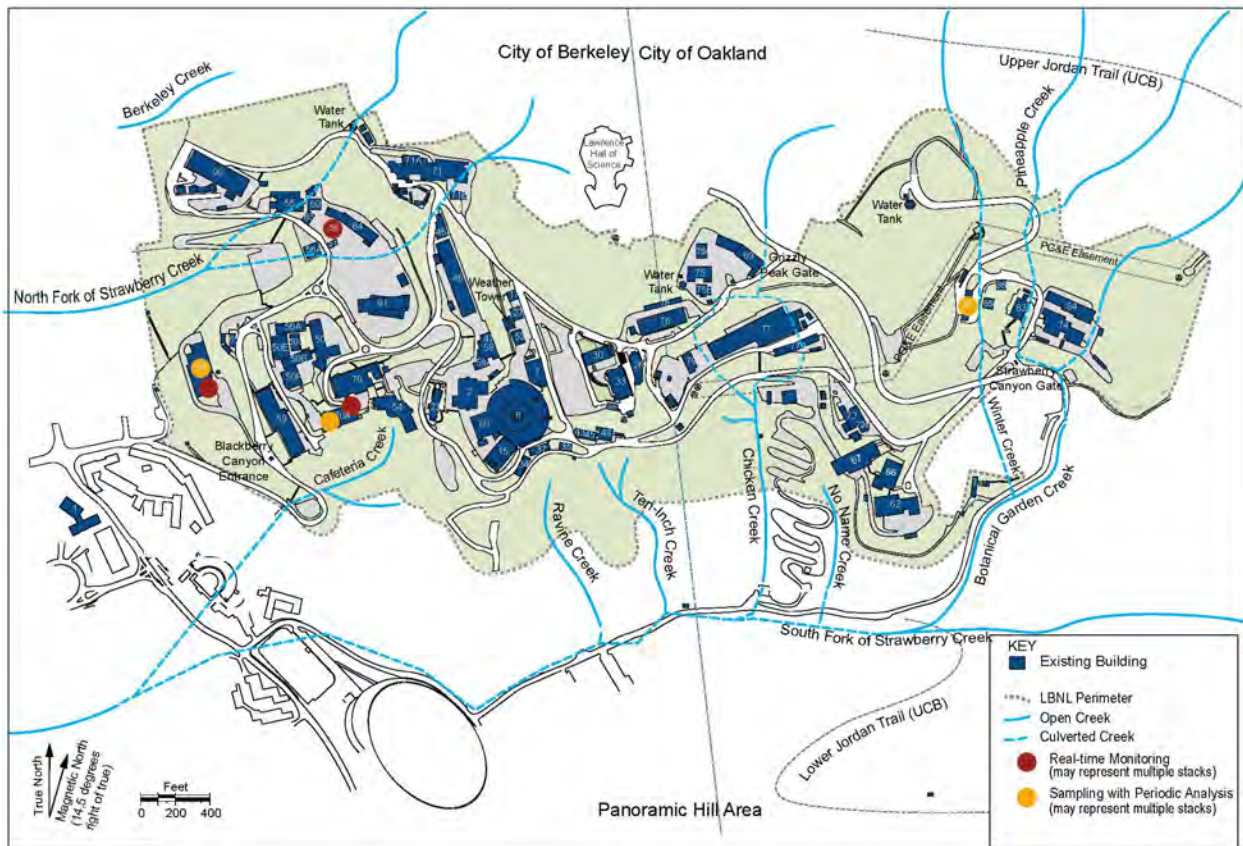


Figure 4-1 Building Exhaust Sampling and Monitoring Locations

Stack exhaust samples were analyzed for three radiological parameters: gross alpha, gross beta, and tritium. Real-time stack air monitoring systems measured alpha emitters and positron emitters. Fluorine-18 (half-life of 1.8 hours) was the predominant positron emitter measured, accounting for nearly 77.6% of the emitted activity from the site. The Building 56 accelerator was the main source of fluorine-18 emissions, at 0.56 curies (Ci). Additional details on stack emissions are available in Berkeley Lab's *Radionuclide Air Emissions Report for 2019* (LBNL, 2020b), which was submitted to DOE and the U.S. EPA, and is available on the Environmental Publications page of ESG's website (<https://ehs.lbl.gov/service/environmental-services/>). For information on the estimated dose from radionuclide emissions, see Chapter 5.

4.2 SURFACE WATER

Surface water quality is evaluated at and around Berkeley Lab by sampling creek water and stormwater.

4.2.1 Creek Sampling

The sampled creeks either flow through or originate within the LBNL site. The following creeks are sampled within the Strawberry Creek watershed (from west to east on Figure 4-2) twice a year – once during the wet season and once during the dry season (if water is flowing in the creek):

- North Fork of Strawberry Creek
- Cafeteria Creek
- Ravine Creek
- Ten-Inch Creek
- Chicken Creek
- No Name Creek
- Winter Creek, which is sampled at two locations (inflow and outflow points to the site)
- Botanical Garden Creek

To establish background water quality values for the area, samples were also collected semiannually from Wildcat Creek at a location in Tilden Regional Park approximately 1.4 miles (2.2 km) north-northwest of UC's Lawrence Hall of Science. Wildcat Creek originates in Tilden Park and flows in a northwest direction away from Berkeley Lab.

Samples from the following subset of creeks were collected semiannually and analyzed for gross alpha, gross beta, gamma emission spectroscopy, and tritium in accordance with DOE Order 458.1 requirements: Chicken Creek, the North Fork of Strawberry Creek, Wildcat Creek, and Winter Creek (inflow and outflow points).

Although LBNL surface waters are not used as a source of public drinking water, Berkeley Lab evaluates creek water results against conservative maximum contaminant level (MCL) drinking water standards, as well as water quality objectives as stated in the *Water Quality Control Plan for the San Francisco Bay Basin* (commonly known as the Basin Plan; RWQCB, 2015). The federal and state MCL values for drinking water are as follows (U.S. EPA, 1976; RWQCB, 2016):

- gross alpha – 15 picocuries per liter (pCi/L)
- gross beta – 50 pCi/L
- tritium – 20,000 pCi/L

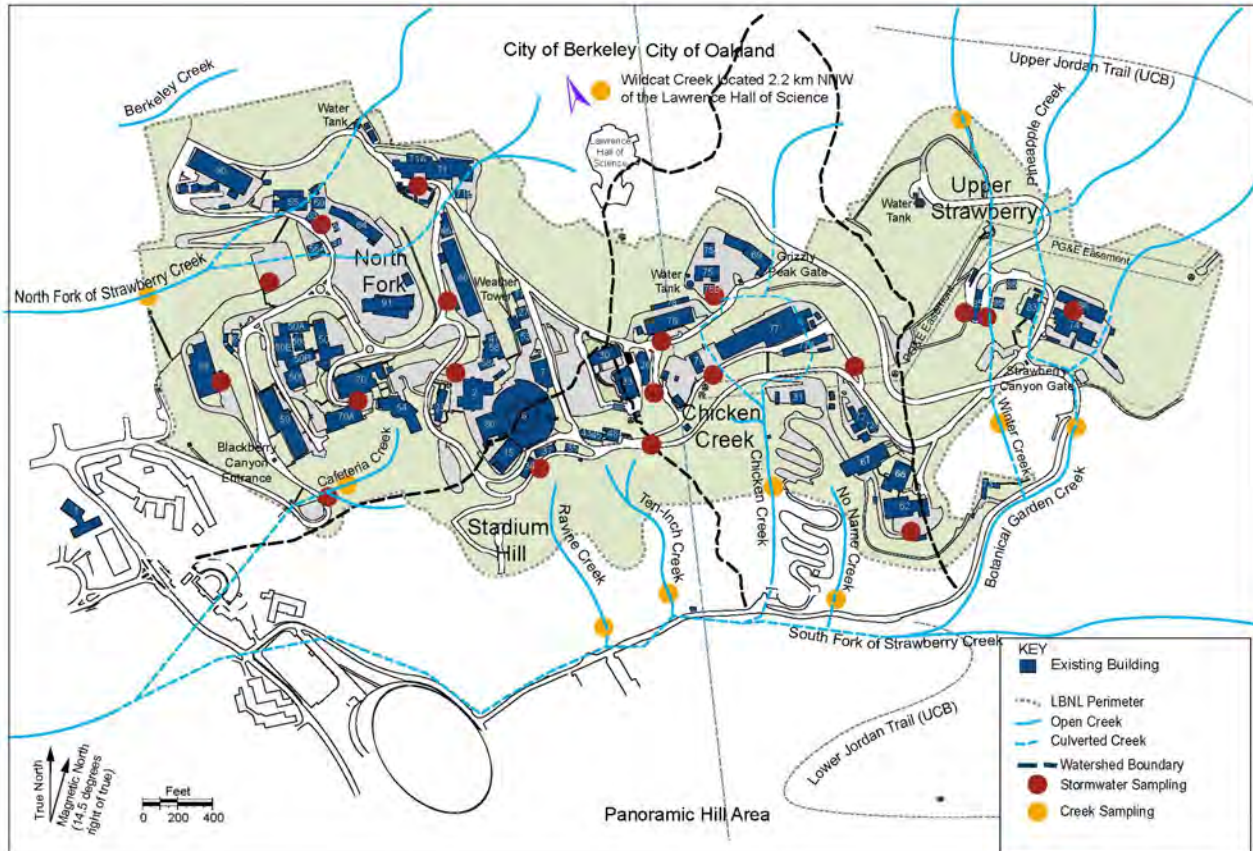


Figure 4-2 Surface Water Sampling Locations

Laboratory analysis reported 21 of the 24 sample results (88%) as below detectable levels. As shown in Table 4-2, three samples had detectable levels of gross alpha or gross beta, although these were no greater than 4% of the federal and state MCL values for drinking water. Naturally occurring radioactive materials, such as potassium-40, uranium-238, thorium-232, and their daughter products, are believed to contribute the majority, if not all, of the detectable gross alpha and gross beta results. Tritium was not detected in any of the samples.

Table 4-2 Detectable Radiological Results from 2019 Creek Sampling

Activity	MCL ^a (pCi/L)	Creek	Sample (pCi/L)	% of MCL
gross alpha	15	Winter Creek	1.9	0.13
gross alpha	15	Chicken Creek	1.9	0.13
gross beta	50	North Fork Strawberry Creek	2.0	4.0

^a MCL = maximum contaminant level for drinking water, in picocuries per liter (pCi/L)

Using gamma spectroscopy for specific radionuclides, the results indicated that 60 of the 146 radionuclides reported (41%) were below detectable levels. Radiological activities for the remaining samples with detectable results were consistently low and within historical environmental levels monitored by Berkeley Lab.

Creek samples were also sampled and analyzed for PCBs, VOCs, pH, and metals. No PCBs or VOCs were detected, but the following metals were detected: aluminum, antimony, arsenic, barium, chromium, copper, iron, lead, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc. Metals and pH results were within historical levels for Berkeley Lab, well below the water quality objectives listed in the Basin Plan, and well below the drinking water standard.

4.2.2 Stormwater Sampling

Berkeley Lab's *Stormwater Monitoring Implementation Plan* describes the sampling rationale, sampling locations (see Figure 4-2), and analytical parameters for each specific industrial activity (LBNL, 2019d). The Industrial General Permit also requires visual observation of the surface water runoff from each qualifying storm event, monthly dry weather visual observations of non-stormwater discharges, and an annual sitewide inspection.

Under the terms of the Industrial General Permit, Berkeley Lab must conduct stormwater sampling each reporting year during four storm events that meet a set of permit-specific conditions. Two of the sampling events typically occur within the first half of each reporting year (July 1–December 31), with the remaining two then taking place during the second half of the reporting year (January 1–June 30).

In August 2018, Berkeley Lab evaluated the applicability of its historical Standard Industrial Classification (SIC) codes and revised its classification from multiple codes to the single SIC code #8733 Noncommercial Research Organization, which best describes current site activities. In addition, in September, Berkeley Lab conducted a sitewide pollutant source assessment (PSA), which identified four potential point-source areas of industrial activity conditionally subject to the General Permit's monitoring requirements. Based on Berkeley Lab's current SIC code, the PSA findings, and the General Permit's monitoring requirements, beginning in the first half of the 2018/2019 season, stormwater samples were collected for the following five parameters:

1. aluminum
2. iron
3. pH
4. oil and grease
5. total suspended solids

The 2015/2016 reporting year was the first under a significantly modified Industrial General Permit, which initially set all facilities in the state operating under this permit at the "Baseline" compliance status. To remain at Baseline, a facility would need to maintain the average results for each sampled parameter below that parameter's Numeric Action Level (NAL) established by the State Water Board. The results from the four sampling events for the first reporting year under the new permit showed that two parameters sampled by Berkeley Lab, aluminum and iron, exceeded their NALs of 0.750 and 1.000 mg/L, respectively. This resulted in a change in compliance status from Baseline to Level 1 for the 2016/2017 reporting year. In the subsequent reporting year (2017/2018), sample results again showed that averages for aluminum (at 1.271 mg/L) and iron (at 1.75 mg/L) were above their respective NALs, causing Berkeley Lab's compliance status to change from Level 1 to Level 2.

The change in status resulted in a requirement that Berkeley Lab identify additional stormwater controls to implement in order to prevent future exceedances of NALs. These additional controls fell into the two categories of administrative and structural/treatment controls.

1. Administrative controls were in the areas of updated procedures and expanding stormwater training for LBNL staff, vendors, and contractors.
2. Structural/treatment controls included additional asphaltic berms and check dams, and enhanced filtration for metal treatment.

The change in status also resulted in an update to the SWPPP to include the additional stormwater controls, then submitting an Exceedance Response Action Level 2 Report to the State Water Board outlining actions taken for the site.

With additional best management practices in place to address aluminum and iron for the 2017/2018 reporting year, Berkeley Lab was successful in achieving sample results that were below the NALs, thereby allowing its return to the Baseline compliance status for the 2018/2019 reporting year. However, repeated exceedances of aluminum and iron detected in the first half of reporting year 2019/2020 have again elevated Berkeley Lab's status to Level 2.

4.3 WASTEWATER

As required by permits issued by EBMUD, Berkeley Lab samples wastewater discharges at its two monitoring stations downstream of the main site. Sampling is also conducted to assess permit compliance for discharges of treated water from hydraugers and groundwater extraction wells. Sampling was performed at the Building 77 Ultra-High Vacuum Cleaning Facility until April 2018, when the treatment system was shut down to upgrade to a wastewater recycling system. In August 2019, EBMUD representatives inspected the newly installed zero-discharge treatment system at the Building 77 Ultra-High Vacuum Cleaning Facility, and a new permit was issued for the system in September 2019. The City of Berkeley also inspected the zero-discharge treatment system in 2019, and no violations were found.

For the current reporting year, all monitoring results were below EBMUD discharge limits. Monitoring results, an overview of monitoring locations, and a summary of any sanitary sewer spills are discussed in the following subsections.

4.3.1 Wastewater Monitoring Locations

As discussed in Section 3.4.6.2, Berkeley Lab holds EBMUD wastewater discharge permits for general sitewide activities and treated groundwater operations at eight locations. Each permit specifies periodic monitoring and reporting requirements. As discussed above, Berkeley Lab requested termination of the wastewater discharge permit for the metal finishing operations in the Ultra-High Vacuum Cleaning Facility at Building 77 in May 2018, with permit issuance for the new zero-waste-discharge system in September 2019.

Berkeley Lab's sanitary sewer system, shown on Figure 4-3, has two monitoring stations, each located near the outfall of one of the two main sewer system branches:

1. The Hearst Monitoring Station is located at the head of Hearst Avenue below the western edge of Berkeley Lab immediately before the connection to the City of Berkeley's sewer main. Discharges from Berkeley Lab's western and northern areas flow through this monitoring station.
2. The Strawberry Monitoring Station is located next to Centennial Drive in lower Strawberry Canyon. Discharges from Berkeley Lab's eastern and southern areas, as well as from several upstream UC Berkeley campus facilities, are routed through this monitoring station before tying into UC-owned piping downstream and then into the City of Berkeley's sewer system.

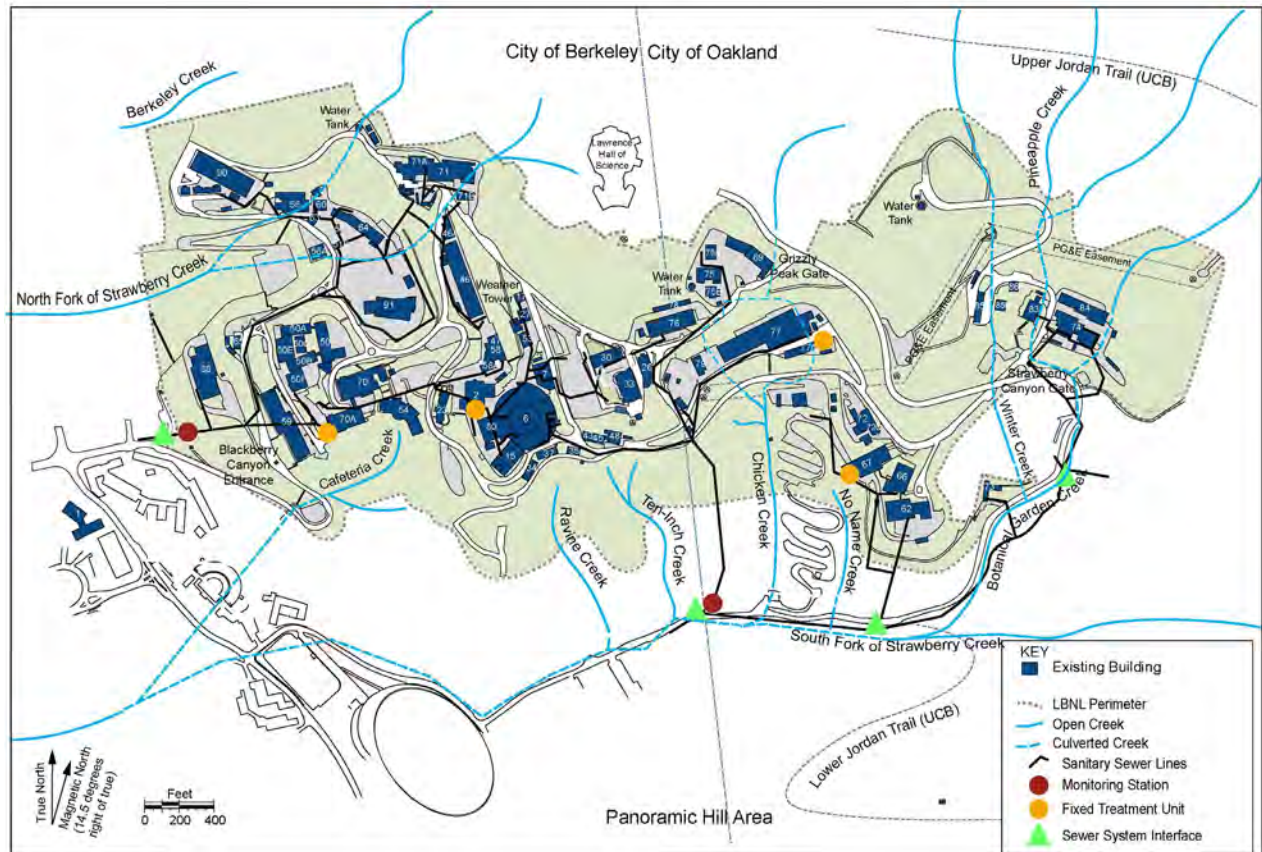


Figure 4-3 Sanitary Sewer System (Main Lines)

4.3.2 Hearst and Strawberry Sewer Outfalls

In 2019, Berkeley Lab discharged approximately 16.7 million gallons through the Hearst branch of the sewer system and 17.4 million gallons through the Strawberry branch, as measured by flow meters installed at both outfalls. Sampling and monitoring are conducted at these sewer outfalls as described briefly below; additional details are given in Sections 4.3.2.1 and 4.3.2.2.

- Radiological monitoring is required by DOE Order 458.1 (DOE, 2013) and corresponding guidance (DOE, 2015). Monitoring verifies compliance with radiological limits established by DOE to regulate the use of radioactive materials.

- Nonradiological samples collected at the Hearst and Strawberry outfalls are analyzed for pH, total identifiable chlorinated hydrocarbons, chemical oxygen demand, PCBs, total suspended solids, and specific metals.

4.3.2.1 Radiological Monitoring

For radiological monitoring, time-interval (every hour) composite samples are collected every month at the Hearst and Strawberry outfalls and analyzed by a state-certified laboratory for gross alpha, gross beta, iodine-125, tritium, and carbon-14. All samples taken at the Hearst and Strawberry sanitary sewer outfalls in 2019 were below the minimum detectable activity levels for carbon-14, iodine-125, and tritium. Although sewer discharges are not used for drinking water, positive results are very conservatively compared to MCLs as a demonstration of compliance with DOE Order 458.1 (DOE, 2013). Three positive results for gross alpha were detected at 2.4, 1.98, and 1.03 pCi/L, which are below the federal and state MCL for drinking water of 15 pCi/L. Positive results for gross beta were consistently detected throughout the year at the Hearst and Strawberry sewer outfalls, and are likely due to naturally occurring radioactive material such as potassium-40. The highest monthly gross beta concentration was 36.1 pCi/L, which is below the federal and state MCL for drinking water of 50 pCi/L.

In accordance with DOE guidance (DOE, 2011b), annual discharges are estimated by multiplying the maximum sample result's activity by the total annual volume discharged, even when the activity level is below the minimum detection limits. Since carbon-14, iodine-125, and tritium were below minimum detectable concentration levels, they are considered estimated values. The federal and state regulatory limits for radioisotopes in wastewater are based on total amounts discharged per year. The annual discharge estimated from tritium values totaled 1.40×10^{-2} Ci, or 0.28% of the tritium discharge limit of 5 Ci. The annual discharge estimated from carbon-14 values totaled 2.81×10^{-3} Ci, or 0.28% of the carbon-14 discharge limit of 1 Ci. These estimates are very conservative because they use the maximum concentration for each sample result, even if this value is below the minimum detectable concentration. For example, all sample results for carbon-14 and tritium were below the minimum detectable concentration. The estimated annual discharge for all other radioisotopes (gross alpha, gross beta, and iodine-125) was 5.73×10^{-3} Ci, or 0.57% of the combined discharge limit of 1 Ci.

DOE Order 458.1 requires facilities to control discharges into sanitary sewers if average monthly activity at the point of discharge is greater than five times Derived Concentration Standard (DCS) values for ingested water specified in DOE-STD-1196-2011, *Derived Concentration Technical Standard* (DOE, 2011b). Compliance is demonstrated when the fraction of each DCS value is calculated, based on consecutive 12-month average concentrations, and totaled. Applying conservative assumptions to the radionuclides responsible for the gross alpha (thorium-232), gross beta (strontium-90), carbon-14, iodine-125, and tritium activity, the calculated discharges were 0.014 (1.4%) and 0.019 (1.9%) of the allowable fractional DCS values in the Strawberry and Hearst sanitary sewer systems, respectively.

4.3.2.2 Nonradiological Monitoring

Berkeley Lab collected two nonradiological samples from both the Hearst and Strawberry outfalls in March and September, in accordance with the self-monitoring sample collection schedule specified by the EBMUD permit. All metals and total identifiable chlorinated hydrocarbon results were below EBMUD permit limits, and many were also below detection limits. All pH results were well above 5.5, as required by the permit. Total suspended solids

and chemical oxygen demand do not have discharge limits and are measured to determine wastewater strength, which forms the basis for EBMUD's wastewater treatment charges. Samples were also analyzed for 176 different PCB congeners as required by the permit, although EBMUD has not designated a discharge limit for PCB congeners in wastewater.

EBMUD visited both outfalls in May and September to collect grab samples and 24-hour composite samples. All results were within EBMUD permit discharge limits.

4.3.3 Treated Hydrauger and Extraction Well Discharge

Berkeley Lab currently has eight treatment systems permitted by EBMUD to discharge treated groundwater to the sanitary sewer. Sources of this treated groundwater are certain hydraugers, groundwater extraction wells, and well purging and development activities. The treatment process consists of first filtering the groundwater to remove sediment and then passing the contaminated groundwater through a carbon adsorption (i.e., GAC) system to remove hydrocarbons. Samples of the treated water are collected and analyzed for VOCs using U.S. EPA–approved methods. Sampling results have never exceeded the EBMUD permissible discharge limits.

4.3.4 Building 77 Ultra-High Vacuum Cleaning Facility Wastewater

Cleaning processes at the Ultra-High Vacuum Cleaning Facility at Building 77 include passivating (making a metal surface less chemically reactive), acid and alkaline cleaning, and ultrasonic cleaning of metal parts used in research and support activities. Acid and alkaline rinse waters that contain metals from this facility's operations are routed to FTU 006. As noted earlier, this FTU was shut down in April 2018 to upgrade to a zero-waste-discharge recycling system; EBMUD issued a permit for the system in September 2019.

The September 2019 permit requires that Berkeley Lab submit an annual discharge prevention compliance report certifying that Building 77 is not discharging any regulated process wastewater to the sanitary sewer. The annual discharge prevention compliance report must be submitted by January 31 of every year.

4.3.5 Sewer System Management Plan

Berkeley Lab's *Sewer System Management Plan* (LBNL, 2015) addresses the State Water Board's requirements (Order No. 2006-0003-DWQ) for maintaining Berkeley Lab's sanitary sewer systems and preventing and reporting overflows. SWRCB regulations require that any public agency owning or operating a wastewater collection system with piping longer than 1 mile prepare a written Sewer System Management Plan (SSMP) to address the proper operation, maintenance, and funding for maintenance and capital improvements of the system. This plan must be reviewed every five years to ensure that information is current and available. The most recent review and update was completed in April 2015. In addition, the plan must be audited by an independent party every two years. The last audit was completed in 2018.

The State Water Board's *Sanitary Sewer Order, Amending Monitoring and Reporting Program for Statewide General Waste Discharge Requirements for Sanitary Sewer Systems*, requires that all spills be reported. Also, monthly reporting is required regardless of whether any sanitary sewer overflow has occurred (SWRCB, 2013). Sanitary sewer overflow reporting is accomplished through the online California Integrated Water Quality System

(<http://www.waterboards.ca.gov/ciwqs/>), which is used by the State Water Board and the Regional Water Quality Control Boards to track water quality–related information. No sanitary sewer overflows occurred in 2019.

4.4 GROUNDWATER

This section describes Berkeley Lab’s groundwater monitoring program and provides a brief summary of the site’s groundwater contaminant plumes and the corrective measures applied to each. More detailed information on RCRA Corrective Action Program activities is provided each year in the Environmental Restoration Program’ Annual Progress Reports, which contains the site groundwater monitoring data, maps showing monitoring well locations and contaminant concentrations, and graphs showing variations in contaminant concentrations over time. These reports are available at the main branch of the Berkeley Public Library and on the program’s website at <https://ehs.lbl.gov/resource/environmental-restoration-program/>.

4.4.1 Groundwater Monitoring Overview

The groundwater monitoring network consists of more than 178 wells, including 17 that are used to monitor for potential migration of VOC-contaminated groundwater beyond the developed areas of the site (see Figure 4-4). The objectives of groundwater monitoring are as follows:

- Evaluate the continued effectiveness of the corrective measures that have been implemented for cleanup of contaminated groundwater.
- Document that groundwater plumes continue to be stable or attenuating and are not migrating off site.
- Monitor progress toward attaining the required groundwater cleanup levels.
- Monitor progress toward attaining the long-term goal of restoring all groundwater at the site to drinking water standards, if practicable. (Groundwater at Berkeley Lab is not used for domestic, irrigation, or industrial purposes.)

The groundwater monitoring data continue to indicate that the corrective measures have been effective in reducing VOC concentrations in the groundwater, and that groundwater contaminant plumes are stable or diminishing and contaminants are not migrating off site.

VOCs: Berkeley Lab has identified four principal plumes of VOC-contaminated groundwater at the site: Old Town, Building 51/64, Building 51L, and Building 71B. The geometry and distribution of chemicals in the Old Town Plume indicate that the plume consists of three lobes (i.e., Building 7, Building 25A, and Building 52 lobes) that were originally separate plumes but subsequently merged. In addition to the four principal plumes, VOC-contaminated groundwater is present in the following six localized areas: former Building 51A, former Building 51 Vacuum Pump Room, Building 69A, Building 75/75A, Building 76, and Building 77. The locations of the plumes and other areas of groundwater contamination are shown on Figure 4-5.

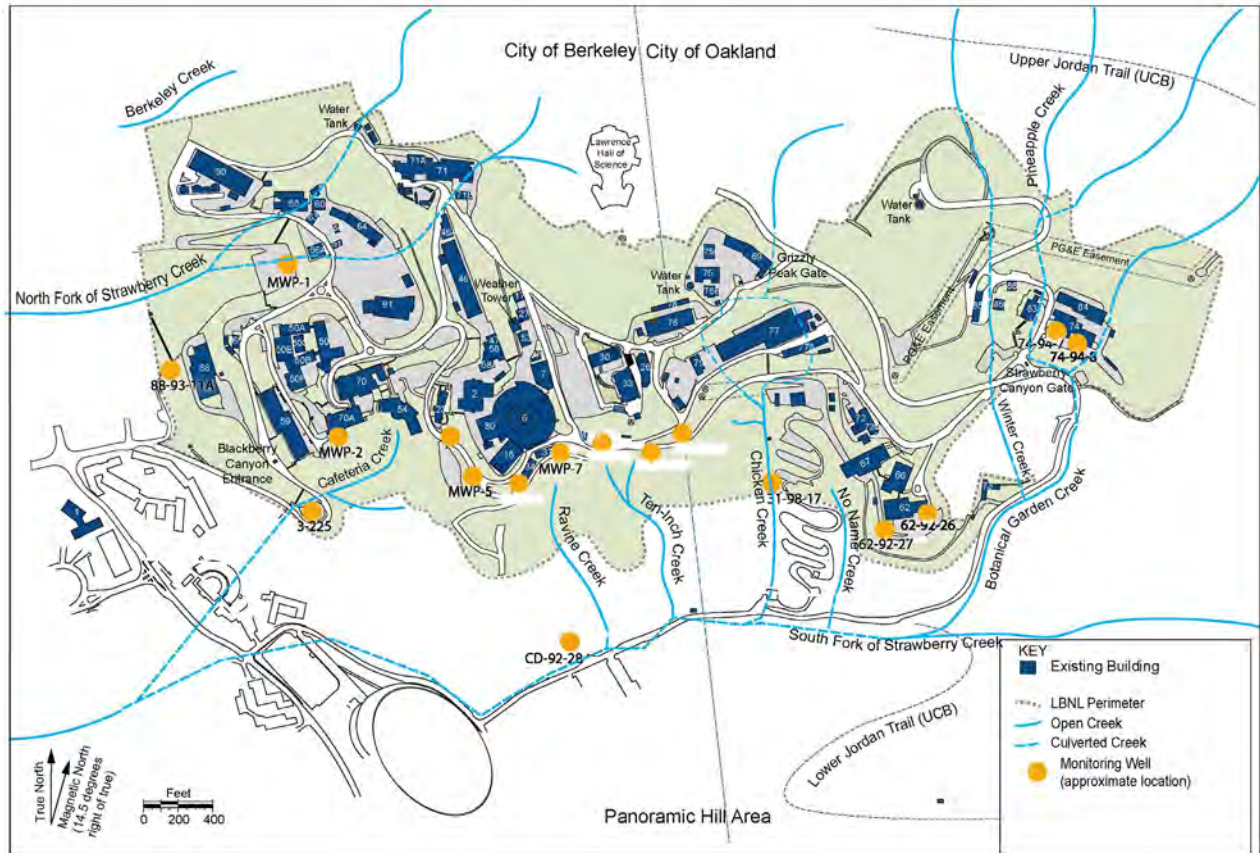


Figure 4-4 Groundwater Monitoring Wells Closest to the Site Boundary

The primary VOCs detected in the groundwater are chlorinated VOCs (e.g., tetrachloroethylene, trichloroethylene, 1,1,1-trichloroethane, carbon tetrachloride) and their associated degradation products (e.g., 1,1-dichloroethylene, cis-1,2-dichloroethylene, 1,1-dichloroethane, and vinyl chloride). Concentrations of VOCs in most areas have declined significantly, mainly as a result of the implemented corrective measures. However, VOC concentrations remain above MCLs in several areas. The areas where VOC concentrations in the groundwater exceed MCLs are shown on Figure 4-5.

Tritium: A plume of tritium-contaminated groundwater extends southward from the Building 75 area. The source of the plume was the former National Tritium Labelling Facility (NTLF), which ceased operation in December 2001. Since closure of the NTLF, concentrations of tritium detected in the groundwater have declined steadily, with concentrations below the drinking water standard of 20,000 pCi/L (U.S. EPA, 1976; RWQCB, 2016) since February 2005. The maximum concentration of tritium detected in 2019 was approximately 45% of the MCL. The location of this tritium plume is shown on Figure 4-5. Concentrations of tritium that were well below the drinking water standard were also previously detected in groundwater samples collected in the Building 71B area and beneath the central area of the former Bevatron site during demolition activities of this structure in 2010. Tritium was last detected in the Building 71B area in 2014, when it was detected at a concentration of 2% of the MCL.

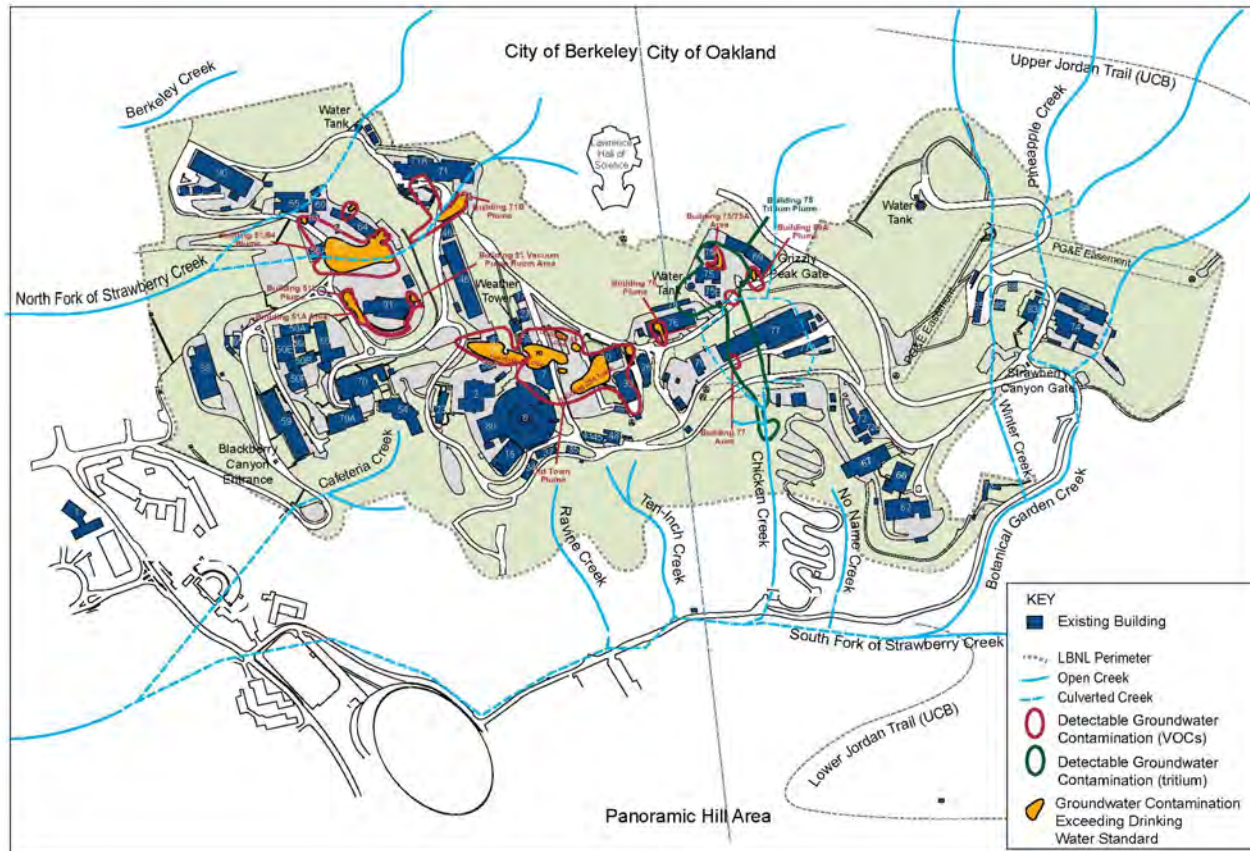


Figure 4-5 Locations of Groundwater Contamination

4.4.2 Treatment Systems

Berkeley Lab is extracting contaminated groundwater from collection trenches, extraction wells, and subdrains to control the migration of groundwater plumes and to clean up contaminated groundwater. Ten GAC treatment systems were in operation in 2019 to treat extracted groundwater, which totaled approximately 6.5 million gallons for the year. The cumulative volume of groundwater treated from 1991 through the end of 2019 exceeds 200 million gallons. The treated water is either injected into the subsurface, if needed for soil flushing, or discharged to the sanitary sewer system in accordance with the EBMUD permit for this type of discharge (EBMUD, 2016).

4.5 SOIL AND SEDIMENT

This section summarizes monitoring results for soil and sediment samples collected in the fall of 2019 and required by DOE Order 458.1 and guidance (DOE, 2015). Locations for soil and sediment sampling are shown on Figure 4-6.

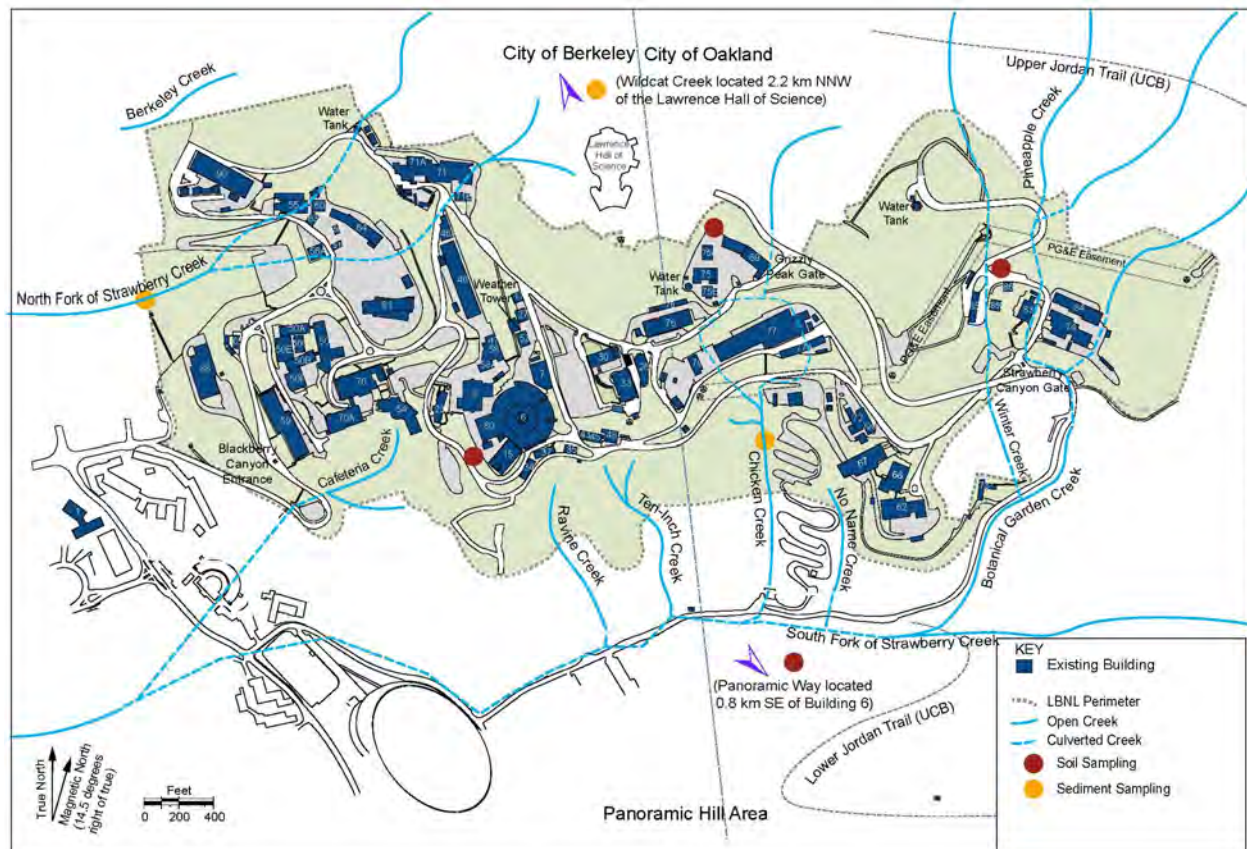


Figure 4-6 Soil and Sediment Sampling Sites

4.5.1 Soil Sampling

Soil samples obtained from the top 2 inches of surface soil were collected from three locations within the LBNL site (near Buildings 75, 80, and 85) and from one off-site environmental monitoring station (on Panoramic Way southeast of Building 6). The sample from the Building 85 location was split for quality control purposes. Samples were analyzed for gross alpha, gross beta, gamma emitters, tritium, moisture content, pH, and 15 metals.

The radiological results for gross alpha, gross beta, and gamma emitters at each of the sampling locations were similar to background levels that would be attributable to naturally occurring radioactive elements commonly found in soils (Eisenbud, 1973; NCRP, 1987). Only one anthropogenic radionuclide, cesium-137, was detected above the minimum detectable concentration. However, the detected concentration was similar to the background level. Further, cesium-137 is considered ubiquitous in nature due to nuclear power plant accidents and nuclear bomb testing. Tritium measurements at each sampling location were below minimum detectable concentrations.

Moisture content and pH levels at each of the sampling locations were within the historical range for soils at Berkeley Lab. With the exception of mercury, metals results were within both the established LBNL background levels (LBNL, 2009) and levels commonly found in soils in the United States (Shacklette and Boerngen, 1984).

At the Building 80 sampling locations, mercury was detected at concentrations of 2.4 milligrams per kilogram (mg/kg), which is above the established LBNL soil background concentration for mercury (0.42 mg/kg) but below the SF Bay Regional Water Board's commercial/industrial environmental screening level of 44 mg/kg (RWQCB, 2019) and DTSC's modified commercial/industrial screening level of 4.4 mg/kg (DTSC, 2019).

4.5.2 Sediment Sampling

Sediment samples were collected at Chicken Creek and the North Fork of Strawberry Creek within the LBNL main site and at Wildcat Creek in Tilden Regional Park. Due to limited sediment availability, several grab samples from the general sampling area of each location were composited and analyzed for gross alpha, gross beta, gamma emitters, tritium, 15 metals, moisture content, pH, petroleum hydrocarbons (diesel and oil/grease), and PCBs. The sample from Chicken Creek was split for quality control purposes.

The radiological results for gross alpha, gross beta, and gamma emitters at each of the sampling locations were similar to background levels of naturally occurring radioactive elements commonly found in soils (Eisenbud, 1973; NCRP, 1987). Tritium measurements at each sampling location were below detection limits.

The results of nonradiological analysis for pH, moisture content, and petroleum hydrocarbons (diesel and oil/grease) measurements at each of the sampling locations were within the historical range for sediments at Berkeley Lab. PCB measurements at each sampling location were below detection limits. Metals results were within both the established LBNL soil background levels (LBNL, 2009) and levels commonly found in soils in the United States (Shacklette and Boerngen, 1984).

4.6 VEGETATION AND FOODSTUFFS

Sampling and analysis of vegetation and foodstuffs can provide information regarding the presence, transport, and distribution of radioactive emissions in the environment. This information can be used to detect and evaluate changes in environmental radioactivity resulting from LBNL activities, and to calculate the potential human dose that would occur from consuming vegetation and foodstuffs.

As a result of past air emissions from the former NTLF located at Building 75, vegetation near that site contains measurable concentrations of tritium. Berkeley Lab analyzes vegetation for both chemical forms in which tritium occurs, namely, organically bound tritium and tissue-free water tritium. Since the closure of the NTLF in December 2001, tritium emissions from LBNL activities have decreased sharply, as noted in Section 4.4.1. Tritium concentrations in vegetation have decreased also, albeit more slowly.

To document changes in the concentrations of tritium in the local vegetation, Berkeley Lab has sampled vegetation every five years since the NTLF was closed. The most recent sampling, in the fall of 2015, confirmed that although vegetation in the vicinity of the former NTLF hillside stack contains measurable tritium concentrations, the concentration continues to decrease. Concentrations in much of the area around this former stack are projected to decrease to below the detection limit by the next scheduled vegetation sampling event.

4.7 PENETRATING RADIATION MONITORING

Radiation-producing machines (e.g., accelerators, x-ray machines, and irradiators) and various radionuclides are used at Berkeley Lab for high-energy particle studies and biomedical research. Accelerator operations are the primary contributors of penetrating radiation, and when operating, accelerators may produce gamma and neutron radiation. The accelerators include the Advanced Light Source (Building 6), the Biomedical Isotope Facility (Building 56), the 88-Inch Cyclotron (Building 88), and the Laser Accelerator Center (Building 71). The system in Building 71 is an experimental laser-driven accelerator that does not emit measurable gamma or neutron radiation into the environment. Smaller radiation-producing machines (x-ray machines and irradiators) at Berkeley Lab do not measurably increase the dose to the public.

Berkeley Lab uses two methods to determine the environmental radiological impact from accelerator operations, as follows:

1. Real-time monitors (near Building 6 and Building 88) that continuously detect and record gamma radiation and neutron dose.
2. Passive detectors known as optically stimulated luminescence dosimeters (at eight site locations and one background location) which provide an integrated dose over time from gamma radiation.

The real-time monitors are used to satisfy criteria in DOE Order 458.1. Passive detectors supplement the real-time monitors and confirm that the dose from LBNL operations is negligible and comparable to the measured background location. The locations of real-time monitors and dosimeters are shown on Figure 4-7. The results of both measurement methods are given in terms of dose (see Section 5.2).

4.8 RADIOLOGICAL CLEARANCE OF PROPERTY

Radiological clearance is the process by which property with the potential to contain residual radioactive material is evaluated and then transferred or disposed of. Requirements for this process are set by DOE Order 458.1, which specifies that property can be cleared only if it has been demonstrated that levels of radioactivity are indistinguishable from background. In addition, Berkeley Lab's safety principle of "as low as reasonably achievable" (ALARA) requires that property not be cleared for unrestricted release from radiological control under DOE Order 458.1 and 10 CFR 835 if it contains residual radioactivity that is distinguishable from background.

Berkeley Lab applies the required release and clearance criteria to all property under consideration, and property is released only when it can be demonstrated that it does not contain residual radioactive material, or that residual radioactivity has been characterized sufficiently to demonstrate through process knowledge or radiological survey that it contains only levels of radioactive material indistinguishable from background. Any property that does not meet release criteria is transferred either to another DOE radiological facility for reuse or to a licensed radioactive waste facility for disposal.

In 2019, Berkeley Lab's Radiation Protection Group performed 129 release and clearance surveys. The survey results were used to determine whether the equipment could subsequently be reused on site or released to the public. Three major structures were surveyed and released in the Bayview Area of Berkeley Lab: Building 51F, the Former Bevatron Utility Tunnels, and the Former Bevatron Slab. Additionally, Berkeley Lab's radiological soil assessment program supported eight soil excavation projects during this time.

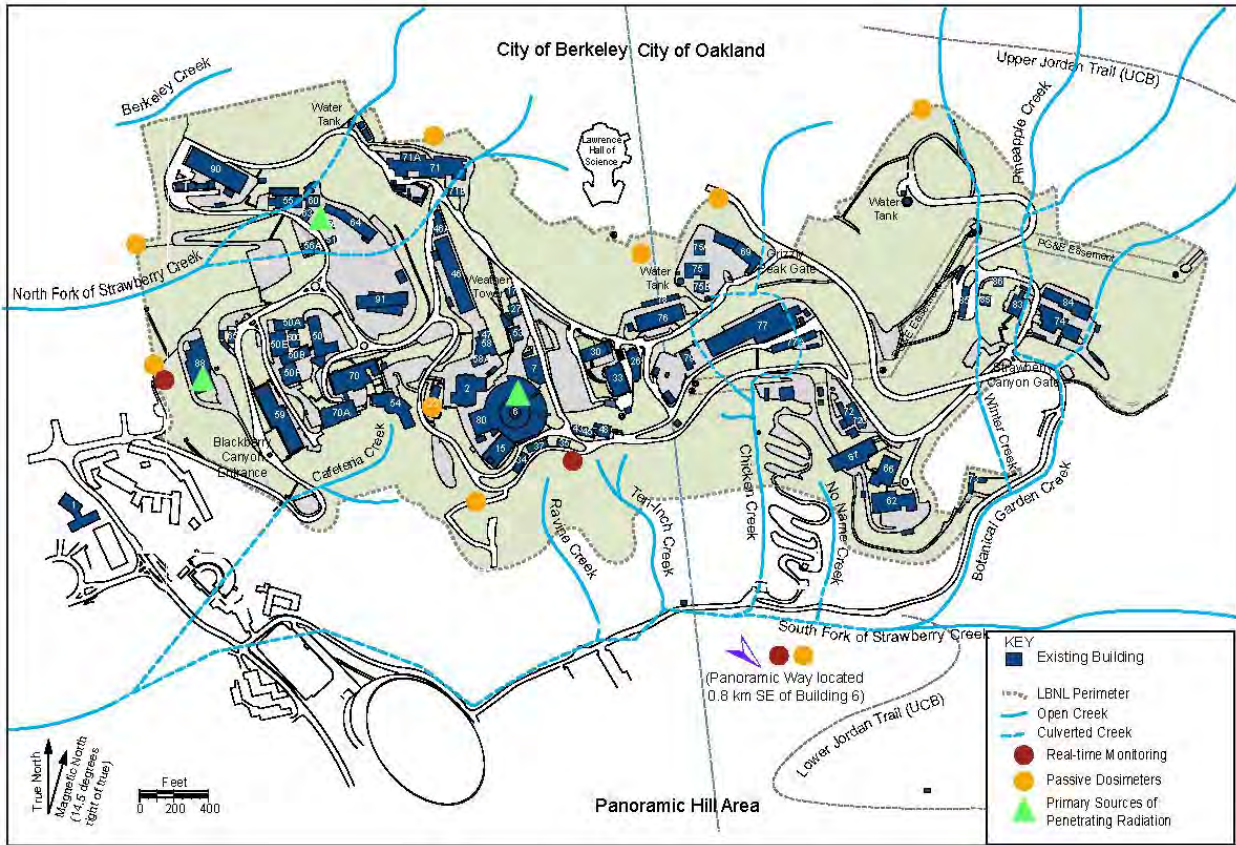


Figure 4-7 Environmental Penetrating Radiation Primary Sources and Monitoring Stations

5 Radiological Dose Assessment

5.1 BACKGROUND

Radiological dose is the energy deposited in tissue mass through external irradiation, inhalation, or ingestion due to exposure to radioactive material. The annual dose to the public and the environment from Berkeley Lab's radiological operations is very low. The health effects from such a low dose are either too small to be observed or nonexistent (Health Physics Society, 2010).

This chapter presents maximum potential estimated dose results from Berkeley Lab's penetrating radiation and airborne radionuclide monitoring programs. The results include the annual dose to nearby individual members of the public and the dose to the general population in the region extending 50 miles from the site. Within this region, the daytime population is approximately 7,253,000 (LandScan, 2014). The potential dose to humans projected from each monitoring program is presented in Sections 5.2 and 5.3, and the results are discussed in Section 5.4 in terms of the overall impact of Berkeley Lab's radiological activities on members of the public in the form of total dose. The radiological impact of Berkeley Lab's operations on local animals and plants is discussed in Section 5.5.

To ensure that radiological impacts to the public and the environment remain very low, Berkeley Lab manages work activity so that radioactive emissions and external exposures are as low as reasonably achievable (ALARA). Berkeley Lab's Environmental Radiological Protection Program ensures that a screening (qualitative) review is performed on activities that could result in a dose to the public or the environment (LBNL, 2020b). Potential dose from activities that may generate airborne radionuclides is estimated through the required National Emission Standards for Hazardous Air Pollutants (NESHAP) regulatory process (U.S. EPA, 1989), as discussed in Section 4.1. An in-depth quantitative review is required if the potential for a public dose is greater than 1 mrem to an individual or 10 person-rem to a population. No quantitative reviews were required or performed in 2019.

5.2 DOSE FROM PENETRATING RADIATION

As discussed in Section 4.7, penetrating radiation from LBNL operations is measured by real-time monitors and passive dosimeters. The results of real-time penetrating radiation measurements indicate that the maximum potential annual dose from gamma and neutron radiation to a person outside the northern boundary of the site was 0.14 mrem. This potential dose was located at the Lawrence Hall of Science, about 1,150 feet from the primary contributing source, which was the Advanced Light Source accelerator. This dose is statistically higher than the measured background for Berkeley Lab, but represents a small fraction (0.14%) of the DOE Order 458.1 compliance limit of 100 mrem per year for the dose to any member of the public.

The annual population dose to people in the surrounding region that extends 50 miles from the site was estimated at 1.56 person-rem, based on the most recent population figure and measured dose from the 88-Inch Cyclotron and the Advanced Light Source accelerator. A network of passive optically stimulated luminescence dosimeters located around the Berkeley Lab site validates the real-time penetrating radiation measurements and confirms

that the dose from LBNL activities is negligible. The dose from penetrating radiation is not affected by wind patterns.

5.3 DOSE FROM DISPERSIBLE AIRBORNE RADIONUCLIDES

Dose due to dispersible contaminants represents the time-weighted exposure to a concentration of a substance, whether the contaminant is inhaled in air, ingested in drink or food, or absorbed through skin contact with soil or other environmental media.

Very small quantities of dispersible radionuclides originate as emissions from building exhaust points that are generally located on rooftops, as discussed in Section 4.1. Once emitted, these radionuclides may interact with environmental media such as air, water, soil, plants, and animals. Each of these media represents a potential pathway of exposure affecting human dose.

The dose to an individual or the population is calculated by computer programs that estimate dispersion of airborne radionuclide emissions while factoring in wind speed and direction, atmospheric stability, and precipitation. The radiological NESHAP regulation requires DOE facilities that potentially release airborne radionuclides to assess the impact of such releases using a U.S. EPA–approved computer program. Berkeley Lab satisfies this requirement by using both CAP88-PC and COMPLY.

In late 2016, U.S. EPA Region 9 approved Berkeley Lab’s request to use a streamlined approach to model dispersion of radiological air emissions through a single virtual stack to comply with NESHAP requirements. This methodology was then used to prepare the annual radionuclide air emissions report submitted to DOE and the U.S. EPA. Previously, the dose assessment process was performed by collecting information and evaluating radionuclide emissions from approximately 10 grouped stack locations. Use of the single virtual stack method resulted in a much more efficient process for performing this assessment and preparing the annual report. Details of dose calculations from dispersible airborne radionuclide emissions are included in the *Radionuclide Air Emissions Report for 2019* (LBNL, 2020b).

In compliance with NESHAP requirements, the location of the maximally exposed individual to airborne emissions must be determined. For the main LBNL site, this location was identified as the Lawrence Hall of Science, a UC Berkeley public science center located just beyond the northern edge of the site and downwind of the primary contributing source: fluorine-18 emissions from Building 56. The maximum possible dose at this location is a hypothetical and conservative value because the exposure calculation assumes that the person is always present at the location the entire year. For 2019, the calculated annual dose from airborne radionuclides was 1.48×10^{-3} mrem, which is approximately 0.015% of the DOE and U.S. EPA annual limit for airborne radionuclides of 10 mrem/yr (DOE, 2013; U.S. EPA, 1989).

As with penetrating radiation, the collective dose from airborne radionuclides to the population is estimated within a radius of 50 miles of the site. The estimated population dose from all airborne emissions from the LBNL main site for 2019 was 2.68×10^{-2} person-rem. There is no regulatory standard for the collective dose metric.

5.4 TOTAL DOSE TO THE PUBLIC

The total radiological impact to the public from penetrating radiation and airborne radionuclides is well below applicable standards and less than local background radiation levels by several orders of magnitude. As shown on Figure 5-1, the maximum effective dose equivalent from penetrating radiation and airborne radionuclides from LBNL operations to an individual residing near Berkeley Lab in 2019 was approximately 0.19 mrem/yr. Penetrating radiation (i.e., gamma and neutron radiation) from accelerators at Berkeley Lab and radionuclides from airborne radionuclide emissions contributed to this total dose, which is a conservatively high estimate since the location of the maximum dose for penetrating and airborne radiation differ slightly, as described in previous sections. Yet, this value is very low at approximately 0.061% of the average natural background radiation dose (310 mrem/yr) in the United States (NCRP, 2009), and approximately 0.19% of the DOE annual limit from all sources (100 mrem/yr) (DOE, 2013).

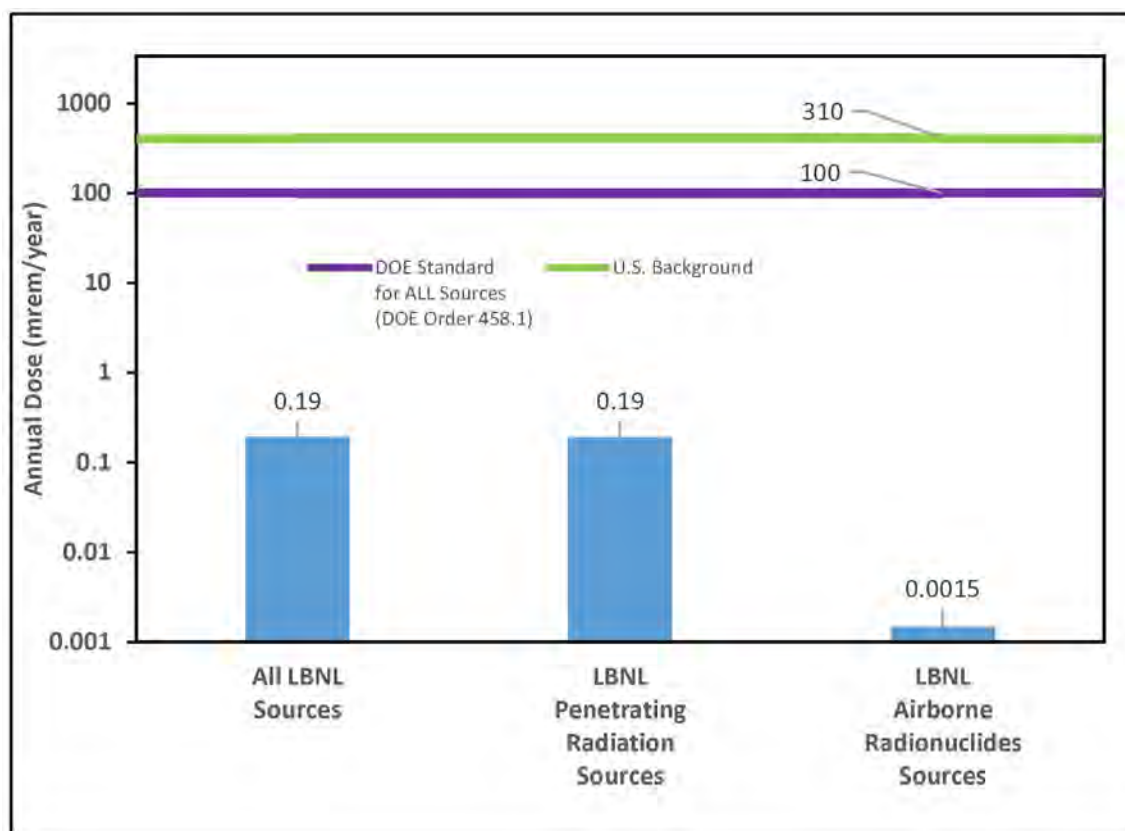


Figure 5-1 Comparative Radiological Doses for 2019

5.5 DOSE TO ANIMALS AND PLANTS

As described in DOE technical standard DOE-STD-1153-2019, *A Graded Approach for Evaluating Radiation Dose to Aquatic and Terrestrial Biota* (DOE, 2019a), DOE requires that animals and plants be protected from liquid and airborne emissions by limiting the radiation dose to aquatic animals and terrestrial plants (1 rad/day) and riparian and terrestrial animals (less than 0.1 rad/day).

To estimate the dose to animals and plants, the following sources of exposure were considered:

- Animal ingestion of vegetation, water, and soil
- Animal inhalation of dusty soil
- Plant uptake of water
- External exposure of animals and plants to radionuclides in water, soil, and sediment

Samples of creek water, sediment, and soil were collected and analyzed for several radionuclides, including tritium and gamma-emitting radionuclides. Measured levels of these radionuclides were either similar to natural background levels or well below applicable standards. The impact of these sample results was evaluated using the DOE-endorsed computer model RESRAD-BIOTA. This evaluation showed that both terrestrial and aquatic systems passed the “site-specific screening process of the analysis phase” described in DOE-STD-1153-2019, and confirmed that the calculated dose for terrestrial or aquatic systems is far below DOE dose limit requirements.

6 Quality Assurance

6.1 OVERVIEW

Berkeley Lab's overarching quality assurance (QA) policy is documented in the *Requirements and Policies Manual* (LBNL, 2014). Details on the operating principles and practices used by organizations to achieve reliable, safe, and high-quality performance are provided in the *Quality Assurance Program Description* (QAPD) (LBNL, 2013b), which describes the elements necessary to integrate QA, management systems, and process controls into LBNL operations. The QAPD provides the framework for LBNL administrators, managers, supervisors, and staff to plan, manage, perform, and assess their work. Berkeley Lab's Environment, Waste & Radiation Protection Department implements elements of the QAPD through its *Quality Management Plan* (LBNL, 2016), which describes a graded approach to quality and programmatic assurance based on the scope of the department's technical programs.

Berkeley Lab's *Environmental Monitoring Plan* (LBNL, 2013a) and guidance from DOE (2015b) and the U.S. EPA (1989) are also part of the QA system. The monitoring and sampling activities and results presented in this report were conducted in accordance with those guidelines. Whenever extra QA and quality control (QC) measures are required, a Quality Assurance Project Plan is developed and implemented. The radiological NESHAP Compliance Program (LBNL, 2019c) and the Environmental Restoration Program (LBNL, 2017a) both have a program-specific Quality Assurance Project Plan.

In 2019, Berkeley Lab had contracts with five commercial analytical laboratories for specific analytical services:

1. ALS (Fort Collins, Colorado)
2. BC Laboratories (Bakersfield, California)
3. Enthalpy Analytical (Berkeley, California)
4. GEL Laboratories (Charleston, South Carolina)
5. Vista Analytical Laboratory (El Dorado Hills, California)

All of these laboratories are certified through California's Environmental Laboratory Accreditation Program (ELAP) by having demonstrated the capability to analyze samples for environmental monitoring using approved testing methods (CDPH, 1994). These laboratories must meet demanding QA and QC specifications and certifications that were established to define, monitor, and document laboratory performance (LBNL, 2012; DoD/DOE, 2018), and their QA and QC data are incorporated into Berkeley Lab's data quality assessment processes.

Each data set (batch) received from these analytical laboratories is systematically evaluated and compared to established data quality objectives before the results can be authenticated and accepted into the environmental monitoring database. Categories of data quality objectives include accuracy, precision, representativeness, comparability, and completeness. When possible, quantitative criteria are used to define and assess data quality.

In addition to the ELAP certification, analytical laboratories supporting DOE facilities are subject to third-party audits by accrediting bodies. Once audited, these analytical laboratories receive accreditation to perform work for DOE facilities following DOE's Quality Systems Manual (DoD/DOE, 2018). In 2019, all five analytical laboratories were accredited to perform for DOE facilities.

Complementing the objectives of Berkeley Lab's QAPD, the DOE Berkeley Site Office's Oversight and Issues Management Program (DOE, 2014) enables its staff to participate in LBNL operational activities such as audits/inspections, document reviews, and day-to-day communications. This interaction provides an effective and efficient means of meeting contractual requirements between DOE and UC while allowing Berkeley Lab to accomplish its assigned missions. This assurance system includes attributes such as metrics and targets to assess performance, rigorous self-assessment and improvement, identification and correction of negative performance trends before they become significant issues, and timely communication with the DOE Berkeley Site Office (now called Bay Area Site Office) on assurance-related information.

6.2 ENVIRONMENTAL MONITORING SAMPLES AND RESULTS PROFILE

In 2019, a total of 2,420 individual air, sediment, soil, and water samples were collected under Berkeley Lab's environmental monitoring programs, both routine and project-specific, generating 57,110 analytical results. Samples were obtained from over 563 locations on or surrounding the main site. Some of these locations are shown on figures in the sections of [Chapter 4](#) that summarize program results; others are in the referenced project or program documents, such as those available on the Environmental Restoration Program's website (<https://ehs.lbl.gov/resource/environmental-restoration-program/>) or in hard copy at the main branch of the Berkeley Public Library.

The sampling result totals include those from all activities associated the Old Town Demolition Project and Bayview project that were carried out by the demolition subcontractor and provided to Berkeley Lab. These projects accounted for over 53% of the environmental monitoring programs' sampling locations, almost 56% of the individual samples collected, and nearly 53% of the analytical results in 2019.

6.3 SPLIT AND DUPLICATE SAMPLING FROM ENVIRONMENTAL MONITORING

An essential activity undertaken to measure the quality of environmental monitoring results is the regular collection and analysis of split and duplicate samples. In 2019, a total of 57 split and 211 duplicate samples were collected for either radiological or nonradiological analyses, or both. These samples led to 875 split and 3,948 duplicate results. In addition, 255 blank samples were submitted for QA purposes. The primary purpose of a blank sample is to identify artificially introduced contamination.

Berkeley Lab uses the metrics of relative percent difference and relative error ratio to determine whether paired results, such as split or duplicate samples, are within control limits. *Relative percent difference* is defined as the absolute value of the difference between two results divided by the mean of the two results. *Relative error ratio* is defined as the absolute value of the difference between two results divided by the sum of the analytical error of the two results. Relative percent difference is determined in all cases; relative error ratio is applicable only to radiological analyses for which analytical error is included in the same result.

When the primary sample and the split or duplicate sample results are below analytical detection limits, the results from these tests are not meaningful. When QA pair results exceed control limits, the program leader investigates the cause of the discrepancy.

6.4 ANALYTICAL LABORATORY QUALITY CONTROL TESTING

Analytical laboratories routinely perform QC tests to assess the quality and validity of their sample results. These tests are run with each batch of environmental samples submitted by Berkeley Lab. The same relative percent difference and relative error ratio metrics are used to evaluate these control sample results, with the relative error ratio test applicable only to radiological analyses.

In 2019, the five ELAP-certified analytical laboratories performed 2,491 radiological and nonradiological QC analyses to validate the environmental samples submitted by Berkeley Lab. These QC analyses include various types of blank, replicate (duplicate), matrix spike, and laboratory control samples. Table 6-1 shows the breadth and diversity of the QC activity.

In addition to the relative percent difference and relative error ratio tests, lower and upper control limits are established for each analyte and for each type of QC test. As with split and duplicate QA, when QC results exceed established criteria, an investigation is performed to determine the cause of the discrepancy.

Table 6-1 Summary of Quality Control Testing Performed by Analytical Laboratories

Program	Number of Sample Batches	Number of QC Analyses	Number of Laboratories Involved	Radiological ^a	Nonradiological ^b
Stack Air	33	78	2	√	–
Stormwater and Creeks	62	174	4	√	√
Wastewater	101	367	5	√	√
Groundwater	147	621	4	√	√
Sediment	19	54	4	√	√
Soil	14	31	4	√	√
Old Town Demolition, Phase 5	33	119	2	√	√
Old Town Demolition, Phase 7	17	53	1	√	√
Bayview Project	235	994	2	√	√

^a A check mark in this column indicates that the program tests for radiological substances.

^b A check mark in this column indicates that the program tests for nonradiological substances. A dash means no testing occurred.

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Abbreviations

AEDE	annual effective dose equivalent
ALARA	as low as reasonably achievable
AST	aboveground storage tank
BAAQMD	Bay Area Air Quality Management District
Basin Plan	Water Quality Control Plan for the San Francisco Bay Basin
BASO	Bay Area Site Office
BSO	Berkeley Site Office
Btu	British thermal unit
CARB	California Air Resources Board
CATS	Corrective Action Tracking System
CCCSD	Central Contra Costa Sanitary District
CCHS	Contra Costa Health Services
CCR	California Code of Regulations
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
Ci	curie
COB	City of Berkeley
CUPA	Certified Unified Program Agency (California)
CY	calendar year
DCS	derived concentration standards
DHS	Department of Homeland Security
DOE	U.S. Department of Energy
DOECAP	Department of Energy Consolidated Audit Program
DTSC	Department of Toxic Substances Control (California)
E85	85% ethanol / 15% unleaded gasoline fuel blend
EBMUD	East Bay Municipal Utility District
EHS	Environment, Health & Safety Division at Berkeley Lab
ELAP	Environmental Laboratory Accreditation Program
EMS	Environmental Management System
EPCRA	Emergency Planning and Community Right-to-Know Act
EPEAT	Electronics Product Environmental Assessment Tool
ESG	Environmental Services Group
ES&H	environment, safety, and health

F	Fahrenheit
FTU	fixed treatment unit
FY	fiscal year (October 1–September 30)
GAC	granular activated carbon
gal	gallon(s)
GHG	greenhouse gas
HMBP	Hazardous Materials Business Plan
HWHF	hazardous waste handling facility
IGB	Integrative Genomics Building
ILA	industrial, landscaping, and agricultural
ISM	Integrated Safety Management
ISO	International Organization for Standardization
JGI	Joint Genome Institute
kg	kilogram(s)
L	liter(s)
LBNL	Lawrence Berkeley National Laboratory
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mrem	millirem (one thousandth of a rem, or 1×10^{-3} rem)
mrem/yr	millirem per year
MUP	Modular Utility Plant
NAL	Numeric Action Level
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOD	Notice of Deficiency
NTLF	National Tritium Labelling Facility
OIAI	Office of Institutional Assurance and Integrity
OMB	Office of Management and Budget
PCB	polychlorinated biphenyl
pCi/L	picocuries (one trillionth of a curie) per liter
PSA	pollutant source assessment
QA	quality assurance
QAPD	Quality Assurance Program Description
QC	quality control

RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
RWQCB	San Francisco Bay Regional Water Quality Control Board
SAA	satellite accumulation area
SARA	Superfund Amendments and Reauthorization Act
SF ₆	sulfur hexafluoride
SIC	Standard Industrial Classification
SPCC	Spill Prevention, Control, and Countermeasure
SURP	Site Utilities Relocation Project
SWPPP	Stormwater Pollution Prevention Plan
SWRCB	State Water Resources Control Board
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, and disposal facility
UC	University of California
U.S. EPA	United States Environmental Protection Agency
UST	underground storage tank
VOC	volatile organic compound
WAA	waste accumulation area

Glossary

accuracy

The closeness of a measurement to its true value.

Advanced Light Source

An accelerator at Berkeley Lab that is a third-generation synchrotron light source, one of the world's brightest sources of ultraviolet and soft x-ray beams.

alpha particle

A charged particle comprising two protons and two neutrons, which is emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.

analyte

The subject of a chemical analysis.

background radiation

Ionizing radiation from sources other than Berkeley Lab. Background radiation may include cosmic radiation; radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air, and water; and radiation from naturally occurring radioactive elements in the human body.

beta particle

A charged particle identical to the electron that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by less than 0.2 inches of aluminum.

contaminant

Any hazardous or radioactive material present above background levels in an environmental medium such as air, soil, water, or vegetation. *See also* pollutant.

cosmic radiation

High-energy particulate and electromagnetic radiation that originates outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.

curie

Unit of radioactive decay equal to 2.22×10^{12} disintegrations per minute.

detection limit

The lowest concentration of an analyte that can be measured and reported with 99% confidence that the concentration is greater than zero.

discharge

The release of a liquid or pollutant to the environment or to a system (usually of pipes) for disposal.

dose

The quantity of radiation energy absorbed by a human, animal, or vegetation. Dose to humans is also called effective dose equivalent (measured in units of rem), which takes into account the type of radiation and the parts of the body exposed. Dose to animals and vegetation is also called absorbed dose (measured in units of rad), which is the energy deposited per unit of mass.

dosimeter

A portable detection device for measuring the total accumulated dose from ionizing radiation. *See also* optically stimulated luminescence dosimeter.

duplicate samples

Two samples taken from and representative of the same population and carried through all steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variance of the total method, including sampling and analysis.

effective dose equivalent

A measure of the whole-body biological damage to living tissue as a result of external radiation exposure.

emission

A release of air to the environment that contains gaseous or particulate matter having one or more contaminants.

environmental monitoring

The collection and analysis of samples or direct measurements of environmental media (e.g., air, water, soil, foodstuff, biota) from LBNL facilities and their environs for possible contaminants with the purpose of determining compliance with applicable standards and permit requirements, assessing radiation exposures of members of the public, and assessing the effects, if any, on the local environment.

fiscal year

The 12-month period for which an organization plans the use of its funds. For the federal government and its contractors, this is the period from October 1 to September 30 the following year.

gamma radiation

Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation, such as microwaves, visible light, and radio waves, has longer wavelengths (lower energy) and cannot cause ionization.

greenhouse gas

Any of the atmospheric gases (e.g., carbon dioxide, water vapor, and methane) that contribute to the greenhouse effect. The greenhouse effect is the trapping and buildup of heat in the upper atmosphere by gases that absorb infrared radiation. These gases then reradiate some of this heat back toward the earth's surface.

groundwater

Water below the earth's surface in a zone of saturation.

half-life, radioactive

The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains ($1/2 \times 1/2$); after three half-lives, one-eighth of the original activity remains ($1/2 \times 1/2 \times 1/2$); and so forth.

hazardous waste

Waste exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or extraction procedure-toxicity (yielding toxic constituents in a leaching test). Because of its concentration, quantity, or physical or chemical characteristics, it may (1) cause or significantly contribute to an increase in mortality rates or cases of serious irreversible illness or (2) pose a substantial present or potential threat to human health or the environment when improperly treated, stored, transported, disposed of, or handled.

hydrauger

A sub-horizontal drain used to extract groundwater for slope stability purposes.

low-level radioactive waste

Waste containing radioactivity that is not classified as high-level waste, transuranic waste, spent nuclear fuel, by-product material (as defined in Section 11(e)(2) of the Atomic Energy Act of 1954, as amended), or naturally occurring radioactive material.

millirem

A common unit for reporting human radiation dose. One millirem is one thousandth (10^{-3}) of a rem. *See also* rem.

mixed waste

Any radioactive waste that is also a RCRA-regulated hazardous waste.

nuclide

A species of atom characterized by what constitutes the nucleus, which is specified by the number of protons, number of neutrons, and energy content; or, alternatively, by the atomic number, mass number, and atomic mass. To be regarded as a distinct nuclide, the atom must be able to exist for a measurable length of time.

optically stimulated luminescence dosimeter

A type of dosimeter in which the material that has been exposed to radiation luminesces after being stimulated by laser light. The amount of light that the material emits is proportional to the amount of radiation absorbed (dose). *See also* dosimeter.

organic compound

A chemical whose primary constituents are carbon and hydrogen.

person-rem

The sum of the radiation doses to individuals of a population. *See also* population dose.

pH

A measure of hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, basic solutions have a pH greater than 7, and neutral solutions have a pH of 7.

plume

A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction in which they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

pollutant

Any hazardous or radioactive material present in an environmental medium such as air, water, or vegetation. *See also* contaminant.

population dose

The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem. For example, if 1,000 people each received a radiation dose of one rem, their population dose would be 1,000 person-rem.

positron

A particle that is equal in mass to the electron but opposite in charge. A positively charged beta particle.

precision

The degree of agreement between measurements of the same quantity.

rad

The conventional unit of absorbed dose from ionizing radiation, commonly used for dose to animals and vegetation.

radiation

Electromagnetic energy in the form of waves or particles.

radioactivity

The property or characteristic of a nucleus of an atom to spontaneously disintegrate, accompanied by the emission of energy in the form of radiation.

radiological

Arising from radiation or radioactive materials.

radionuclide

An unstable nuclide. *See also* nuclide, radioactivity.

relative percent difference

The absolute value of the difference between two results divided by the mean of the two results.

relative percent error

The absolute value of the difference between two results divided by the sum of the analytical error of the two results.

rem

Acronym for “roentgen equivalent man.” A unit of ionizing radiation, equal to the amount of radiation needed to produce the same biological effect to humans as one rad of high-voltage x-rays. It is the product of the absorbed dose, quality factor, distribution factor, and other necessary modifying factors. It describes the effectiveness of various types of radiation in producing biological effects.

remediation

The process of improving a contaminated area to an uncontaminated or safe condition.

source

Any operation or equipment (e.g., pipe, ditch, well, or stack) that produces, discharges, and/or emits pollutants, or the location where a pollutant was released to the environment.

split sample

A single well-mixed sample that is divided into parts for analysis and comparison of results.

stack

A pipe, usually vertical, through which air and contaminants are vented to the atmosphere. A stack may be associated with a building or a vehicle (e.g., bus, heavy-duty truck). At Berkeley Lab, stacks are typically constructed of metal; they may discharge air from a local area such as a fume hood, or they may carry air from multiple areas of a building

terrestrial

Pertaining to or deriving from the earth.

terrestrial radiation

Radiation emitted by naturally occurring radionuclides, with the major radionuclides of concern being potassium-40, uranium-235, uranium-238, thorium-232, and their decay products; radiation levels over oceans and other large bodies of water tend to be about one-tenth of the terrestrial background.

tritium

A radionuclide of hydrogen with a half-life of 12.3 years, which decays by emitting a low-energy beta particle.

water year

The term used by hydrologists and climatologists to represent rainfall occurring between October 1 of one year and September 30 of the next year.

wind rose

Meteorological diagram that depicts the distribution of wind direction over a period of time.

